

# Do data characteristics change according to the number of scale points used? An experiment using 5-point, 7-point and 10-point scales

John Dawes

Ehrenberg-Bass Institute for Marketing Science, University of South Australia

## INTRODUCTION

Rating scales are one of the most widely used tools in marketing research and commercial market research. They are used to capture information on a range of phenomena. In consumer research, respondents may be asked about their attitudes, perceptions or evaluations of products, brands or messages – among many other possibilities. In other marketing research streams, respondents such as managers or marketing personnel may be asked to rate their company's performance, type of strategic focus, personnel, degree of marketing excellence, training regimes and so forth using such scales.

Rating scales typically require the respondent to select their answer from a range of verbal statements or numbers. Scales that use verbal statements include semantic differential scales and Likert scales. An example of the semantic differential scale is *very good ... very bad*, or *pleasant ... unpleasant*. An example of the Likert response scale is as follows: *strongly disagree, disagree, neither disagree nor agree, agree, strongly agree*. This particular example is a 5-point Likert scale utilising verbal response descriptors. Likert scales may also use numerical descriptors where the respondent selects an appropriate number to denote their level of agreement. For example, a question could be worded like this: 'Indicate your agreement from 1 to 5 where 1 equals strongly disagree and 5 equals strongly agree.'

The range of possible responses for a scale can vary. Textbooks on the subject typically portray 5- or 7-point formats as the most common (e.g. Malhotra & Peterson 2006, ch. 10); 10- or 11-point scales are also frequently used (Loken *et al.* 1987). Hereafter in this study the term 'scale format' is used to refer to scales with differing numbers of response categories.

In terms of the interface between the respondent and the interviewer in a telephone survey, there are some advantages and disadvantages of each scale format. With a 5-point scale, it is quite simple for the interviewer to read out the complete list of scale descriptors ('1 equals strongly

disagree, 2 equals disagree ...'). This clarification is lengthier for the 7-point format. Such a verbal clarification becomes quite impractical for a 10-point format as the gradations of agreement become too fine to easily express in words. In this case, the interviewer normally reads out the verbal meaning of the end points. The 10-point format therefore places greater reliance on the respondent using a numerical response, for which the precise meaning has not been defined. However, this disadvantage is balanced against the fact that many people are familiar with the notion of rating 'out of 10'.

There have been numerous studies on the topic of how scale format affects scale reliability and validity. Far less attention has been paid to how it influences data characteristics such as mean and variance. The issues of reliability and validity are outside the scope of this study. Suffice to say, simulation studies and empirical studies have generally concurred that reliability and validity are improved by using 5- to 7-point scales rather than coarser ones (those with fewer scale points). But more finely graded scales do not improve reliability and validity further.

The next section presents some theoretical reasons for why the scale format might influence the mean score, variance, skewness and kurtosis. The small number of empirical studies that have examined this issue are then reviewed.

## **WHY WOULD SCALE FORMAT INFLUENCE DATA CHARACTERISTICS?**

One of the most basic summary data characteristics is the mean. Scores for Likert-type questions are often 'negatively skewed' (e.g. Peterson & Wilson 1992; Dawes 2002a). This term is counterintuitive and refers to the fact that more responses are at the positive end of the scale and the 'tail' is at the negative end. If more respondents tend to give positive responses, then a finer scale, with more response options, could result in a slightly lower mean score. This can be illustrated by considering the range of positive response options for 5-, 7- and 10-point formats. First, consider a 5-point scale. There are only two options for a positive response: points 4 and 5. If we average those two responses and rescale to the equivalent score on a 10-point scale (using the method described and used later under 'rescaling') the result is 8.9/10. If we undertake the same procedure for a 7-point scale the positive responses are 5, 6 and 7 for an average of 6, which rescales to a score of 8.5/10. The positive responses for a 10-point scale are 6, 7, 8, 9 and 10, which averages to 8/10. Therefore, based on the arithmetic properties of the scales, the three scale formats would produce somewhat different comparative mean scores if the majority of responses were on the positive side of the mid-point. The potential of these different formats to produce comparatively different mean scores seems worthwhile to investigate.

In relation to the distribution of data about the mean, more scale points, by definition, provide more options for the respondent. Therefore, finer scales could result in a greater spread of the data. This would result in a larger variance, and possibly more negative kurtosis. Negative kurtosis means that the data are less peaked, and 'flatter' around the mean, with shorter tails.

More scale response options may also conceivably result in less skewed data. This is illustrated using the situation whereby a scale is used to measure a construct that most respondents give a particularly positive response for. A coarse scale will provide few options for this positive sentiment and so the responses may be 'bunched up' at the positive end of the scale. A finer scale could reduce this negative skew by allowing for more gradations of positive response. This could also reduce the overall mean score, for the reasons outlined above.

The empirical studies examining scale format and its association with data characteristics are now reviewed.

## Studies Examining Level and Shape of Data

There are only a small number of studies on this issue. One is by Finn (1972), which reported means and variances for 3-, 5-, 7- and 9-point scales. They were 1.6, 2.2, 4.1 and 4.9 for means and 0.32, 0.60, 1.32 and 4.0 for variances respectively. Applying a rescaling formula from Preston and Colman (to be discussed in more detail later in the analysis section), these reported means are transformed to a score out of 100. The transformed scores are 30, 30, 52 and 49 respectively. This suggests the 7- and 9-point formats produced comparatively higher scores. This is counter to the theoretical expectation outlined above. In terms of the variance, taking its square root and dividing this by the original mean score gives the coefficient of variation. This is a standardised measure of variance that controls for the differing number of scale points. The coefficient of variation for Finn's four scale formats is calculated to be 0.35, 0.35, 0.28 and 0.41 for the 3-, 5-, 7- and 9-point scales respectively. It appears the nine-point format produced higher comparative variance in that study compared to the coarser scales.

Two other studies are pertinent to the issue of how the number of scale points affects data characteristics such as the mean score. One of these was many years ago, in which Ghiselli (1939) conducted an experiment using undergraduate students who were asked to indicate whether they thought the advertising messages for 41 different brands were *sincere*. One group answered using a 2-point (yes/no) scale, the other group answered using a 4-point scale ('very sincere ... very insincere'). The 4-point scale resulted in higher ratings for the perceived sincerity of the advertising than the 2-point scale.

Another study was by Dawes (2002b), who analysed two split-sample experiments in which groups of respondents were administered questions with either 5-point or 11-point scales. He found that once the 5-point scale was rescaled to 11-point equivalence, the means from the 11-point scale were slightly higher by an average of 0.25 points, although no inferential test was applied. This result could be partially attributable to the 11-point scale having an anchor value of zero (i.e. a zero to 10 scale). This characteristic may have artificially lowered the mean score for the 5-point data from the rescaling process. For example, a score of 1 out of 5 was rescaled to zero out of 10. In that study, the 11-point scale also produced slightly more dispersion in the data as measured by the coefficient of variation, but there was no difference in skewness or kurtosis between the two scales. Only one other study has examined the issue of scale format and skewness, which was by Johnson *et al.* (1982). They found that a 2-point format produced more skewness than a 5-point format.

This review makes it apparent that basic issues to do with the mean and distribution of the data, and how they are affected by scale format, have not been closely studied. There also seems to be some variation in the results from previous studies. While Dawes (2002b) found that rescaled means from 5- to 11-point scales were almost the same, an inspection of the data reported in Finn (1972) showed more marked differences. Likewise, one prior study found that coarse scales resulted in more skewness (Johnson *et al.* 1982), albeit between 2- and 5-point scales, the former of which is rarely used in marketing studies. Another study found no appreciable difference between 5- and 11-point scales in this regard (Dawes 2002b).

## RESEARCH QUESTIONS AND RATIONALE

We know that scales are ubiquitous in both market research and academic marketing research. But there is a less than comprehensive amount of documented knowledge on the topic. Therefore further investigation of the way scale format might influence the data is warranted. There are at least three reasons for this.

First, the sophistication of analytical methods is increasing. Techniques such as confirmatory factor analysis and structural equation modelling are now commonplace in marketing research. These tools are sensitive to the characteristics of the data, such as variance, kurtosis and skewness (e.g. Bentler 1995). Therefore more knowledge about how scale format affects these characteristics would be desirable.

Second, in many cases the data from a survey are not just reported, rather they are analysed with the objective of 'explaining' or accounting for the variance in a dependent variable. Examples of the dependent variable might be overall customer satisfaction, probability of purchase, or attitudes towards a brand or organisation. The analyst wishes to find out what other variables might be strongly related to higher or lower scores on the dependent variable. In this situation, more variance in the dependent variable is desirable. For example, if all respondents gave the same score for customer satisfaction there would be no variance to explain. If there were very little variance, with all responses at either 6 or 7 on a 7-point scale, then standard OLS regression would not be an appropriate analysis method. More complex techniques, such as logistic regression, would be needed.

The third reason is that in industry, many organisations periodically track consumer sentiment and, often, scales of the type discussed here are a major part of the research. For example, many service organisations, such as banks, telecommunication companies or insurance companies, routinely survey customers about their perceived levels of service quality or customer satisfaction. For a variety of reasons, the choice of scale is sometimes changed – say, from a 5-point scale to a 7-point scale. The reasons for this could be personnel changes, the appointment of a different research provider, department mergers, and so on. Obviously the information gleaned from the data, such as mean scores, is based on the number of scale responses used. But are the data dependent on the scale to the extent that the mean score relative to the highest possible score is different for one scale compared to another? There are some theoretical grounds for thinking scale format might affect the data, as outlined earlier. Also, there is little guidance on this apparently practical and important issue, and indeed some conflict in prior results. More knowledge in this area would therefore seem desirable.

This study therefore sought to compare the aggregate-level data characteristics derived from attitudinal questions with either 5-, 7- or 10-point numerical scales. The specific research question is:

If data on the same construct are gathered using three scale formats (5-point, 7-point and 10-point numerical scales) and the data from the 5- and 7-point formats are rescaled to a common 10-point format, are there any differences in terms of mean, variance, kurtosis and skewness?

This question presumes to treat the data as if they were at least interval quality. There is some evidence that the psychological 'distances' between Likert-type scale points are not equal – for example, Bendixen and Sandler (1994) and Kennedy *et al.* (1996). That said, the relation between the original scale values and the 'real' identified scale values is very close in these studies. For example, in Kennedy *et al.* (1996) the notional scale values of 1, 2, 3, 4 and 5 equated to 1, 2.2, 3.1, 4.1 and 5 respectively. The leading texts in the field support the treatment of such scales as if they are equal-interval (e.g. Dillon *et al.* 1993, p. 276; Burns & Bush 2000, p. 314; Aaker *et al.* 2004, p. 285; Hair *et al.* 2006, pp. 365–366). Based on the empirical studies showing a reasonably close approximation to equal-interval, and the apparent precedent shown in the leading texts, the data were analysed as if they were equal-interval.

## DATA

In accordance with the research objective, data were gathered via a survey of consumers drawn at random from the telephone directory. The survey was conducted over the 2005–2006 period by a professional market research organisation using CATI (computer-assisted telephone interviewing).

The questionnaire items were derived from existing 'price-consciousness' scales (Bruner & Hensel 1992). Price consciousness is an example of a subject-centred scale, and it appeared to possess content that respondents could readily understand and easily answer. The scale comprised eight items, which are shown in Table 1. Respondents were asked to answer the questions with the instruction 'please answer using the scale from 1 to  $X$  where 1 equals strongly disagree and  $X$  equals strongly agree'.  $X$  was either 5, 7 or 10 depending on the treatment group. The precise meaning of each scale point was not read out to respondents for any of the three scale formats, whereas normally one would do so for the 5- or 7-point formats. This potentially lowered the utility of those two scale formats, but the aim was to have a consistent approach to administering all three of the scales.

□ **Table 1: Scale items**

The number of respondents in each experimental group was: 10-point scale  $n = 300$ ; 7-point scale  $n = 185$ ; 5-point scale  $n = 250$ . The reason for the varying sample sizes for each group is that the study had other unrelated objectives, and the questionnaire programming used to direct respondents into the three scale format groups was also used to direct them to other question sets, which required different sample sizes. The other survey content did not affect the results reported here.

It was then considered whether the sample sizes were adequate by calculating how large the difference in mean scores across groups would need to be to achieve statistical significance. A difference of half a scale point was set as the magnitude of difference that the experiment should be able to identify as statistically significant. Three treatment groups were considered, with the smallest group numbering 185 respondents. To ascertain their adequacy, a conservative inferential test was conducted using simulated data of three groups of  $n = 185$ . First, a series of 185 scores with a mean of 6.0 and a standard deviation of 2.0 were generated using Microsoft Excel. These data characteristics were taken from the results of a previous study (Dawes 2002b). Two other series were then generated, such that three data series were produced that differed to each other by 0.5 scale points. This process was repeated with data series that exhibited progressively smaller differences in mean scores. It was found that if there was a mean difference of 0.3 scale points (or more) between each of three groups of this size, an analysis of variance would be statistically significant at the  $p = 0.05$  level. Since two of the groups had a larger number of respondents than this, the sample sizes appeared to be adequate for the purpose.

The survey sample was broadly representative of the general population, excepting that younger respondents were under-represented. The age breakdown of the sample is shown in Table 2. The gender breakdown was 42% male and 58% female. Ideally the survey would have obtained an age and gender breakdown closer to the general population but, in order to do so, data collection costs would have increased, which was not feasible for this study. The issue of whether the results are comparable for age and gender sub-groups to ensure the results are not biased by the sample, is discussed later.

□ **Table 2: Survey breakdown**

## ANALYSIS

Rescaling

To examine the various data characteristics of interest, it is convenient to rescale the data so that the three scale formats are comparable, each with the same upper limit, such as out of 10 or out of 100. Note that the purpose of this rescaling is to facilitate comparison between the scale formats, not to find a specific functional transformation that will minimise any rescaled differences.

There are a number of straightforward methods by which this could be done. One is based on a formula used by Preston and Colman (2000). They used the formula  $(\text{rating} - 1)/(\text{number of response categories} - 1) \times 100$ . This rescales to a common score out of 100. For the purpose of this paper we could use the same formula but adapted to be  $(\text{rating} - 1)/(\text{number of response categories} - 1) \times 10$ , which rescales all scale formats to a score out of 10. A feature of this method is that any score using the lowest scale point of any scale becomes zero. For example, a score of 1 on a 5-point scale would become  $(1 - 1)/(5 - 1) \times 10 = \text{zero}$ .

Another method is that employed by Dawes (2002b). This is a simple arithmetic procedure whereby the scale end points for the 5- and 7-point versions are anchored to the end points of the 10-point scale. The intervening scale values are inserted at equal numerical intervals. For example, to rescale the 5-point scale to 10 points, 1 remains as 1, 5 is rescaled to 10, the mid-point of 3 on the 5-point scale is adjusted to be as per the mid-point between 1 and 10 (namely 5.5), and so on. This is shown in Table 3.

Table 3: Rescaling method for this study

The second approach has the appealing feature for the present research that the 10-point scale remains unchanged, and the other scales are altered to be comparable to it. However, it may result in a slight biasing effect, due to the lowest scale point. This is because it takes a score of 1 out of 5 or 1 out of 7 and rescales it to be equivalent to 1 out of 10 – the latter being a lower score in proportional terms. Therefore if there are any responses using these lowest scale points for the 5- or 7-point formats, the rescaled score expressed as a mean out of 10 will be marginally lower than it was originally. However, preliminary analysis showed that the method based on Preston and Colman (2000) and Dawes (2002b) produced virtually identical results. The latter method was used because it was slightly simpler. The method used did not bias the empirical results, as will be discussed later.

RESULTS

Mean Scores

The rescaled mean scores for each item are shown below, for each of the three scale formats. The data are ordered according to the mean score on the 10-point scale for clarity.

The rescaled 5-point and 7-point scales produced more instances of higher scores compared to the 10-point format. For seven out of the eight questions, the 5-point format (once rescaled) produced slightly higher scores than the 10-point format. For six out of the eight questions, the 7-point format (once rescaled) produced slightly higher scores than the 10-point format. There appeared to be little difference between the 5-point and 7-point format.

To test if the overall mean scores from the eight items were statistically significantly different according to scale format, a one-way ANOVA was run. Since there was virtually no difference between the 5-point and 7-point formats they were combined as one factor. The average

rescaled scores of the eight scale items were the dependent variable, and the factors were the scale formats (5-point rescaled and 7-point rescaled combined as one factor, and 10-point scale comprising the other factor). The result was statistically significant ( $F = 4.1$ ;  $df\ 1,733$ ;  $p = 0.04$ ).

□ **Table 4: Mean scores according to scale format**

Based on this result, it seems that a 10-point scale format will produce slightly lower scores compared to the scores generated from 5-point or 7-point formats, once the latter are rescaled for comparability. Note that earlier in the discussion it was mentioned that the rescaling method used could potentially bias the rescaled 5- and 7-point scores downwards slightly. The empirical result reported here is in the opposite direction to that potential bias, so the results are not due to the method.

## VARIANCE

Variance is usually measured using the standard deviation. It was decided to examine the standard deviation for the rescaled 5- and 7-point data compared to the 10-point data. If the data are not dependent on the choice of scale format, then once the data are rescaled to a score out of 10, all three scale formats should exhibit the same standard deviation.

Looking across the three scale formats in Table 5, the differences in standard deviation for the individual scale items are quite small, of the order of zero to 0.2. It appears that scale format does not have a marked influence on variation about the mean. To clarify this formally, it was decided to test the overall average score for each format using the Levene test for homogeneity of variance. The test was not significant (Levene statistic = 0.21;  $df\ 2,732$ ;  $p = 0.81$ ). Scale format therefore did not have an association with variance in this experiment.

□ **Table 5: Standard deviation according to scale format**

An examination of the standard deviation tells us about the dispersion of scores about the mean for a particular questionnaire item or variable. It does not, however, tell us about how individual respondents have used the scale. For example, if we ask respondents to answer eight questions using a 1 to 5 scale, how many different scale points will they use? Obviously the precise answer depends on what the questions pertain to. However, researchers generally want respondents to use more response options over a series of questions, rather than fewer. The reason is that this indicates those questions are generating more discrimination in responses. Therefore, as a supplementary analysis, I also examined how many different scale points respondents actually used, and whether this differed according to the scale format. I found that, over the eight questions, the average number of scale points used for the 5-point scale was 2.9, for the 7-point scale it was 3.6 and for the 10-point scale respondents used 4.0 different scale points on average. An analysis of variance confirmed that there was a statistically significant difference between the scale formats in terms of the number of scale points used by respondents ( $F = 54$ ;  $df\ 2,732$ ;  $p < 0.01$ ). Therefore, there is evidence that respondents do use more scale points when given a scale format with more response options.

## SKEWNESS

Data may be normally distributed, or may be positively skewed or negatively skewed. If the data are negatively skewed this means they tend to cluster at the 'high' end of the scale with a long tail to the lower scale values. The figures for skewness are shown in Table 6.

□ **Table 6: Skewness according to scale format**

The data from all three scale formats are negatively skewed. There are some differences among the individual scale items according to scale format, but nothing systematic. In terms of the skewness of the overall mean score, there is less than one standard error difference between each scale format, therefore this is not statistically significant.

## KURTOSIS

Kurtosis refers to the shape of the data around the mean and the tails of the distribution. A normal distribution has a kurtosis value of zero. Data that exhibit positive kurtosis are more 'peaked' about the mean, and the tails of the distribution are longer. A negative kurtosis score occurs when the data exhibit heavier 'shoulders' about the mean and have shorter tails. A distribution may have the same mean and standard deviation but exhibit different levels of kurtosis. Hypothetical examples of distributions with the same mean and standard deviation but with either zero, positive or negative kurtosis are shown in Figure 1, to help elaborate the term.

### Figure 1: Examples of distributions with the same mean and standard deviation but different kurtosis

The analysis of kurtosis is shown in Table 7. All three scale formats tend to produce data with negative kurtosis scores. There are only minor differences between the scale formats for the individual scale items. The overall score from each scale format exhibits negative kurtosis, and the differences between them are not managerially or statistically significant.

### Table 7: Kurtosis according to scale format

## SUBGROUP ANALYSIS

As mentioned earlier, the sample used for this experiment was biased somewhat towards older respondents and females. To ensure the results are not influenced by this sample bias, the next step was to run the analysis for two sets of subgroups: older vs younger respondents and male vs female respondents. There were no significant differences in mean score, variance, skewness or kurtosis within these subgroups. Therefore there is no reason to think that the slight gender bias in the composition of the sample has influenced the overall results.

## DISCUSSION AND CONCLUSIONS

This study conducted a split-sample experiment to assess the impact of scale categories on responses to questions. The study compared data obtained from using 5-point, 7-point and 10-point numerical scale formats. The 5-point and 7-point data were rescaled to scores out of 10. The 10-point format produced lower mean scores than the (rescaled) 5- or 7-point formats. Indeed, an analysis of the average score over the eight question items found the 10-point format produced a 0.3-point lower score, which was statistically significantly different to the other two formats at under the  $p = 0.05$  level. In terms of the other data characteristics, the three different scale formats exhibited no appreciable differences in terms of standard variation, skewness or kurtosis. The study also found that if a multi-item scale with more response options was administered, respondents did use more response options.

Based on these findings it seems reasonable to conclude that data gathered from a 5-point format can readily be transferred to 7-point equivalency using a simple rescaling method. If the analyst wishes to compare data from 5- or 7-point formats to data from a 10-point format, a simple arithmetic adjustment and rescaling using the method described here produces comparable data.



This outcome may be welcome news to those market research departments that ponder whether data gathered using one scale format can be transformed to make it comparable to another. It also answers a potential question regarding whether results might conceivably have been better (e.g. a higher relative score) had a different scale format been used. The answer appears to be that a scale with more response options produces *slightly* lower scores, relative to the upper limit of the scale.

In terms of the other data characteristics, no scale format produced data with markedly lower variances about the mean. This suggests that none of the three formats is less desirable from the viewpoint of obtaining data that will be used for regression analysis. Kurtosis and skewness were likewise all very similar for each format. Therefore either 5-, 7- or 10-point scales are all comparable for analytical tools such as confirmatory factor analysis or structural equation models in this respect.

## DIRECTIONS FOR FUTURE RESEARCH

This study examined scale formats that differed in the number of response categories but were all numerical scales. They all required respondents to nominate a number within a specified range. Such numerical scales are but one type of response scale; it is also common for market researchers and academics to ask respondents to use scales that employ only verbal anchors. This paper, therefore, has tackled only one aspect of a wider issue pertaining to the use and comparability of rating scales in market research. More insight into the effect of the number of response categories on the resultant data when using scales that are only verbally anchored would also be a useful addition to current knowledge. Likewise, this study examined the effect of scale format using only telephone survey methodology. There is scope to examine whether the results found here would generalise to other data collection methods such as self-completion or face to face.

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#### ABOUT THE AUTHOR

Dr John Dawes is an Associate Professor at the Ehrenberg-Bass Institute for Marketing Science, University of South Australia. His research interests include buyer response to price, market structure analysis, and brand performance measures. He has also published a number of studies on survey research issues.

Address correspondence to: Ehrenberg-Bass Institute for Marketing Science University of South Australia, Level 4, Yungondi Building, 70 North Terrace, Adelaide SA 5000

Email: [John.Dawes@marketingscience.info](mailto:John.Dawes@marketingscience.info)



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85 Newman Street, London, United Kingdom, W1T 3EX

Tel: +44 (0)20 7467 8100, Fax: +(0)20 7467 8101

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