Using Fine-Grained Likert Scales in Web Surveys

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Abstract

Online surveys offer measurement possibilities that paper surveys do not. This study examines fine-grained Likert scales. Usual Likert items limit respondents to five or seven points on a scale. Fine-grained items let respondents select any point on the scale. The paper (1) shows how fine-grained scales can be implemented on Web-based surveys, (2) tests the effect of fine-grained scales on power, and (3) presents data on respondents' use of fine-grained scales in practice. We conclude that the extra effort needed to implement fine-grained scales is worthwhile.

1. Introduction

Likert scales are a staple of survey research. They usually offer only a few response choices when used on paper surveys, as shown in Figure 1. When moved to the Web, Likert items are often implemented using HTML radio buttons, as shown in Figure 2.

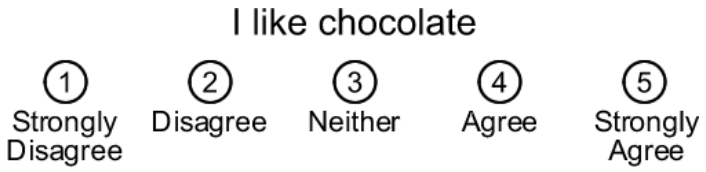

Figure 1. Paper-and-Pencil Likert Scale

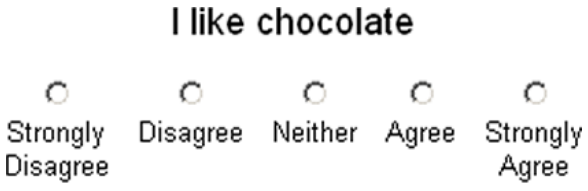

Figure 2. Radio Button Likert Scale

Scale coarseness refers to the number of scale points into which the underlying (presumably continuous) distribution is collapsed. The scale in Figure 2 uses five points, each centered on a text anchor like 'Agree.' Respondents must choose one of these five points. They cannot express intermediate choices like 'Somewhat agree.' The survey designer could increase the number of options to, say, seven, but the basic problem remains.

Paper surveys use coarse scales like that in Figure 2 to simplify data coding, that is, transferring responses from paper to a computer for analysis. However, coding is automatic when the survey is on the Web. A program written in a Web application development language like ASP, PHP, or Perl writes responses directly to a computer file. There is no separate data coding step.

A program could let respondents choose any point on the scale they wish, including points between the anchors. However, such fine-grained items are more complex to implement than the simple coarse-grained items shown in Figure 2. Is the extra complexity worthwhile? Some research suggests it might be [1]. Studies generally conclude that finer scales reduce bias [2] and improve correlation estimates among variables [3]. Information loss from coarse scales reduces power when assessing the effects of moderating variables in regression [4, 5]. It has also been shown that computer-administered questionnaires can improve power in detecting moderating effects [6].

The present research has three goals:

(1) To present a simple but effective technique for delivering fine-grained Likert scales in Web-based surveys.

(2) To extend past research on the effect of scale granularity on power.

(3) To determine whether respondents will actually use scale points that are not on the semantic anchors. If they do not, perhaps because past habits limit them to the anchors, adding fine-grained scales will accomplish nothing.

2. Implementing Fine-Grained Items

Ideally, a fine-grained Likert control for the Web should run on most browsers, should not require browser plugins (like Flash), and should be easy to create and use. It's also desirable to have a program automatically generate the code for the control, rather than require manual programming. This would mean survey designers could store scale definitions in a file or database. They could add, change, or delete scales without writing any code.

Our implementation uses simple HTML, with a little straightforward JavaScript. It does not use DHTML features like absolute positioning. We chose not to use cascading style sheets (CSS) because of uneven support in major browsers [7]. This is expected to change in the future, but we decided to wait for better standardization before using CSS.

Figure 3 shows a fine-grained scale before use. Respondents click anywhere on the scale to record their opinion. The control then shows a red mark, as in Figure 4. To change their answer, respondents click on a different point, and the red mark moves there. Since the scale starts out empty (with no red mark), respondents can see easily whether a scale has been used. This helps when a page contains several items.

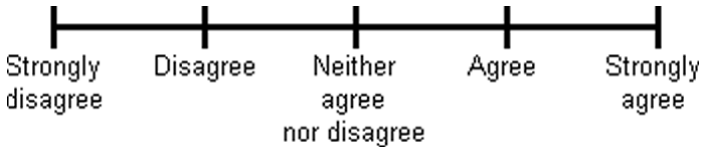

Figure 3. Initial State of a Fine-Grained Likert Scale

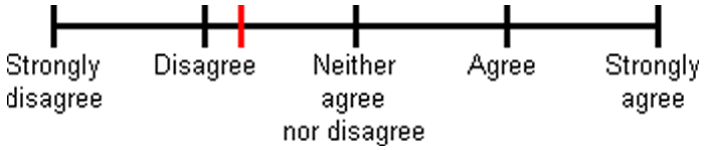

Figure 4. Clicked Fine-Grained Likert Scale

Figure 5 shows an HTML code sample. The scale is a simple table, with a cell for each point. The first cell is a spacer to correctly position the scale relative to the anchor text. The next cell (named `tick0`) shows the scale mark for the first anchor point (the left-most vertical black line on the scale). It contains the image `1x1_black.gif` which, as its name suggests, is a one-pixel black image. The image is resized to occupy the desired amount of screen space. Cells `tick1` to `tick29` are cells for each clickable point on the scale between the scale marks for the first and second anchor points. They contain the image `scale.gif`, which renders the scale marks between the anchor points. Cell `tick30` is the second anchor point. The sequence continues until the end of the scale, where another spacer are drawn. A second HTML table displays the text for the anchor points.

Figure 6 shows the accompanying JavaScript. The script draws a red mark in the clicked table cell, after storing the cell's original image in case the user clicks on another cell and the original image needs to be restored.

The HTML in Figure 5 is generated by the ASP script shown in Figure 7. For simplicity, the code uses constants for the scale values, labels, and so on. The values are read from a database in practice.

```
<FORM name="f">
<TABLE cellSpacing="0" cellPadding="0">
  <TR>
    <TD><IMG height="21" src="1x1_trans.gif" width="45" /></TD>
    <TD><IMG onclick="makeTick(0)" height="21" src="1x1_black.gif"
      width="3" border="0" name="tick0" /></TD>
    <TD><IMG onclick="makeTick(1)" height=”21" src="scale.gif"
      width="3" border="0" name="tick1" /></TD>
    <TD><IMG onclick="makeTick(2)" height=”21" src="scale.gif"
      width="3" border="0" name="tick2" /></TD>
. . .
    <TD><IMG onclick="makeTick(29)" height="21" src="scale.gif"
      width="3" border="0" name="tick29" /></TD>
    <TD><IMG onclick="makeTick(30)" height="21" src="1x1_black.gif"
      width="3" border="0" name="tick30" /></TD>
    <TD><IMG onclick="makeTick(31)" height="21" src="scale.gif"
      width="3" border="0" name="tick31" /></TD>
. . .
    <TD><IMG onclick="makeTick(119)" height="21" src="scale.gif"
      width="3" border="0" name="tick119" /></TD>
    <TD><IMG onclick="makeTick(120)" height="21" src="1x1_black.gif"
      width="3" border="0" name="tick120" /></TD>
    <TD><IMG height="21" src="1x1_trans.gif" width="45" border="0" /> </TD>
  </TR>
</TABLE>
<TABLE cellSpacing="0" cellPadding="0">
  <TR>
    <TD valign="top" align="middle" width="90">Disagree</TD>
    <TD valign="top" align="middle" width="90">Somewhat<BR>disagree</TD>
    <TD valign="top" align="middle" width="90">Neither agree nor
disagree</TD>
    <TD valign="top" align="middle" width="90">Somewhat<BR>agree</TD>
    <TD valign="top" align="middle" width="90">Agree</TD>
  </TR>
</TABLE>
<INPUT name="val" type="hidden" />
</FORM>
```

Figure 5. HTML Code for a Scale

```
<SCRIPT>
var oldImage;
var oldTickNumber;
var bFirstTimeThru = true;
function makeTick(tickNumber) {
      var tickName;
      document.f.val.value = tickNumber / 30 + 1;
      tickName = 'tick' + tickNumber;
      if (!bFirstTimeThru) {
            eval('document.f.tick' + oldTickNumber +
                  '.src = oldImage');
      }
      oldImage = eval('document.f.'+tickName+'.src');
      oldTickNumber = tickNumber;
      bFirstTimeThru = false;
      evCal('document.f.'+tickName+'.src="1x1_red.gif"');
}
</SCRIPT>
```

Figure 6. JavaScript for Storing Respondent's Choice

```
<%
option explicit

dim iTickWidthPixels          'Pixels per tick on the scale
dim iCellHeightPixels         'Height of the scale
dim sMinValue                 'Minimum scale value
dim sMaxValue                 'Maximum scale value
dim iValueRange               'Scale range
dim iTicksPerUnitValue        'Ticks per unit
dim tLabels()                 'Anchors
dim i,j

iTickWidthPixels = 3
iCellHeightPixels = 21
sMinValue = 1
sMaxValue = 5
iValueRange = sMaxValue - sMinValue
iTicksPerUnitValue = 30
redim tLabels(iValueRange)
tLabels(0) = "Disagree"
tLabels(1) = "Somewhat<br>disagree"
tLabels(2) = "Neither agree nor disagree"
tLabels(3) = "Somewhat<br>agree"
tLabels(4) = "Agree"

%>

<html>
<head>
. . .
<form name=f>
<table cellpadding=0 cellspacing=0>
<tr>
<%
'Write out the first table - the scale
'Write out a cell that is half a scale unit value
response.write "<td><img src='1x1_trans.gif' width=" & _
      iTicksPerUnitValue/2*iTickWidthPixels & _
      " height=" & iCellHeightPixels & "></td>" & vbCRLF
'Write out each scale interval
for I = 0 to iValueRange-1
      'Black tick to start it
      response.write "<td><img src='1x1_black.gif' name='tick" &_
            I*iTicksPerUnitValue & "' height=" & iCellHeightPixels &_
            " width=" & iTickWidthPixels & _
            " border="0" onclick='makeTick(" & I*iTicksPerUnitValue & _
            ")'></td>"
      'Now regular ticks for the rest of the scale interval
      for j = 1 to iTicksPerUnitValue-1
            response.write "<td><img src='scale.gif' name='tick" &_
                  I*iTicksPerUnitValue+j & "' height=" & _
                  iCellHeightPixels & " width=" & iTickWidthPixels &_
                  " border="0" onclick='makeTick(" & _
                  I*iTicksPerUnitValue+j & _
                  ")'></td>"
      next
next
'Write out final tick
response.write "<td><img src='1x1_black.gif' name='tick" & _
      iValueRange*iTicksPerUnitValue & "'  height=" & _
```

```
      iCellHeightPixels & " width=" & iTickWidthPixels & _
      " border="0" onclick='makeTick(" & _
      iValueRange*iTicksPerUnitValue & ")'></td>"
'Write out a cell that is half a unit value
response.write "<td><img src='1x1_trans.gif' width=" & _
      iTicksPerUnitValue/2*iTickWidthPixels & _
      " height=" & iCellHeightPixels & " border="0"></td>" & vbCRLF
%>
</tr>
</table>
<table cellpadding=0 cellspacing=0>
<tr>
<%
'Write out the label table
for I = 0 to iValueRange
      response.write "<td align='center' valign='top' width=" & _
            iTicksPerUnitValue*iTickWidthPixels & ">" & _
            tLabels(i) & "</td>"
next
%>
</tr>
</table>
<input type='hidden' name='val'>
</form>
```

Figure 7. ASP Code Generating the Item

3. Effects on Power

We suspected that tests of means with data gathered using fine-grained scales would be more powerful than tests with data using coarse-grained scales. We wrote a simulation in Java that:

- Created *n* pairs of normally distributed samples from two populations with possibly different means but common variances, i. e., *n* samples from $N(\mu_1,\sigma)$ and $N(\mu_2,\sigma)$.
- Moved each data point to the nearest value on a five-point Likert scale to simulate a coarse-grained scale, and computed *t* statistics and *p* values for a test for equality of two means.
- Moved each data point to the nearest 100th part of the scale to simulate a fine-grained scale, and computed *t* statistics and *p* values for a test for equality of two means.
- Repeated steps 1 to 3 for 1,000 experiments.

We fixed the standard deviation at 0.5 and alpha at 0.05. We varied the true differences between sample means from 0 to 2 in steps of 0.1 for 10, 20, 50, and 100 data pairs. The simulation thus yielded 2,600,000 data pairs. The source code for the simulation is available at <URL> **(URL identifies the authors. Zip file submitted with this paper includes the simulation code and results)**.

Figure 8 shows the results. Although we used two-tailed *t* tests, only the right half of each power curve is shown. The results confirmed our expectations. Analyses of data gathered using the fine-grained scale were more powerful. The differences in power were

greatest when the sample size and the true difference between means were relatively small, as is often the case in social science research. Figure 9 shows the fine-grained scale's gain in power over the coarse-grained scale for different sample sizes.

4. Will Respondents Use the Scale?

So far, we have code to implement the scale, and evidence that its use increases statistical power. However, while coarse-grained scales are familiar to respondents, fine-grained scales are not. Would respondents take advantage of the scale's precision? That is, would they choose points other than those corresponding to the semantic anchors?

We used the scale in a study of the way students define "philosophy of life." The survey was delivered over the Web using the code given above. Respondents read about the new scale in the study's introduction. They were given a sample item, and encouraged to experiment with it. The practice item was "I like chocolate," with a scale from "Strongly agree" to "Strongly disagree."

Eighty-seven respondents completed 11 items using the fine-grained scale, for a total of 764 responses after incomplete data was removed. Each scale had seven anchor points, that is, seven points with vertical ticks and text labels (see Figure 3). There were a total of 150 clickable points on each scale, most between the anchor points.

Of the 764 responses, 434 (57%) were not on one of the anchor points, that is, they were between the vertical ticks (see Figure 3). These responses could not have been precisely measured with a traditional coarse-grained Likert scale.

While most of the responses were off the anchor points, a substantial minority *were* on the anchor points. Since each scale had 150 clickable points, there were many more responses on the anchor points than would have been predicted by chance if the probability of selecting each clickable point was equal. It seems that, although there is substantial use of points between the anchors, respondents are still attracted to the anchor points.

This is not too surprising, given that coarse-grained Likert scales (on which only the anchor points are clickable) are familiar to respondents, while fine-grained scales are not. We had hoped to counteract this effect by giving respondents a practice fine-grained item, and encouraging them to experiment with it. We may not have been as successful as we had hoped.

However, further analysis shows an interesting effect. We divided respondents into two groups based on their response to the practice item: (1) those who selected an on-anchor point for the practice item, and (2) those who selected an off-anchor point for the practice item. For each group, we computed the number of their responses for all items that were on-anchor or off-anchor. Table 1 shows the resulting contingency table (because of missing data and the separation of practice items from the others, the totals are not the same as those presented earlier). Responses are unevenly distributed ($\chi^2 = 59.2$, d.f. = 1, $p < 0.001$). So, respondents who chose an on-anchor point for the practice item tended to use on-anchor points for the rest of the items. Those who chose an off-anchor point for the practice item tended to use more off-anchor points for the rest of the items.

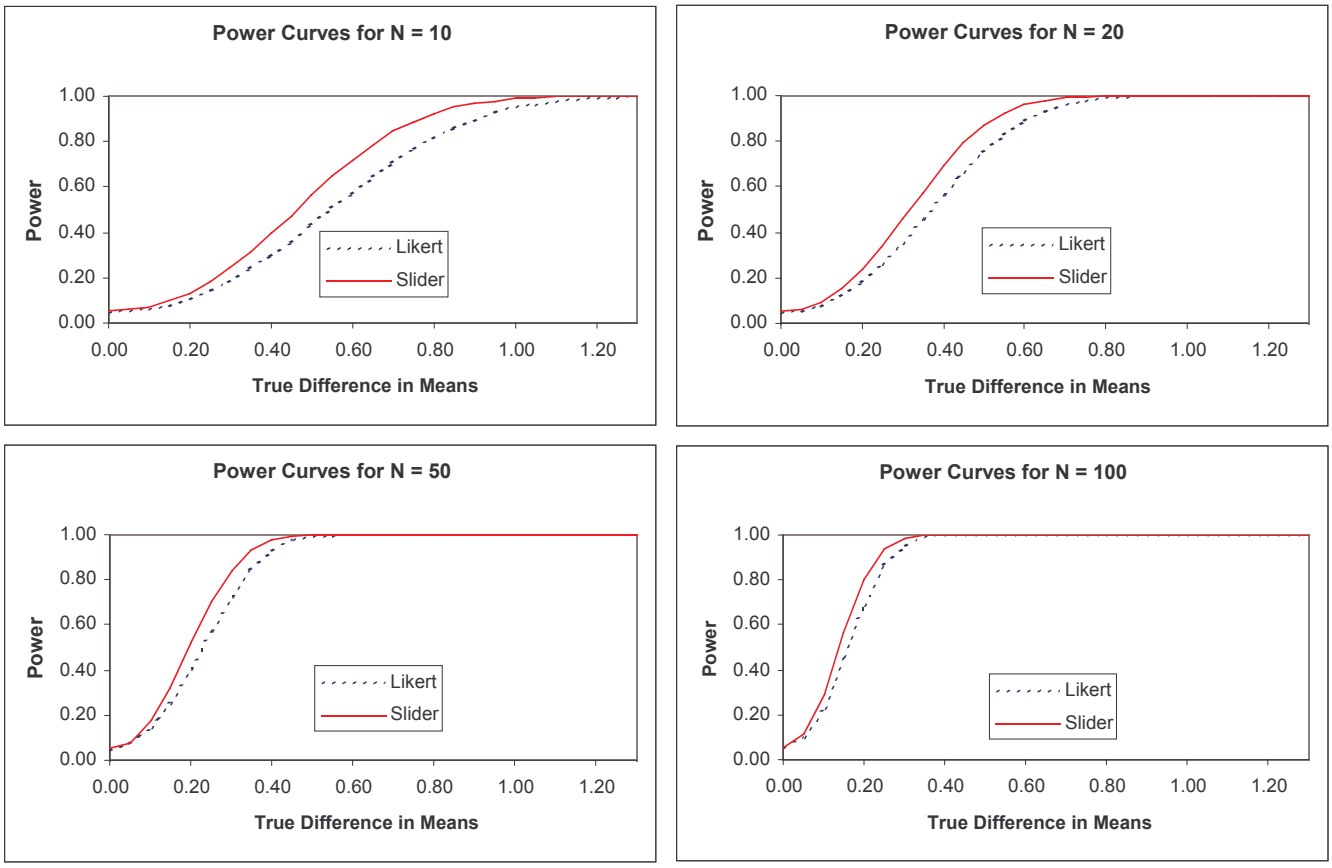

Figure 8. Power Curves for Different Sample Sizes

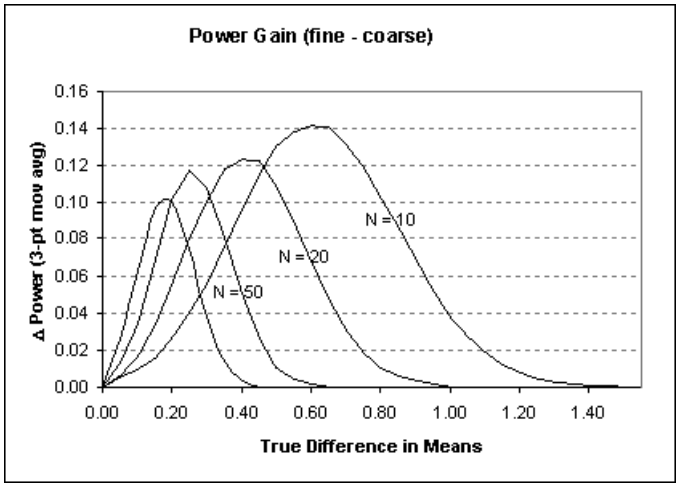

Figure 9. Power Gains for Different Sample Sizes

		Other items		
		Off-anchor	On-anchor	Totals
Practice item	Off-anchor	267	125	392
	On-anchor	81	143	224
Totals		348	268	616

Table 1. Off and On-Anchor Responses

It could be that respondents who consistently chose the on-anchor points did not read the instructions given with the practice item, and therefore did not know that they could choose off-anchor points. Perhaps the problem could be avoided if the survey software forced them to choose an off-anchor point for the practice item. For example, it would not proceed to the next screen unless the respondent chose an off-anchor point.

5. Conclusions

Limiting the granularity of Likert scales is reasonable for paper surveys, because it simplifies data coding. However, this constraint does not apply to computer-based surveys since data capture is automatic. Fine-grained Likert scales can be implemented fairly easily for Web-based surveys. Analyses using fine-grained scales are more powerful than those using coarse scales, particularly for the smaller sample and effect sizes often encountered in social research. Respondents will use the off-anchor points on the scale, even though the scale is not familiar. However, survey software should ensure that respondents know they can use off-anchor points.

Our findings suggest that researchers should consider using fine-grained scales. Given the costs of running surveys, the small increase in complexity will be worthwhile in many research contexts.

References

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