CREATING SINGLE-SUBJECT DESIGN GRAPHS IN MICROSOFT EXCEL^{TM} 2007

MARK R. DIXON, JAMES W. JACKSON, STACEY L. SMALL,
MOLLIE J. HORNER-KING, NICHOLAS MUI KER LIK,
YORS GARCIA, AND ROCIO ROSALES

SOUTHERN ILLINOIS UNIVERSITY

Over 10 years have passed since the publication of Carr and Burkholder's (1998) technical article on how to construct single-subject graphs using Microsoft Excel. Over the course of the past decade, the Excel program has undergone a series of revisions that make the Carr and Burkholder paper somewhat difficult to follow with newer versions. The present article provides task analyses for constructing various types of commonly used single-subject design graphs in Microsoft Excel 2007. The task analyses were evaluated using a between-subjects design that compared the graphing skills of 22 behavior-analytic graduate students using Excel 2007 and either the Carr and Burkholder or newly developed task analyses. Results indicate that the new task analyses yielded more accurate and faster graph construction than the Carr and Burkholder instructions.

DESCRIPTORS: computer software, graphing, single-subject design, technology

_____

Carr and Burkholder (1998) published a set of useful task analyses for creating single-subject design graphs using Microsoft Excel. Their article allowed advanced and perhaps even novice Excel users to easily construct graphs that looked professional and adhered to many of the publication standards for graphical depiction by behavior-analytic journals. Over a decade has passed since Carr and Burkholder's article was published. In that time, Microsoft has released three new versions of Excel, each differing slightly from the version used by Carr and Burkholder in their report. The spring of 2007 marked the most radical renovation of the Excel interface in recent years. Many new features have been added to the software, including replacement of most of the original toolbars with graphical panels. As more people update older versions of Microsoft Excel to the newest version (Excel 2007), they will find the Carr and Burkholder report somewhat dated. Although many of the steps the authors described may continue to work, others are

more difficult to accomplish. Therefore, the purpose of the present article is to provide new task analyses for creating single-subject design graphs in Excel 2007 and empirically evaluate their utility.

EMPIRICAL EVALUATION

Method

Twenty-two graduate students (21 women, 1 man), recruited from a behavior analysis graduate program, participated in the study for extra course credit. All students had varying levels of experience creating single-subject design graphs in Microsoft Excel. The study was conducted in three small rooms housed within a laboratory of a large midwestern university. Each room contained a Dell Dimension PC equipped with a 32-in. or 24-in. monitor, keyboard, mouse, and Microsoft Excel 2007 software.

Prior to the study, the experimenter provided each participant with a packet of materials that included instructions for completing the study, three sets of hypothetical data, and one of two technical articles that provided information for the creation of three single-subject design graphs (i.e., reversal, multielement, and multiple baseline designs [MBD]) in Microsoft Excel.

Participants were randomly assigned to one of two groups. Participants in Group 1 received the instructions presented later in this article on creating graphs in Excel 2007. Participants in Group 2 received the technical article by Carr and Burkholder (1998), which contained instructions that were relevant for all of the software versions before Excel 2007.

All participants completed a brief survey requesting demographic data and information regarding experience creating various types of single-subject design graphs in Microsoft Excel (both the 2003 and 2007 versions). Participants estimated the number of reversal, multielement, and MBD graphs they had created in the past with both software versions. Participants were also asked to rank their overall level of experience with creating graphs of any type in both Microsoft Excel 2003 and 2007 on a 5-point Likert scale ranging from 1 (*no experience*) to 5 (*regularly make graphs*).

The experimenter instructed participants to use their technical article to create three graphs from the three hypothetical data sets they were provided. The experimenter instructed participants to complete the three graphs in sequential order (i.e., reversal, multielement, and MBD), pausing after each graph was created. At this point the experimenter saved the current graph, deleted the participant's data, opened a new instance of Excel 2007, and instructed the participant to begin the next graph. The observer recorded the duration required to complete each graph, as well as the total duration to complete all three graphs.

The 66 graphs were scored by one of two board-certified behavior analysts (BCBAs). The raters developed a criterion checklist based on graphing conventions recommended by a widely used applied behavior analysis textbook (Cooper, Heron, & Heward, 2007). A separate checklist was created for each type of graph, and one point was assigned for each component. To be included in the scoring criteria, each component must have been agreed upon by both raters as well as mentioned in Cooper et al. A total of 13, 15, or 16 points were available for the multielement, reversal, and multiple baseline designs, respectively. Each of the raters received 33 graphs to rate individually and was naive to group assignment. Twenty-two (33%) graphs were rated by both BCBAs, and item-by-item agreement was determined for each criterion component. Interobserver agreement was calculated by dividing the total number of agreements by agreements plus disagreements. Mean interobserver agreement for all 22 graphs was 92% (range, 82% to 100%).

Results and Discussion

Analysis of the differences between the two groups based on demographic characteristics and level of prior experience creating single-subject design graphs with either Excel 2003 or Excel 2007 suggested that the groups were not different on a number of variables. Independent samples t tests revealed no significant difference in age, $t(20) = -1.497$, $p = .150$ (two-tailed), gender, $t(20) = 1.00$, $p = .329$ (two-tailed), personal rating of experience with Excel 2003, $t(20) = 1.054$, $p = .304$ (two-tailed), or with Excel 2007, $t(20) = 1.491$, $p = .152$ (two-tailed), number of reversal design graphs created in Excel 2003, $t(20) = 1.262$, $p = .222$ (two-tailed), or Excel 2007, $t(20) = 1.00$, $p = .329$ (two-tailed), and number of multielement-design graphs created in Excel 2003 and MBD graphs created in Excel 2003, $t(20) = 1.534$, $p = .141$ (two-tailed), and $t(20) = 1.708$, $p = .103$ (two-tailed), respectively. No participant in either group reported any history of creating multielement or MBD graphs using Excel 2007.

Overall time to completion for all graphs was examined with independent samples t tests. Results revealed significant differences between groups. Participants in Group 1 took less time overall to complete all three graphs: $M_{\text{Group 1}} = 68.7$ min ($SD = 14.7$), $M_{\text{Group 2}} = 93.3$ min ($SD = 18.0$), $t(20) = -3.521$, $p = .002$. Participants in Group 1 took significantly less time to complete the reversal design graph:

$M_{\text{Group 1}} = 24.7$ min ($SD = 5.6$), $M_{\text{Group 2}} = 31.1$ min ($SD = 6.3$), $t(20) = -2.507$, $p = .021$ (two-tailed). Participants in Group 1 took significantly less time to complete the multielement design graph: $M_{\text{Group 1}} = 13.6$ min ($SD = 3.93$), $M_{\text{Group 2}} = 27.3$ min ($SD = 12.7$), $t(20) = -3.421$, $p = .003$ (two-tailed). Although participants in Group 1 completed the MBD graph faster than those in Group 2 ($M_{\text{Group1}} = 30.4$ min ($SD = 9.01$), $M_{\text{Group 2}} = 35.0$ min ($SD = 6.9$), differences between groups failed to reach significance, $t(20) = -1.334$, $p = .197$ (two-tailed).

Examination of the mean accuracy ratings for all graphs with independent samples t tests revealed significant differences between groups for both the reversal and multielement design graphs. Reversal graphs for Group 1 were rated significantly higher in accuracy than those from Group 2: $M_{\text{Group 1}} = 12.91$ ($SD = 1.8$), $M_{\text{Group 2}} = 10.0$ ($SD = 3.4$), $t(20) = 2.535$, $p = .020$ (two-tailed). Multielement graphs from Group 1 were rated significantly higher in accuracy than those for Group 2 as well: $M_{\text{Group 1}} = 11.45$ ($SD = 1.4$), $M_{\text{Group 2}} = 6.64$ ($SD = 2.5$), $t(20) = 5.538$, $p = .000$ (two-tailed). Mean ratings for MBD graphs from Group 1 were higher than those for Group 2; $M_{\text{Group 1}} = 11.27$ ($SD = 2.6$), $M_{\text{Group 2}} = 10.27$ ($SD = 1.5$), but the differences failed to reach significance, $t(20) = 1.12$, $p = .278$ (two-tailed). All statistical analyses were conducted at the .05 alpha level.

The results obtained from the empirical evaluation indicate a need for updated task analyses for creating single-subject design graphs in Excel 2007. Individuals who received the updated task analyses generally created graphs more quickly and accurately than those receiving the Carr and Burkholder (1998) instructions.

TASK ANALYSES FOR CREATING GRAPHS IN EXCEL 2007

The task analyses that follow will describe how to construct reversal, multielement (often used to evaluate functional analysis data), and multiple baseline designs. Additional suggestions are provided for exporting the graphs to other software programs. At this point it is assumed the reader has Microsoft Excel 2007 correctly installed and open on the computer.

REVERSAL DESIGNS
Creating a Reversal Design Graph

1. Enter the text "Session #" in Cell A1 and enter the text "Data" in Cell B1.
2. Enter the session numbers or dates in the first column below the text "Session #". You may wish to color code the condition types for ease of visual discrimination.
3. Underneath the text "Data," enter the values that correspond to the session numbers. Following our example, enter the data and dates as shown in Figure 1.
4. With the mouse, highlight the cells that contain both the text (i.e., Cells A1 and B1) and the data as shown in Figure 1.
5. With the data and the text highlighted, select the menu option INSERT from the option bar at the top of the screen. When you are done you will see a variety of icons positioned across the top of the screen. This is the new graphical interface for the various types of objects that can be inserted into a spreadsheet. Note the center panel titled CHARTS. In this panel select the second option, LINE. In the LINE submenu, select the first option in the second row under the 2-D LINE options, which is called LINE WITH MARKERS. A graph should immediately appear.

Editing the Default Graph

1. The first step is to remove the unnecessary data path that displays your session numbers. Right click on a blank area of the chart. From the available options choose SELECT DATA.
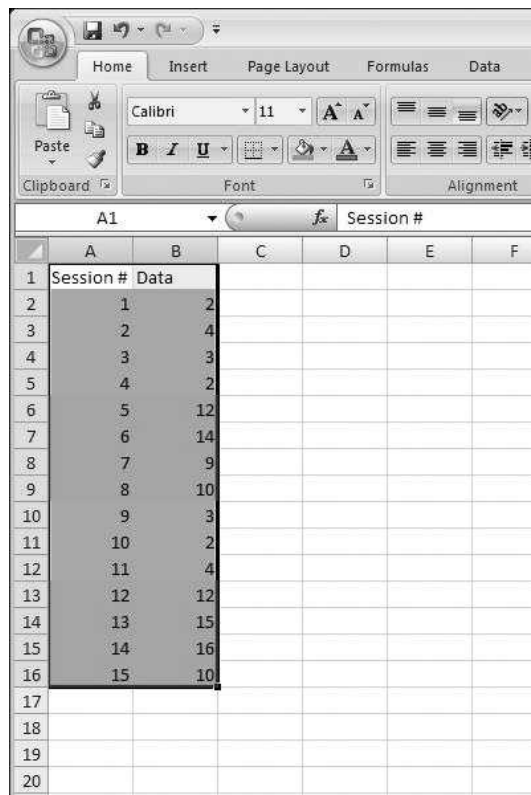
Figure 1. Sample data entered into a spreadsheet for a reversal design graph.

2. In the **SELECT DATA SOURCE** window, under the Legend Entries (Series) box, select **SESSION NUMBER** so it is highlighted. Next, click on the RE-MOVE button.

3. Remain in the **SELECT DATA SOURCE** window. Under the Horizontal (Category) Axis Labels box click on EDIT.

4. In the resulting **AXIS LABELS** dialogue box, highlight Cells A2 through A16, which you will use for the values contained on the *x* axis. Once done click OK. To close the **SELECT DATA SOURCE** window, click OK.

5. The next step is to remove the lines connecting data points between different phases. In our example, baseline data were collected on Sessions 1 through 4 and 9 through 11, with the remaining session numbers corresponding to intervention conditions. To remove the data series line between Data Points 4 and 5, position the mouse on the data series. Click the left button once to highlight the series. Position your mouse pointer directly on Data Point 5 and keep it there.

6. Click the left button once. The highlighted series should disappear, leaving only Data Point 5 highlighted. Right click and select the last option entitled FORMAT DATA POINT. From the FORMAT DATA POINT window, select the option LINE COLOR from the options listed on the left. Select the suboption NO LINE from the list on the right and close.

7. At this time you will notice the legend has changed considerably. For now ignore these changes and proceed to disconnect the data series line between Data Points 8 and 9. To do this, select Data Point 9 as described above and press the F4 key. This shortcut repeats the last step Excel 2007 performed. Do this again between Data Points 11 and 12.

8. Remove the unnecessary legend by selecting it once with the left mouse button and pressing the delete key. At this point your graph should be completed and ready for customization, which may include the addition of phase-change lines, axis labels, and condition labels.

Customizing Your Graph

1. An exciting new feature of Excel 2007 that was not available on earlier versions of the software is the graphical interface for quick customization of your chart. This interface, named "Chart Tools," provides you with a means to customize your chart very quickly; this saves time from the laborious steps necessary in
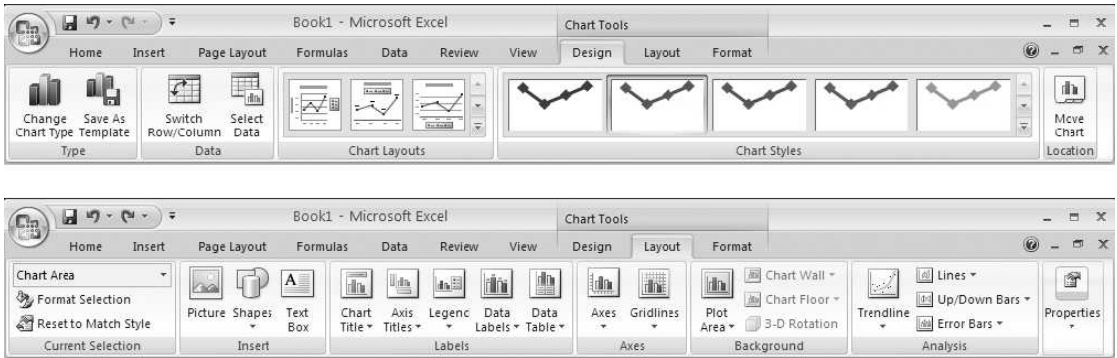
Figure 2.   New design and layout options in Microsoft Excel 2007.

earlier versions of Excel. The top panel of Figure 2 displays the new chart designs, and the lower panel of Figure 2 displays the various layout options of the Chart Tools in the new graphical interface. Select the LAYOUT tab and add axis titles to your graph by selecting option Axis Titles from the third panel of icons named LABELS. Click on AXIS TITLES and select PRIMARY HORIZONTAL AXIS and the second suboption TITLE BELOW AXIS.

2. In the resulting text box below the *x* axis, enter the text you wish to use for your *x*-axis label. Do this by clicking in the text box and highlighting the default text already there (i.e., Axis Title). Replace the default text and type in your text. Following along with our example, we have used Observation Sessions.

3. Repeat the previous two steps for the *y*-axis title by selecting the PRIMARY VERTICAL AXIS TITLES using the second suboption (i.e., ROTATED TITLE), which will automatically rotate the *y* axis 270 degrees, optimally displaying it as desired for *y*-axis labeling. Following with our example, enter the text Words Correct in the new text box.

4. To edit the chart title, in the third panel LABELS, select CHART TITLE and select the third option (i.e., Above Chart).

5. Click once on the chart title. Highlight it with the mouse and enter the chart title. Following our example, title the chart Mary's Spelling Performance.

6. Now remove the horizontal gridlines displayed on the graph. Remain within the LAYOUT tab of chart tools. In the fourth panel labeled AXES, select the second icon GRIDLINES and select the first option PRIMARY HORIZONTAL GRIDLINES and the first suboption NONE.

7. To insert phase-change lines, first make sure you have clicked your mouse on the graph to highlight it and not the spreadsheet. If you have the spreadsheet highlighted instead of the graph, your phase-change line will end up in the spreadsheet area and not on the desired graph. After clicking once on the graph to select it, choose the SHAPES icon within the INSERT panel (i.e., the second panel). At this point, a large menu will appear that includes lines, arrows, rectangles, and various other shapes.

8. Select the first line option, which is depicted by a small diagonal line, by clicking on it once. Position the mouse pointer on the *x* axis between Sessions 4 and 5. Click once to initiate the line, and while holding down the mouse button, drag the pointer straight up the graph so

that it is parallel with the entire y axis. You can ensure that the line will be perfectly vertical (or horizontal) if you hold down the shift key while drawing the line.

9. At this point, you will notice the top menu has changed to DRAWING TOOLS. Remain here because you need to change the type of line from a solid line to a dashed line. To do this, locate the second panel SHAPE STYLES and select SHAPE OUTLINE. In the SHAPE OUTLINE drop-down window, select the second to last option from the bottom, DASHES, and then choose the dash type you prefer. Following with our example, select the fourth option. From the SHAPE STYLES panel you can also change the color of the phase-change line from its default of blue to black. To do so make sure your newly drawn line is selected by clicking on the line once, then click on the SHAPE OUTLINE option. In the SHAPE OUTLINE drop-down window, select black from the various color options offered.

10. To add the next two phase-change lines, with your newly dashed line highlighted, right-click on the line and select the option COPY, and then right-click again outside the data plot area (i.e., around the chart title) and select the option PASTE. You will now notice that the newly added line is in the top left corner of the chart. Based on where the newly pasted line is added, it can sometimes be difficult to select the newly pasted line and move it to the desired position without also moving the entire graph. What we have found is that, for best results, first click outside the chart (on the spreadsheet) to make sure that neither the graph nor the newly pasted line is selected. Then, select the new line by clicking on it and position it between

Data Points 8 and 9. Once your second line has been positioned correctly, right-click anywhere outside the data plot area (e.g., around the chart title) and select the PASTE option to add the final phase-change line. Position this final line between Data Points 11 and 12.

11. The next step is to add phase labels to the chart. Select the TEXT BOX icon from the INSERT panel, position the mouse pointer in the top portion of the first baseline condition, and proceed to insert a small rectangle within which you will enter the text "Baseline." Repeat the above steps for the remaining phase labels, adding the appropriate text for each phase. Alternatively, you can highlight the textbox that you had just created on your graph and right-click on it. From the submenu that appears, select the COPY option and then right-click again and select the PASTE option. A copy of the phase label should appear, and you can position it above the appropriate phase in the graph. Do this as many times as necessary.

12. The final steps for formatting the graph involve steps to ensure that the graph will not look out of place when pasted or transferred to another program such as Microsoft Word or Microsoft Power-Point. What this involves is removing any fill and border colors from the chart area (i.e., the area with the boundaries of the chart surrounding the graph where the axis labels and chart title can be found), the plot area (i.e., the area in which the data are graphed), and from all of the text boxes used as phase labels. To first remove the border and fill colors from the chart area, right-click on any spot in the chart area. From the resulting option select FORMAT CHART AREA.

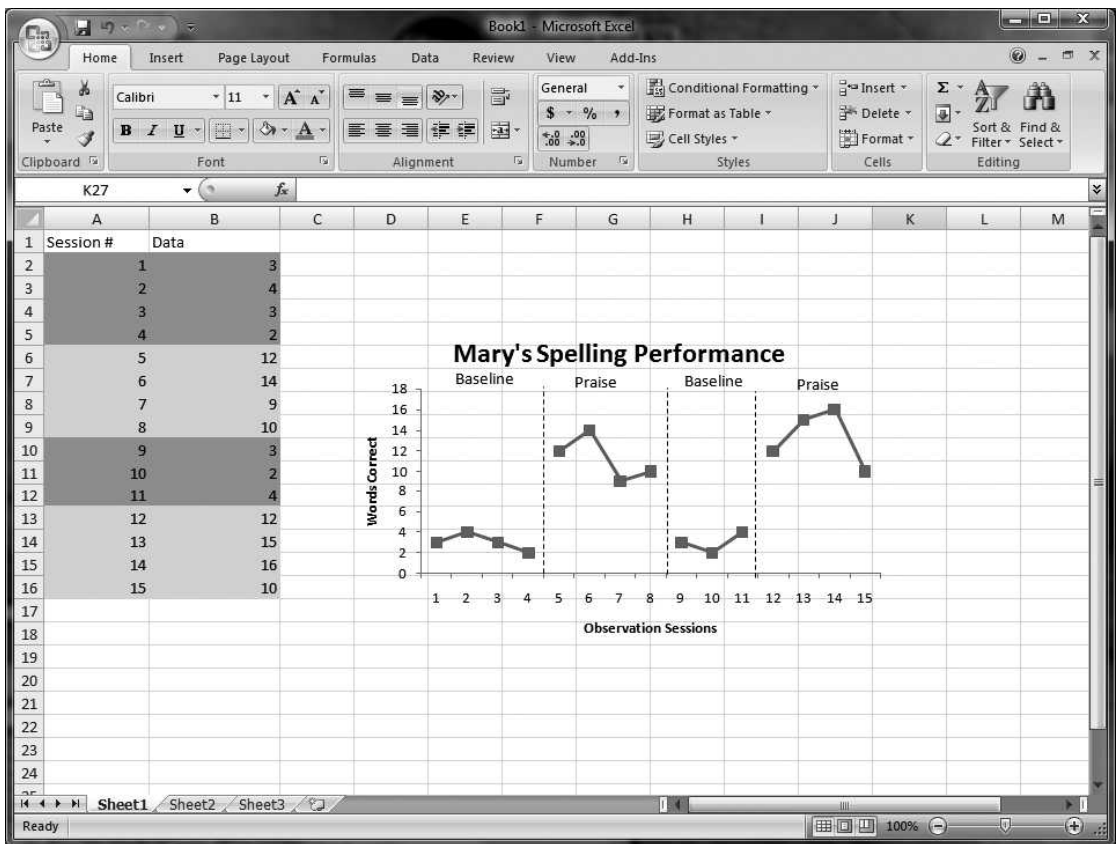13. In the resulting FORMAT CHART AREA dialogue box, select the first

Figure 3. The completed reversal design graph.

option, FILL, and from the resulting options on the right select NO FILL.

14. To remove the border from the CHART AREA, while still in the FORMAT CHART AREA dialogue box, select the second option on the left, BORDER COLOR, and from the resulting options select NO LINE, and click the CLOSE button.

15. To remove the border and fill colors for the plot rea, right-click on any spot in the plot area and select the FORMAT PLOT AREA option. The resulting FORMAT PLOT AREA dialogue box is essentially identical to the one described for the chart area in Step 13 above, so to remove the border and fill colors, follow the steps described in Steps 13 and 14.

16. To remove the border and fill colors for the text boxes used as phase labels, click on the desired text box to select it, then right-click and select the FORMAT SHAPE option. In the resulting FORMAT SHAPE dialogue box, follow the steps described previously to remove the fill and border colors. Repeat as necessary for the remaining text boxes. Your final graph should look similar to the one displayed in Figure 3.

Saving the Graph as a Template

Another convenient feature of Excel 2007 is the ability to save graphs as templates. This feature allows you to completely format a graph as you see fit, then save all of those features to apply to similar graphs you may create in the

future. Now that we have completed the reversal design graph, we will describe the steps necessary to save the graph as a template for later use. We will describe further how best to use saved templates in the section on creating MBD graphs.
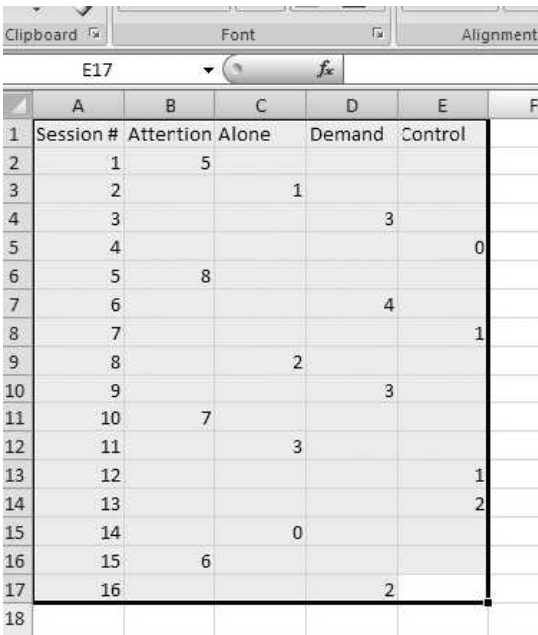
1. The completed graph is ready to be saved as a template. Begin by selecting the graph by clicking somewhere in the chart area, clicking on the DESIGN tab of CHART TOOLS, and selecting the second option of the panel, which is SAVE AS TEMPLATE.

2. A save chart template window will appear. Change the file name from Chart 1 to "Reversal Design," leaving the .CRTX file extension intact. Click the SAVE button at the lower right corner of the window and return to the spreadsheet.

3. To create graphs using this template in the future, we simply need to highlight the data we wish to graph, select our saved template, select the INSERT tab on the main menu, select OTHER CHARTS from the CHARTS panel, and select the last option ALL CHART TYPES. From the resulting INSERT CHART window, one simply selects the first option TEMPLATES and the newly created "Reversal Design" option displayed under MY TEMPLATES, then select OK to return to the new graph.

<center>MULTIELEMENT DESIGNS</center>
Creating a Multielement Design Graph

One of the most common applications of multielement designs is for evaluating the results of an experimental functional analysis. Thus, the following instructions for creating a multielement design are presented in the context of creating a graph to depict functional analysis data. To begin, enter the session headings, session numbers, and data values as depicted in Figure 4.

1. To create the chart, highlight Cells A1 through E17. Select the INSERT tab, the

	A	B	C	D	E
1	Session #	Attertion	Alone	Demand	Control
2	1	5			
3	2		1		
4	3			3	
5	4				0
6	5	8			
7	6			4	
8	7				1
9	8		2		
10	9			3	
11	10	7			
12	11		3		
13	12				1
14	13				2
15	14		0		
16	15	6			
17	16			2	
18					

Figure 4.   Sample data entered into a spreadsheet for a multielement design graph.

LINE GRAPH, and the first option in the second row in the line graph submenu, titled LINE WITH MARKERS. The graph will look similar to the type created for the reversal design.

2. Repeat the previously described steps from the reversal design instructions to delete the unnecessary session number data series and edit the *x*-axis labels. You can also remove the horizontal grid lines at this time.

3. In contrast to the reversal design graph, the use of empty cells in your data has resulted in an absence of connecting lines between the data points within each series. To connect the data points for each functional analysis condition, it will require Excel 2007 to ignore the empty cells between actual data points.

4. To configure Excel 2007 to do this, highlight the graph, right-click on it, and select the option SELECT DATA. With the SELECT DATA SOURCE window open, select the HIDDEN
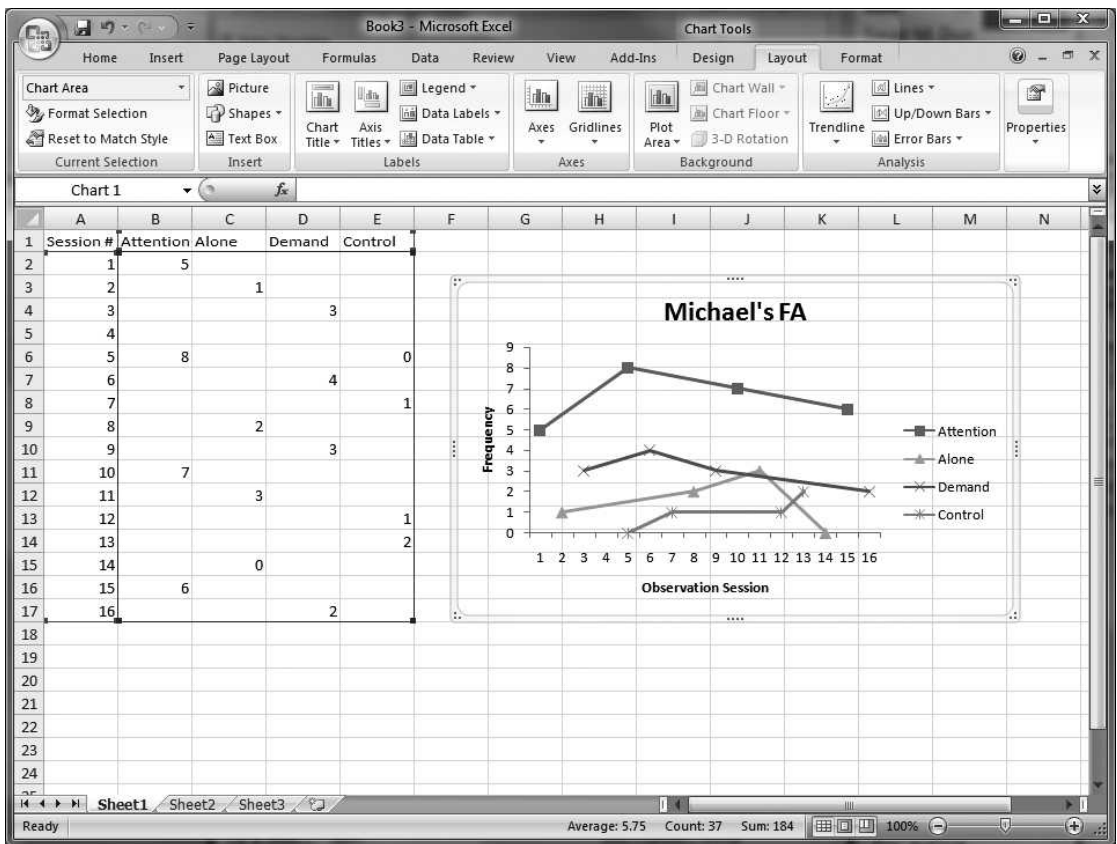
Figure 5. The completed multielement design graph.

AND EMPTY CELLS button in the bottom left corner of the window. A small window will appear titled HIDDEN AND EMPTY CELL SETTINGS.

5. Choose the third option, SHOW EMPTY CELLS AS, and choose CONNECT DATA POINTS WITH LINE. Click the OK button, which will return you to the SELECT DATA SOURCE window. Click the OK button within the SELECT DATA SOURCE window to return to the graph. At this point, the data points should be properly connected on the graph.

6. In addition to removing border and fill colors and editing the chart titles, axis labels, and condition labels, you can edit the data series markers, lines, and colors by simply selecting the data series you wish to edit, right-clicking on it while the series is highlighted, and selecting the last option, FORMAT DATA SERIES. The FORMAT DATA SERIES window will appear and give you various options with which you can edit the markers, lines, and colors in multiple ways. Also at this time you can follow the previously described steps and save this graph as a template that can be used for all future multielement design graphs. Your completed graph should look similar to the one depicted in Figure 5.

MULTIPLE BASELINE DESIGNS
Creating a MultipleBaseline Design Graph

Excel 2007, similar to earlier versions of the software, does allow the construction of MBD
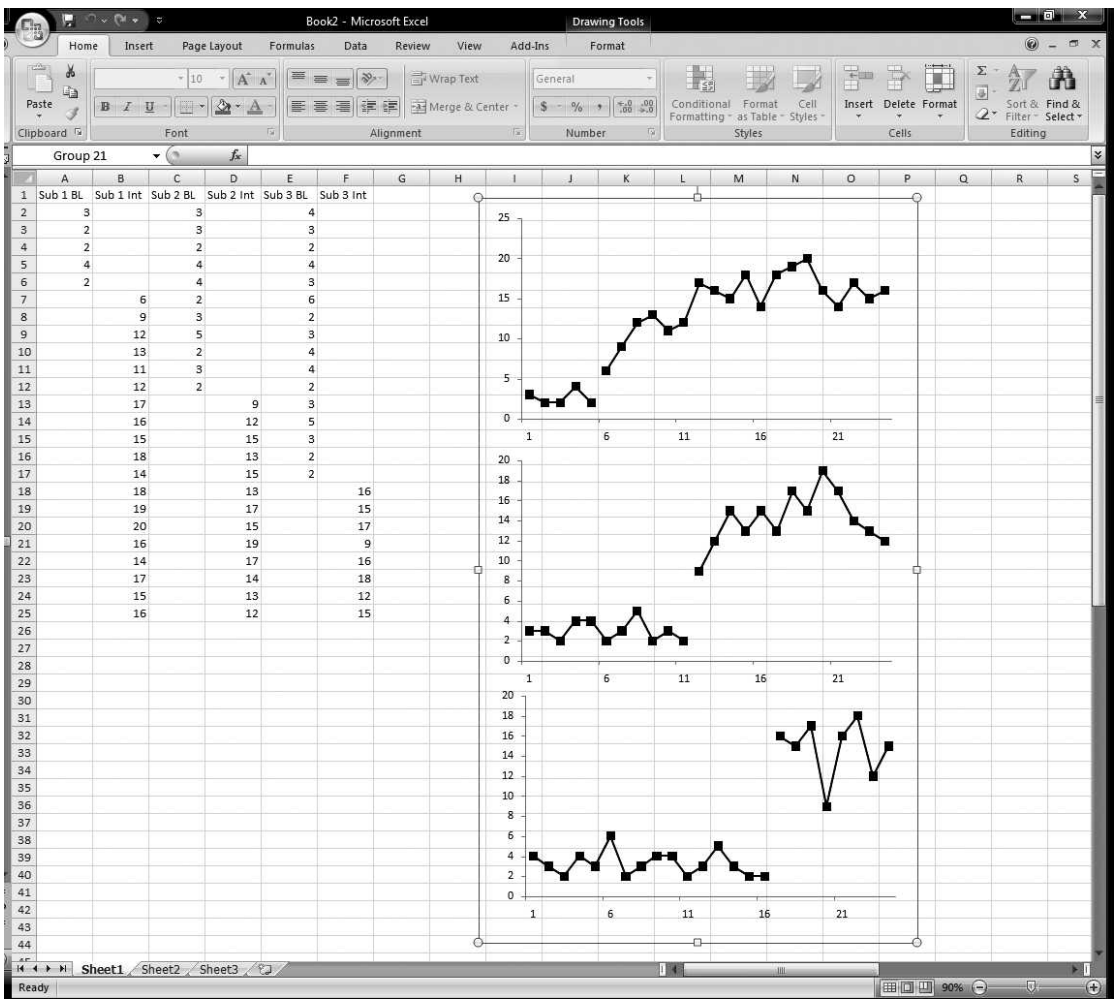
Figure 6.   Sample data and early graphs of a multiple baseline design.

graphs. However, in contrast to the graphing procedures described above that rely on only the production of a single graphic object, when constructing MBD graphs, you will need to construct a series of individual graphs, vertically align them, and eventually link them together. The steps to complete this process are different in Excel 2007 than in prior versions. However, our previous description of the method for saving graphs as templates for later use in Excel 2007 will help to expedite the process.

Although the following instructions are presented for MBDs across participants, they also apply to MBDs across behaviors and settings.

Inserting the Initial Graph

1. Enter the data for the 3 hypothetical participants as displayed in Figure 6. Note that the baseline and intervention data are staggered across columns, which will allow you to later plot trend lines and use other Excel 2007 functions. However, you could have just as easily entered the baseline and intervention data under one column, as described in the prior sections on creating reversal design graphs.

2. Highlight the data in Columns A and B that correspond to the 1st participant's baseline and intervention data. Click on

the INSERT tab and select LINE GRAPH, and then the fourth option in the line graph submenu, titled LINE WITH MARKERS. Carr and Burkholder (1998) described a process by which you can copy your first graph and paste the identical graph immediately below it, after which you change the data series of the second graph to the data representing the 2nd participant. We have already described the utility and process of saving a graph as a template for later use with new data. However, the existing graph we have created is in need of modifications before it is ready to be converted into a template.

3. Begin the modifications by deleting the legend by left-clicking on it once and pressing the DELETE key. Delete the grid lines by clicking once on one of the grid lines, which will highlight all of them, and then press the DELETE key.

4. At this time we can also remove the border and fill colors from the chart area and plot areas, as described for previous graphs. Depending on your preference settings in Excel 2007, the graph may or may not have a background by default.

5. You may wish to edit the line colors and marker styles at this time. To do so, right-click on the data series you wish to edit. From the FORMAT DATA SERIES window, select MARKER OPTIONS and the suboption BUILT-IN. Choose a marker type you wish to use. With the BUILT-IN option selected, you may choose the type and size of marker you wish to use on the graph.

6. Change the line color by selecting the option LINE COLOR, selecting the option SOLID LINE, and, using the drop-down menu for color, choose the color you wish to use. You may also need to change the marker fill color and marker line color as well. Once all three

options are set to the same color, press CLOSE to return to the graph. To make the same changes to your other data series, repeat the steps previously described.

7. As you may notice, the *x*-axis tick-mark labels range from 1 to 24 in our example, which appear to be quite cumbersome. In Excel 2007, we can easily alter this *x*-axis display by selecting the LAYOUT tab under the chart tools, and under the LAYOUT tab in the fourth panel, select the AXIS option. Then select the PRIMARY HORIZONTAL AXIS and then select the last option, MORE PRIMARY HORIZONTAL AXIS OPTIONS.

8. From the FORMAT AXIS window, select the AXIS OPTIONS, and then change the intervals between tick marks from 1 to 5. Then, select SPECIFY INTERVAL UNIT and change this from 1 to 5. Now click the CLOSE button to return to the graph.

9. There are various other options you may wish to explore to edit other characteristics of the axes. For now, the ones described above will suffice. Some of the new features of Excel 2007 include changing the axis types to dates, presenting the axis in 3-D formats, and aligning the text in various directions and angles.

10. Before we save this edited chart as a template, we must decide whether we wish to add phase-change lines here on the individual graphs. Unlike the other types of graphs described in this task analysis, the MBD graph will require phase-change lines that cross multiple graphs; however, this is not possible when one draws the lines directly on a graph, as described previously for the reversal design graphs, because lines will not extend beyond the border of the chart area. We suggest that for MBD graphs you forgo drawing phase-change

lines directly on graphs and wait until all graphs are completed and aligned to add phase-change lines. We will describe this process below.

Saving the Graph as a Template and Using the Saved Template for Subsequent Graphs

1. The graph is now ready to be saved as a template. Save the graph as a template as previously described, using the text "Multiple Baseline" for the file name when saving the template file.
2. To create the graph for the 2nd participant, highlight that participant's data, select INSERT, OTHER CHARTS from the CHARTS panel, and select the last option ALL CHART TYPES.
3. From the INSERT CHART window, select the first option TEMPLATES and the newly created "Multiple Baseline" option displayed under MY TEMPLATES. Select OK and return to the graph. You will now see a second graph with identical formatting, but with the data series for the 2nd participant. Repeat this process for the 3rd participant's data.

Aligning and Grouping the MBD Graphs

1. At this point, you will have three graphs of different data that are identically formatted. To arrange them into a multiple baseline display, align the graphs horizontally and vertically so that each subsequent participant's graph is below the previous participants' graphs. Once all three graphs are aligned vertically and horizontally, we can group all three graphs so that if we need to move the graphs on the spreadsheet in the future, we will simply have to move one item instead of three.
2. To group all three graphs, hold down the Ctrl key and left-click once on the chart area of each graph. This should select all

three graphs. Now right-click and select the GROUP option. Now you should be able to select and reposition all three graphs as one item by clicking on the area surrounding the three graphs. If completed properly, you should see a box around all three graphs like the one displayed in Figure 6.

3. At this point we need phase-change lines added to the graphs, and as stated previously, these lines need to cross multiple graphs. To accomplish this, make sure that you have selected somewhere on the spreadsheet outside the graphs by clicking on any cell away from the graphs. To draw the first line, click on the INSERT tab of the main menu, and in the ILLUSTRATIONS panel select the SHAPES option and select the first LINE option displayed.
4. With the mouse draw a vertical line in an area of the spreadsheet away from the graphs. You can ensure the line will be perfectly vertical (or horizontal) if you hold down the shift key while drawing the line. Change the color, solid or dashed style, and other options of the line as described previously, then with the mouse reposition the line over the graphs to separate phases of the graph. You may need to extend the length of the line by either clicking and dragging on the ends of the line or, once the line has been selected, you may click on the FORMAT option on the menu, then locate the SIZE panel. The length of the line can be adjusted in specified increments by adjusting the SHAPE WIDTH option (i.e., the second numeric up-down box in the SIZE panel).
5. You can repeat these steps for the remaining phase-change lines, or you may simply copy, paste, and adjust the just-completed line, as described previously.

6. In most MBD graphs, single *x*- and *y*-axis labels are used to describe all participants' data. To create single *x*- and *y*-axis labels, you will need to move outside the graphs and create the labels on the spreadsheet, using text boxes.

7. To do this, click on a spreadsheet cell outside the charts, click on the INSERT tab, and in the panel TEXT, select the first option (TEXT BOX), and then draw your text box on the spreadsheet away from your graphs.

8. Type in the desired *x*-axis label. Following our example, enter the text "Session."

9. To move the *x*-axis label below the 3rd participant's graph, select it by left-clicking on it once. While holding down the left mouse button, drag it to the bottom of the 3rd participant's graph.

10. Repeat this process for the *y*-axis label. Enter the text "Frequency" for the *y*-axis label.

11. You may need to rotate the *y*-axis label 270 degrees. With the text box highlighted, right-click and select FORMAT SHAPE from the options that appear. From the FORMAT SHAPE window, select the last option, TEXT BOX, the suboption TEXT DIRECTION, and the drop-down menu option ROTATE 270 DEGREES. Select CLOSE to return to the spreadsheet.

12. Resize the text box and position it to the left of the 2nd participant's *y*-axis values.

13. Remove the border and background color of the text boxes, as described previously.

14. Repeat the process described previously for reversal design graphs to create labels for the different phases. Position the resulting text boxes above the data series of the 1st participant. The resulting MBD graph should look similar to the one depicted in Figure 7.

Exporting the Graph into Another Program

Even though instructing readers in the use of Excel 2007 to create graphs is the ultimate goal of this paper, displaying those graphs only in Excel 2007 is rarely the ultimate goal of those who create graphs. Ultimately, we will present graphs of our data elsewhere, such as word processing (e.g., Microsoft Word[TM]) or presentation (Microsoft PowerPoint[TM]) software. The point is that ultimately we will need to know how to transport a finished graph from Excel 2007 to other applications.

1. To export your final product from Excel 2007 into other applications, use your mouse to highlight the entire figure consisting of all three graphs by left-clicking on a cell to the left and above all aspects of the graphs. Then while holding down the left mouse button, drag to a cell to the right and below all aspects of the graphs. Make sure to include the *x*- and *y*-axis labels. When highlighted, the area should look like Figure 7. With all of the elements highlighted, right-click and choose the COPY option. When the graph to be transferred is selected, the simplest option is to open the desired program, right-click in the area of your new document you wish to display the graph in, and select PASTE. A safer option that can be used when transferring graphs to Word or PowerPoint is to use the Paste as Picture option located under the PASTE SPECIAL options of either Word or PowerPoint. This option generally does a better job of retaining all features of a graph; however, the user will lose the ability to modify any features of the graph in its new location except for its size.

2. Excel 2007 has additional features for transporting your graphs to other programs. With the figure highlighted, select the Office 2007 icon in the top left corner of the screen. This icon is titled the
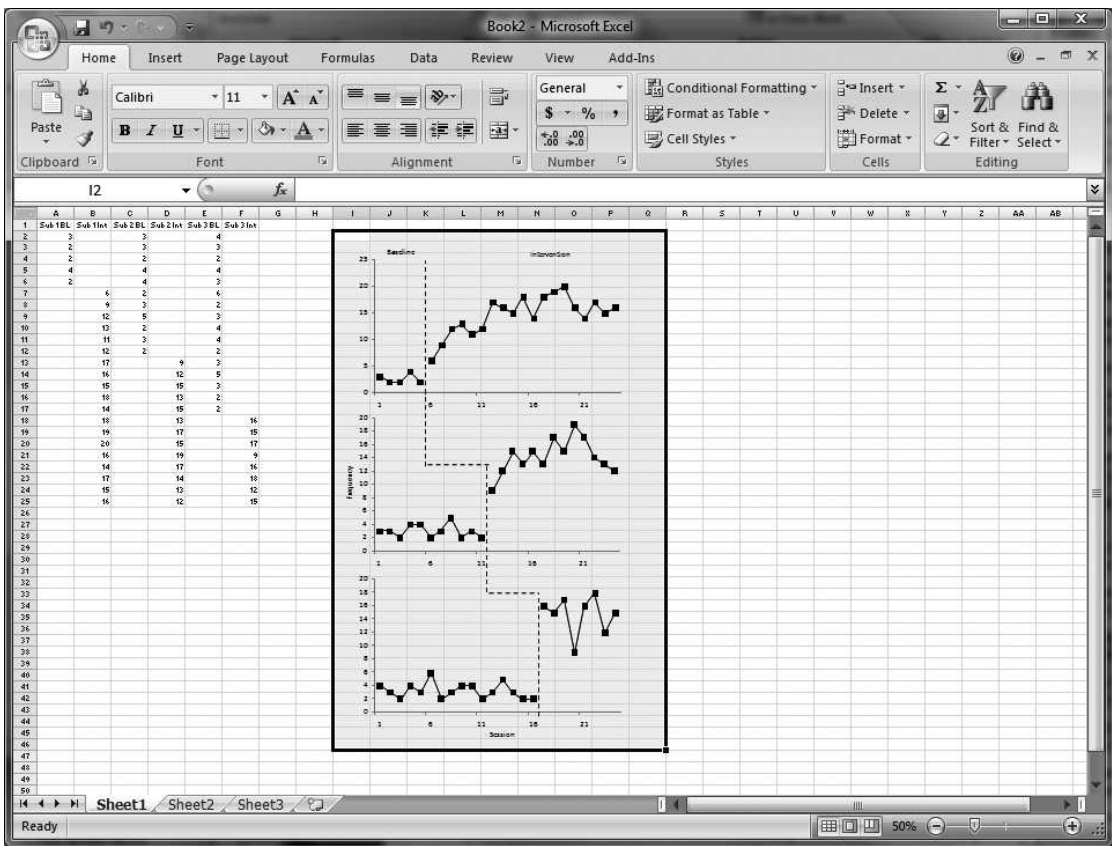
Figure 7.   The completed multiple baseline design graphs with the all of the graphs highlighted.

OFFICE BUTTON, and will display options such as PREPARE, SEND, and PUBLISH. These three options will allow you to do many things, such as e-mail the whole spreadsheet or figure, publish it as an independent document, and prepare it for final encryption. If the reader owns a copy of Adobe Acrobat, a SAVE AS option will allow automatic conversion of the figure into a .pdf file. Even if the reader does not own Acrobat, there are free add-ins available for download from Microsoft's Web site (http://www.microsoft. com/downloads/), including the Flash-Paper Toolbar and the Microsoft Save as PDF or XPS that make saving spread-sheets and figures as .pdf and .xps files a simple option.

Improvements in the Visual Formatting of Spreadsheets

Thus far we have described the basic components of Excel 2007 that you should be familiar with to create common single-subject design graphs. To illustrate these features we have employed relatively simple data sets. However, real data often result in relatively busy spreadsheets. To prevent graphs from cluttering your spreadsheet, you may transfer them to a separate spreadsheet within the same Excel 2007 file. To do this, simply highlight the graph, right-click, and select COPY. Locate the tabbed spreadsheet labels in the bottom left corner of the work space and select SHEET 2 (or any other sheet). When SHEET 2 has been highlighted, right-click and select PASTE. The graph will now appear on the new spreadsheet.

Using a new separate spreadsheet is even more helpful with multiple graphs that may need very careful alignment.

Excel 2007 offers many either new or improved features that make the visual display of spreadsheets more easily customizable. Earlier, when we described how to set up a spreadsheet, we mentioned that users may wish to color code cells manually to correspond to a given phase (e.g., baseline, treatment). Excel 2007 features an interface for applying conditional formatting rules to cells in a spreadsheet that is much improved over previous versions of the software. Given the color-coding example we just mentioned, one could apply a rule that would automatically change either the text color or the highlight color of a cell or group of cells based on the text entered. One could also apply rules based on some function of a series of values in a group of cells. One can apply conditional formatting rules that change text or highlight colors of the top 10 scores in a series of values, the top 10% of scores in a series of values, the bottom 10% of scores in a series of values, only those values above a mean of a certain series of values, or only those values below a mean of a certain series of values. Multiple rules can be set for a block of cells so that more than one of these types of rules can be applied, with the order of which rules to apply first left modifiable. It is not hard to see that the possibilities can easily get complicated.

To illustrate some of the ways that these features could be applied, we will use the example of a spreadsheet set up to display data in a type of research design most readers should be familiar with, the changing-criterion design. Consider a scenario in which one wants to increase the number of mands emitted by a client per session. One may wish to take baseline data for a number of sessions and then apply an initial criterion for advancement through a training protocol. A simple way to set up a spreadsheet might be to place a header in the first column (Column A) for the phase

and a header in the second column (Column B) for the frequency of mands. Data entered in the first column would consist of text corresponding to phase (BL for baseline, TXCT1 for the first training criterion, TXCT2, for the second, etc., for all remaining criterion levels), and data in the second column would consist of the frequency of mands emitted per session or observation. To serve as a more salient visual reference, you might wish to highlight the cells in the phase column with a specific color based on the phase entered. The following instructions illustrate this process.

1. Click on Column A to highlight the entire column.
2. From the main menu at the top of the screen make sure the HOME tab is selected and locate the CONDITIONAL FORMATTING option from the STYLES panel at the top of the screen.
3. Click on CONDITIONAL FORMATTING and from the resulting option select the NEW RULE option.
4. In the resulting NEW FORMATTING RULE dialogue box, select the FORMAT ONLY CELLS THAT CONTAIN option from the SPECIFIC RULE TYPE box.
5. In the EDIT THE RULE DESCRIPTION box, select the SPECIFIC TEXT option from the first drop-down box, select the CONTAINING option from the second drop-down box, and in the text box on the right enter the text you want to enter in the cells for the first phase of the study (BL for baseline).
6. Click on the FORMAT button to open the FORMAT CELLS dialogue. From this dialogue, click on the FILL tab and select the color you wish the cells to be highlighted with, then click the OK button to return to the NEW FORMATTING RULE dialogue box. Click on the OK button to finalize the new rule.
7. Repeat the steps above to add additional rules for highlighting the cells in the

phase column with different colors when text for the other phases is entered (i.e., TXCT1, TXCT2).

8. Test the results of the rules by entering the text "BL" in the first five cells in the phase column, the text "TXCT1" in the next 5 to 10 cells, and the text "TXCT2" in the next 5 to 10 cells.

Now assume you collect baseline data for five sessions and obtain frequencies of 10, 15, 11, 12, and 14 mands per session for your baseline observations, for a mean of 12.4 mands per session. At this point, we might begin to implement a training protocol, and we might set a criterion of observing at least four of five consecutive sessions with frequencies equal to or greater than 25% over the mean baseline rate before moving to the next criterion level. As we enter data for these sessions in the TXCT1 phase, we want any values that meet the criterion to be displayed in red text so we could quickly visually determine if four of the last five sessions have met the current criterion level. Again, we can add rules with the conditional formatting options to accomplish this.

1. In Cell E1, enter the text "Criterion Level 1."
2. In Cell F1, enter the following text to create a formula to calculate the criterion level: "=1.25 * AVERAGE(B2:B6)." This formula calculates the mean of the five baseline observations and multiplies it by 125% to obtain the first criterion level.
3. We also want to add in the second criterion level. In Cell E2, enter the text "Criterion Level 2."
4. We want the second criterion level to be 25% greater than the previous level, so in Cell F2 enter the following formula "=1.25 * F1."
5. Select all the cells in the frequency column by clicking on Column B.
6. Click on the CONDITIONAL FOR-MATTING tab in the STYLES panel and select the NEW RULE option.

7. In the resulting NEW FORMATTING RULE dialogue box, select the FOR-MAT ONLY CELLS THAT CON-TAIN option in the SELECT A RULE TYPE box.
8. In the EDIT THE RULE DESCRIP-TION box, make sure that CELL VAL-UE is selected in the first drop-down box and that GREATER THAN OR EQUAL TO is selected in the second drop-down box.
9. In the third box you can either enter a specific value or select a value from a specific cell in the spreadsheet by clicking on the selection icon on the right side of the box, selecting the appropriate cell in the spreadsheet (in this case, Cell F1, in which we entered the formula for calcu-lating Criterion Level 1) containing the value you want to use, and clicking on the selection icon again to return to the EDIT FORMATTING RULE dialogue box.
10. Click on the FORMAT button to open the FORMAT CELLS dialogue box, select the FONT tab, select red from the COLOR drop-down box in the middle of the dialogue box, and click on the OK button to return to the EDIT FORMAT-TING RULE dialogue box. Click the OK button to complete the rule.
11. Repeat Steps 6 to 10 to create another rule to make all values greater than or equal to the second criterion level a different color of text, except in Step 7 select Cell F2 and in Step 10 select a color other than red.
12. Finally, to test if the new rules work, enter numerical values into Cells B7 and B27. Values between the two criterion levels should be displayed in red, and those greater than or equal to the second criterion level should be displayed in the color you chose in Step 11.

The steps described above only begin to scratch the surface of the formatting options

available in Excel 2007. In addition to the text and highlighting options described in the preceding section, the conditional formatting option has many more features and additional rules that can be applied to spreadsheets. Users who wish to explore additional options on their own may benefit by consulting the help screen in Excel 2007. By clicking on the question mark within the blue circle in the upper right corner of Excel 2007 and typing "conditional formatting" into the resulting search box, one can find links to demonstrations and downloads from Microsoft that may help to illustrate the use of many of these additional options.

SUMMARY

Microsoft's Excel 2007 spreadsheet program remains useful for behavior analysts desiring to create single-subject design graphs. We have described the necessary steps for a few common graph types using Excel's latest version, and with slight modifications, many others are possible. In the present article we have only scratched the surface of the graphing and data analysis possibilities in Excel 2007. Future explorations might include tutorials for calculating interobserver agreement, developing macros for data analysis, or the construction of other types of graphical displays.

REFERENCES

Carr, J. E., & Burkholder, E. O. (1998). Creating single-subject design graphs with Microsoft Excel[TM]. *Journal of Applied Behavior Analysis, 31,* 245–251.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied behavior analysis* (2nd ed.). Upper Saddle River, NJ: Merrill/Prentice Hall.