Enhanced Written Instructions for Creating Publication-Quality Single-Case Design Graphs in Microsoft Excel

By

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Kelsey M. Dachman
MA, University of Kansas, 2018
BA, University of Iowa, 2014

Submitted to the graduate degree program in Applied Behavioral Science and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Chairperson: Jan B. Sheldon, PhD, JD

Claudia L. Dozier, PhD, BCBA-D, LBA-K

Florence D. DiGennaro Reed, PhD, BCBA-D

Derek D. Reed, PhD, BCBA-D, LBA-K

Nancy Brady, PhD

Date Defended: 22 July 2020

The dissertation committee for Kelsey M. Dachman certifies that this is the approved version of the following dissertation:

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Chairperson: Jan B. Sheldon, PhD, JD

Date Approved: 22 July 2020

Abstract

Graphs are visual descriptors of functional relations between behavior and the environment, and behavioral researchers and clinicians make informed decisions on current and future procedures by evaluating such functional relations. Thus, graphically depicting and visually inspecting single-subject data is foundational in the science of behavior. Microsoft Excel is the most prevalent program used by behavior analysts to create single-case design graphs; however, the Excel literature mostly includes brief tutorials and descriptions of its utility, neither of which evaluate methods of training Excel's comprehensive capabilities. Self-directed training with enhanced written instructions (EWI) is a viable option to train graphing skills as it alleviates the amount of resources required by in-person trainings. However, published evaluations of EWI as a method to train graphing are limited in quantity, rely on permanent product measures, and exclude assessments of maintenance and generalization. We used a multiple baseline across participants design to evaluate the effects of EWI to train seven undergraduate students to create publication-quality single-subject design graphs in Excel. We measured graphing accuracy and latency to graph completion using real-time, live-Excel, and permanent product measures. We also assessed response maintenance and generalization. EWI resulted in immediate, robust effects, and we observed generalization and maintenance across all participants. We discuss these results and their implications regarding staff training, Excel's utility, and data measurement.

Keywords: enhanced written instructions, Excel, graphing, self-directed training, task analysis

Acknowledgments

First and foremost, I would like to thank my advisor, Dr. Jan Sheldon, for her mentorship over the past 6 years. Your wealth of knowledge and passion for helping others is inspiring, and I admire your assiduous advocation for justice and equality. You inspire me to change the world. You have taught me the meaning of hard-work, determination, and passion. You are my greatest advocate, and I could not imagine a better role-model. I am grateful to have had the opportunity to work closely with you and to witness, firsthand, the impact you continue to make on the lives of countless individuals, mine included. You have become my Kansas family, and I will sincerely miss you (thank goodness for Zoom 😊).

To Alicia Morgan, thank you for keeping me grounded and focused on the important things. Thank you for your endless support and friendship and for having the biggest heart. I will miss laughing with you.

Thank you to Drs. Alec Bernstein, Florence DiGennaro Reed, and Pamela Neidert for your contributions to this study and for making my PhD possible. I am forever grateful. Thank you to Ashley Romero, Emily Meiring, and Sara Diaz de Villegas for your assistance in data collection and analysis, and to my wonderful participants for their time and effort.

To my parents whom I love dearly, thank you for your endless support, love, and guidance. Thank you for raising me to be strong, loyal, and independent. You encouraged me to chase my dreams and challenged me to be the best version of myself. I have you to thank for my biggest accomplishments, PhD included. You both mean the world to me.

Finally, thank you, Alec, for being my rock and for supporting me in all that I do. Thank you for keeping me laughing, for making each day better than the last, and for being the best dad to Harper, Nola, and Murphy. You have changed my world for the better, and I cannot wait for our next adventure. I love you.

In dedication to Murphy Dachman

Table of Contents

Enhanced Written Instructions for Creating Publication-Quality Single-Case Design Graphs in Microsoft Excel 1

Graphing Mediums 3

Training Graphing Skills 6

Current Study 15

Method 15

Participants 16

Settings and Materials 17

Video Recording 19

Hypothetical Data Sets 19

Data-Entry Spreadsheets 21

Sample Graphs 22

Written Instructions 23

Enhanced Written Instructions 23

Response Measurement 24

Interobserver Agreement 27

Procedures 28

Validation of Enhanced Written Instructions and Mastery Criteria 28

Pre- and Post-Session 30

Baseline 31

Training (Enhanced Written Instructions) 32

Maintenance 32

Generalization 33

Procedural Integrity 33

Pre- and Post-Study Questionnaires 34

Results 35

Discussion 43

References 53

List of Figures

Figure 1 61

Figure 2 62

Figure 3 63

List of Tables

Table 1 64

List of Appendices

Appendix A: General Instructions 65

Appendix B: Session Start-Stop Prompter 66

Appendix C: Tutorial Data-Entry Sheet (Dates) 67

Appendix D: Example Target Data-Entry Sheet (Sessions) 68

Appendix E: Generalization Data-Entry Sheet (Dates) 69

Appendix F: Tutorial Data Sample Graph (Dates) 70

Appendix G: Example Target Data Sample Graph (Sessions) 71

Appendix H: Generalization Data Sample Graph (Dates) 72

Appendix I: Tutorial Data Written Instructions (Dates) 73

Appendix J: Target Data Written Instructions (Sessions) 74

Appendix K: Generalization Data Written Instructions (Dates) 75

Appendix L: Enhanced Written Instructions (Dates) 76

Appendix M: Enhanced Written Instructions (Sessions) 98

Appendix N: Sample Real-Time Data Collection Sheet (Dates) 120

Appendix O: Sample Real-Time Data Collection Sheet (Sessions) 121

Appendix P: Sample Live-Excel Data Collection Sheet 122

Appendix Q: Sample Permanent Product Data Collection Sheet 123

Appendix R: Procedural Integrity Data Sheet 124

Appendix S: Pre-Study Questionnaire 125

Appendix T: Post-Study Questionnaire 127

Enhanced Written Instructions for Creating Publication-Quality Single-Case Design Graphs in Microsoft Excel

Graphs are visual descriptors of functional relations between behavior and the environment (Bourret & Pietras, 2012; Cooper et al., 2020; Johnston & Pennypacker, 2009; Tufte, 2001). Because behavioral researchers and clinicians make informed decisions on current and future procedures by evaluating such functional relations (Bailey & Burch, 2016; Bushell & Baer, 1994; Fahmie & Hanley, 2008; Johnston & Pennypacker, 2009), graphically depicting and visually inspecting single-subject data is foundational in the science of behavior (Horner et al., 2005). Moreover, the field's credentialing office, the Behavior Analyst Certification Board® (BACB), requires credentialed behavior analysts to graph data per the *Professional and Ethical Compliance Code for Behavior Analysts* (3.01 & 3.04; BACB, 2017). Thus, graphing is a socially significant behavior that warrants attention.

Several graphing conventions enhance the functionality and readability of a graph. Certain conventions, however, have changed over time (Cole & Witts, 2015; Mitteer et al., 2018; Pritchard, 2008) and, therefore, warrant further research, training, and discussion toward a consistent, publication-quality graphing style. According to the seventh edition of the *Publication Manual of the American Psychological Association* (American Psychological Association [APA], 2020), conventions that enhance a graph's simplicity and readability include (a) consistently sized (8- to 14-pt font) sans serif text, (b) labels and headings with title case, (c) limited special effects (e.g., shading, three-dimensional effects, and layered text), (d) legends placed within or underneath the graph (rather than to the side), and (e) abbreviations and symbols (e.g., denote percentage as "%"). Finally, graphs should be produced at a high resolution to allow for accurate reproduction (e.g., printing).

The *Journal of Applied Behavior Analysis* (*JABA*) – the seminal behavior-analytic journal – reiterates many of the conventions described by the APA (2020) and suggests additional conventions of publication-quality graphs. Such conventions include (a) readable data points that are depicted as closed, black circles for graphs with one data path or that alternate between closed (i.e., greyscale colored) and open (i.e., white) symbols for graphs with multiple data paths, (b) axes and lines that are consistent in thickness, (c) legends and arrows with text that aid in identifying components of the graph but do not interfere with other text and data, (d) tick marks that extend outward of both *x*- and *y*-axes so corresponding labels are easily readable, (e) removal of the "0" from the range of values included on the *x*-axis, and (f) a raised "0" value on the *y*-axis slightly above the *x*-axis (i.e., a floating "0") to avoid data points overlapping the *x*-axis.

Researchers have addressed many of these graphing conventions and more through technical and empirical publications. For example, Mitteer and colleagues (2018) reviewed the literature on graphing and visual inspection and on creating computer-generated single-case design graphs to determine the desirable features of publication-quality graphs to include in their training (for the comprehensive list of articles, see Mitteer et al., 2018). Of the 18 reviewed sources, at least 72% mentioned use of (a) appropriately scaled axes and tick marks, (b) disconnected data paths across phases, (c) a wide aspect-ratio, (d) descriptive labels of phases, axes, and data paths, (e) a floating "0" on the *y*-axis, and (f) no unnecessary ink. At least 61% directly mentioned use of visually distinguishable data points and the removal of the "0" on the *x*-axis.

Our literature search yielded four articles (Berkman et al., 2019; Kranak et al., 2019; Mitteer et al., 2020; Su, 2008) in addition to those included in Mitteer and colleagues (2018). Su

(2008) focused on the limitations of Microsoft Excel's default graphing options. Mitteer and colleagues (2020) replicated and extended Mitteer et al. (2018) and included the same graphing conventions for their training. Berkman and colleagues (2019) and Kranak and colleagues (2019) suggested they also taught several of the previously identified conventions (e.g., floating "0" on the *y*-axis, appropriate axis scaling and tick marks, removal of unnecessary information, and appropriate labels). Although further research on the social validity of these conventions is needed, it is evident that professionals have identified several conventions of professional-quality graphs, which they both promote (e.g., journal publication requirements and technical articles) and adhere to (e.g., empirically-based publications and clinical use). There are several programs from which professionals can create publication-quality graphs. These programs, however, come at differential costs and range in published trainings on their utility.

Graphing Mediums

Professionals have several options to create high-quality graphs (e.g., Systat SigmaPlot [SigmaPlot], Red Rock DeltaGraph [DeltaGraph], GraphPad Prism [Prism], and Microsoft Excel [Excel]). Scientific graphing software (e.g., SigmaPlot, DeltaGraph, and Prism) often produces higher quality graphs than more general graphing programs such as Excel (Berkman et al., 2019; Mitteer et al., 2018; Su, 2008). The default settings of graphing-specific software generally include greyscale with minimal nonessential components, and manipulating graphing conventions requires few additional steps (Berkman et al., 2019; Su, 2008). Limitations of these programs include complicated installation processes and steep costs (Vanselow & Bourret, 2012), which may impact one's decision to use such software (Haddock & Iwata, in press).

SigmaPlot is designed specifically for Windows-based systems. SigmaPlot costs up to $799 depending on the version and user license. Macintosh users must download and install

virtualization software (e.g., Parallels® Desktop for Mac) to operate SigmaPlot, spending an additional $99.99 on Parallels for a total of $898.99. DeltaGraph includes versions for both Windows and Macintosh users, but the Macintosh version is incompatible with its latest version (i.e., macOS Catalina 10.15) and there is currently no release date for a compatible version. DeltaGraph also costs up to $299 depending on the version and user license. Unfortunately, there are limited data on the prevalence of SigmaPlot and DeltaGraph for creating single-subject designs and there are limited tutorials on their use. Users would likely need to informally self-train to become adequate in producing publication-quality graphs in these programs.

Prism is a more prevalent scientific graphing software. Prism allows for easy exportation of graphs into various file types (e.g., .EPS, .PDF) in high resolutions (Mitteer et al., 2018) and a relatively easy-to-use interface for basic functions (Berkman et al., 2019). Prism, however, is less intuitive for more complex skills (Berkman et al., 2019), and there were no published tutorials on Prism's use to create single-case design graphs until recently (i.e., Berkman et al., 2019; Mitteer et al., 2018, 2020). Although Prism includes versions for both Windows and Macintosh devices, it is costly compared to other graphing programs. For individual users, an annual subscription costs up to $252 depending on the license type; Prism also offers a group subscription for academic teams, which costs up to $5,400 for 100 activations. Prism is also limited in its data-management capabilities as users cannot enter formulas into cells for data analysis (Mitteer et al., 2018). Further published trainings on more generalizable versions of scientific graphing programs may increase their utility and outweigh their cost. Until then, researchers and professionals may continue to default to more accessible graphing mediums (i.e., Excel; Haddock & Iwata, in press).

Excel is a widely available electronic graphing program (Vanselow & Bourret, 2012) that is included through purchase of Microsoft 365. Microsoft 365 which includes Microsoft's cloud-based services, Excel, Word, PowerPoint, and other premium applications. Microsoft 365 is compatible with Windows, Macintosh, Android, and iOS devices, and costs as low as $69.99 per year for the one-user personal license or $99.99 per year for the six-user family license. Additionally, Excel includes a versatile platform for data entry and analysis (Mitteer et al., 2018). Even though Excel is not considered a scientific graphing program, authors have reported its frequent use to create publication-quality graphs. Haddock and Iwata (in press) interviewed 112 editors of *JABA* and the *Journal of the Experimental Analysis of Behavior* regarding their use of various graphing programs. Almost 91% of the editors reported graphing in Excel in some capacity.

Although Excel produces sufficient graphs for publication (Lo & Starling, 2009) at a lower financial strain, Excel is considered a spreadsheet application rather than a scientific graphing program (Haddock & Iwata, in press) and does have its limitations. Excel is limited in its ability to produce exportable graphs at high resolutions (e.g., 1200 dpi; Mitteer et al., 2018) that mirror those of its scientific-graphing software competitors (Haddock & Iwata, in press). Its default settings also require users to make substantial changes toward a publication-quality graph (Su, 2008). Several technical articles on Excel's usability for graphing, nonetheless, describe methods to create conventions of single-case design graphs, therefore, helping (a) counter the limitation of Excel's need for user changes to default settings, and (b) further the user's ability to produce the highest quality graphs possible Barton & Reichow, 2012; Carr & Burkholder, 1998; Cole & Witts, 2015; Deochand et al., 2015; Dixon et al., 2009; Hillman & Miller, 2004; Lo & Konrad, 2007; Lo & Starling, 2009; Moran & Hirschbine, 2002; Pritchard, 2008; Reed, 2009;

Reed et al., 2012; Tyner & Fienup, 2015; Vanselow & Bourret, 2012). These technical publications, however, are not without limitation.

System updates to Excel require amendments to the tutorials (Cole & Witts, 2013; Deochand et al., 2015; Dixon et al., 2009; Vanselow & Bourret, 2012). Carr and Burkholder (1998) created the first tutorial for creating single-case design graphs in Excel 1997 based on the 1996 graphing conventions of *JABA.* Pritchard (2008) updated Carr and Burkholder's (1998) tutorial to adhere to the updated 2000 *JABA* graphing conventions, and updates continue to be warranted. Most published tutorials, if not already outdated, are tailored to address one or several graphing components (e.g., creating phase-change lines; Deochand, 2017; Deochand et al., 2015; Dubuque, 2015) but rarely serve as a tutorial on creating an entire graph in Excel from start to finish (e.g., Moran & Hirschbine, 2002). Although these tutorials offer efficient, focused methods and advance previous literature on graphing single-case design data in Excel, tutorials that include a synthesis of graphing steps for a comprehensive training may further streamline the graphing process and lower the user's response requirement. Whether tutorials were specific to certain graphing conventions or comprehensive, the empirical evaluation of these tutorials to increase graphing skills is limited (Cole & Witts, 2015; Deochand et al., 2015; Dixon et al., 2009; Lo & Starling, 2009; Tyner & Fienup, 2015), and fewer included single-subject analyses for doing so (Cole & Witts, 2015; Lo & Starling, 2009). Further research is warranted on evaluating procedures to train graphing skills in Excel given its prevalence as a graphing program for behavior analysts (Haddock & Iwata, in press).

Training Graphing Skills

There are several staff training strategies, many of which have been used to teach graphing. Behavioral skills training (BST) is a highly effective teaching procedure that includes

instruction, modeling, rehearsal, and feedback (DiGennaro Reed et al., 2018; Miles & Wilder, 2009; Miltenberger, 2003; Nigro-Bruzzi & Sturmey, 2010; Nosik et al., 2013; Sarokoff & Sturmey, 2004). Kranak and colleagues (2019) used a multiple probe across behaviors (i.e., graphing a reversal, alternating treatments, and multiple baseline design) design to evaluate the effects of BST to train three graduate students to graph single-subject research designs using Excel. The researchers implemented one BST session for training each design. All participants' responding increased to near-100% accuracy and maintained at a 2-week follow-up condition. Kranak and colleagues also identified that participants were able to graph a reversal, alternating treatments, and multiple baseline design in 17, 11, and 24 min, respectively, following BST, with even lower latencies to completion during maintenance. BST sessions, however, lasted an average of 31 min; the researchers spent over 4 hr training three students. While effective, BST is time intensive, costly, and requires the presence of a trained professional (Shapiro & Kazemi, 2017). Clinicians may find other training procedures more efficient and cost effective, especially given such high rates of turnover (LeBlanc et al., 2009).

Self-directed trainings include similar components to BST (e.g., instructions and modeling) but do not require the presence of a trained professional making these procedures potentially more economical and time efficient than BST (Berkman et al., 2019; DiGennaro Reed et al., 2013; Shapiro & Kazemi, 2017). Individuals can also reference self-directed materials long after the initial training (Berkman et al., 2019; Charlop-Christy et al., 2000; Mitteer et al., 2018). Video modeling (VM) and written instructions (WI) are two common self-directed training methods.

VM includes a professional task analyzing a complex behavior and creating a recording of how to accurately complete each component response (Catania et al., 2009; Tyner & Fienup,

2015). Research suggests that VM is effective in training graphing (Berkman et al., 2019; Mitteer et al., 2018, 2020; Vanselow & Bourret, 2012) and other skills (for a review, see Erath & DiGennaro Reed, 2020). Moore and Fisher (2007) found that VM depicting multiple exemplars of therapist and client behavior was sufficient in training clinicians to implement functional analysis procedures. Additionally, Mitteer and colleagues (2018) used VM to train staff to create publication-quality graphs in Prism. They later replicated and extended their study to train additional staff to enter data and create publication-quality graphs in Prism, further validating VM as a self-directed training for graphing and suggesting its generality (Mitteer et al., 2020). Although effective and more cost efficient than BST (Shapiro & Kazemi, 2017), VM requires certain technology that may not be available to all clinicians (Graff & Karsten, 2012) and may require extensive time and effort to create (Tyner & Fienup, 2015). Additionally, creating a script for the video model likely requires one to document the steps intended for teaching. This invites the question of whether WI are a more efficient training procedure.

WI are a second method of self-directed training that are easily disseminated at a low cost and with few technological demands (Shapiro & Kazemi, 2017; Shapiro et al., 2016). Researchers have presented WI for several skills (e.g., graphing and conducting preference assessments) in two primary formats: full prose (Moran & Hirschbine, 2002; Roscoe et al., 2006; Roscoe & Fisher, 2008) and bulleted or numbered steps (Tyner & Fienup, 2015, 2016), sometimes both (Ramon et al., 2015). *Full prose WI* typically resemble an abstract or an abbreviated method section of a seminal journal article (Moran & Hirschbine, 2002). Roscoe and colleagues (2006) presented WI in the form of an abbreviated method section to train five staff members how to conduct a paired-stimulus (PS) and multiple stimulus without replacement (MSWO) preference assessment. Full prose WI resulted in responding below mastery criteria

across all staff and responding only increased for both tasks following feedback and contingent money. Berkman and colleagues (2019) included full prose WI during baseline when training staff to graph in Prism. Responding varied from low to moderate levels of accuracy and responding only increased following a more structured WI format. Results of Roscoe et al. (2006) and Berkman et al. (2019) are representative of the overall literature on WI as full prose (e.g., Graff & Karsten, 2012; Rosales et al., 2015; Shapiro & Kazemi, 2017; Shapiro et al., 2016; Tyner & Fienup, 2015) suggesting the need for a more systematic, effective presentation of WI.

Bulleted or numbered WI, also known as a *task analysis* (TA), includes a list of small, more manageable component behaviors toward a complex skill (Wong et al., 2014). TAs are a prevalent training procedure (DiGennaro Reed & Henley, 2015) and are also time and cost efficient (Shapiro & Kazemi, 2017). Dixon and colleagues (2009) used a between-groups design to compare the relative effects of their TA (i.e., updated with additional steps that aligned with the new version of Excel 2007) with the original TA developed by Carr and Burkholder (1998) on graphing accuracy in 22 graduate students. Results suggested that the group who had access to the updated TA created graphs more quickly and accurately than those who had access to the original TA. These results suggest the efficacy of a TA as a self-directed training, but effects at the individual level are unknown due to the group design. Dixon et al. also highlight the need to update and evaluate TAs as new software become available.

Lo and Starling (2009) used a multiple probe across participants design to evaluate the effects of a TA on graphing accuracy in Excel 2007 for three graduate students. The TA (adapted from Lo & Konrad, 2007) included 110 steps with some images of the software and the graph in progress. Researchers used the TA for both training and as a checklist to measure accuracy of the finalized graph (i.e., a permanent product measure). The TA resulted in a large increase in

accuracy for one student, but only a moderate increase in accuracy for the second student and a minimal increase in accuracy for the third student. The researchers also used a participant self-report questionnaire to measure whether they followed the steps of the TA to create the final graph. A real-time measure of behavior that does not require the researcher's presence would eliminate the reliance on self-report data and provide a more direct measure of behavior while maintaining the feasibility and practicality of their procedures. The results of Dixon and colleagues (2009) and Lo and Starling (2009) represent the variable efficacy of a TA as a training procedure. Given inconsistent findings, evaluating the relative effects of a TA compared to other validated methods of self-directed training (e.g., VM) is warranted.

Tyner and Fienup (2015) used a between-groups design to evaluate the relative effects of three instructional formats (i.e., full prose WI, TA, and VM) on graphing accuracy and duration in Excel 2007. Full prose WI included a description of graphing conventions. The TA included full sentences throughout 41 PowerPoint slides, 12 of which included images of the software and the graph in progress. The VM was a video tutorial of the same components of the TA. Statistical analyses suggested that, on average, students who used VM created significantly more graph elements correctly in fewer minutes than students who used the TA; students who used the TA formatted more graph elements correctly compared to students who used full prose, but this difference was statistically insignificant. However, Tyner and Fienup used a group-design, limiting the evaluation of individual effects. The researchers also mentioned, as previous researchers have suggested, that creating the video models required extensive time and effort. Perhaps increasing aspects of the TA would increase its efficacy to match that of VM.

Overall, TAs are idiosyncratic and vary in (a) the amount of steps and pictures included, (b) the degree of specificity, and (c) the overall structure, likely dependent on the complexity and

topography of the target behavior (Cole & Witts, 2015; Dixon et al., 2009; Graff & Karsten, 2012; Lerman et al., 2000; Lo & Konrad, 2007; Lo & Starling, 2009; Roscoe & Fisher, 2008; Roscoe et al., 2006; Tyner & Fienup, 2015, 2016). Evaluating manipulations to TAs may be necessary to enhance their effectiveness, generality, and continue advancements toward a method of training that is equally effective as BST and VM but also cost and time efficient. Doing so should include more direct measures of behavior and single-subject designs to evaluate individual effects of the self-directed training.

Graff and Karsten (2012) used a multiple baseline across behaviors design to evaluate the effects of an improved TA as a self-directed training to teach 11 staff members to conduct a PSPA and MSWO. Similar to previous research (e.g., Roscoe et al., 2006), baseline included full prose WI, which were drawn from the method sections of previously published articles and supplemented with a detailed data sheet. Treatment included *enhanced written instructions* (EWI), which were step-by-step instructions (i.e., a TA) with minimal technical jargon, supplemental pictures, and diagrams to supplement the steps. Full prose WI were ineffective for teaching staff to conduct preference assessments at 90% accuracy. However, EWI immediately increased performance to near 100% accuracy for all teachers across both preference assessments. These results maintained and generalized during a follow-up session in the teachers' natural environment. Results suggested that TAs enhanced with additional stimulus prompts may be an effective self-directed training method. One limitation to Graff and Karsten (2012) was that the participants had extensive behavior-analytic training. It is unclear whether EWI would be an effective method of training with participants with minimal to no experience with behavior analysis.

Shapiro and colleagues (2016) replicated and extended Graff and Karsten (2012) with five behavior technicians who had no prior experience observing stimulus preference assessments but did have other behavior-analytic training and seven undergraduate students who had no experience observing stimulus preference assessments or behavior-analytic training. Results demonstrated that EWI were effective in training three of the five behavior technicians to implement preference assessments at 90% accuracy but were ineffective for all seven undergraduate students. One behavior technician and six undergraduate students required a modified version of the EWI which included stimulus prompts (e.g., increasing the text size, boldface type font, additional pictures, and multiple exemplars) to achieve accuracy at or above 90%. One behavior technician and one undergraduate student required the addition of a brief feedback session to achieve accuracy at or above 90%. Results suggested that EWI may be a sufficient method of training individuals who have some history with the skill being taught and EWI with additional prompts, pictures, and exemplars may be a sufficient method of training individuals who have no history with the skill being taught. Additionally, performance feedback may be necessary when EWI with many prompts, pictures, and exemplars are ineffective. Further research on ways to improve EWI (e.g., including additional prompts) such that performance feedback is unnecessary is warranted, and additional research on EWI for teaching other socially significant behaviors (e.g., graphing) is necessary to evaluate its generality as a training procedure.

Tyner and Fienup (2016) replicated and extended Graff and Karsten (2012), Tyner and Fienup (2015), and Shapiro and colleagues (2016) by enhancing their original TA (Tyner & Fienup, 2015) with descriptions of relevant antecedent stimuli (e.g., color of icon) and performance criteria (e.g., “the line should be straight”). The researchers used a between-groups

design to evaluate the relative effects of their original TA with their enhanced TA (i.e., EWI) on graphing accuracy and duration in 16 undergraduate students who had no prior experience graphing in Excel. Students with the EWI created more accurate graphs and in a shorter duration than students with the original TA; however, the difference in duration across groups was not statistically significant. It is possible that students with the original TA spent less time reading but more time searching for respective stimuli, whereas students with the EWI spent more time reading due to the additional text but less time searching for stimuli. Differences in graphing accuracy may be because of the increased saliency of each step of the EWI leading to greater instructional control. It is also possible that descriptions of performance criteria prompted participants to correct their errors. However, as the researchers used a permanent product measure, it is unclear what factors contributed to the variation in responding between groups. A real-time data collection system would allow the researchers to observe the specific steps that led to behavior change and the amount of time spent on each step which may provide some insight to the underlying mechanisms responsible for the increased efficacy of EWI. It is also of interest to evaluate whether pictures and diagrams are a more efficient method of enhancing task analyses as they do not add additional text. This warrants further investigation of the necessary and sufficient components of EWI. Additionally, the relative effects of EWI compared to other methods of self-directed training (e.g., VM) remain unclear. Regardless, results demonstrated that EWI with additional pictures, exemplars, and stimulus prompts may be an effective method of training for participants with no prior experience with graphing.

Berkman et al. (2019) compared the relative effects of EWI (similar to Tyner & Fienup, 2016) and VM in training 11 teachers to graph using Prism. VM consisted of a video tutorial of the steps included in the EWI. The researchers quartered the TA and randomly assigned EWI to

two sections and VM to two sections. They evaluated within-subject effects by (a) implementing a multiple baseline across TA sections design and (b) concurrently embedding a multielement design across training methods. Furthermore, the researchers evaluated between-subject effects by implementing a multiple baseline across participants design. Results demonstrated that both self-directed trainings were immediately and equally effective for increasing the targeted graphing skills. VM produced slightly lower latencies to graph completion; however, EWI required less time to create and results of the social validity questionnaire suggested that the participants preferred EWI over VM. Although preliminary, the results suggested the efficacy of EWI as a self-directed training for graphing.

However, there are noteworthy limitations to Berkman et al. (2019). First, their design did not allow for the true comparison of effects of VM and EWI. Although the researchers quartered the TA as equally as possible, they noted that creating completely equal sections regarding difficulty, steps, and time requirement was likely not possible. The design, therefore, only allows for the true comparison of each training procedure to itself across sections of the TA. Second, the method of data collection involved evaluating the participants' live-Prism files. That is, the researchers implemented a more stringent measure of graphing accuracy by clicking within each participant's completed Prism graph to identify whether the conventions matched those instructed (e.g., required line width was 1 pt and the screen read 1 pt). Although this method, in comparison to permanent product, allows for a more conservative measure of graphing, live-Prism data collection still does not identify whether the participants engaged in the steps listed in the TA. Only real-time data collection would allow this evaluation. Third, there were no measures of maintenance and generalization, which are pivotal during staff training (Shapiro & Kazemi, 2017).

The literature on EWI and, more specifically, its use in teaching graphing, suggests its efficacy as a self-directed training. However, further evaluations are warranted to validate its effects using single-subject methodology, more directly assess the effects of EWI with real-time data and evaluate the generality of EWI to training graphing in Excel. Additionally, only two studies have assessed maintenance of graphing skills in the absence of training materials and did so following BST (Kranak et al., 2019) and VM (Vanselow & Bourret, 2012). Long-term maintenance of graphing skills following training with EWI has yet to be evaluated.

Current Study

The purpose of the current study was to use single-subject methodology and real-time data to directly evaluate the efficacy of EWI as a self-directed training for creating publication-quality single-subject design graphs in Excel. We also directly evaluated short- and long-term maintenance through a reversal to baseline following mastery during EWI and a 2-week follow-up, as well as response generalization through various probes. Further, we compared real-time data analysis to the more commonly used analyses of permanent product and live-document (i.e., live-Excel) to evaluate potential differences in measurement systems.

Method

It is important to note the contributions of Drs. Alec Bernstein and Pamela Neidert to the development of this project. They originally designed the study to be conducted in-vivo. Due to the COVID-19 pandemic, the study was transitioned online during the weeks of March 16, 2020 and March 23, 2020, and all subsequent sessions were conducted virtually. I transitioned and implemented the study online, made minor revisions to the original procedures, and graphed and analyzed the data. The University of Kansas Human Research Protection Program approved both versions of the study.

Participants

We recruited and obtained consent from seven undergraduate students majoring in applied behavioral science at a midwestern university. All participants had access to a desktop or laptop computer with a Windows-operating system. Participants' responses to a pre-study questionnaire (see section Pre- and Post-Study Questionnaire) suggested none had graduate-level behavior-analytic training or prior experience with EWI as an intervention to teach graphing. Additionally, participants had minimal to no experience graphing single-subject data in Excel; however, all participants reported that learning to graph in Excel would help them in their current or future job- or practicum-related responsibilities.

Three participants (Elizabeth, Corbin, and Hazel) were undergraduate practicum students credentialed as Registered Behavior Technicians® by the BACB and working as 1:1 therapists in an early intervention program serving children (2-12 years) with intellectual and developmental disabilities. Therapists were responsible for graphing single-subject data using Prism. Elizabeth was a 20-year-old female. Corbin and Hazel were 21-year-old females.

Four participants (Allaire, Jewel, Mimi, and Suzy) were research assistants conducting behavioral observations at a local alternative school for middle and high school students. Jewel and Allaire were both 21-year-old females. Mimi, a 22-year-old female, also served as a practicum student working 1:1 with legally truant youth where she was required to use Excel to graph attendance data as bar graphs. However, Mimi used an automated spreadsheet which allowed her to simply enter the data in the appropriate cells and the bar graphs automatically populated. She had no experience creating line graphs in Excel. Suzy, a 21-year-old female, previously worked as a practicum student in an early intervention program with the same responsibilities as Elizabeth, Corbin, and Hazel.

Elizabeth, Corbin, and Hazel began participating in the study in person prior to COVID-19. We conducted 100% of Elizabeth's sessions in-person. For Corbin, we conducted Session 1-11 in-person and Session 12-13 virtually. For Hazel, we conducted Session 1-4 in person and Session 5-22 virtually. We conducted all sessions for Allaire, Mimi, Suzy, and Jewel virtually.

Settings and Materials

We conducted 1-4 sessions per day, 4-5 days per week. Sessions lasted 45 min or until the participant self-terminated, whichever occurred first. We used a timer to ensure sessions did not exceed 45 min. All sessions were conducted in a location with minimal distractions. In-person sessions took place in a University office on-site that included a desk, chair, Dell desktop computer (Version XPS 8930 SE) installed with Windows 10, mouse, and mousepad. For virtual sessions, both the researcher and participant were in a secluded location within their respective homes that included a desk or table, chair, and desktop or laptop (model varied) installed with Windows 10. All computers had Excel (Version 16.37) pre-installed.

The content of materials remained constant across in-person and virtual sessions; however, the method of presentation varied. For in-person sessions, we presented some materials to the participant in hardcopy format and some materials in e-format. We presented all materials in e-format for virtual sessions.

During virtual sessions, we contacted participants and conducted sessions using Zoom Pro (Version 5.0.4), a cloud-based platform for video and audio conferencing, live chats, and screen-sharing. We initiated all Zoom meetings by creating and sending the participant a meeting invitation via email that included a link to the specific meeting and a unique password. All meetings were password protected. We instructed participants to have their camera and sound on during the initial portion of the meeting to verify the attending individual was the target

participant and to allow for pre-session communication. Once the participant joined the meeting, we shared the session materials using Microsoft OneDrive for Business (Version v6.4.2), a cloud-based storage and file sharing service. We removed the participant's access to the shared file immediately following each session such that the participant could not re-access the training materials. The University provided Zoom and OneDrive free-of-charge to all students and faculty. Both were available across devices by logging on to the University website and using one's University-assigned credentials.

We provided general instructions (see Appendix A) and the Session Start-Stop Prompter (see Appendix B) prior to beginning each session. General instructions described the (a) study's purpose, (b) session procedures, (c) purpose and use of the Session Start-Stop Prompter (including session duration), and (d) purpose of video recording. These instructions remained constant throughout each condition, and we delivered these as a printed copy in a laminated sheet cover during in-person sessions and as a PDF during virtual sessions. We presented the Session Start-Stop Prompter as a PDF for both in-person and virtual sessions. The top half of the prompter was green and read, "Start session by closing this screen ('X' in top left)," and the bottom half was red and read, "End session by reopening this screen (desktop file)." These directions coincided with the general instruction's description of the Session Start-Stop Prompter and its use within the general instructions. Because we scored all sessions post hoc from a video recording of the screen, the Session Start-Stop Prompter allowed us to identify the exact time at which the session began and concluded, denoted by the time at the bottom of the participant's screen.

Video Recording

We recorded the participant's computer screen during all sessions using VideoLAN VLC (VLC; Version 3.0.10) media player for Windows. VLC is a software program that records and plays multimedia files. For in-person sessions, VLC was running on the computer in which the participant was working but was minimized to not interfere with their ability to manipulate the screen. For virtual sessions, we instructed the participant to share their screen using Zoom and we ran VLC on our personal computers which allowed us to record the participant's computer screen. We recorded the participant's screen from immediately before the participant minimized the Session Start-Stop Prompter until slightly after the participant maximized the Session Start-Stop Prompter.

Hypothetical Data Sets

We created 10 unique, hypothetical data sets such that participants graphed a variety of data throughout the study. As it is common to graph both dates and sessions on the *x*-axis, we created five data sets for scaling dates to the *x*-axis and five data sets for scaling sessions to the *x*-axis. Each category (i.e., dates or sessions) included one tutorial, three target, and one generalization data set (similar to Mitteer et al., 2018). Additionally, we quasi-randomly delivered data sets throughout the study such that participants never graphed the same data set during consecutive sessions and never graphed sessions or dates on the *x*-axis for more than two consecutive sessions.

The tutorial data set for scaling dates to the *x*-axis was used to create the version of EWI for scaling dates to the *x*-axis. That is, the pictures, diagrams, and examples included throughout the EWI matched the hypothetical data included in the tutorial data set. The tutorial data set for scaling sessions to the *x*-axis was used to create the version of EWI for scaling sessions to the *x*-

axis. Each tutorial data set included one topography of measured behavior, one phase-change line, and one *x*-axis break. The tutorial data set for scaling dates to the *x*-axis included 12 data points and the tutorial data set for scaling sessions to the *x*-axis included 14 data points. Participants graphed the tutorial data only during the first two sessions of the initial training condition, and we counterbalanced the order of tutorial data sets across participants. We did this to control for participants creating their graph solely from the pictures within the EWI and not following the written instructions.

Each category also included three target data sets. The hypothetical data included in the target data sets did not directly match the pictures, diagrams, and examples in the EWIs, but the steps of the EWI to create a graph remained constant. Target data sets were similar to tutorial data sets such that they included one topography of measured behavior, one phase-change line, and one *x*-axis break. Target data sets for scaling dates to the *x*-axis included 12 to 18 data points (*M*= 16) and target data sets for scaling sessions to the *x*-axis included 12 to 15 data points (*M*= 14.7). Participants graphed target data during all sessions other than the first two sessions in the initial training condition and generalization probes.

Finally, each category included one generalization data set. Generalization data sets included three topographies of measured behavior each with different data markers, two phase-change lines, and one *x*-axis break. The generalization data set for scaling dates to the *x*-axis included 60 data points and the generalization data set for scaling sessions to the *x*-axis included 63 data points. The EWIs did not include any instructions specific to generalization data, and participants graphed generalization data only during generalization probes.

Data-Entry Spreadsheets

We created a data-entry spreadsheet in Excel for each hypothetical data set (see Appendix C-E for examples) to resemble a spreadsheet that clinicians would typically use when graphing client data. These were the working documents participants used during sessions. Data-entry spreadsheets included pre-entered hypothetical data and descriptive information regarding these data. The first row of descriptive information included a brief goal giving context to the data and procedures. The second row included a target category summarizing the topography or topographies of behavior (e.g., compliance, problem behavior), along with the start date, mastered date, and general notes (e.g., client name, location of sessions). The third, fourth, and fifth rows included more specific information regarding the topography of the target behavior (e.g., fine motor, physical aggression), information on data collection (e.g., frequency, duration, partial interval) and analysis (e.g., rate, percentage) for the relative topography, as well as additional notes for the relative topography (e.g., rate = responses-per-hour [RPH]; PA = physical aggression). Some of this information was necessary for titling and labelling the graph.

Hypothetical data spanned several of the columns below the descriptive information. For all data-entry templates, from left to right, the first column read "Dates;" the second column read "Sessions;" the third, fourth, and fifth columns read the same topography entered in the third, fourth and fifth rows of descriptive information, respectively; the sixth row read "Phase change;" the seventh row read "X-Axis Break;" and the eighth row read "Notes." We entered dates or sessions depending on the hypothetical data we were creating. We always included data for each listed topography (corresponding with every date or session), as well as phase change and *x*-axis break (when necessary). The data entered for phase change and *x*-axis break denoted where the *x*-axis intersects the *y*-axis on the graph (i.e., slightly below to raise the 0 of the *y*-axis). These

were physical data points on the graph and, therefore, would maintain their position if more data were added to the graph. We included a note to describe each phase change (e.g., "Treatment: Prompt Fading) and *x*-axis break (e.g., "School Closure"). A note was also provided on the first row of data to describe the various conditions (e.g., baseline and treatment). For data entry spreadsheets specific to scaling dates to the *x*-axis, we left a blank cell for rows where we entered data for a phase change or *x*-axis break. For data entry spreadsheets specific to scaling sessions to the *x*-axis, we set the session number to .5 greater than the previous session number for rows where we entered data for a phase change or *x*-axis break. We also left a blank cell between topography data for rows where we entered data for a phase change or *x*-axis break. This allowed the phase-change line and *x*-axis breaks to be plotted between data points.

Sample Graphs

A sample graph (see Appendix F-H for examples) corresponded with each hypothetical data set and served as a 100% accurate depiction of these data. We created these graphs in Excel and from the same hypothetical data set participants used during sessions. Participants referenced the corresponding sample graphs during sessions and attempted to recreate this graph. We delivered the sample graph as a printed copy in a laminated sheet cover during in-person sessions and as a PDF during virtual sessions. Graphing conventions adhered to those suggested by *The APA Publication Manual (7th ed.)*, *JABA*, and previous literature. These conventions included appropriately scaled axes with a sensible number of tick marks; descriptive labels for phases, axes, data paths, and panels; disconnected data paths across experimental phases; a floating "0" on the *y*-axis; omission of the "0" from the *x*-axis range; removal of chart junk (e.g., graph borders and gridlines); visually distinguishable data points (i.e., 1 pt width) depicted as closed black circles for graphs with one data path; and Times New Roman, black font.

Written Instructions

We created full prose WI for each hypothetical data set using Word (see Appendix I-K for examples). Similar to Mitteer and colleagues (2018) and Berkman and colleagues (2019), WI included a brief abstract-like paragraph describing and giving context to the data set. For example, WI described the dependent and independent variable as well as the overall level and trends of the data. We delivered WI as a printed copy in a laminated sheet cover during in-person sessions and as a PDF during virtual sessions.

Enhanced Written Instructions

As Excel requires users to select a different type of graph based on whether they are scaling dates or sessions to the *x*-axis, we created two versions of EWI—one specific to scaling dates on the *x*-axis (see Appendix L) and one specific to scaling sessions on the *x*-axis (see Appendix M). Both EWIs included a detailed TA (i.e., step-by-step instructions) for creating a publication-quality graph in Excel with minimal technical jargon, text boxes with brief rationales and additional clarifying information, pictures of the software and graph in progress, diagrams, and descriptions of relevant antecedent stimuli and performance criteria. Each step required only one response. We delivered EWI as a printed copy in a laminated sheet cover during in-person sessions and as a PDF during virtual sessions.

We created the two versions of EWI in Word using recommendations prescribed by Carr and Burkholder (1998), Deochand et al. (2015), Dixon et al. (2009), and Vanselow and Bourret (2012) as well as our own experience graphing in Excel and feedback from undergraduate-level and graduate-level students both familiar and unfamiliar with Excel. EWIs were validated by experts (see section Procedures). Both EWIs were similar regarding the number and difficulty of steps, only differing on which graph to select and how to format the *x*-axis. EWI for dates scaled

to the *x*-axis included 205 steps; EWI for sessions scaled to the *x*-axis included 200 steps. Both EWIs included the same additional 32 steps during generalization probes.

EWIs had 10 major sections including (a) create graph, (b) format *x*-axis, (c) format *y*-axis, (d) data path, (e) create phase-change line, (f) break *x*-axis, (g) delete chart junk, (h) export graph, (i) title phases, axes, and graph, and (j) format graph. Each section was broken down in to smaller, component steps. For example, Step 1 in the first section (i.e., create graph) on both EWIs described how to select data:

1a. Click and hold on the red data-header, "Dates."

1b. Drag down to the last date/session entered and release your click. These cells should now all be highlighted.

1c. While holding down "Ctrl" on your keyboard, click on the red data-header topography abbreviation under "Topography 1."

1d. Drag down to the cell equal to that of the last date/session entered (i.e., you should be highlighting the same number of cells as you did before but within a different column). These cells should now all be highlighted, too.

1e. While still holding down "Ctrl," repeat Steps #1c and #1d for:

i. "Phase Change," and

ii. "*X*-Axis Break."

1f. Release "Ctrl."

Response Measurement

We included three measures of step accuracy: real-time, live-Excel, and permanent product. We used a separate checklist per measure to collect data (see Appendix N-Q). We analyzed all three accuracy measures as percentage of opportunities by dividing the number of

correctly completed steps by the sum of correctly and incorrectly completed steps and multiplying by 100.

For *real-time accuracy*, we watched the VLC recording of the participant's screen and denoted whether the participant correctly or incorrectly completed, or had no opportunity to complete, each step included in the EWI. Data collectors were able to manipulate (e.g., fast forward and rewind) the video in any way necessary to score sessions. Correct completion included the participant completing the step as written, independent from any previous step. For example, Step 3 (on both EWIs) described how to select an area of the graph to format:

3a. Click on the graph.

3b. Click "Format," located at the top center of your Excel document.

3c. Above "Current Selection."

3ci. Click "Format Selection," located at the top left of your Excel document. A window (i.e., formatting window) should appear to the right of your Excel document.

3cii. Above "Format Selection," click the down arrow next to the textbox and select your current graph area in need of changing (see following steps for which area you will need to select).

If the participant clicked on the graph, then clicked Format, and above Current Selections clicked Format Selection, followed by the arrow next to this textbox, we scored 3a-3cii as correct (we did not record data for 3c is this step did not require a specific action). Note that there are multiple ways to complete various aspects of graphing in Excel. If the participant did not complete these steps as written (i.e., functionally obtained the same outcome without following the written steps or did not attempt the steps at all), we scored the relative step as incorrect.

However, for example, if Format was already selected such that clicking Format again would have not functionally changed the options, we scored 3b as no opportunity. We did not require participants to follow each EWI step in order. We, however, advised them to do so in the directions at the top of the EWI, which a researcher read at the start of each EWI session. Fixing mistakes or completing steps out of order occasionally required us to re-score steps. Because each step was a component behavior toward creating a graph but not necessarily dependent on its previous step, we only re-scored steps if the participant's responding suggested they were working toward functionally changing graphing conventions. This helped us discriminate between scrolling behavior and functional behavior.

For *live-Excel accuracy*, we viewed the participant's completed data-entry spreadsheet – this included the completed graph – and denoted whether the participant correctly or incorrectly completed a subset of steps included on the EWI (i.e., 86 individual steps with an additional 17 for generalization probes). We were able to objectively measure this subset of steps by clicking on the participant's graph and opening the windows and options related to each individual step. Correct completion included the participant's window or option accurately corresponding with the step requirement (e.g., step required the *x*-axis to be set to 1 pt and the participant's formatting window denoting *x*-axis conventions suggested the line was set to 1 pt). Incorrect completion included the participant's formatting window reporting anything other than what the step required. Live-Excel accuracy provided a less stringent and less direct measure of accuracy than real-time but a more stringent measure than permanent product.

For *permanent product accuracy*, we viewed a PDF of the participant's completed graph and denoted whether the participant correctly or incorrectly completed a subset of EWI steps (i.e., 75 individual steps with an additional 13 for generalization probes). We manually saved the

participant's graph as a PDF by moving the graph to its own tab (if not completed already) and saving the file as a PDF. Correct completion included the participant's graph accurately corresponding with the step requirement through visual analysis (e.g., step required the *x*-axis to be set to 1 pt and, to the data collector, the participant's *x*-axis appeared to be set to 1 pt). Incorrect completion included the participant's graph visually representing anything other than what the step required. Permanent product accuracy provided the least stringent measure of accuracy while also providing a measure similar to those evaluated in previous literature.

For *latency to graph completion*, we used the VLC recording to denote the start and stop time of the session located at the bottom right of the participant's screen. The start time was the time at which the participant minimized the Session Start-Stop Prompter and the stop time was the time at which the participant maximized the Session Start-Stop Prompter. We analyzed completion in min by subtracting the start time from the stop time.

Interobserver Agreement

A second observer independently collected data on all dependent variables for an average of 48.4% of sessions (range, 36.5%-71.7%) for each phase and participant. An agreement was scored when two independent observers recorded the step as correct, incorrect, or no opportunity to complete. We calculated step-by-step interobserver agreement (IOA) for all three accuracy measures by dividing the total number of agreements by the number of agreements plus disagreements and multiplying by 100 to yield a percentage. Mean IOA for real-time accuracy was 93.6% (range, 90.7%-96.5%) for Hazel, 94.5% (range, 91.5%-97%) for Suzy, 96.9% (range, 94.1%-100%) for Jewel, 98% (range, 92.5%-100%) for Mimi, 97.4% (range, 93%-100%) for Allaire, 95.6% (range, 83.9%-99.5%) for Corbin, and 93.4% (range, 83.5%-99.3%) for Elizabeth. Mean IOA for live-Excel accuracy was 99.6% (range, 98.8%-100%) for Hazel, 98.2%

(range, 90.7%-100%) for Suzy, 99.4% (range, 98%-100%) for Jewel, 99.2% (range, 96.5%-100%) for Mimi, 98.6% (range, 94.2%-100%) for Allaire, 98.7% (range, 93%-100%) for Corbin, and 98% (range, 89.5%-100%) for Elizabeth. Mean IOA for permanent product accuracy was 99.5% (range, 98.6%-100%) for Hazel, 97.4% (range, 89.3%-100%) for Suzy, 99.4% (range, 97.7%-100%) for Jewel, 99.8% (range, 98.7%-100%) for Mimi, 97.5% (range, 91%-100%) for Allaire, 98.7% (range, 92%-100%) for Corbin, and 99.3% (range, 93.3%-100%) for Elizabeth.

We calculated total-duration IOA for latency to graph completion by dividing the lower observed total session duration (min) by the higher observed total session duration (min) and multiplying by 100 to yield a percentage. Mean IOA for latency to completion was 100% for Hazel, Suzy, Jewel, Mimi, Corbin, and Elizabeth, and 98.8% (range, 88.9%-100%) for Allaire.

Procedures

We evaluated the effects of EWI on graphing accuracy and latency to graph completion using a nonconcurrent multiple baseline across participants design (Baer et al., 1968) with embedded reversals to evaluate short- and long-term maintenance effects. We also conducted generalization probes throughout the study to evaluate whether the skills acquired to graph generalized to untrained skills necessary for creating more complex graphs.

Validation of Enhanced Written Instructions and Mastery Criteria

We developed the EWIs based on previous graphing research (e.g., Deochand et al., 2015; Deochand, 2017) and our own experience graphing in Excel. Our initial EWIs were then reviewed by undergraduate-level and doctoral-level students, those familiar and unfamiliar with Excel, and those familiar and unfamiliar with graphing single-case data. Based on their feedback, we developed what we considered to be our final EWIs.

We recruited two participants to validate the finalized EWIs and establish mastery criteria for subsequent participants. We considered both participants to be experts in data collection, data analysis, and graphing. Both participants were Board Certified Behavior Analysts® and, although familiar with graphing in Excel, mostly created publication-quality single-case design graphs in Prism. The first expert participant earned her PhD in behavior analysis and served as the professor of practice for a behavior-analytic, early-education program. The second expert participant was a senior-level PhD student in a behavior analysis program. We included EWI during expert sessions (a) due to the participants' limited experience graphing in Excel, (b) to validate the EWI, and (c) to provide measures of responding under a context that is comparable to the study's procedures and a clinician's natural environment (clinicians may access training materials after the training occurs). Expert participants completed one session scaling dates to the *x*-axis and one session scaling sessions to the *x*-axis. Because responding was similar across both data sets, we set the mastery criteria for subsequent participants as the lowest scores across both participants for all dependent measures regardless of the data set. Mastery criteria for accuracy was 93% for real-time, 96% for live-Excel, and 98% for permanent product. Mastery criteria for latency to graph completion was 45 min, which also served as the maximum session duration. High accuracy scores validated the efficacy of our EWIs while establishing criteria sensitive to clinical expectations (i.e., allowing some mistakes) without compromising the overall quality of final graphs. We considered a participant to have mastered graphing skills once the above criteria were met for three consecutive sessions with EWI and the participant to have maintained these skills once the above criteria were met for three consecutive sessions without EWI.

Pre- and Post-Session

All materials were downloaded to the computers before sessions began. For in-person sessions, we logged in to the computer, opened and saved on the desktop the data-entry spreadsheet for the predetermined hypothetical data set, and resized the spreadsheet such that all data were easily readable. We then opened and maximized the Session Start-Stop Prompter such that the document was in view. We also provided a printed hardcopy of the corresponding sample graph, instructions (i.e., written or enhanced and written), and general directions, each of which was enclosed in a laminated cover sheet. Once the participant was seated in the office, we read the general directions aloud and allowed the participant approximately 2 min to review the materials. During this time, we initiated and minimized VLC such that VLC began recording the computer screen but was out-of-view. Following session completion, we maximized VLC and pressed the stop button to end recording. We then saved the participant's completed data-entry spreadsheet and VLC video file to a central location, deleted all documents from the desktop, and emptied the computer's trash bin.

For virtual sessions, we scheduled a Zoom meeting and sent the participant a direct invitation via email. We initiated the Zoom meeting as scheduled. Once the participant signed on to the meeting, we sent a direct invitation with a link permitting the participant access to the session's OneDrive folder and the participant was instructed to share their screen so we could help direct the participant to download and open the session materials. The participant was instructed to click the link, access the session's folder, and download the general directions, Session Start-Stop Prompter, WI, sample graph, and data-entry spreadsheet. During training, the participant opened, rather than downloaded, the EWI through their web browser (i.e., OneDrive) such that the document was not downloaded on to their computer and stored in their computer

downloads. This controlled for the participants access to the training materials following the completion of the session. The participant was first instructed to save the data-entry spreadsheet to their desktop. Next, we instructed the participant to maximize the general directions, which we read aloud. We then allowed the participant to review all materials for approximately 2 min and then assisted the participant in situating their screen such that they could access all materials with relative ease. When the participant stated they were ready to begin the session, we instructed them to maximize the Session Start-Stop Prompter on their computer screen. During this time, we initiated and minimized VLC such that it began recording the computer screen but was out-of-view, and we maximized their Zoom window such that the participant's shared screen was in full view. Following session completion, we maximized VLC and pressed the stop button to end recording. We instructed the participant to save their data-entry spreadsheet, upload it to the shared OneDrive folder, and delete or close all session materials. We then instructed the participant to empty their computer's trash bin. We exported the completed data-entry spreadsheet and saved this along with the VLC video file to a central location. We then removed the participant's access to the OneDrive session folder.

Except for pre- and post-session setup and the presentation format (printed copy vs. PDF) of some documents, session procedures remained the same across conditions for in-person and virtual sessions.

Baseline

Sessions started once the participant minimized the Session Start-Stop Prompter. We remained present (i.e., in the physical room during in-person sessions or in a home office during virtual sessions such that we could view the participant's screen) until this occurred. Once the participant minimized the Start-Stop Prompter, we started the timer and the 45 min began. For

in-person sessions, we left the office and remained in an adjacent room following the start of the session. For virtual sessions, we remained in our home office but muted our Zoom audio and video.

During baseline, the participant had access to the predetermined hypothetical data set's data-entry spreadsheet, sample graph, and full prose WI. The participant used the information provided within these documents to recreate the sample graph in Excel from the pre-entered hypothetical data. We only intervened at the end of the 45 min or when the participant self-terminated the session by maximizing the Session Start-Stop Prompter.

Training (Enhanced Written Instructions)

We implemented training in a staggered formation across participants. That is, we implemented training with Participant 1 once we observed a baseline level of responding that was below our mastery criteria. Once we observed responding during training at or near our mastery criteria for Participant 1 as well as a stable baseline measure for Participant 2, we implemented training with Participant 2. This continued until the training was implemented with all participants. The materials and session procedures used during training were similar to those used in baseline; however, during training the participant also had access to the EWI and we read the instructions located at the top of the document aloud.

Maintenance

We evaluated short-term maintenance by reversing to baseline contingencies after observing responding at or above our mastery criteria during EWI. Once we observed short-term maintenance (i.e., three consecutive sessions with responding at or above our mastery criteria during baseline contingencies), the study paused for 2 weeks. We then evaluated long-term maintenance by conducting a 2-week follow-up baseline probe. If the participant's level of

responding during the follow-up baseline probe was below our mastery criteria, we implemented a single treatment session (i.e., EWI). We conducted maintenance sessions the same as baseline sessions.

Generalization

We conducted generalization probes to evaluate whether the trained skills generalized to untrained skills that are required to create more complex graphs. Untrained skills included selecting pre-entered data for two additional topographies, selecting different marker shapes (square and triangle vs. circle) and colors (white vs. black) for the two additional data paths, creating a third experimental phase, adding a descriptive title for the third phase, and creating a second phase-change line. Initially, we conducted a generalization probe only after we observed short-term maintenance. We followed these procedures for Corbin and Elizabeth, and for sessions 1-5 for Hazel. We reconsidered our evaluation of generalization following the transition to a virtual format. To better assess generalization, we conducted a generalization probe (a) during the initial baseline phase, (b) after we observed response maintenance during the reversal to baseline, (c) after we observed responding at or above our mastery criteria during the second EWI phase (if needed), (d) after we observed responding at or above our mastery criteria at the 2-week follow-up, and (e) after we observed responding at or above our mastery criteria during the 2-week follow-up single treatment session (if needed). We followed these procedures for Jewel, Suzy, Allaire, and Mimi. We also followed these procedures for sessions 5-22 for Hazel, which is why she does not have a generalization probe during baseline. We conducted all generalization sessions following the respective condition procedures with the exception that we randomly delivered one of two hypothetical generalization data sets.

Procedural Integrity

A second observer measured procedural integrity for an average of 48.4% of sessions (range, 36.5%-71.7%) in each phase of the study for each participant. We included session duration and material delivery in our measure of procedural integrity. *Session duration* included the researcher's termination of the session between 43 and 47 min, regardless of whether the participant or researcher prompted session termination. This allowed for a minimal margin of error for the 45-min session duration. *Material delivery* included the researcher's delivery of all session materials (i.e., general instructions, Session Start-Stop Prompter, hypothetical data-entry sheet, sample graph, and instructions) that aligned with the pre-identified hypothetical data and phase of the study (see Appendix R). Procedural integrity was calculated by dividing the number of steps performed correctly by the researcher by the total number of steps and multiplying by 100 to yield a percentage. Mean procedural integrity was 100% across all phases and participants.

Pre- and Post-Study Questionnaires

We distributed a pre-study questionnaire (see Appendix S) to collect each participant's demographic and background information and their perception of the importance of learning how to graph in Excel. In accordance with Wolf (1978), we distributed a post-study questionnaire (see Appendix T) to assess the social validity of the goals of the study. Similar to Gresham and Lopez (1996) and Berkman and colleagues (2019), the questionnaire assessed each participant's level of agreement or satisfaction in various areas (e.g., the overall effectiveness of EWI as a self-directed training procedure, generality of EWI, outcomes of the training, and knowledge of graphing in Excel). Social validity was assessed using a 5-point Likert type scale (i.e., 1=*low/disagree* and 5= *high/agree*), in which higher scores represent greater social validity. We also included open-ended questions. Elizabeth, Corbin, and Hazel completed their pre-study

questionnaire in-person and their post-study questionnaire through Qualtrics, a web-based survey tool that was available through the University. Allaire, Mimi, Suzy, and Jewel completed their pre- and post-study questionnaire through Qualtrics.

Results

Figure 1 depicts the percentage of steps completed (scaled to the left *y*-axis) and the latency to graph completion (scaled to the right *y*-axis) for Elizabeth (top panel), Mimi (middle panel), and Allaire (bottom panel). No participant met the mastery criteria during the initial baseline phase. Mean accuracy for Elizabeth was 15.4% (range, 15.1%-15.7%) for real-time, 43.6% (range, 39.5%-47.7%) for live-Excel, and 63.3% (range, 58.7%-68%) for permanent product. Mean latency to graph completion for Elizabeth was 37.5 min (range, 32 min-43 min). Mean accuracy for Mimi was 0% for real-time, live-Excel, and permanent product. Mean latency to graph completion for Mimi was 1.3 min (range, 1 min-2 min). Mean accuracy for Allaire was 6.1% (range, 1.5%-9.3%) for real-time, 15.8% (range, 5.9%-22.1%) for live-Excel, and 24.5% (range, 10.7%-33.3%) for permanent product. Mean latency to graph completion for Allaire was 14.4 min (range, 5 min-41 min). We observed low levels of responding across measures during the generalization probe for Mimi and Allaire. Accuracy for Mimi was 0% for real-time, live-Excel, permanent product, and real-time generalization-only steps. Latency to graph completion for Mimi was 2 min. Accuracy for Allaire was 5.2% for real-time, 17.5% for live-Excel, 23.9% for permanent product, and 6.3% for real-time generalization-only steps. Latency to graph completion for Allaire was 6.3 min.

We observed an immediate increase in responding across accuracy measures during the initial EWI phase for all participants. Mean accuracy for Elizabeth was 94.3% (range, 78.8%-100%) for real-time, 93.3% (range, 75.6%-100%) for live-Excel, and 91.3% (range, 68%-100%)

for permanent product. Mean latency to graph completion for Elizabeth was 37 min (range, 31 min-45 min), equal to that of baseline, but with a decreasing trend from the first EWI session to the last. Mean accuracy for Mimi was 82.3% (range, 55.6%-99.4%) for real-time, 83.6% (range, 57%-98.8%) for live-Excel, and 86.4% (range, 64%-100%) for permanent product. Mean latency to graph completion for Mimi was 36.4 min (22 min-45 min). Mean accuracy for Allaire was 92.7% (range, 70.8%-100%) for real-time, 92.5% (range, 77.9%-100%) for live-Excel, and 94.5% (range, 81.3%-100%) for permanent product. Mean latency to graph completion for Allaire was 27.4 min (range, 18 min-45 min). The number of sessions prior to meeting mastery criteria varied across participants (range, 4-7; *M*= 5), and no participant completed the EWI within 45 min during their first EWI session.

Once a participant met mastery criteria during the initial EWI phase, we reversed to baseline to assess short-term maintenance of responding. Responding maintained at mastery criteria for Elizabeth, Mimi, and Allaire. Mean accuracy for Elizabeth was 96.4% (range, 94.1%-98.2%) for real-time, 98.1% (range, 97.7%-98.8%) for live-Excel, and 98.2% (range, 97.3%-98.7%) for permanent product. Mean latency to graph completion for Elizabeth was 23.7 min (range, 21 min-27 min). Mean accuracy for Mimi was 98.5% (range, 98.3%-98.8%) for real-time, 98.5% (range, 97.7%-98.8%) for live-Excel, and 98.7% for permanent product. Mean latency to graph completion for Mimi was 16.3 min (range, 11 min-26 min). Mean accuracy for Allaire was 97.8% (range, 95.9%-100%) for real-time, 98.8% for live-Excel, and 98.7% for permanent product. Mean latency to graph completion for Allaire was 14.7 min (range, 14 min-15 min). We also observed response generalization during the reversal to baseline for all participants. Accuracy for Elizabeth was 97.9% for real-time, 99% for live-Excel, 98.9% for permanent product, and 100% for real-time generalization-only steps. Latency to graph

completion for Elizabeth was 27 min. Accuracy for Mimi was 99% for real-time, 99% for live-Excel, 98.9% for permanent product, and 100% for real-time generalization-only steps. Latency to graph completion for Mimi was 15 min. Accuracy for Allaire was 94.9% for real-time, 93.2% for live-Excel, 92.1% for permanent product, and 86.8% for real-time generalization-only steps. Latency to graph completion for Allaire was 20 min.

We conducted a 2-week follow-up baseline probe to assess the long-term maintenance of responding. Responding maintained for Mimi and Allaire. Accuracy for Mimi was 98.8% for real-time, 98.8% for live-Excel, and 98.7% for permanent product. Latency to graph completion for Mimi was 16 min. Accuracy for Allaire was 98.8% for real-time, 98.8% for live-Excel, and 98.7% for permanent product. Latency to graph completion for Allaire was 16 min. We also observed response generalization at the 2-week follow-up probe for Mimi and Allaire. Accuracy for Mimi was 100% for real-time, live-Excel, permanent product, and real-time generalization-only steps. Latency to graph completion for Mimi was 14 min. Accuracy for Allaire was 96.4% for real-time, 96.1% for live-Excel, 95.5% for permanent product, and 96.3% for real-time generalization-only steps. Latency to graph completion for Allaire was 14 min.

Figure 2 includes the same graphing conventions to depict the results for Corbin (top panel), Hazel (second panel), Jewel (third panel), and Suzy (bottom panel). For Corbin, mean accuracy was 21.4% for real-time, 57% for live-Excel, and 72% for permanent product during the initial baseline phase. Latency to graph completion was 29 min during the initial baseline phase. Mean accuracy increased to 94.4% (range, 85.6%-100%) for real-time, 99.2% (range, 98.8%-100%) for live-Excel, and 99.3% (range, 98.7%-100%) for permanent product following EWI. Mean latency to graph completion was 21 min (range, 13 min-39 min) following EWI. Corbin met mastery after six sessions. Responding maintained for Corbin during a reversal to

baseline. Mean accuracy was 95.3% (range, 94.6%-96.2%) for real-time, 98.4% (range, 97.7%-98.8%) for live-Excel, and 98.2% (range, 97.3%-98.7%) for permanent product. Mean latency to graph completion was 10.3 min (range, 10 min-11 min). We also observed response generalization for Corbin. Accuracy was 98.4% for real-time, 99% for live-Excel, 98.9% for permanent product, and 100% for real-time generalization-only steps during the generalization probe. Latency to graph completion was 24 min. Therefore, we conducted a 2-week follow-up baseline probe to assess long-term maintenance of responding. Responding did not maintain. Accuracy was 88.4% for real-time, 94.2% for live-Excel, and 93.3% for permanent product. Latency to graph completion was 9 min. A single, subsequent treatment session resulted in an increase in responding to mastery criteria across all measures. Accuracy was 95.9% for real-time, 100% for live-Excel, and 100% for permanent product. Latency to graph completion was 15 min.

For Hazel, mean accuracy was 17.1% (range, 10.8%-21.1%) for real-time, 47.7% (range, 39.5%-50%) for live-Excel, and 60.9% (range, 46.7%-72%) for permanent product during the initial baseline phase. Mean latency to graph completion was 11.7 min (range, 11 min-13 min). Mean accuracy increased to 96.4% (range, 89.2%-100%) for real-time, 98.8% (range, 87.7%-100%) for live-Excel, and 99% (range, 98.7%-100%) for permanent product following EWI. Mean latency to graph completion was 32.8 min (range, 29 min-37 min). Hazel met mastery after four sessions. Responding, however, did not maintain during a reversal to baseline. Mean accuracy was 88% (range, 81.7%-92.9%) for real-time, 81.4% (range, 74.4%-94.2%) for live-Excel, and 87.1% (range, 81.3%-97.3%) for permanent product. Mean latency to graph completion was 25.3 min (range, 19 min-34 min). Therefore, we reversed to EWI and observed an immediate increase to mastery-level responding, as well as response generalization. During EWI, mean accuracy was 98.8% (range, 98.8%-98.9%) for real-time, 98.8% for live-Excel, and

98.7% for permanent product. Mean latency to graph completion was 21.3 min (range, 19 min-25 min). During the generalization probe, accuracy was 99% for real-time, 99% for live-Excel, 98.9% for permanent product, and 100% for real-time generalization-only steps. Latency to graph completion was 21 min. Then, we reversed to baseline, which also resulted in short-term maintenance and generalization. During the reversal to baseline, mean accuracy for Hazel was 97.5% (range, 96.6%-98.2%) for real-time, 98.8% for live-Excel, and 98.7% for permanent product for baseline. Mean latency to graph completion for Hazel was 11.7 min (range, 10 min-14 min). During the generalization probe, accuracy was 97.9% for real-time, 98.1% for live-Excel, 97.7% for permanent product, and 100% for real-time generalization-only steps. Latency to graph completion was 17 min. Next, we conducted 2-week follow-up sessions: first a generalization probe and then a baseline probe. During the generalization probe, accuracy was 97.4% for real-time, 98.1% for live-Excel, 97.7% for permanent product, and 100% for real-time generalization-only steps. Latency to graph completion was 20 min. During the baseline probe, accuracy was 95.2% for real-time, 95.4% for live-Excel, and 94.7% for permanent product. Latency to graph completion was 11 min. Therefore, we reversed to EWI. Accuracy was 98.3% for real-time, 98.8% for live-Excel, and 98.7% for permanent product. Latency to graph completion was 18 min. A subsequent generalization probe resulted in accuracy at 98.4% for real-time, 99% for live-Excel, 98.9% for permanent product, and 100% for real-time generalization-only steps. Latency to graph completion was 18 min.

For Jewel, mean accuracy was 0.7% (range, 0%-1.5%) for real-time, 2.9% (range, 1.2%-4.7%) for live-Excel, and 4.3% (range, 2.7%-5.3%) for permanent product during the initial baseline phase. Mean latency to graph completion was 3 min (range, 2 min-5 min). We also observed no response generalization during the baseline probe. Accuracy was 0.4% for real-time,

0% for live-Excel and permanent product, and 3% for real-time generalization-only steps during the initial generalization probe. Latency to graph completion was under 1 min. Mean accuracy increased to 91.2% (range, 69%-99.4%) for real-time, 92.1% (range, 64%-98.8%) for live-Excel, and 93% (range, 65.3%-98.7%) for permanent product following EWI. Mean latency to graph completion was 26.9 min (range, 15 min-45 min). Jewel, however, did not complete the EWI within 45 min during her first EWI session. Jewel met mastery after nine sessions. Responding, however, did not maintain but did remain near-mastery during a reversal to baseline. Mean accuracy was 93.2% (range, 92.9%-93.5%) for real-time, 95.3% (range, 93%-96.5%) for live-Excel, and 96.4% (range, 94.7%-97.3%) for permanent product. Mean latency to graph completion was 15 min (range, 13 min-17 min). Therefore, we reversed to EWI and observed an immediate increase to mastery-level responding, as well as response generalization. During EWI, mean accuracy was 97.9% (range, 96.5%-98.8%) for real-time, 99.2% (range, 98.8%-100%) for live-Excel, and 99.1% (range, 98.7%-100%) for permanent product. Mean latency to graph completion was 14 min (range, 13 min-15 min). During the generalization probe, accuracy was 94.3% for real-time, 97.1% for live-Excel, 96.6% for permanent product, and 81.8% for real-time generalization-only steps. Latency to graph completion was 22 min. Then, we reversed to baseline, which resulted in short-term maintenance and moderate generalization. During baseline, mean accuracy was 98.2% (range, 97.6%-99.4%) for real-time, 98.5% (range, 97.7%-98.8%) for live-Excel, and 99.1% (range, 98.7%-100%) for permanent product. Mean latency to graph completion was 12.7 min (range, 11 min-16 min). During the generalization probe, accuracy was 99% for real-time, 98.1% for live-Excel, 97.7% for permanent product, and 90.9% for real-time generalization-only steps. Latency to graph completion was 15 min. Next, we conducted 2-week follow-up sessions: first a generalization probe and then a baseline probe.

During the generalization probe, accuracy for Jewel was 98.5% for real-time, 98.1% for live-Excel, and 100% for permanent product and real-time generalization-only steps. Latency to graph completion for Jewel was 17 min. During the baseline probe, Accuracy was 97.6% for real-time, 97.7% for live-Excel, and 100% for permanent product. Latency to graph completion was 10 min.

For Suzy, mean accuracy was 11.4% (range, 7.1%-18.7%) for real-time, 32.1% (range, 25.6%-38.4%) for live-Excel, and 42.9% (range, 30.7%-58.7%) for permanent product during the initial baseline phase. Mean latency to graph completion was 9.6 min (range, 6 min-19 min). We also observed no response generalization during the probe. Accuracy was 9.4% for real-time, 22.3% for live-Excel, 21.6% for permanent product, and 41.7% for real-time generalization-only steps. Latency to graph completion was 14 min. Mean accuracy increased to 92.8% (range, 64%-100%) for real-time, 91.4% (range, 58.1%-100%) for live-Excel, and 90.5% (range, 54.7%-100%) for permanent product following EWI. Mean latency to graph completion was 30.9 min (range, 19 min-45 min). Suzy, however, did not complete the EWI within 45 min during her first EWI session. Suzy met mastery after seven sessions. Responding, however, did not maintain during a reversal to baseline. Mean accuracy was 83.1% (range, 82.8%-83.3%) for real-time, 77.9% for live-Excel, and 86% (range, 85.3%-86.7%) for permanent product. Mean latency to graph completion was 25 min (range, 19 min-31 min). Therefore, we reversed to EWI, and we observed an immediate increase to mastery-level responding, as well as response generalization. During EWI, mean accuracy was 99.8% (range, 99.4%-100%) for real-time, 99.6% (range, 98.8%-100%) for live-Excel, and 99.6% (98.7%-100%) for permanent product. Mean latency to graph completion was 17.7 min (range, 15 min-19 min). During the generalization probe, accuracy was 99.5% for real-time, 99% for live-Excel, 98.9% for permanent product, and 100%

for real-time generalization-only steps. Latency to graph completion was 29 min. Then, we reversed to baseline, which resulted in short-term maintenance and response generalization. During baseline, mean accuracy was 98.5% (range, 97.6%-99.4%) for real-time, 98.1% (range, 97.7%-98.8%) for live-Excel, and 100% for permanent product. Mean latency to graph completion was 16 min (range, 12 min-23 min). During the generalization probe, accuracy for Suzy was 97.9% for real-time, 97.1% for live-Excel, 98.9% for permanent product, and 95.5% for real-time generalization-only steps. Latency to graph completion for Suzy was 18 min. Next, we conducted 2-week follow-up sessions: first a baseline probe and then a generalization probe. During the baseline probe, accuracy was 95.6% for real-time, 97.7% for live-Excel, and 98.7% for permanent product. Latency to graph completion for Suzy was 38 min. During the generalization probe, accuracy for Suzy was 95.4% for real-time, 98.1% for live-Excel, 98.9% for permanent product, and 100% for real-time generalization-only steps. Latency to graph completion was 17 min.

Figure 3 depicts the mean total percentage of real-time steps completed across the 10 sections of our EWI before, during, and after training. During pre-training conditions (i.e., baseline and generalization probes), accuracy for real-time was below 30.7% for all 10 sections (range, 0%-30.7%). During training (i.e., EWI), accuracy for real-time was above 86.2% for all 10 sections (range, 86.2%-99%). During post-training conditions (i.e., baseline and generalization probes), accuracy for real-time was above 85.6% (range, 85.6%-100%).

Table 1 depicts the results for the post-study social validity questionnaire. Overall, participants scored EWI, and each component of EWI, as effective for teaching graphing skills. Participants were also satisfied with EWI as a self-directed training procedure, agreed that EWI would likely have generality to other skills and other individuals, and would recommend EWI as

a self-directed training. Regarding EWI as a self-directed training, participants responded that the steps were easy to follow once acclimated to the format, especially for those with a history using Excel and learning through trial-and-error during the initial baseline phase. Regarding whether participants observed their own behavior change during the study, participants responded that they became more efficient in creating quality graphs and the more they followed the EWI, the more accurate the quality graph became.

Discussion

We evaluated the efficacy of EWI as a self-directed training to teach undergraduate students to graph publication-quality single-subject data using Excel. For all seven students, accuracy across measures immediately increased to mastery with access to EWI, and the latency to create quality graphs decreased with exposure to EWI which continued following its removal. In general, these results are consistent with previous literature suggesting that EWI are effective in teaching graphing skills (Berkman et al., 2019; Tyner & Fienup, 2016) and are also consistent with previous literature suggesting that EWI with additional stimulus prompts (e.g., several images, rationales, and descriptions of antecedent stimuli and performance criteria; Berkman et al., 2019; Shapiro et al., 2016, Tyner & Fienup, 2016) and a single response per TA step (Crist et al., 1984) may be particularly effective for training those with minimal prior experience. We also observed short- and long-term maintenance effects of EWI, as well as generalization to untrained skills. Further, we observed more specific patterns of responding worth discussing.

For Elizabeth, Hazel, and Suzy, we observed a slight increasing trend in accuracy for permanent product and live-Excel measures during the initial baseline phase. Researchers have reported similar effects (Lo & Starling, 2009; Mitteer et al., 2018). The increasing trend may have occurred for a couple reasons. First, it is possible that participants learned to graph certain

components through trial-and-error with increased exposure to Excel's interface. It is also possible that when scrolling through Excel's interface, some behaviors may have been reinforced when these behaviors resulted in changes to the participant's graph that resembled the sample graph. The purpose of the sample graph was to serve as a model. However, participants with no prior history with Excel may have scored higher with a model than if we were to simply ask them to graph the hypothetical data only. Anecdotally, we taught ourselves to use aspects of Excel through trial-and-error with similar exemplars. Second, it is possible that participants were able to create certain components of their graph (e.g., maximum and major *x*- and *y*-axis values and appropriate number of tick marks) by referring to the sample graph rather than referring to the hypothetical data and the information included in the EWI. Again, the sample graph may have served as a discriminative stimulus for creating accurate conventions inflating scores and confounding a true baseline measure. Regardless, neither extended access to Excel nor the sample graph increased responding to near-mastery levels. We do suggest that researchers consider including a true baseline measure of graphing skills in the future.

We also observed three interesting patterns of responding regarding latencies to graph completion, some of which differ while others support previous research (Mitteer et al., 2018, 2020). First, we observed overall lower latencies to graph completion during the initial baseline phase relative to other phases. Mitteer and colleagues (2018) used 45-min sessions but reported all participants' latencies to completion to be near 45 min across baseline. Mitteer and colleagues (2020) reported slightly lower but similar latencies to completion. Note that our study and Mitteer et al. (2018, 2020) recruited participants of similar demographics. Differences in baseline latencies across studies may be attributed to the use of Prism versus Excel. Prism is a scientific-graphing software purposed to create quality graphs at relative ease of the user, whereas Excel is

less intuitive for novel users and requires substantial changes to produce high-quality graphs (Haddock & Iwata, in press). Participants in Mitteer et al. (2018, 2020) may have more easily contacted enough reinforcement for their scrolling behavior to maintain their attempts to create a quality graph. Our participants' scrolling behavior, however, may have been less likely to contact reinforcement resulting in the participant self-terminating the session and an overall lower latency to completion.

Second, we observed participants' longest latency to graph completion during the first sessions of the initial EWI phase. This effect was unobserved in Mitteer et al. (2018, 2020) likely due to their already high latencies to completion. However, we may have observed this effect due to the novelty, length, and reading component of EWI. This may also be why most participants did not complete the entire training within the allotted 45 min during the first session in the initial EWI phase. Lo and Starling (2009) and Tyner and Fienup (2016) reported that their participants had difficulty completing the entire training during its initial introduction. Further, the researchers suggested that, if this was true, the lower-than-expected accuracy during these sessions may have been a function of failing to complete the training. Our data support Lo and Starling (2009) and Tyner and Fienup (2016). We re-analyzed accuracy for incomplete sessions for all participants by including only the completed (correctly and incorrectly) steps during the 45 min. That is, we removed from our calculation the steps that were scored "0" following the conclusion of the 45-min session. For Elizabeth's incomplete Session 3, accuracy was 72% for real time, 79.1% for live-Excel, and 84.5% for permanent product; for Mimi's incomplete Session 5, accuracy was 98.9% for real time, 97% for live-Excel, and 87.9% for permanent product; for Allaire's incomplete Session 7, accuracy was 77.6% for real time, 81.7% for live-Excel, and 83.6% for permanent product; for Jewel's incomplete Session 6, accuracy was 94.5%

for real time, 91.7% for live-Excel, and 96.1% for permanent product; and for Suzy's incomplete Session 9, accuracy was 99.1% for real time, 98% for live-Excel, and 97.6% for permanent product. The above scores provide merit to the possibility that additional time may have led to increased accuracy for some participants.

Third, we observed a decreasing trend in latency to graph completion following the implementation of EWI. Mitteer and colleagues (2018) reported gradual reductions in latency to graph completion following VM for two of three participants. Mitteer and colleagues (2020) reported a slight reduction in latency to graph completion following VM for one participant. A decreasing trend may be expected as participants are given repeated exposure to an intervention. We further observed a decreasing trend in latency following the removal of EWI. These results replicate those of Mitteer et al. (2020) and may have direct clinical implications. Although preliminary, the effects of EWI on latency to graph completion strengthen the support for EWI as a self-directed training.

Our methods further the literature on self-directed trainings in numerous ways. We conducted our procedures in-person and virtually. The generality of EWI was evident through minimal variation in levels of responding across settings. More specifically, we observed this effect within participants for Corbin and Hazel and across participants as we conducted at least some sessions in-person for Elizabeth, Corbin, and Hazel and all sessions online for Mimi, Jewel, Suzy, and Allaire. EWI's generality may be especially important given our world's current circumstances and the need for social distancing. We provide an alternative and efficacious way to teach graphing in Excel when face-to-face training is not possible.

To our knowledge, we are the first to use real-time data to evaluate the effects of a self-directed training for graphing. This allowed us to directly observe and objectively measure post-

hoc whether participants adhered to our training procedures. Differential scores across measures during the initial baseline phase may be expected. There are several ways to create graphs in Excel, our EWI being only one way. However, we identified that permanent product measures may overestimate a participant's ability to create quality graphs. For example, it was difficult to visually discriminate an embedded phase-change line from one that was inserted manually. Manually inserting phase-change lines is problematic because it requires the user to reposition the lines every time new data are added (Cole & Witts, 2015; Deochand et al., 2015). This is inefficient and likely difficult to maintain across users. Additionally, if phase-change lines are incorrect, behavior analysts may inaccurately interpret the data. We sometimes had difficulty visually discriminating whether lines were 1 pt and black and whether font was 14, 12, or 10 pt. Live-Excel data provided a more sensitive measure of graphing accuracy, hence the slightly lower accuracy scores, but we were still unable to directly evaluate if the participant had obtained the above examples following the steps prescribed in our EWI. Graphing some components differently than we prescribed may leave users susceptible to error. Our expert participants anecdotally suggested that they typically created some graph components in Excel differently than we prescribed but suggested that our steps were easier to consume in a TA format and, therefore, left trainees less prone to user error. For example, both participants reported they double-clicked on components of their graph (e.g., *x*-axis, *y*-axis, data path) to open the formatting window, which then allowed them to adjust the conventions (e.g., width and color of lines). However, we found, for example, that double clicking on a single data point occasionally resulted in only some data points being selected for formatting, resulting in the user changing the format of only the selected data points. The unselected data points remained in the default settings. Our EWI require the user to click the Format tab in the Excel toolbar and select

the component (e.g., Data Series 1) to be formatted, which reduces the likelihood of formatting errors. We recommend that researchers continue to validate self-directed trainings using real-time data. However, we recommend that clinicians defer to live-Excel measures. Live-Excel data were quicker to collect and provided sufficient information for us to accurately determine where participants likely encountered difficulty. It is also possible that the addition of brief performance feedback following live-Excel data analysis of the first training session (i.e., when participants made the most amount of errors) would reduce the amount of time necessary to increase graphing accuracy to mastery criteria. This may also increase the efficiency of the training. This is, however, an empirical question.

The current study has a few noteworthy limitations. We determined our mastery criteria based on the two experts' accuracy scores when using the EWIs. Other researchers have set mastery criteria using the expert's baseline sessions. Thus, our criteria may have been slightly overzealous. For example, Mitteer and colleagues (2018) had professionals create a graph without the use of the video model. Their mastery criterion was set at 85% accuracy for permanent product. We identified mastery criteria with the use of EWI for a few reasons. First, the use of EWI provided a more stringent criteria as our expert participants were familiar with Excel but not considered experts. Second, this was more representative of what would be expected of participants in the natural environment (i.e., the EWI would be available noncontingently across all clinical and research settings). Third, there are different ways to create the various components of a graph in Excel. Our procedures demonstrate one method. Identifying a mastery criterion for real-time accuracy without introducing the expert participants to EWI would be insensitive as a measure of mastery.

Additionally, we equally weighted all components of the EWI during data analysis. However, some steps (e.g., removing gridlines, adding phase change titles, and titling axes) affect the readability of a graph more than other steps (e.g., using the toolbar rather than the formatting window to change the color to black). Researchers may find it beneficial to objectively determine and place a greater weight on steps that if performed incorrectly are detrimental to the graph's quality and functionality.

Regarding measures of integrity, we did not collect data on the researchers' vocal behavior prior to each session. We did not verify whether the researchers read the general directions or instructions listed at the top of the EWIs aloud. We also did not verify whether the participants read and understood the WI at the beginning of each session. Researchers may find it beneficial to read all session instructions aloud and to audio record the researcher's vocal behavior as a more stringent measure of procedural integrity.

We also did not collect data on errors of commission. Anecdotally, this did not occur often post-training; however, errors of commission were prevalent during the initial baseline condition. For example, participants often created their phase-change lines by inserting a shape and using Excel's drawing tools. Additionally, Allaire created one graph per condition and placed them together to provide the illusion of a single graph. Future research should measure errors of commission that diminish the functionality or publication-quality of a graph (e.g., multiple graphs) in combination with errors of omission for a more complete representation of baseline data.

Further, our tutorial and target graphs were all AB designs, which are relatively simple in comparison to other single-subject designs (e.g., multiple-baseline design). We chose to target an AB design for training because it is included in many other designs (e.g., reversal and ABAB)

and is a commonly used design in clinical settings. Researchers may find it beneficial to expand our training to more complex designs. On the other hand, as we observed generalization of graphing skills to an ABA design, it is possible that the skills acquired through our EWI would generalize to more complex graphs (e.g., ABAB or multiple-baseline design). Future research should expand our generalization assessment to evaluate the extent to which our targeted skills during training generalize to more complex graphs (e.g., multiple-baseline design). It is possible that training an AB design is sufficient to evoke generalized responding to more complex graphs, which would save researchers and clinicians additional time and resources.

Also regarding generalization, we did not conduct generalization probes during the initial baseline phase for Corbin, Hazel, and Elizabeth. We would have likely observed low levels of response generalization in baseline considering their low levels of responding as well as the low levels of responding during generalization probes for the other four participants; however, without an initial generalization probe, we do not have a true comparison of response generalization pre-and post-training for these participants. Additionally, we were unable to conduct a follow-up session with Elizabeth as we were unable to reach her following the transition of the study online due to COVID-19.

Finally, there was only one session conducted during Corbin's initial baseline phase in which accuracy was 71% for permanent product. Without repeated measures, it remains unclear whether she would have met mastery criterion for permanent product with prolonged exposure to Excel's interface. However, as discussed previously, higher accuracy for permanent product in comparison to live-Excel and real-time measures does not suggest a higher-quality graph, and her accuracy for live-Excel and real-time measures during the initial baseline phase suggested that she did not have the skills to create a quality graph (see Mitteer et al., 2018). Additionally,

the purpose of our study was to evaluate the immediate and robust effects of EWI to teach graphing. Thus, we did not extend her initial baseline phase.

There remain additional areas for future research with direct clinical implications. As cost and time efficiency are main reasons for using self-directed trainings, researchers may find it beneficial to conduct component and parametric analyses to evaluate which components, and their quantity, are necessary to promote the most effective EWI. It is possible that the necessary components may depend on skill complexity and the target population. For example, Crist and colleagues (1984) evaluated the number of responses described per step in three TAs of vocational tasks for individuals with intellectual disabilities. Results suggested that participants made more errors using a TA with steps that included multiple responses than with steps that included a single response. It remains unclear whether the same results would be found if the study was completed with typically developing individuals. Differences may also be observed when evaluating the effects of EWI with adults who have well-developed behavioral repertoires than with children. Additionally, it would be interesting to determine what type of pictures and examples are necessary to promote accurate responding in an efficient manner. Furthermore, researchers may find time-cost analyses advantageous. Berkman and colleagues (2019) recorded that it took 20 hr to complete their EWIs and an additional 2 hr to complete the video models. All materials were free besides Prism. Given (a) both trainings increased graphing skills, (b) participants preferred EWI over VM, (c) EWI required less cumulative time to complete, and (d) EWI did not require knowledge of and access to video software, researchers and clinicians may find EWI more efficacious and just as cost-sensitive as VM. Further research, however, is required to validate these findings.

Additionally, our EWIs were designed for Windows users. Thus, the step-by-step instructions, pictures of the software and graph in progress, and descriptions of relevant antecedent stimuli and performance criteria are specific to a Windows-based system. Given the robust effects of our EWI on graphing accuracy across all participants, researchers may find it beneficial to adapt our EWI for other systems (e.g., Macintosh), which would also increase the generality of EWI as a self-directed training.

Graphing is a complex task that may present challenges for clinicians and researchers alike. Inaccurate graphs could lead to a decrease in data-based decision making and negatively affect treatments decisions for clients. Inaccurate graphs could also lead to difficulty disseminating socially important results. Thus, it is essential to identify efficacious trainings for graphing that can be generalized across users and platforms to increase the likelihood that individuals create high-quality graphs. EWI provides a potential avenue to accomplish that, especially as the time, money, and resources available to therapists and researchers may be limited. Hopefully, our study provides researchers and clinicians with the tools necessary to teach personnel to graph data and to continue making data-based decisions.

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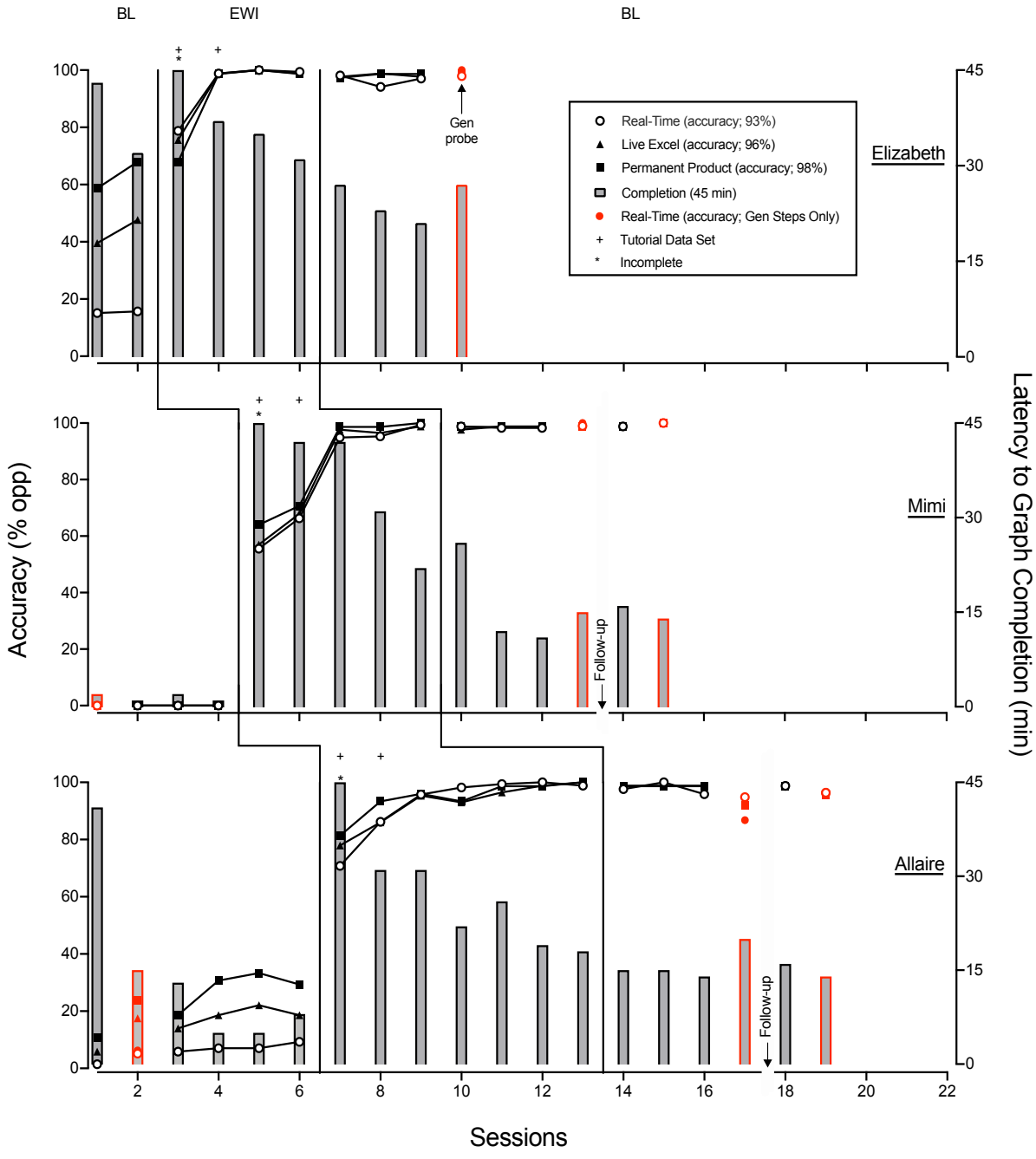
Figure 1

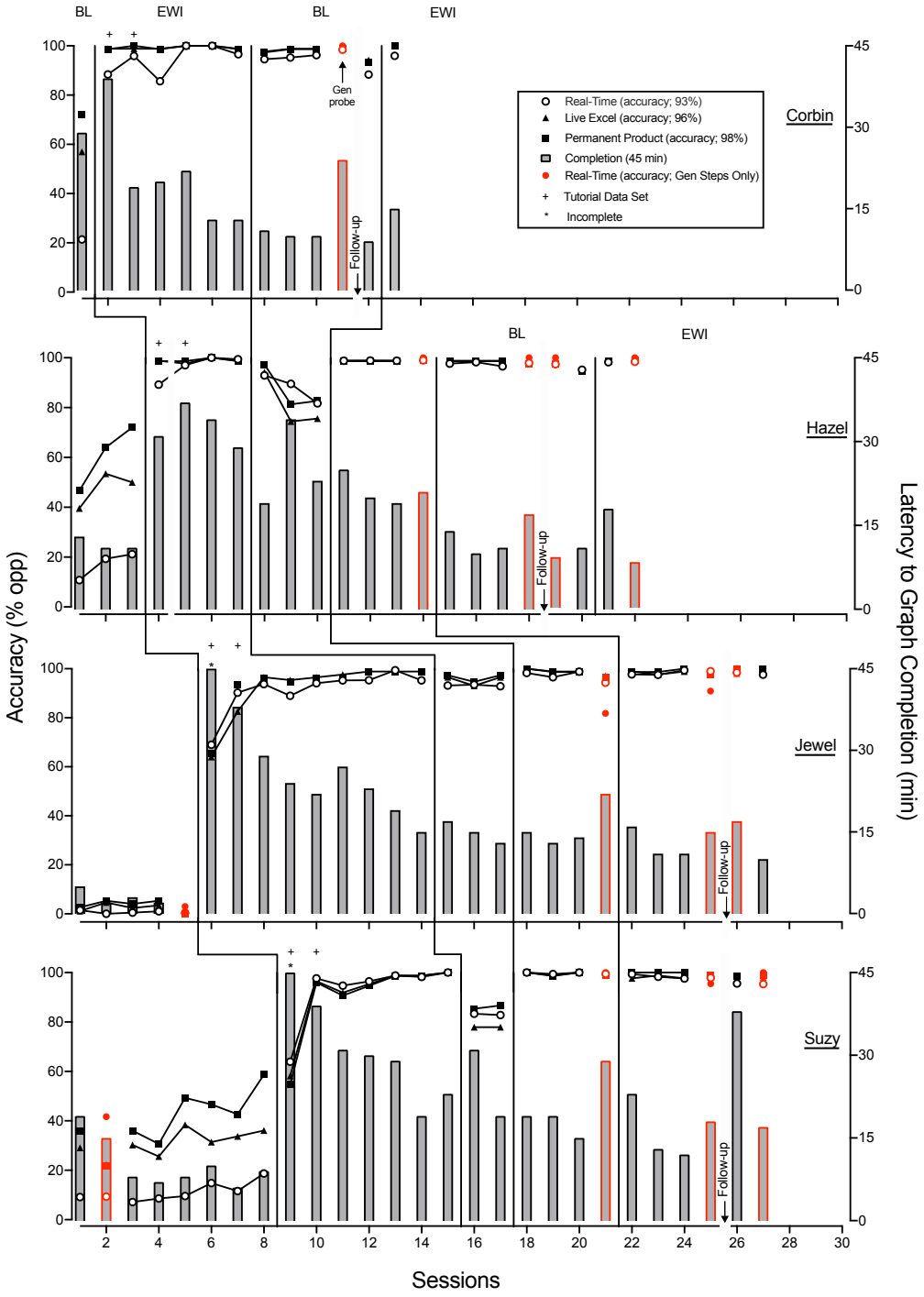
Percentage of Steps Completed and Latency to Graph Completion for Elizabeth, Mimi, and Allaire.



Note. BL= baseline; EWI= enhanced written instructions.

Figure 2

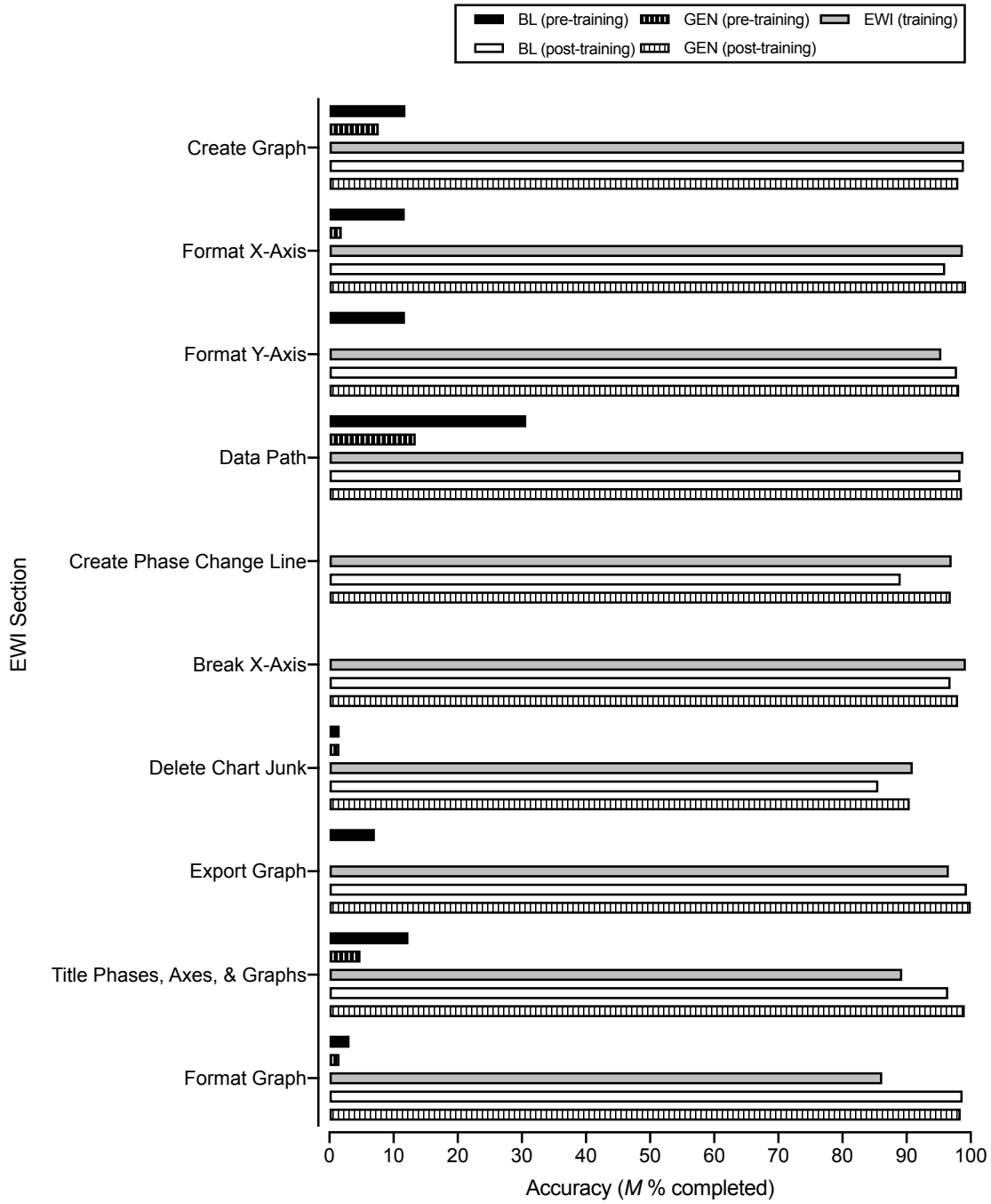
Percentage of Steps Completed and Latency to Graph Completion for Corbin, Hazel, Jewel, and Suzy.



Note. BL= baseline; EWI= enhanced written instructions.

Figure 3

Mean total percentage of real-time steps completed across the 10 sections of the EWI before, during, and after training.



Note. BL= baseline; GEN= generalization; EWI= enhanced written instructions.

Table 1

Post-Study Social Validity Questionnaire Responses

Question	*M*
How effective were the written instructions (WI) alone in helping you complete the study's procedures?	1.43
Do you think WI is good self-directed training procedure to be implemented in similar situations such as yours (i.e., for individuals currently or likely to be required to enter and graph data)?	1.43
How effective were the individual components of EWI in helping you complete the study's procedures?	
Limited technical jargon.	4.57
Pictures/diagrams.	4.86
Brief explanations (additional information & note boxes).	4.43
Do you think EWI is good self-directed training procedure to be implemented in similar situations such as yours (i.e., for individuals currently or likely to be required to enter and graph data)?	5.00
EWI could be made better as a self-directed training procedure?	1.71
Do you think that EWI was effective in teaching you skills toward the creation and maintenance of graphs?	5.00
EWI was relatively easy to follow?	4.83
Did you observe your own behavior change?	4.83
How confident are you that you could now adequately, confidently, and independently complete similar procedures to those outlined within the study without the use of the study materials?	4.83
How likely are you to reference these materials again in the future?	3.43
Are you satisfied with the outcomes of EWI?	5.00
How well would EWI work to increase similar skills in the future or with other individuals?	4.67
Would you recommend EWI as self-directed training procedures to other individuals with similar responsibilities as yourself?	4.83

Note. Participants scored each question using a 5-point Likert type scale (i.e., 1= *low/disagree* and 5= *high/agree*).

Appendix A

General Instructions

Overview

Graphs, when established correctly, are simple visual descriptors of responding across time and under certain conditions. There are many options to graph data (e.g., GraphPad Prism, SigmaPlot, Microsoft Excel), but Excel is the cheapest with the most information published on its use. Nonetheless, few of these are empirically validated and written as a training procedure. Even fewer publications focus on self-directed (i.e., self-teaching) training procedures. Therefore, the current investigation aims to evaluate the effects of enhanced written instruction (EWI) as a self-directed training procedure for graphing in Microsoft Excel.

Session Directions

We will give you pre-entered, hypothetical data in an Excel spreadsheet (i.e., Data-Entry Sheet). We will also give you a graph of these data. ***Your task is to re-create this hypothetical graph from the pre-entered data.*** Please do your best to complete the requirements in the allotted period. Do not worry if you do not know how to complete something! We are evaluating how well EWI serves as a self-directed training procedure – we are less worried about you as an individual and your current skill! ☺

Starting & Stopping Sessions: Session Start & Stop Prompt

The Session Start & Stop Prompt is a split screen with green and red sections. ***Minimizing or closing this screen officially starts the session.*** From there, will have the amount of time the proctor has noted to complete all graphing requirements. ***When you are complete with all graphing requirements, or cannot progress further, open this Session Start & Stop Prompter again.*** Please be careful! Intentionally or accidentally pulling up the Prompter will terminate your session!

VLC Media Player

We will also record your actions on your device using VLC Media Player (VLC). We will only record your screen, and this recording is only for the purpose of data collection. We will start and stop this recording – please do not do so on your own.

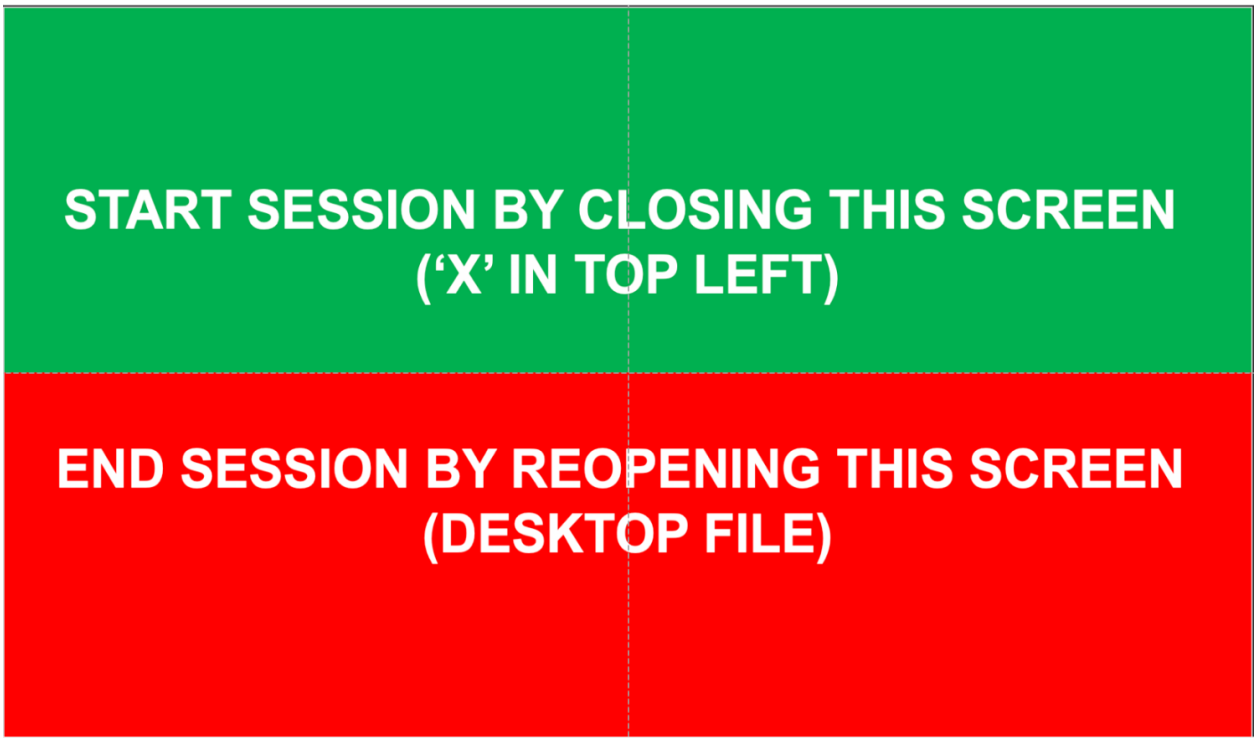
Questions

We will be able to see your movements and, again, will be recording the screen. However, unless initiated by you, we will not intervene until 45 min has expired or you reopen the Start & Stop Session Prompt effectively terminating your session, whichever occurs first. We may be able to answer *why* questions. However, remember, this is a self-directed training ☺!

Thank you!

Appendix B

Session Start-Stop Prompter



Appendix C

Tutorial Data-Entry Sheet (Dates)

DATA ENTRY SHEET							
Goal:	Client's problem behavior will decrease by 80%.						
Target Category:	Problem Behavior	**Date Start:**	10/23/19	**Date Mastered:**	Ongoing	**Notes:** *(General)*	Location: Clinic
Abbreviation: *(Topography 1)*	SIB	**Data Collection:** *(Topography 1)*	Frequency	**Data Analysis:** *(Topography 1)*	Rate	**Notes:** *(Topography 1)*	Rate = responses per minute (RPM); SIB = self-injurious behavior
Abbreviation: *(Topography 2)*		**Data Collection:** *(Topography 2)*		**Data Analysis:** *(Topography 2)*		**Notes:** *(Topography 2)*	
Abbreviation: *(Topography 3)*		**Data Collection:** *(Topography 3)*		**Data Analysis:** *(Topography 3)*		**Notes:** *(Topography 3)*	

		Topography 1	*Topography 2*	*Topography 3*			
Date	**Session**	**SIB**			**Phase Change**	**X-Axis Break**	**Notes**
10/23/19		6.00					Baseline: no programmed consequences
10/24/19		5.00					
10/25/19		5.50					
					-0.25		Treatment: token system
10/28/19		6.00					
10/29/19		2.00					
10/30/19		0.00					
						-0.25	Vacation: 10/31/19 - 11/4/19
11/5/19		1.00					
11/6/19		0.00					
11/7/19		0.00					
11/8/19		0.00					
11/9/19		0.00					
11/12/19		0.00					

Appendix D

Example Target Data-Entry Sheet (Sessions)

DATA ENTRY SHEET							
Goal:	Parent will deliver reinforcement on a dense schedule to increase appropriate behavior of the child at home.						
Target Category:	Reinforcement Delivery	**Date Start:**	2/3/19	**Date Mastered:**	Ongoing	**Notes:** *(General)*	Parent: Mom
Abbreviation: *(Topography 1)*	Reinforce	**Data Collection:** *(Topography 1)*	Frequency	**Data Analysis:** *(Topography 1)*	Rate	**Notes:** *(Topography 1)*	Rate = responses-per-min (RPM)
Abbreviation: *(Topography 2)*		**Data Collection:** *(Topography 2)*		**Data Analysis:** *(Topography 2)*		**Notes:** *(Topography 2)*	
Abbreviation: *(Topography 3)*		**Data Collection:** *(Topography 3)*		**Data Analysis:** *(Topography 3)*		**Notes:** *(Topography 3)*	

		Topography 1	*Topography 2*	*Topography 3*			
Date	**Session**	**Reinforce**			**Phase Change**	**X-Axis Break**	**Notes**
	1	0.00					Baseline: no programmed contingencies
	2	0.00					
	3	1.00					
	4	0.00					
	5	1.00					
	5.5				-0.25		Treatment: feedback
	6	7.00					
	7	8.00					
	8	9.00					
	9	9.00					
	10	9.00					
	11	9.00					
	12	9.00					
	13	9.00					
	14	9.00					
	14.5					-0.25	Vacation: 2/8/19-2/18/19
	15	9.00					

Appendix E

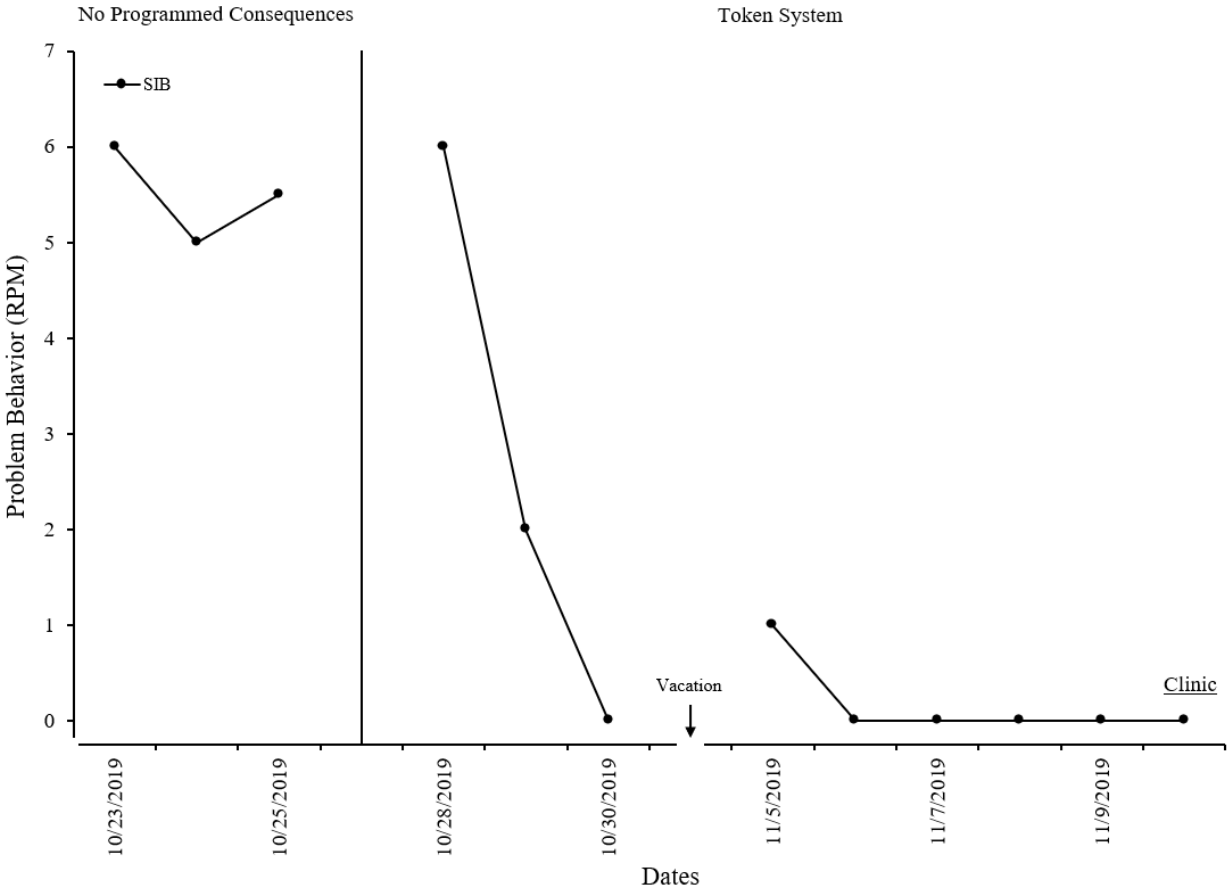
Generalization Data-Entry Sheet (Dates)

DATA ENTRY SHEET							
Goal:	Client will increase appropriate and decrease inappropriate self-feeding.						
Target Category:	Self-Feeding (SF)	**Date Start:**	2/1/20	**Date Mastered:**	Ongoing	**Notes:** *(General)*	Client: Ellie
Abbreviation: *(Topography 1)*	ASF	**Data Collection:** *(Topography 1)*	Freq	**Data Analysis:** *(Topography 1)*	%	**Notes:** *(Topography 1)*	ASF = appropriate self-feeding; % = % opportunities
Abbreviation: *(Topography 2)*	ISF	**Data Collection:** *(Topography 2)*	Freq	**Data Analysis:** *(Topography 2)*	%	**Notes:** *(Topography 2)*	ISF = inappropriate self-feeding; % = % opportunities
Abbreviation: *(Topography 3)*	PB	**Data Collection:** *(Topography 3)*	Freq	**Data Analysis:** *(Topography 3)*	%	**Notes:** *(Topography 3)*	PB = problem behavior; % = % opportunities

		Topography 1	*Topography 2*	*Topography 3*			
Date	**Session**	**ASF**	**ISF**	**PB**	**Phase Change**	**X-Axis Break**	**Notes**
2/1/20		0.00	90.00	0.00			Baseline: no programmed consequences
2/2/20		0.00	100.00	0.00			
2/3/20		0.00	100.00	0.00			
					-2.5		Treatment:response blocking
2/4/20		60.00	20.00	10.00			
2/5/20		100.00	30.00	20.00			
2/8/20		90.00	0.00	30.00			
2/9/20		90.00	0.00	20.00			
2/10/20		90.00	0.00	20.00			
2/11/20		85.00	0.00	10.00			
2/12/20		100.00	0.00	0.00			
2/15/20		95.00	0.00	0.00			
2/16/20		100.00	0.00	0.00			
2/17/20		100.00	0.00	0.00			
2/18/20		100.00	0.00	0.00			
2/19/20		100.00	0.00	0.00			
						-2.5	School Closure
2/27/20		75.00	0.00	0.00			
2/28/20		80.00	0.00	0.00			
					-2.5		Baseline: no programmed consequences
2/29/20		80.00	40.00	0.00			
3/1/20		10.00	100.00	0.00			
3/2/20		0.00	100.00	0.00			

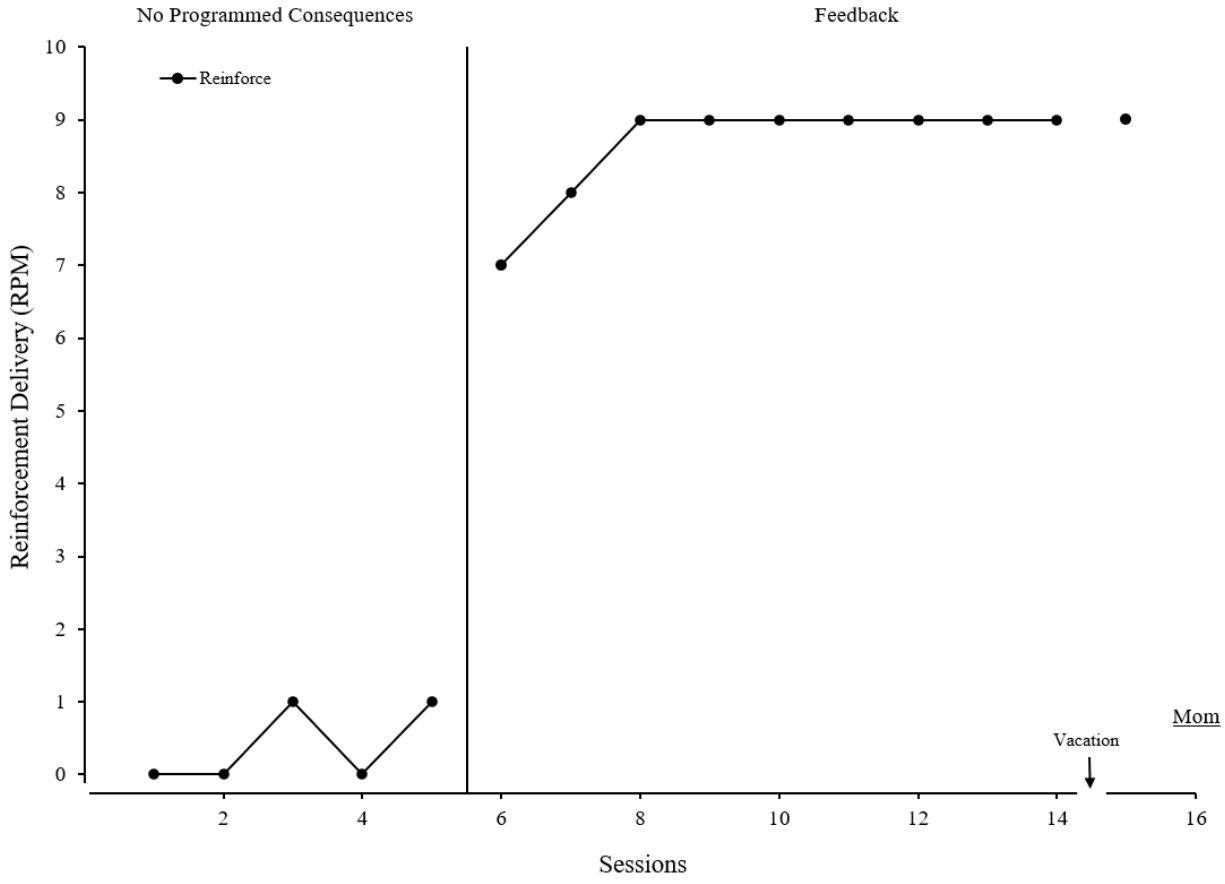
Appendix F

Tutorial Data Sample Graph (Dates)



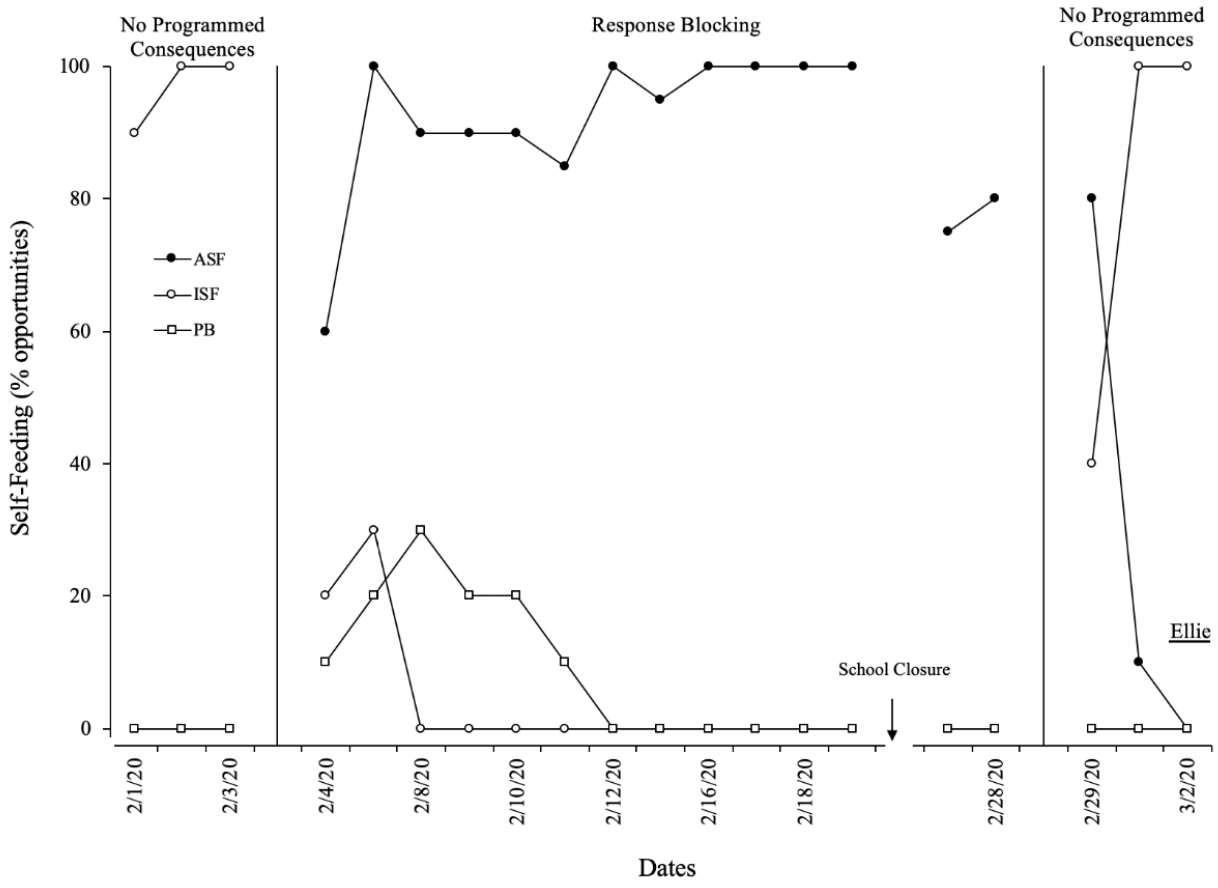
Appendix G

Example Target Data Sample Graph (Sessions)



Appendix H

Generalization Data Sample Graph (Dates)



Appendix I

Tutorial Data Written Instructions (Dates)

Problem Behavior

The effects of a token system were evaluated on problematic behavior (i.e., self-injurious behavior). The rate of self-injury was high during baseline; however, following the implementation of a token system, self-injury decreased to a zero-level.

Appendix J

Example Target Data Written Instructions (Sessions)

Reinforcement Delivery

We evaluated the effects of feedback on a mother's delivery of positive reinforcement to her child. During baseline, the mother rarely delivered reinforcement; however, following instructor feedback, the mother immediately began delivering reinforcement following appropriate behavior.

Appendix K

Generalization Data Written Instructions (Dates)

Response Blocking

The effects of response blocking as an assessment procedure to identify skill and motivation deficits were evaluated using a reversal design. During baseline, no program consequences were delivered. During response blocking, sessions were like baseline except blocking was implemented contingent on attempts to inappropriately self-feed. Levels of inappropriate self-feeding and problem behavior were low during baseline. Following the implementation of response blocking, an immediate increase in appropriate, and an immediate decrease in inappropriate, self-feeding was observed. We replicated effects during our reversal to baseline. Additionally, we measured problem behavior throughout the assessment. Problem behavior slightly increased during the initial implementation of response blocking, but this behavior eventually decreased to a zero level.

Appendix L

Enhanced Written Instructions (Dates)

Enhanced Written Instructions
Graphing *Dates* on X-Axis

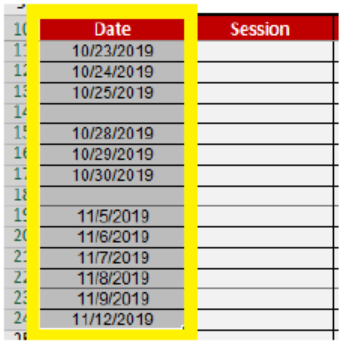
Directions

The following steps apply to all data sets within your Excel document unless otherwise noted. First, **please follow every step below, in order, as they relate to the data set you are graphing.** Second, **text boxes** throughout the instructions will help **clarify and give further direction** on a given step. Please read these! Third, the pictures may not exactly align with your hypothetical data set; however, your progress should look similar to that of the pictures throughout these instructions. Fourth, **note that you make different graphs depending on whether you are graphing *dates* or *sessions* along your x-axis** (note the title above and Step #2). Fifth, please go ahead and **fix any errors you see you have made!** Thank you for helping with this project! ☺

1. Select data for inclusion on your graph.

a. Click and hold on the red, data-header "Dates."

b. Drag down to the last date entered and release your click. These cells should now all be highlighted.



c. While holding down "Ctrl," on your keyboard, and click on the red, data-header topography abbreviation under "Topography 1."

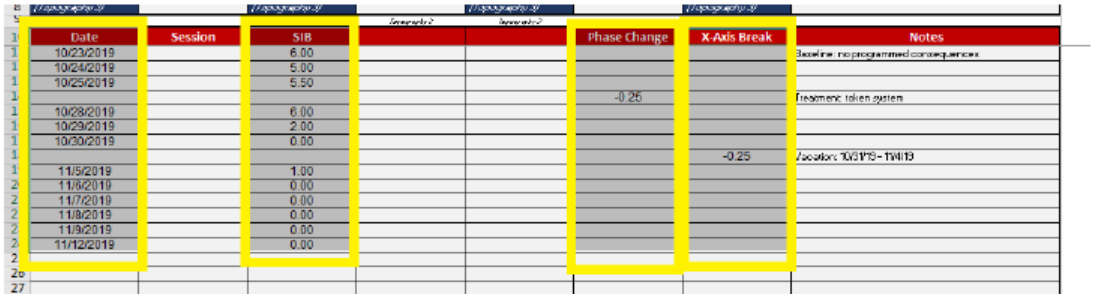
d. Drag down to the cell equal to that of the last date entered (i.e., you should be highlighting the same number of cells as you did before but within a different column). These cells should now all be highlighted, too.

e. While still holding down "Ctrl," repeat Steps #1c and #1d for:

   i. "Phase Change," and

   ii. "X-Axis Break."

f. Release "Ctrl."

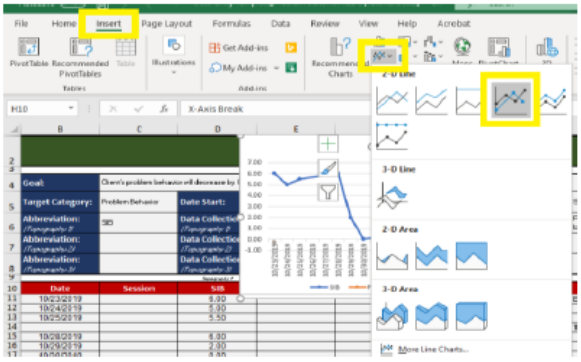


2. Select the appropriate graph for your data.

a. Click "Insert," located at the top, left of your Excel document.

   i. Above "Charts," click "Insert Line of Area Chart" (this appears when you hover over the correct icon).

   ii. Under "2-D Line," click "Line with Markers" (this appears when you hover over the correct icon).



3. Select graph area to format.

a. Click on the graph.

b. Click "Format," located at the top, center of your Excel document.

c. Above "Current Selection,"

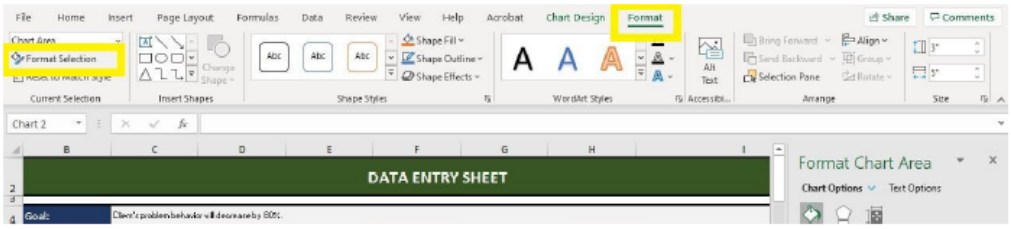
   i. Click "Format Selection," located to the top, left of your Excel document. A window (i.e., formatting window) should appear to the right of your Excel document.

   ii. Above "Format Selection," click the down arrow next to the textbox and select your current graph area in need of changing (see following steps for which area you need to select).

d. The Format Window should appear to the right of your screen.

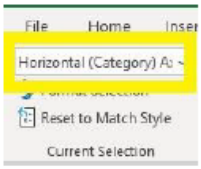
3. Selecting Graph Area & Format Window
Getting to and working in Format Window is going to be used throughout this training. However, you will need to select the respective graph area from the drop-down menu for your changes Format Window to be accurate.

3c. If Format Window Closes
If you close out of your Format Window, follow Step# 3ci to open it back up.

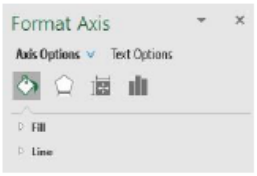


4. Format x-axis.

a. Repeat Step #3 (see p. 2) and click "Horizontal (Category) Axis."



b. Within Format Window, click "Axis Options," located just below "Format Axis" and to the left of "Text Options."

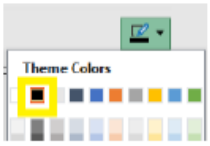


i. Click "Fill & Line" – the spilling paint icon.

1. Click "Line" so its sub-options are available.

a. Next to "Color," click the icon and click "Black, Text 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

b. Set "Width" to "1 pt."



ii. Click "Axis Options" – the three-bar icon.

1. Click "Axis Options" so its sub-options are available.

a. Under "Axis Type," click "Text axis."

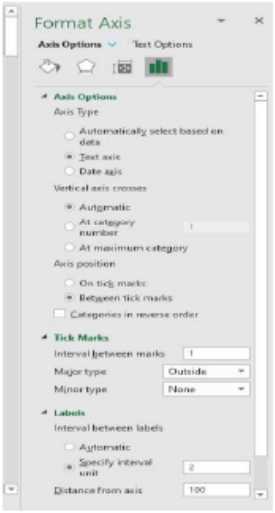
2. Click "Labels" so its sub-options are available.

a. Click "Specify interval unit."

i. Set "Specify interval unit" to best depict your data (see box #4bii below).

3. Click "Tick Marks" so its sub-options are available.

a. Set "Major type" to "Outside."



4bii. "Best Depict Your Data" for the X Axis

You want your reader to easily identify what date relates to which data point. What you don't want is your axis to be overcrowded too spread out. Follow this guideline for *best depicting your data*:

# of Dates Entered	"Specify interval unit"
1-10	1
11-20	2
21-30	5
31-50	10
51-100	10, 20, or 25
101+	20 or 25

iii. Click "Size & Properties" – the measuring square icon.

1. Click "Alignment" so its sub-options are available.

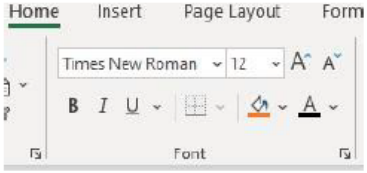
a. Next to "Text direction," click "Rotate all text 270°."

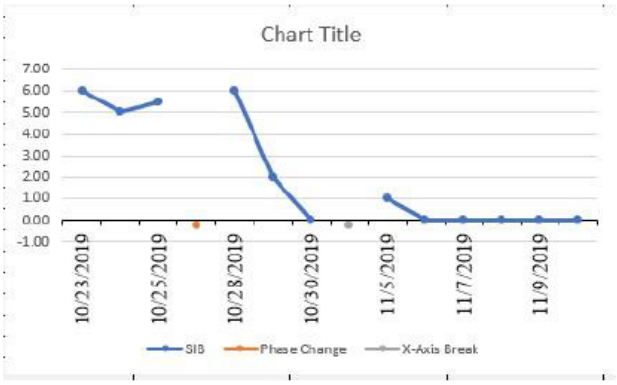
c. Click "Home," located at the top, left of your Excel document. Above "Font,"

i. Click the down arrow next to the font textbox and click "Times New Roman." You may have to scroll down within this drop-down menu.

ii. Click the down arrow next to the font size textbox and click "12."

iii. Click the down arrow next to underlined letter A and click "Black, Text 1."





5. Format y-axis.

a. Repeat Step #3 (see p. 2) and click "Vertical (Value) Axis."

b. Within Format Window, click "Axis Options," located just below "Format Axis" and to the left of "Text Options."

i. Click "Fill & Line" – the spilling paint icon.

1. Click "Line" so its sub-options are available.

a. Next to "Color," click the icon and click "Black, Text 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

b. Set "Width" to "1 pt."

ii. Click "Axis Options" – the three-bar icon.

1. Click "Axis Options" so its sub-options are available.

a. Under "Bounds,"

i. Set "Maximum" to best depict your data (see Box #5bii on p. 6).

5bii. How are my Data Analyzed?
Reference the Data Entry Sheet, and next to Data Analysis, to determine how your data are analyzed.

1. If your data are analyzed as cumulative or rate, set "Maximum" to best depict your data (see Box #5bii to right).
2. If your data are analyzed as percentage, set "Maximum" to "100."

ii. Set "Minimum" to best depict your data (see Box #5bii to right).

b. Under "Units," set "Major" to best depict your data (see Box #5bii to right).

c. Under "Horizontal axis crosses,"

i. Click "Axis value."

ii. Set "Axis value" to best depict your data (see Box #5bii to right).

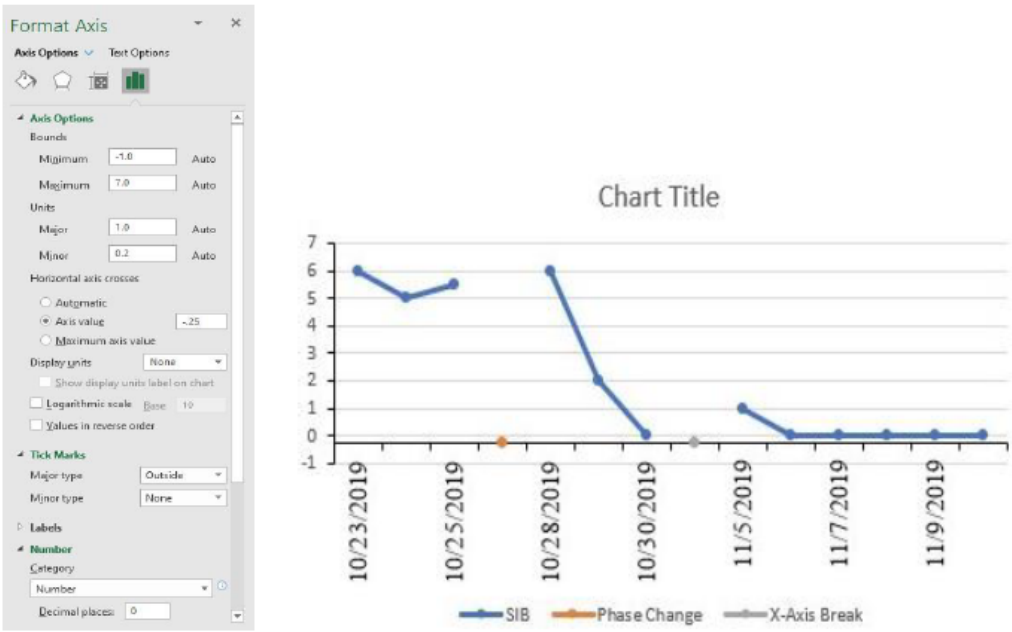
2. Click "Tick Marks" so its sub-options are available.
   a. Set "Major type" to "Outside."
3. Click "Number" so its sub-options are available.
   a. If "Units, Major" was set to an interval other than a whole number (e.g., .25, 1.5), do not make any further changes.
   b. If "Units, Major" was set to a whole number (e.g., 1, 2, 3), set "Decimal places:" to "0."
4. Click "Enter" on your keyboard.

5bii. "Best Depict Your Data" for the Y Axis

You want your reader to easily identify the measurement of each data point. You don't want your axis to be overcrowded or too spread out. Follow this guideline for *best depicting your data:*

Greatest Data Point	"Units, Major" & "Bounds Minimum"	"Bounds, Maximum"	Axis Value
1-10	1 & -1	Next whole number greater than Greatest Data Point	-.25
11-20	2 & -2	Next even, whole number greater than Greatest Data Point (if Greatest Data Point is not already an even number)	-.25
21-30	5 & -5	Next multiple of 5 (if Greatest Data Point is not already a multiple of 5)	-.25
31-50	10 & -10	Next multiple of 10 (if Greatest Data Point is not already a multiple of 10)	-2.5
51-100	10, 20, or 25 & -10, -20, or -25	Next multiple of Unit decided (if Greatest Data Point is not already a multiple of decided Unit)	-2.5
100+	20 or 25 & -20 or -25	Next multiple of Unit decided (if Greatest Data Point is not already a multiple of decided Unit)	-2.5

The Axis Value should also match the number entered on your Data Entry Sheet under Phase Change and X-Axis Break.

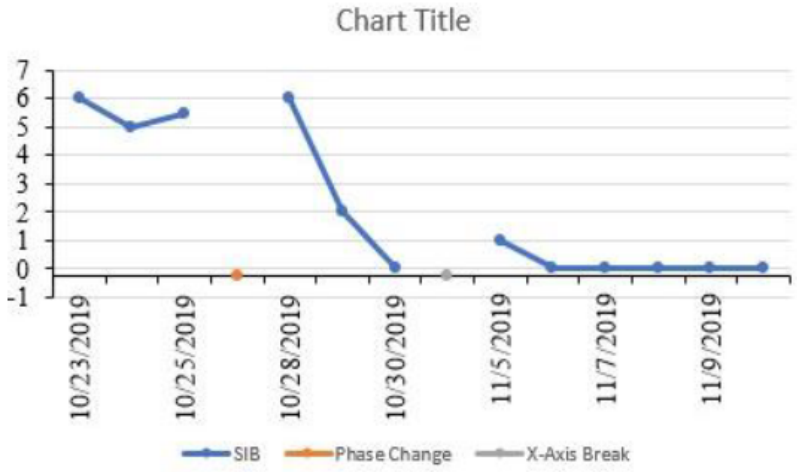


c. Click "Home," located at the top, left of your Excel document. Above "Font,"

i. Click the down arrow next to the font textbox and click "Times New Roman." You may have to scroll down within this drop-down menu.

ii. Click the down arrow next to the font size textbox and click "12."

iii. Click the down arrow next to underlined letter A and click "Black, Text 1."



6. Format data path.

a. Repeat Step #3 (see p. 2) and click the "Series" that corresponds with your target behavior (e.g., "Series 'Spoon'."

b. Within Format Window,

i. Click "Fill & Line" – the spilling paint icon.

1. Click "Line," located to the left of "Marker."

a. Click "Line" so its sub-options are available.

i. Next to "Color," click the icon and click "Black, Text 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

ii. Set "Width" to "1 pt."

2. Click "Marker," located to the right of "Line."

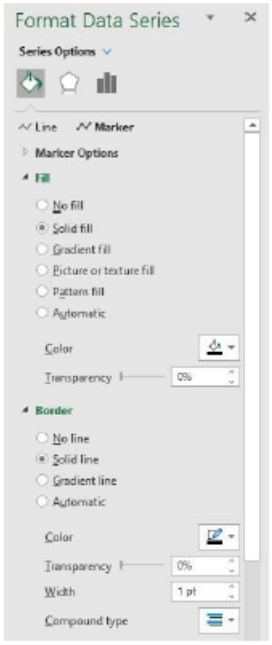
a. Click "Fill" so its sub-options are available.

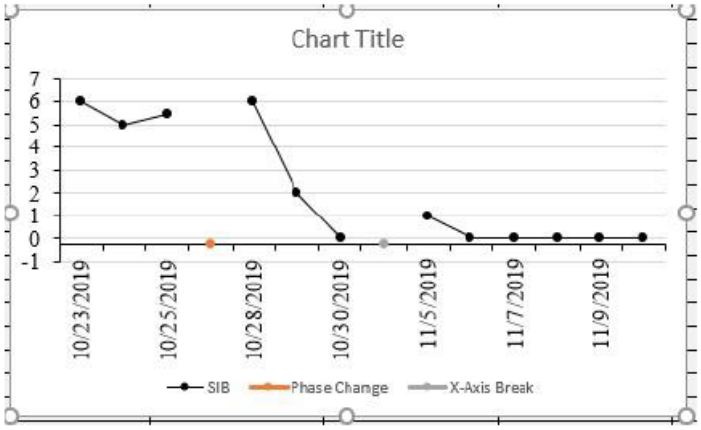
i. Next to "Color," click the icon and click "Black, Text 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

b. Click "Border" so its sub-options are available.

i. Next to "Color," click the icon and click "Black, Text 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

ii. Set "Width" to "1 pt."





7. Format phase change lines.

a. Repeat Step #3 (see p. 2) and click "Series 'Phase Change'."

b. Within Format Window,

   i. Click "Fill & Line" – the spilling paint icon.

      1. Click "Line," located to the left of "Marker."

         a. Click "Line" so its sub-options are available.

            i. Click "No line."

      2. Click "Marker," located to the right of "Line."

         a. Click "Marker Options" so its sub-options are available.

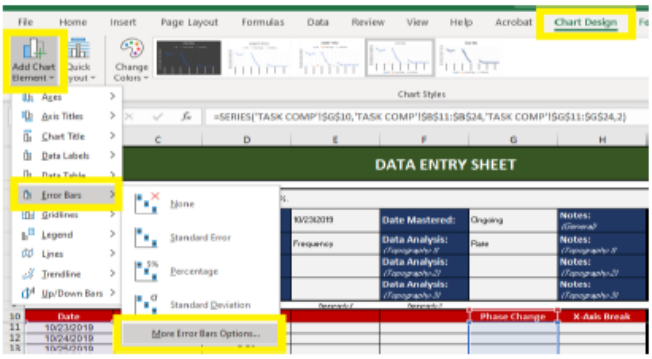
            i. Click "None."

c. Click "Chart Design" (or "Design"), located at the top, center of your Excel document.

   i. Above "Chart Layouts," click "Add Chart Element."

   ii. Click "Error Bars"

   iii. Click "More Error bars Options…." The formatting window should now read, "Format Error Bars."



d. Repeat Step #3 (see p. 2) and click "Series 'Phase Change' X Error Bars" (if necessary).

   i. Click "Backspace" on your keyboard.

e. Repeat Step #3 (see p. 2) and click "Series 'Phase Change' Y Error Bars."

f. Within Format Window,

   i. Click "Fill & Line" – the spilling paint icon.

      1. Click "Line" so its sub-options are available.

         a. Next to "Color," click the icon and click "Black, Text 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

         b. Set "Width" to "1 pt."

   ii. Click "Axis Options" – the three-bar icon.

      1. Click "Vertical Error Bar" so its sub-options are available.

         a. Under "Direction," click "Plus."

         b. Under "End Style," click "No Cap."

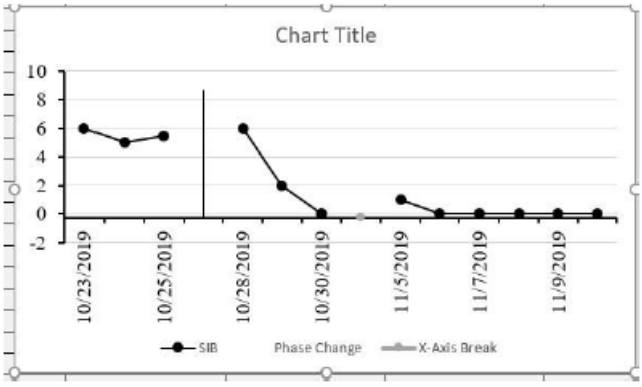
         c. Under "Error Amount," click "Fixed value."

7fii. Absolute Values
The phase change line needs to extend from your x-axis up to the top of your y-axis.

Example:
Y-axis Max= 7
Y-axis Min= -1 (Abs. value: 1)
Phase change: 7+1=8

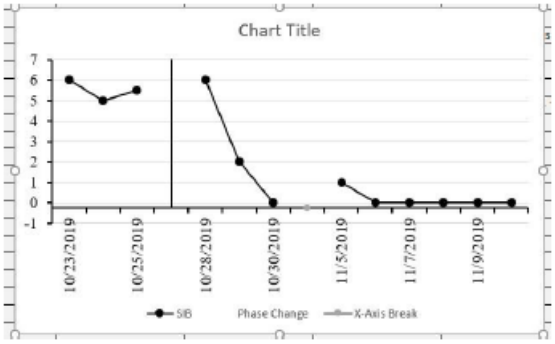
i. Set "Fixed value" to the maximum of your y-axis plus the absolute value of your minimum of your y-axis. To find the absolute value, simply change the negative to a positive (e.g., the absolute value of -1 is 1).

ii. Click "Enter" on your keyboard.



8. Reset your y-axis if this changed due to creating your phase change line (if necessary; otherwise, skip to Step #9.)

a. Repeat Step #5a and Step #5bii1 (see pp. 5-7).



9. Format x-axis breaks.

a. Repeat Step #3 (see p. 2) and click "Series 'X-Axis Break."

b. Within Format Window,

i. Click "Fill & Line" – the spilling paint icon.

1. Click "Line," located to the left of "Marker."

a. Click "Line" so its sub-options are available.

i. Click "No line."

2. Click "Marker," located to the right of "Line."

a. Click "Marker Options" so its sub-options appear.

i. Click "Built-in."

ii. Next to "Type," click the down arrow and click the long, horizontal line just above the circle.

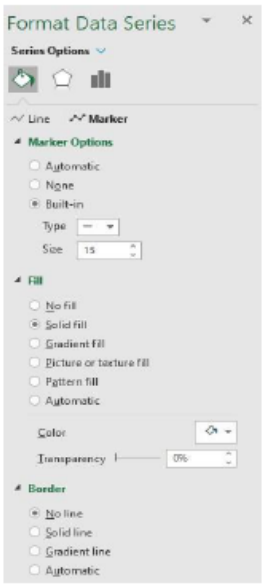
iii. Set the "Size" to "15."

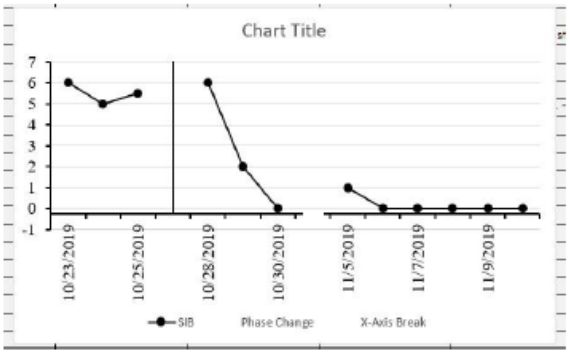
b. Click "Fill" so its sub-options appear.

i. Next to "Color," click the icon and click "White, Background 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

c. Click "Border" so its sub-options appear.

i. Click "No line."



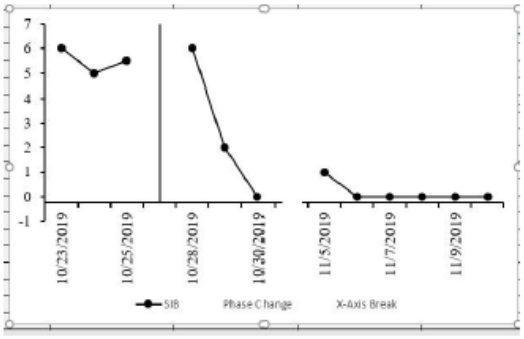


10. Delete chart junk.

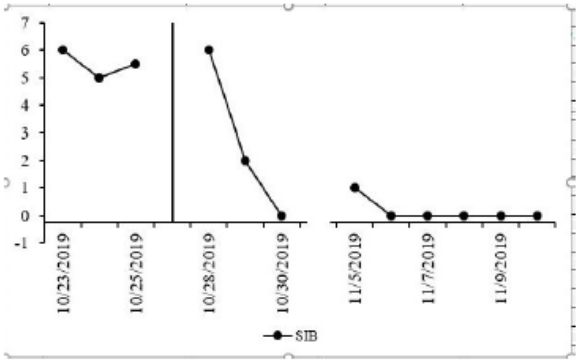
a. Repeat Step #3 (see p. 2) and click "Chart Title."
   i. Click "Backspace" on your keyboard.

b. Repeat Step #10a (see above) for:
   i. "Horizontal (Value) Axis Major Gridlines;" and,
   ii. "Vertical (Value) Axis Major Gridlines.

c. Repeat Step #3 (see p. 2) and click "Chart Area."
   i. Within the formatting window, click "Chart Options," located just below "Format Chart Area" and to the left of "Text Options."
      1. Click "Fill & Line" – the spilling paint icon.
         a. Click "Border" so its sub-options are available.
            i. Click "No line."



d. Repeat Step #3 (see p. 2) and click "Legend."
   i. Within the physical legend on the graph, click specifically on "Phase Change."
      1. Click "Backspace" on your keyboard.
   ii. Repeat Step #10di (see above) but within the physical legend on the graph, click specifically on "X-Axis Break."
      1. Click "Backspace" on your keyboard.
   iii. Repeat Step #3 (see p. 2) and click "Legend."
   iv. Click "Home," located at the top, left of your Excel document.
      1. Above "Font,"
         a. Click the down arrow next to the font textbox and click "Times New Roman." You may have to scroll down within this drop-down menu.
         b. Click the down arrow next to the font size textbox and click "10."
         c. Click the down arrow next to underlined letter A and click "Black, Text 1."



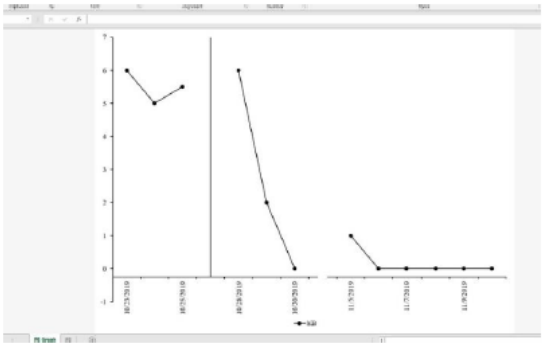
11. Relocate graph to its own, graph-specific tab.

a. Click on the graph.

b. Click "Chart Design" (or "Design"), located at the top, center of your Excel document.

   i. Above "Location," click "Move Chart."

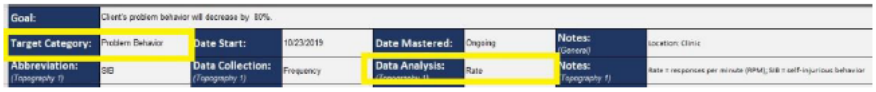
      1. Click "New sheet:"
      2. Rename this new sheet the Target Category abbreviation (i.e., what is written on your tab; e.g., "Feeding") followed by "Graph" (e.g., Feeding Graph).
      3. Click "OK." The graph should now appear in its own tab.



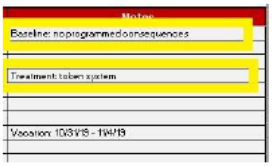
12. Titling phases and axes.

a. Click on tab at the bottom of your Excel document associated with the Data Entry Sheet and write down:

i. What your Target Category and Data Analysis are; and,



ii. What baseline and treatment consisted of (e.g., no programmed consequences, DRA, token system) – this information should appear next to "Baseline" and "Treatment" in the column under the red, data-header section "Notes."

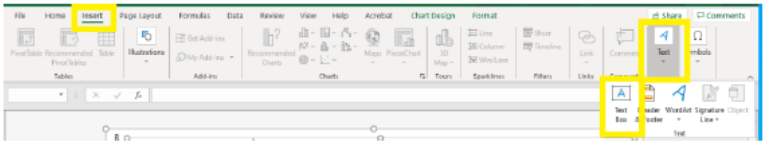


b. Click on tab at the bottom of your Excel document associated with the Graph.

i. Title the x-axis.

1. Click "Insert," located at the top, left of your Excel document.

a. Above "Text," click "Text Box." This may also appear as an italicized A within a box – click that icon and then click "Text Box."



b. Click on the graph. A text box should appear.

c. Type "Dates."

2. Click on the grey outline of the text box.

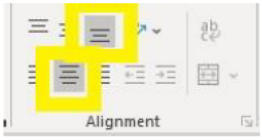
3. Click "Home," located at the top, left of your Excel document.

a. Above "Font,"

i. Click the down arrow next to the font textbox and click "Times New Roman." You may have to scroll down within this drop-down menu.

ii. Click the down arrow next to the font size textbox and click "14."

iii. Click the down arrow next to underlined letter A and click "Black, Text 1."



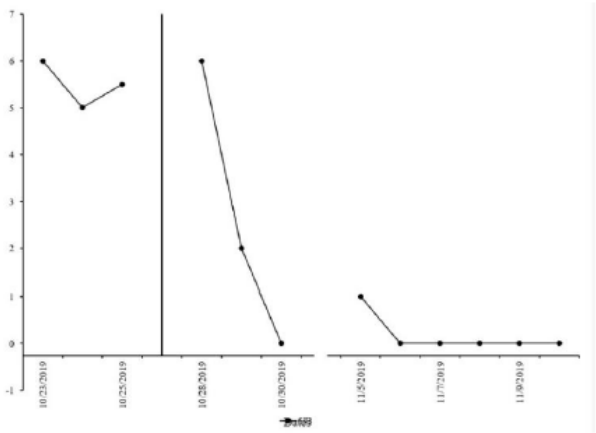
b. Above "Alignment,"

i. Click "Bottom Align" (this appears when you hover over the correct icon).

ii. Click "Center" (this appears when you hover over the correct icon).

4. Resize the text box so there is relatively no unused space above or below the title.

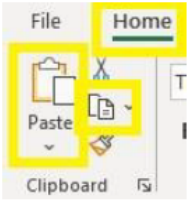
5. Drag the text box so it is centered and flush with the bottom of the page.



ii. Title the y-axis.

12bii1-3. Copy-and-Paste
You will be required to copy-and-paste a variety of text here on out. **Repeating these steps will be stated as "copy-and-paste."**

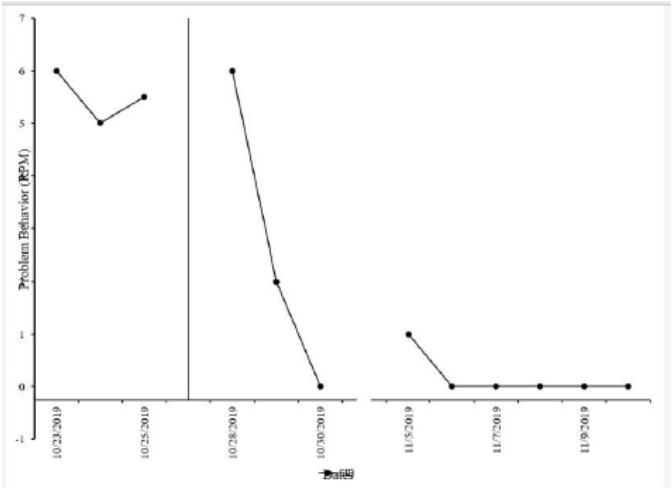
1. Click on the text box you created for the x-axis title.
2. Click again on the grey outline of the text box.
3. Click "Home," located at the top, left of your Excel document.
    a. Above "Clipboard,"
        i. Click "Copy" (this appears when you hover over the correct icon).
        ii. Click "Paste" (this appears when you hover over the correct icon).
        iii. A copy of the text box you created for the x-axis title should appear.



12bii. Titling Y-Axis
Data analyzed as a rate should be titled RPM or RPH, for example. Data analyzed as cumulative can just be titled "cumulative." Data analyzed as a percentage should be titled % Session or % Day, for example.

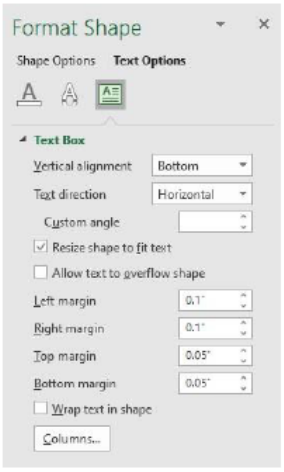
4. Highlight the text within the new text box and type Target Category (e.g., Feeding) – the first letter of each word being capitalized – followed by the method of data analysis in parentheses (e.g., [RPM]).
5. Rotate the text box until 270°, or until the text is vertical and facing the y-axis.
    a. Hold "Shift" on your keyboard and click and hold on the rotating arrow icon located just outside the text box (a rotating arrow should appear when you hover over the correct icon).
    b. Rotate until the text is vertical and facing the y-axis – let go of your click and "Shift."
6. Drag the text box so it is centered and flush to the far left of the page.

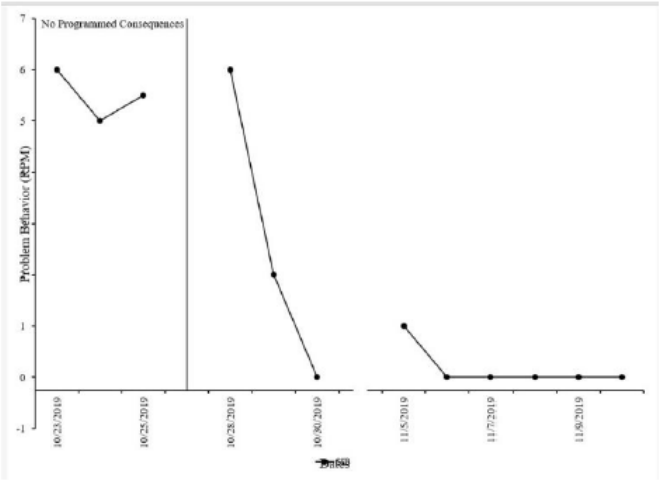
12bii. Rotating the Text Box
You may need to drag the text box so that it is in the middle of the screen in order to see the rotating arrow.



iii. Title the baseline condition.

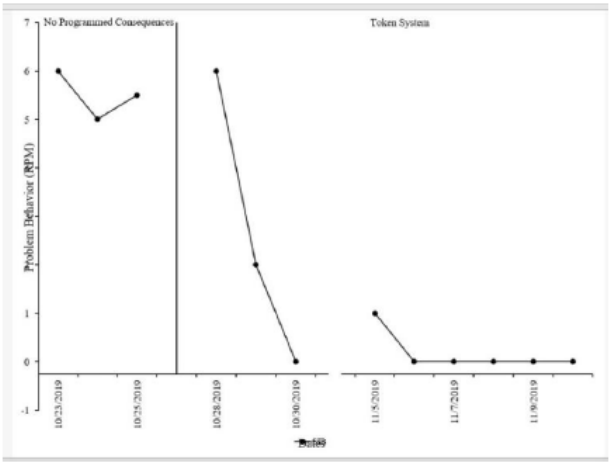
1. Copy-and-paste the text box you created for the x-axis title (see Box #12bii1-3 if needed, p. 15).
2. Highlight the text within the new text box and type what the baseline consisted of (e.g., no programmed consequences) with the first letter of each word being capitalized.
3. Click on the grey outline of the text box.
4. Click "Home," located at the top, left of your Excel document.
    a. Above "Font," click the down arrow next to the font size textbox and click "12."
5. Drag the text box so it is centered between the y-axis as the phase change line, and flush against the top of the page.
6. Within the formatting window, click "Text Options," located just below "Format Shape" and to the right of "Shape Options."
    a. Click "Textbox" – the A within a document icon.
        i. Click "Text Box" so its sub-options are available.
            1. Click the checkbox next to "Resize shape to fit text" so it is now checked.
            2. Unclick the checkbox next to "Allow text to overflow shape" so it is now not checked.





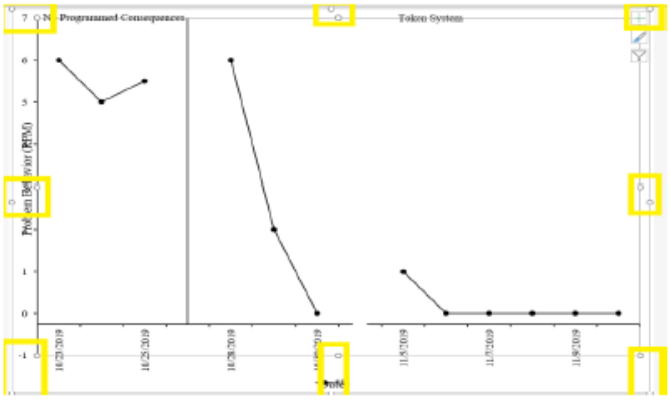
iv. Title the treatment condition.

1. Copy-and-paste the text box you created for the baseline condition (see Box #12bii1-3 if needed, p. 15).
2. Highlight the text within the new text box and type what the treatment consisted of (e.g., prompt fading, BST, token system) with the first letter of each word being capitalized.
3. Drag the text box so it is centered between the phase change line and the end of the graph and located at the top of your page.



13. Resize graph and placement of legend.

a. Click within the graph such that the graph becomes outlined with white circles at all corners of the graph, as well as white circles in the middle of all four sides of the outline. The page itself will also be outlined with the same white circles.



i. Click and hold on the white circle located in the middle, top of the graph's outline, just above the middle of the graph. A black "+" should appear.

1. Drag the top of the graph until it is just below your phase change titles.

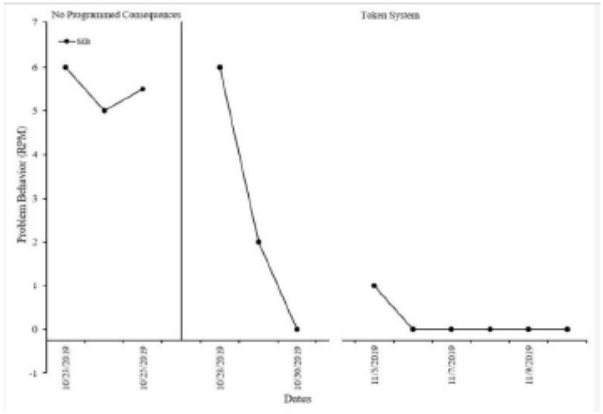
ii. Click and hold on the white circle located in the middle, left of the graph's outline, just to the right of the y-axis labels (i.e., the numbers) the middle of the y-axis. A black "+" should appear.

iii. Drag the left side of the graph until the y-axis labels (i.e., the numbers) are just to the right of your y-axis title.

13c. Legend Placement
Do not place your legend in the bottom right of your graph because your graph title will go here during the next step.

b. Re-center the phase change titles as needed.

c. Click on the legend and drag it into the graph area so it can clearly be read and does not interfere with any data points, data paths, axes, etc.



14. Titling graphs.

a. Click on tab at the bottom of your Excel document associated with the Data Entry Sheet and write down the details within (e.g., client name, location of sessions) – this information should appear in the "General Notes."

b. Click on tab at the bottom of your Excel document associated with the Graph.

   i. Copy-and-paste the text box you created for the baseline condition (see Box #12bii1-3 if needed).

   ii. Highlight the text within the new text box and type what your General Notes said to better describe the graph (e.g., Jackson, Lunch, Clinic) with the first letter of each word being capitalized.

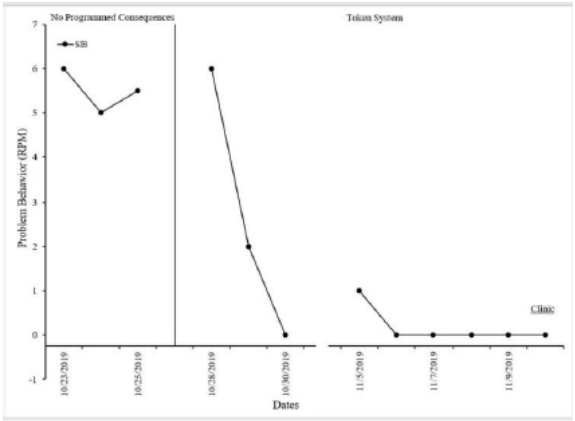
   iii. Click on the grey outline of the text box.

   iv. Click "Home," located at the top, left of your Excel document.

      1. Above "Font," click the underlined U icon to underline your graph's title.

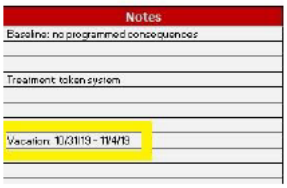
      2. Above "Alignment," click "Align Right" (this will appear when hovering over the correct icon).

   v. Drag the text box so it is to the far right of your graph and does not interfere with any data paths, either just above your x-axis or above your y-axis.



15. Adding descriptive notes and arrows.

a. Click on tab at the bottom of your Excel document associated with the Data Entry Sheet and write down why you broke the x-axis – this information should appear in the column under the red, data-header section "Notes."



b. Click on tab at the bottom of your Excel document associated with the Graph.

c. Add descriptive text box to explain important information.

i. Copy-and-paste the text box you created for the baseline condition (see Box #12bii1-3 if needed).

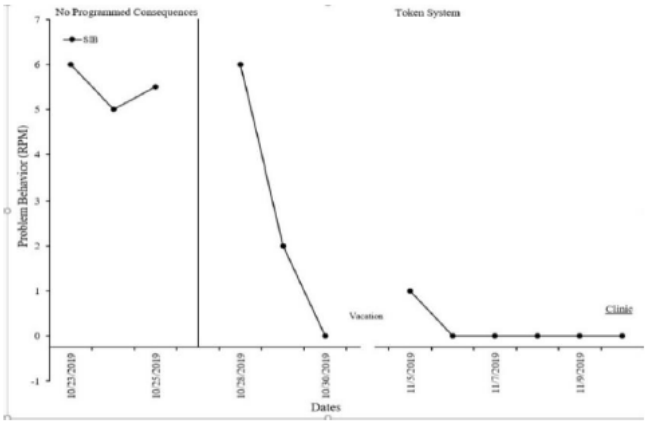
ii. Highlight the text within the new text box and type why you broke your x-axis (e.g., Break, Sick).

iii. Click on the grey outline of the text box.

iv. Click "Home," located at the top, left of your Excel document.

1. Above "Font," click the down arrow next to the font size textbox and click "10."

v. Drag the text box so it is slightly above x-axis break on your graph.

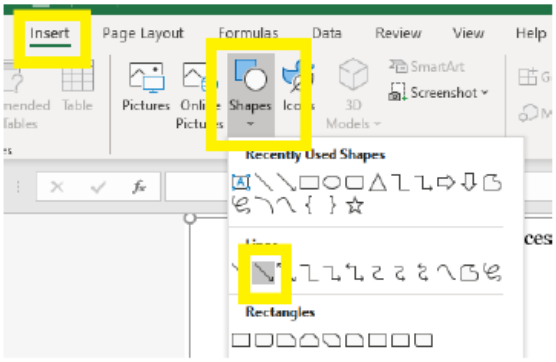


d. Add an arrow to help associate the descriptive text box to the location which you are describing.

i. Click "Insert," located at the top, left of your Excel document.

1. Above "Illustrations," click "Shapes." You may have to click "Illustrations" first.

a. Under "Lines," click "Line Arrow" (this will appear when hovering over the correct icon).



2. Click and hold just below your descriptive note and drag to where on the graph you want this note associated – let go of your click. The arrow should appear pointing to that location.

ii. Click "Shape Format," or "Format," located at the top, middle of your Excel document.

1. Above "Shape Styles," click "Shape Outline."
    a. Below "Theme Colors," click "Black, Text 1" (this will appear when hovering over the correct icon).
2. Above "Shape Styles," click "Shape Outline" again.
    a. Click "Weight."
        i. Click "1 pt."

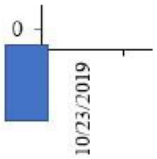
16. Separate X- and Y-Axes.

a. Click "Insert," located at the top, left of your Excel document.

i. Above "Illustrations," click "Shapes." You may have to click on "Illustrations" first.

1. Under "Rectangles," click "Rectangle" (this will appear when hovering over the correct icon).

ii. Click and hold just under and to the left of the 0 on the y-axis and drag until your rectangle covers up until the first date the x-axis and the any numbers less than 0 appearing on your y-axis.



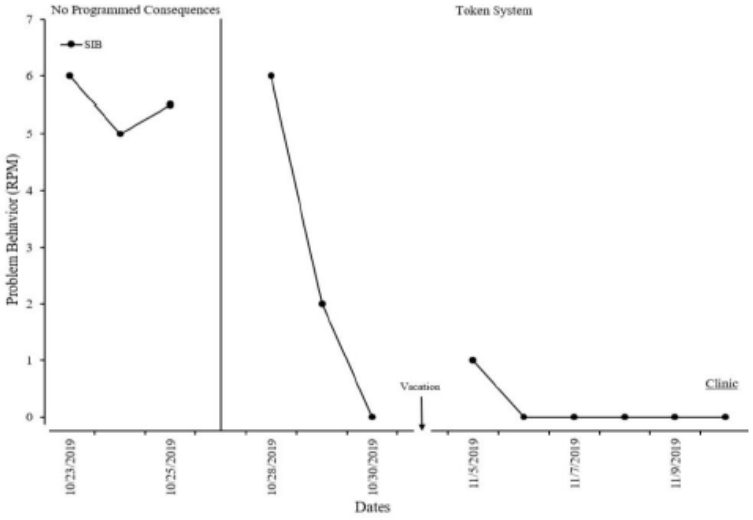
b. Click "Shape Format," located at the top, center of your Excel document.

i. Above "Shape Styles," click "Shape Fill."

1. Below "Theme Colors," click "White, Background 1" (this will appear when hovering over the correct icon).

ii. Above "Shape Styles," click "Shape Outline."

1. Click "No Outline."



YOU ARE COMPLETE!

OPEN THE SESSION START & STOP PROMPT!
SAVE YOUR DOCUMENT!
Click "File," located in the top, left of your Excel document, then click "Save."

Appendix M

Enhanced Written Instructions (Sessions)

Enhanced Written Instructions
Graphing *Sessions* on X-Axis

Directions

The following steps apply to all data sets within your Excel document unless otherwise noted. First, **please follow every step below, in order, as they relate to the data set you are graphing.** Second, **text boxes** throughout the instructions will help **clarify and give further direction** on a given step. Please read these! Third, the pictures may not exactly align with your hypothetical data set; however, your progress should look similar to that of the pictures throughout these instructions. Fourth, **note that you make different graphs depending on whether you are graphing *dates* or *sessions* along your x-axis** (note the title above and Step #2). Fifth, please go ahead and **fix any errors you see you have made!** Thank you for helping with this project! ☺

1. Select data for inclusion on your graph.

a. Click and hold on the red, data-header "Session."

Date	Session	Spoon			Phase Change	X-Axis Break	Notes

b. Drag down to the last session entered and release your click. These cells should now all be highlighted.

Date	Session
	1
	2
	3
	4
	4.5
	5
	6
	7
	8
	9
	9.5
	10
	11
	12
	13
	14

c. While holding down "Ctrl," on your keyboard, and click on the red, data-header topography abbreviation under "Topography 1."

d. Drag down to the cell equal to that of the last session entered (i.e., you should be highlighting the same number of cells as you did before but within a different column). These cells should now all be highlighted, too.

e. While still holding down "Ctrl," repeat Steps #1c and #1d for:

   i. "Phase Change," and

   ii. "X-Axis Break."

f. Release "Ctrl."

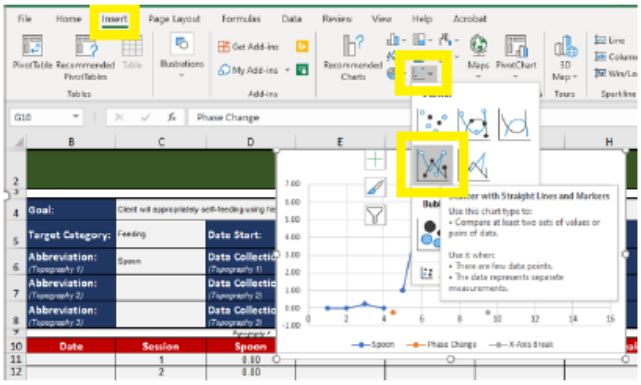
Date	Session	Spoon			Phase Change	X-Axis Break	Notes
	1	0.00					Baseline: no programmed consequences
	2	0.00					
	3	0.25					
	4	0.00					
	4.5				-0.25		Treatment: response blocking
	5	1.00					
	6	6.00					
	7	4.00					
	8	4.00					
	9	4.00					
	9.5					-0.25	Sick: 7/18/19-7/23/19
	10	5.00					
	11	4.00					
	12	6.00					
	13	6.00					
	14	6.00					

2. Select the appropriate graph for your data.

a. Click "Insert," located at the top, left of your Excel document.

i. Above "Charts," click "Insert Scatter (X, Y) or Bubble Chart" (this appears when you hover over the correct icon).

ii. Under "Scatter," click "Scatter with Straight Lines and Markers" (this appears when you hover over the correct icon).



3. Select graph area to format.

a. Click on the graph.

b. Click "Format," located at the top, center of your Excel document.

c. Above "Current Selection,"

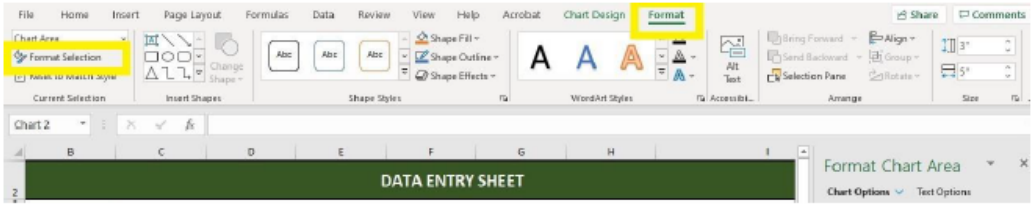
i. Click "Format Selection," located to the top, left of your Excel document. A window (i.e., formatting window) should appear to the right of your Excel document.

ii. Above "Format Selection," click the down arrow next to the textbox and select your current graph area in need of changing (see following steps for which area you need to select).

d. The Format Window should appear to the right of your screen.

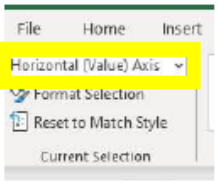
3. Selecting Graph Area & Format Window
Getting to and working in Format Window is going to be used throughout this training. However, you will need to select the respective graph area from the drop-down menu for your changes Format Window to be accurate.

3c. If Format Window Closes
If you close out of your Format Window, follow Step# 3ci to open it back up.

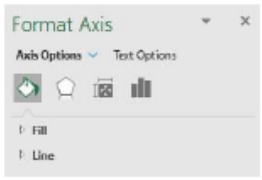


4. Format x-axis.

a. Repeat Step #3 (see p. 2) and click "Horizontal (Value) Axis."



b. Within Format Window, click "Axis Options," located just below "Format Axis" and to the left of "Text Options."

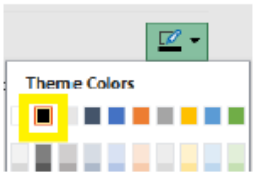


i. Click "Fill & Line" – the spilling paint icon.

1. Click "Line" so its sub-options are available.

a. Next to "Color," click the icon and click "Black, Text 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

b. Set "Width" to "1 pt."



ii. Click "Axis Options" – the three-bar icon.

1. Click "Axis Options" so its sub-options are available.

a. Under "Bounds," set "Maximum" to best depict your data (see Box #4bii below).

b. Under "Units," set "Major" to an interval that best depicts your data (see Box #4bii below).

2. Click "Tick Marks" so its sub-options are available.

a. Set "Major type" to "Outside."

4bii. "Best Depict Your Data" for the X Axis

You want your reader to easily identify what session relates to which data point. What you don't want is your axis to be overcrowded too spread out. Follow this guideline for *best depicting your data:*

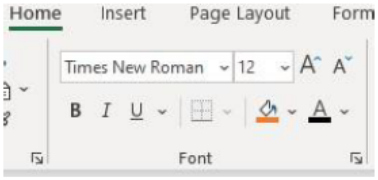
Session # Max	"Units, Major"	"Bounds, Maximum"
1-10	1	Exact Session # Max
11-20	2	Exact Session # Max or next even number (if Max is an odd number)
21-30	5	Exact Session # Max or next multiple of 5 (if Max is not a multiple of 5)
31-50	10	Exact Session # Max or next multiple of 10 (if Max is not a multiple of 10)
51-100	10, 20, or 25	Exact Session # Max or next multiple of decided Major (if Max is not a multiple of decided Major)
101+	20 or 25	Exact Session # Max or next multiple of decided Major (if Max is not a multiple of decided Major)

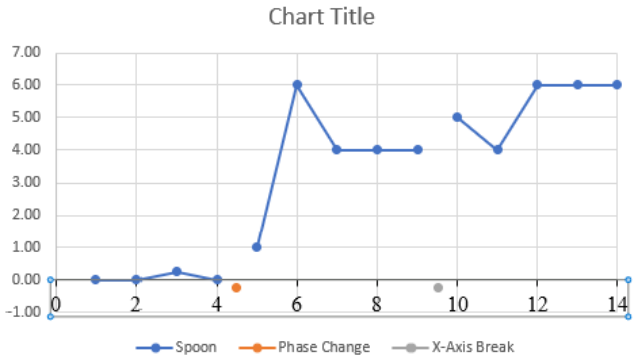
c. Click "Home," located at the top, left of your Excel document. Above "Font,"

   i. Click the down arrow next to the font textbox and click "Times New Roman." You may have to scroll down within this drop-down menu.

   ii. Click the down arrow next to the font size textbox and click "12."

   iii. Click the down arrow next to underlined letter A and click "Black, Text 1."





5. Format y-axis.

a. Repeat Step #3 (see p. 2) and click "Vertical (Value) Axis."

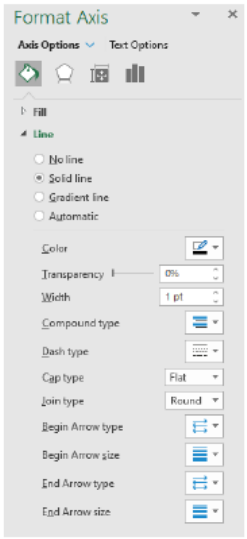
b. Within Format Window, click "Axis Options," located just below "Format Axis" and to the left of "Text Options."

i. Click "Fill & Line" – the spilling paint icon.

1. Click "Line" so its sub-options are available.

a. Next to "Color," click the icon and click "Black, Text 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

b. Set "Width" to "1 pt."



ii. Click "Axis Options" – the three-bar icon.

1. Click "Axis Options" so its sub-options are available.

a. Under "Bounds,"

i. Set "Maximum" to best depict your data (see Box #5bii on p. 6).

5bii. How are my Data Analyzed?
Reference the Data Entry Sheet next to Data Analysis to determine how your data are analyzed.

1. If your data are analyzed as cumulative or rate, set "Maximum" to best depict your data (see Box #5bii to the right).
2. If your data are analyzed as percentage, set "Maximum" to "100."

ii. Set "Minimum" to best depict your data (see Box #5bii to the right).

b. Under "Units," set "Major" to best depict your data.

c. Under "Horizontal axis crosses,"

i. Click "Axis value."

ii. Set "Axis value" to best depict your data (see Box #5bii to the right).

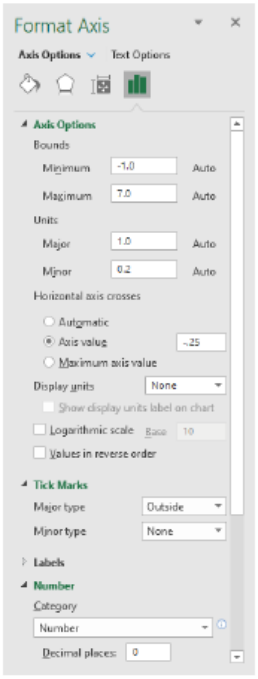
2. Click "Tick Marks" so its sub-options are available.
   a. Set "Major type" to "Outside."
3. Click "Number" so its sub-options are available.
   a. If "Units, Major" was set to an interval other than a whole number (e.g., .25, 1.5), do not make any further changes.
   b. If "Units, Major" was set to a whole number (e.g., 1, 2, 3), set "Decimal places:" to "0."
4. Click "Enter" on your keyboard.

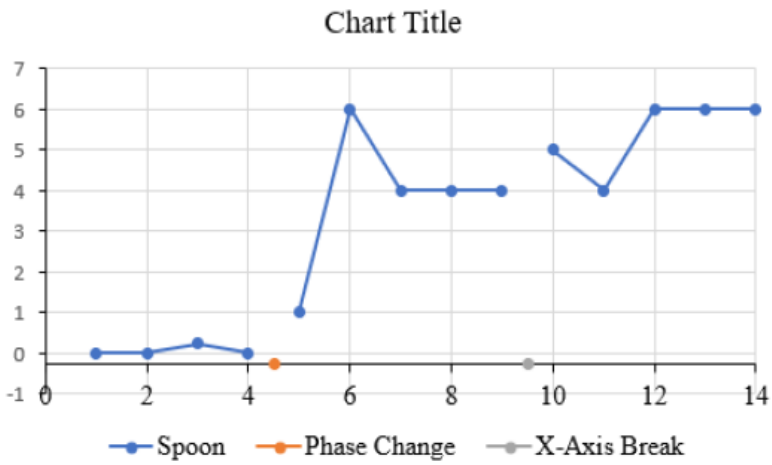
5bii. "Best Depict Your Data" for the Y Axis

You want your reader to easily identify the measurement of each data point. You don't want your axis to be overcrowded or too spread out. Follow this guideline for *best depicting your data:*

Greatest Data Point	"Units, Major" & "Bounds Minimum"	"Bounds, Maximum"	Axis Value
1-10	1 & -1	Next whole number greater than Greatest Data Point	-.25
11-20	2 & -2	Next even, whole number greater than Greatest Data Point (if Greatest Data Point is not already an even number)	-.25
21-30	5 & -5	Next multiple of 5 (if Greatest Data Point is not already a multiple of 5)	-.25
31-50	10 & -10	Next multiple of 10 (if Greatest Data Point is not already a multiple of 10)	-2.5
51-100	10, 20, or 25 & -10, -20, or -25	Next multiple of Unit decided (if Greatest Data Point is not already a multiple of decided Unit)	-2.5
100+	20 or 25 & -20 or -25	Next multiple of Unit decided (if Greatest Data Point is not already a multiple of decided Unit)	-2.5

The Axis Value should also match the number entered on your Data Entry Sheet under Phase Change and X-Axis Break.



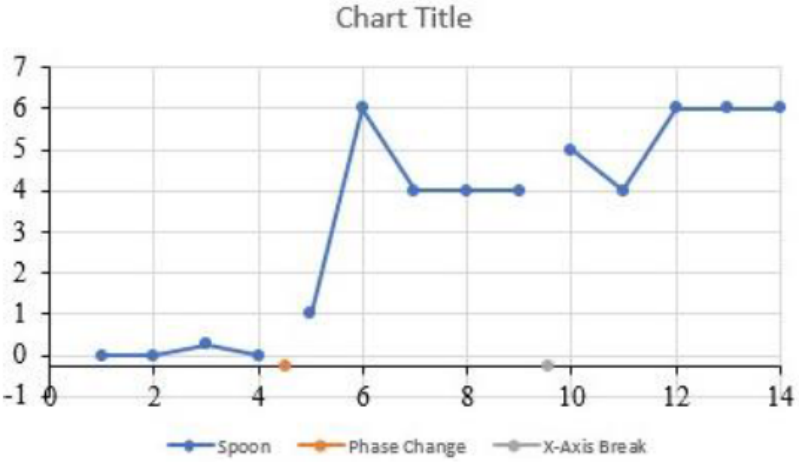


c. Click "Home," located at the top, left of your Excel document. Above "Font,"

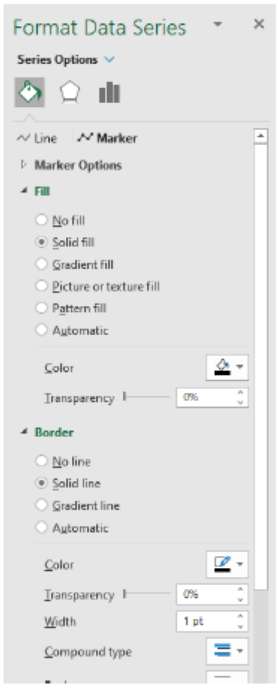
i. Click the down arrow next to the font textbox and click "Times New Roman." You may have to scroll down within this drop-down menu.

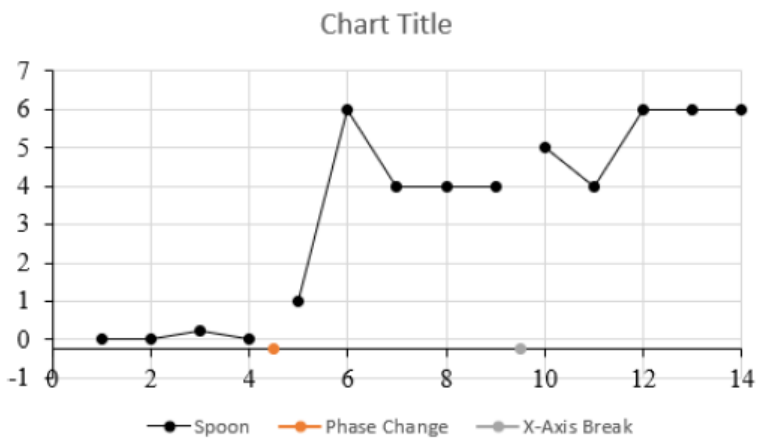
ii. Click the down arrow next to the font size textbox and click "12."

iii. Click the down arrow next to underlined letter A and click "Black, Text 1."



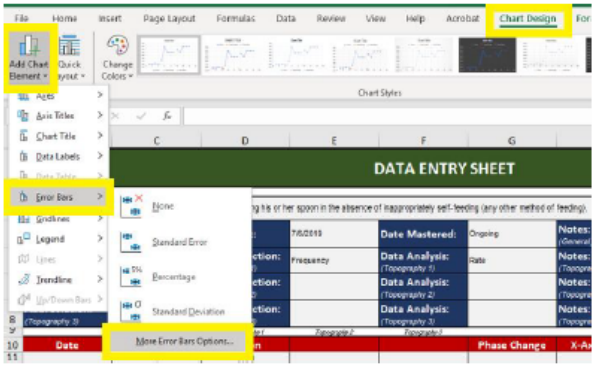
b. Within Format Window,
    i. Click “Fill & Line” – the spilling paint icon.
        1. Click “Line,” located to the left of “Marker.”
            a. Click “Line” so its sub-options are available.
                i. Next to “Color,” click the icon and click “Black, Text 1.” This title should appear when hovering over the correct color, and this can be found in the first row of colors.
                ii. Set “Width” to “1 pt.”
        2. Click “Marker,” located to the right of “Line.”
            a. Click “Fill” so its sub-options are available.
                i. Next to “Color,” click the icon and click “Black, Text 1.” This title should appear when hovering over the correct color, and this can be found in the first row of colors.
            b. Click “Border” so its sub-options are available.
                i. Next to “Color,” click the icon and click “Black, Text 1.” This title should appear when hovering over the correct color, and this can be found in the first row of colors.
                ii. Set “Width” to “1 pt.”





b. Within Format Window,
    i. Click "Fill & Line" – the spilling paint icon.
        1. Click "Line," located to the left of "Marker."
            a. Click "Line" so its sub-options are available.
                i. Click "No line."
        2. Click "Marker," located to the right of "Line."
            a. Click "Marker Options" so its sub-options are available.
                i. Click "None."

c. Click "Chart Design" (or "Design"), located at the top, center of your Excel document.
    i. Above "Chart Layouts," click "Add Chart Element."
    ii. Click "Error Bars"
    iii. Click "More Error bars Options…." The formatting window should now read, "Format Error Bars."



d. Repeat Step #3 (see p. 2) and click "Series 'Phase Change' X Error Bars" (if necessary).
    i. Click "Backspace" on your keyboard.

e. Repeat Step #3 (see p. 2) and click "Series 'Phase Change' Y Error Bars".

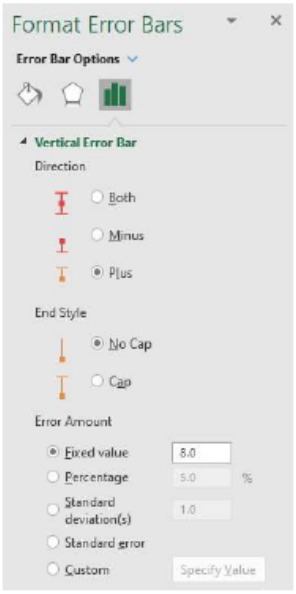
f. Within Format Window,
    i. Click "Fill & Line" – the spilling paint icon.
        1. Click "Line" so its sub-options are available.
            a. Next to "Color," click the icon and click "Black, Text 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.
            b. Set "Width" to "1 pt."
    ii. Click "Axis Options" – the three-bar icon.
        1. Click "Vertical Error Bar" so its sub-options are available.
            a. Under "Direction," click "Plus."
            b. Under "End Style," click "No Cap."
            c. Under "Error Amount," click "Fixed value."

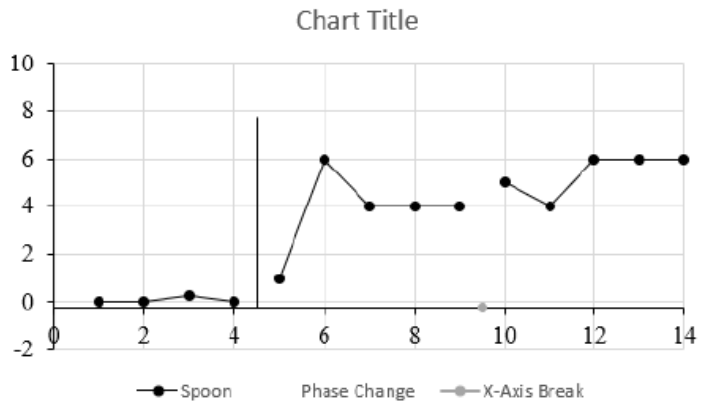
7fii. Absolute Values
The phase change line needs to extend from your x-axis up to the top of your y-axis.

Example:
Y-axis Max= 7
Y-axis Min= -1 (Abs. value: 1)
Phase change: 7+1=8

i. Set "Fixed value" to the maximum of your y-axis plus the absolute value of your minimum of your y-axis. To find the absolute value, simply change the negative to a positive (e.g., the absolute value of -1 is 1).

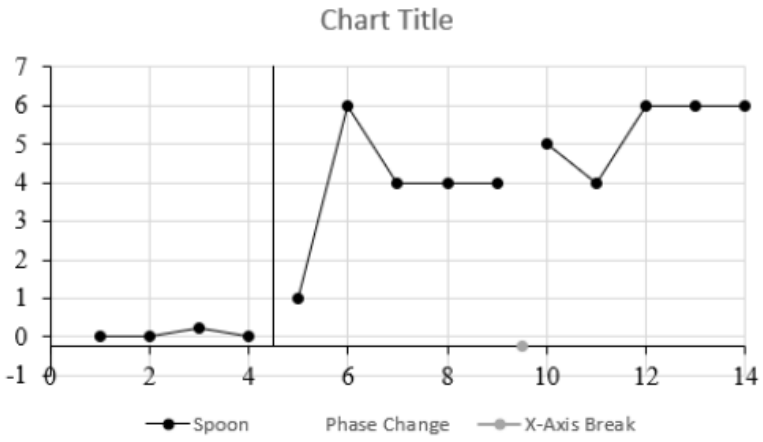
ii. Click "Enter" on your keyboard.





8. Reset your y-axis if this changed due to creating your phase change line (if necessary; otherwise, skip to Step #9.)

a. Repeat Step #5a and Step #5bii1 (see pp. 5-7).



9. Format x-axis breaks.

a. Repeat Step #3 (see p. 2) and click "Series 'X-Axis Break."

b. Within Format Window,

i. Click "Fill & Line" – the spilling paint icon.

1. Click "Line," located to the left of "Marker."

a. Click "Line" so its sub-options are available.

i. Click "No line."

2. Click "Marker," located to the right of "Line."

a. Click "Marker Options" so its sub-options appear.

i. Click "Built-in."

ii. Next to "Type," click the down arrow and click the long, horizontal line just above the circle.

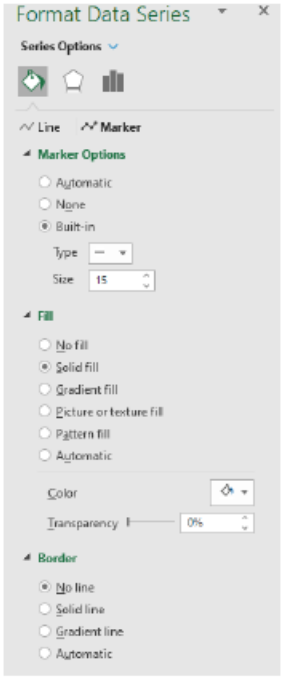
iii. Set the "Size" to "15."

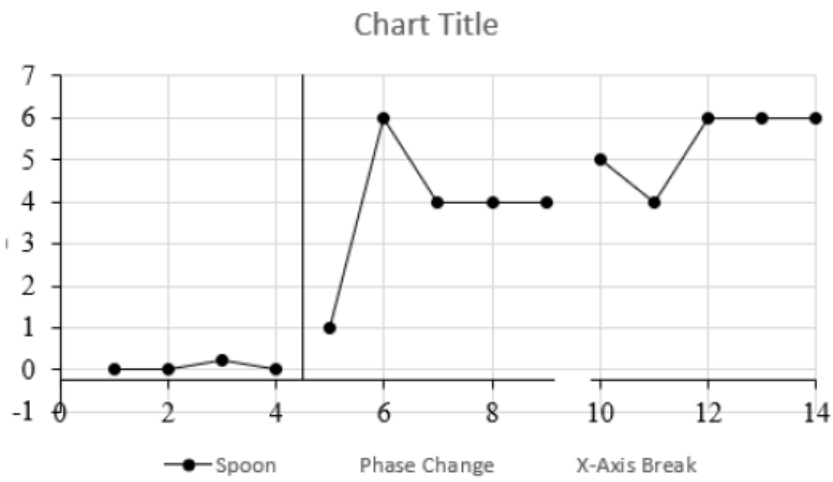
b. Click "Fill" so its sub-options appear.

i. Next to "Color," click the icon and click "White, Background 1." This title should appear when hovering over the correct color, and this can be found in the first row of colors.

c. Click "Border" so its sub-options appear.

i. Click "No line."



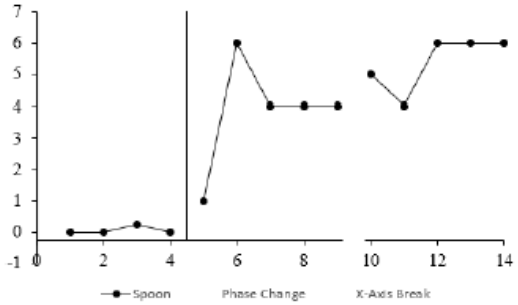


10. Delete chart junk.

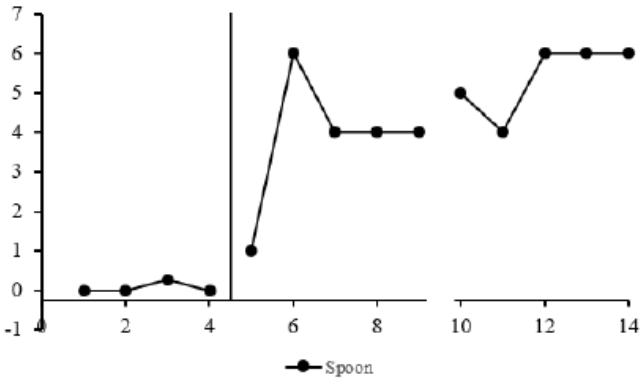
a. Repeat Step #3 (see p. 2) and click "Chart Title."
   i. Click "Backspace" on your keyboard.

b. Repeat Step #10a (see above) for:
   i. "Horizontal (Value) Axis Major Gridlines;" and,
   ii. "Vertical (Value) Axis Major Gridlines.

c. Repeat Step #3 (see p. 2) and click "Chart Area."
   i. Within the formatting window, click "Chart Options," located just below "Format Chart Area" and to the left of "Text Options."
      1. Click "Fill & Line" – the spilling paint icon.
         a. Click "Border" so its sub-options are available.
            i. Click "No line."



d. Repeat Step #3 (see p. 2) and click "Legend."
   i. Within the physical legend on the graph, click specifically on "Phase Change."
      1. Click "Backspace" on your keyboard.
   ii. Repeat Step #10di (see above) but within the physical legend on the graph, click specifically on "X-Axis Break."
      1. Click "Backspace" on your keyboard.
   iii. Repeat Step #3 (see p. 2) and click "Legend."
   iv. Click "Home," located at the top, left of your Excel document.
      1. Above "Font,"
         a. Click the down arrow next to the font textbox and click "Times New Roman." You may have to scroll down within this drop-down menu.
         b. Click the down arrow next to the font size textbox and click "10."
         c. Click the down arrow next to underlined letter A and click "Black, Text 1."



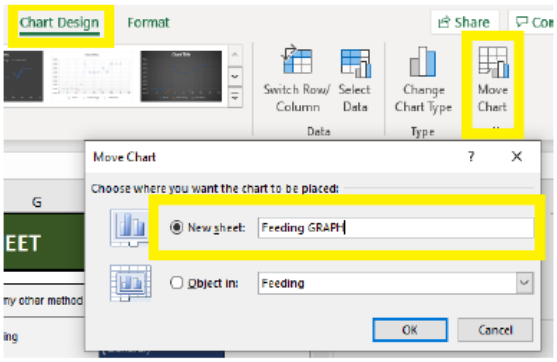
11. Relocate graph to its own, graph-specific tab.

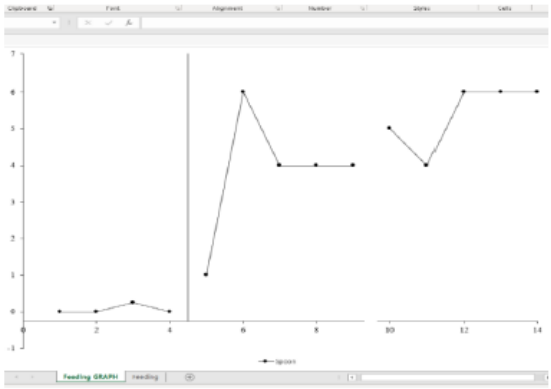
a. Click on the graph.

b. Click "Chart Design" (or "Design"), located at the top, center of your Excel document.

   i. Above "Location," click "Move Chart."

      1. Click "New sheet:"
      2. Rename this new sheet the Target Category abbreviation (i.e., what is written on your tab; e.g., "Feeding") followed by "Graph" (e.g., Feeding Graph).
      3. Click "OK." The graph should now appear in its own tab.



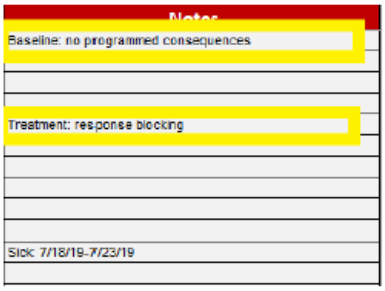


12. Titling phases and axes.

a. Click on tab at the bottom of your Excel document associated with the Data Entry Sheet and write down:

i. What your Target Category and Data Analysis are; and,

ii. What baseline and treatment consisted of (e.g., no programmed consequences, DRA, token system) – this information should appear next to "Baseline" and "Treatment" in the column under the red, data-header section "Notes."

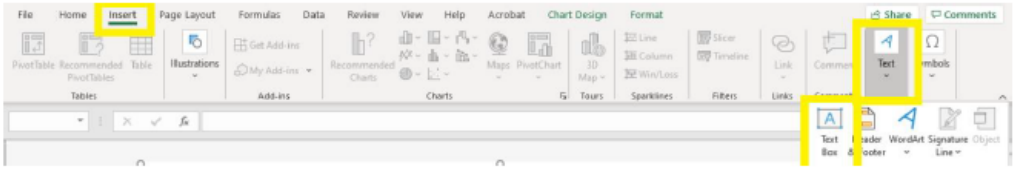


b. Click on tab at the bottom of your Excel document associated with the Graph.

i. Title the x-axis.

1. Click "Insert," located at the top, left of your Excel document.

a. Above "Text," click "Text Box." This may also appear as an italicized A within a box – click that icon and then click "Text Box."



b. Click on the graph. A text box should appear.

c. Type "Sessions."

2. Click on the grey outline of the text box.

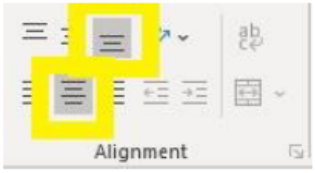
3. Click "Home," located at the top, left of your Excel document.

a. Above "Font,"

i. Click the down arrow next to the font textbox and click "Times New Roman." You may have to scroll down within this drop-down menu.

ii. Click the down arrow next to the font size textbox and click "14."

iii. Click the down arrow next to underlined letter A and click "Black, Text 1."



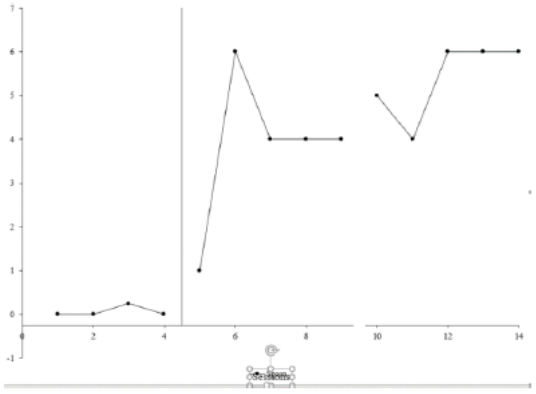
b. Above "Alignment,"

i. Click "Bottom Align" (this appears when you hover over the correct icon).

ii. Click "Center" (this appears when you hover over the correct icon).

4. Resize the text box so there is relatively no unused space above or below the title.

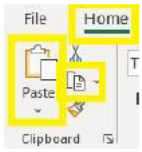
5. Drag the text box so it is centered and flush with the bottom of the page.



ii. Title the y-axis.

12bii1-3. Copy-and-Paste
You will be required to copy-and-paste a variety of text here on out. **Repeating these steps will be stated as "copy-and-paste."**

1. Click on the text box you created for the x-axis title.
2. Click again on the grey outline of the text box.
3. Click "Home," located at the top, left of your Excel document.



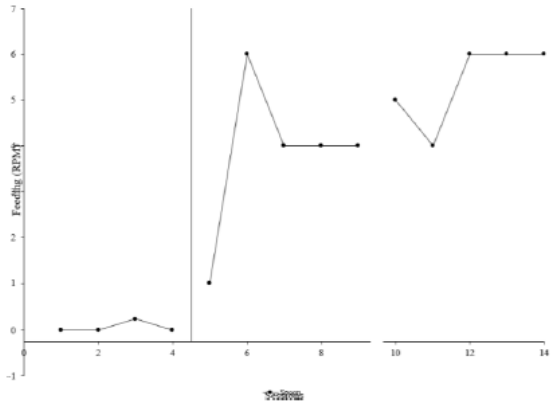
   a. Above "Clipboard,"
      i. Click "Copy" (this appears when you hover over the correct icon).
      ii. Click "Paste" (this appears when you hover over the correct icon).
      iii. A copy of the text box you created for the x-axis title should appear.
4. Highlight the text within the new text box and type Target Category (e.g., Feeding) – the first letter of each word being capitalized – followed by the method of data analysis in parentheses (e.g., [RPM]).

12bii. Titling Y-Axis
Data analyzed as a rate should be titled RPM or RPH, for example. Data analyzed as cumulative can just be titled

5. Rotate the text box until 270°, or until the text is vertical and facing the y-axis.

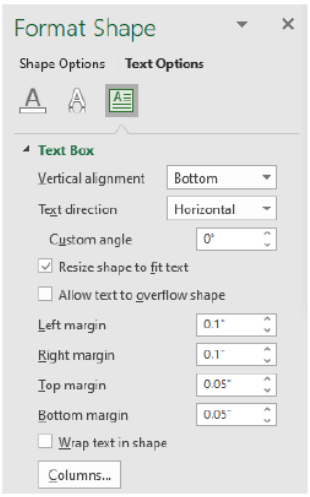
12bii. Rotating the Text Box
You may need to drag the text box so that it is in the middle of the screen in order to see the rotating arrow.

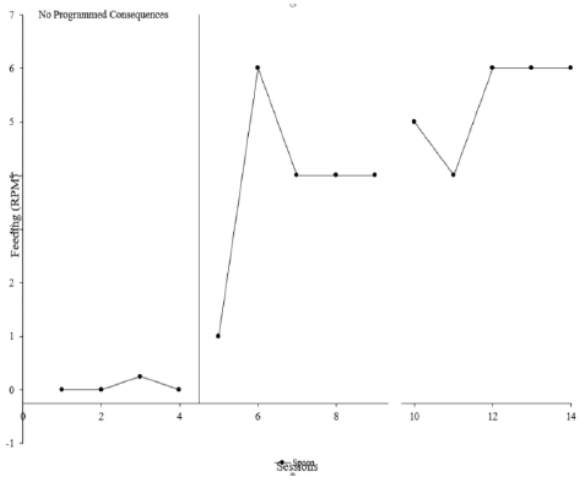
   a. Hold "Shift" on your keyboard and click and hold on the rotating arrow icon located just outside the text box (a rotating arrow should appear when you hover over the correct icon).
   b. Rotate until the text is vertical and facing the y-axis – let go of your click and "Shift."
6. Drag the text box so it is centered and flush to the far left of the page.



iii. Title the baseline condition.

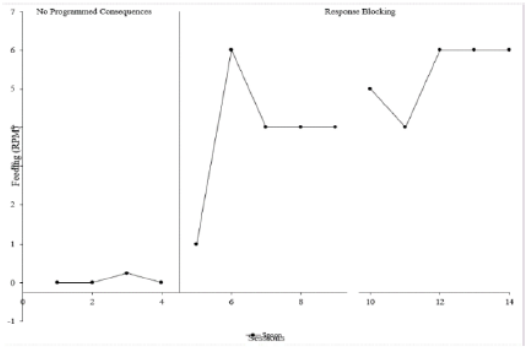
1. Copy-and-paste the text box you created for the x-axis title (see Box #12bii1-3 if needed).
2. Highlight the text within the new text box and type what the baseline consisted of (e.g., no programmed consequences) with the first letter of each word being capitalized.
3. Click on the grey outline of the text box.
4. Click "Home," located at the top, left of your Excel document.
    a. Above "Font," click the down arrow next to the font size textbox and click "12."
5. Drag the text box so it is centered between the y-axis as the phase change line, and flush against the top of the page.
6. Within the formatting window, click "Text Options," located just below "Format Shape" and to the right of "Shape Options."
    a. Click "Textbox" – the A within a document icon.
        i. Click "Text Box" so its sub-options are available.
            1. Click the checkbox next to "Resize shape to fit text" so it is now checked.
            2. Unclick the checkbox next to "Allow text to overflow shape" so it is now not checked.





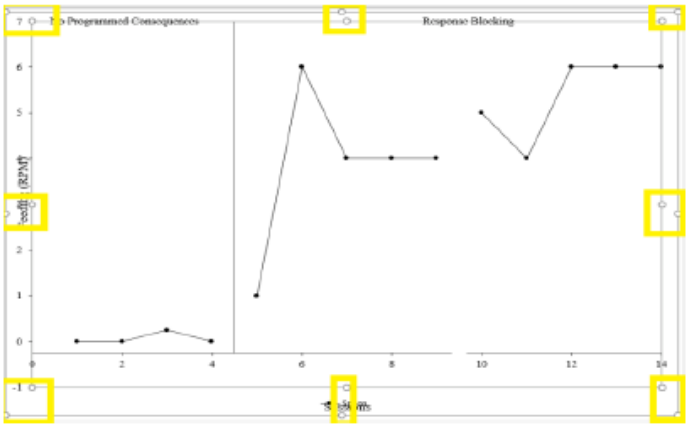
iv. Title the treatment condition.

1. Copy-and-paste the text box you created for the baseline condition (see Box #12bii1-3 if needed).
2. Highlight the text within the new text box and type what the treatment consisted of (e.g., prompt fading, BST, token system) with the first letter of each word being capitalized.
3. Drag the text box so it is centered between the phase change line and the end of the graph and located at the top of your page.



13. Resize graph and placement of legend.

a. Click within the graph such that the graph becomes outlined with white circles at all corners of the graph, as well as white circles in the middle of all four sides of the outline. The page itself will also be outlined with the same white circles.



i. Click and hold on the white circle located in the middle, top of the graph's outline, just above the middle of the graph. A black "+" should appear.

1. Drag the top of the graph until it is just below your phase change titles.

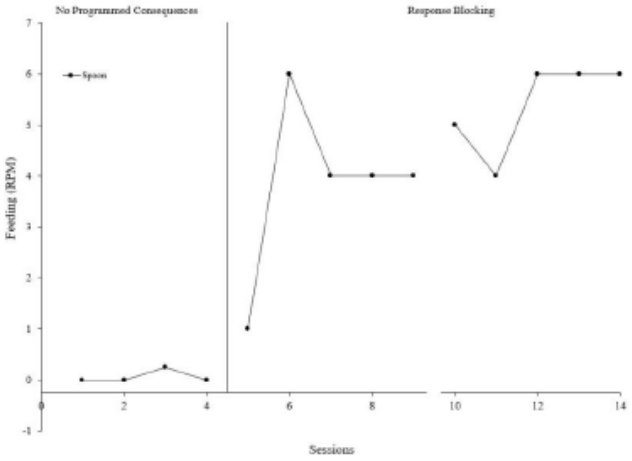
ii. Click and hold on the white circle located in the middle, left of the graph's outline, just to the right of the y-axis labels (i.e., the numbers) the middle of the y-axis. A black "+" should appear.

iii. Drag the left side of the graph until the y-axis labels (i.e., the numbers) are just to the right of your y-axis title.

b. Re-center the phase change titles as needed.

c. Click on the legend and drag it into the graph area so it can clearly be read and does not interfere with any data points, data paths, axes, etc.

13c. Legend Placement
Do not place your legend in the bottom right of your graph because your graph title will go here during the next step.



14. Titling graphs.

a. Click on tab at the bottom of your Excel document associated with the Data Entry Sheet and write down the details within (e.g., client name, location of sessions) – this information should appear in the "General Notes."

b. Click on tab at the bottom of your Excel document associated with the Graph.

i. Copy-and-paste the text box you created for the baseline condition (see Box #12bii1-3 if needed).

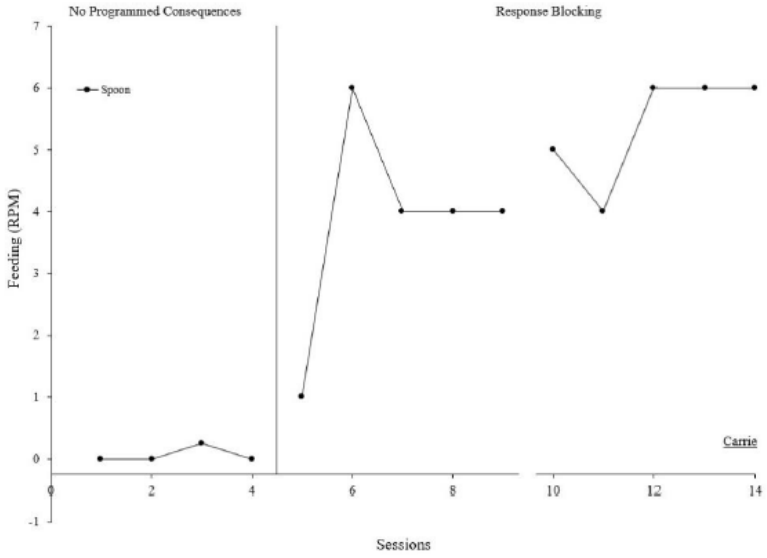
ii. Highlight the text within the new text box and type what your General Notes said to better describe the graph (e.g., Jackson, Lunch, Clinic) with the first letter of each word being capitalized.

iii. Click on the grey outline of the text box.

iv. Click "Home," located at the top, left of your Excel document.

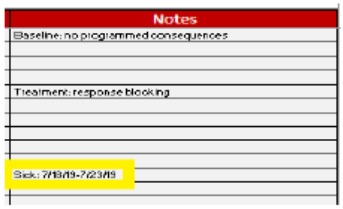
1. Above "Font," click the underlined U icon to underline your graph's title.
2. Above "Alignment," click "Align Right" (this will appear when hovering over the correct icon).

v. Drag the text box so it is to the far right of your graph and does not interfere with any data paths, either just above your x-axis or above your y-axis.



15. Adding descriptive notes and arrows.

a. Click on tab at the bottom of your Excel document associated with the Data Entry Sheet and write down why you broke the x-axis – this information should appear in the column under the red, data-header section "Notes."



b. Click on tab at the bottom of your Excel document associated with the Graph.

c. Add descriptive text box to explain important information.

   i. Copy-and-paste the text box you created for the baseline condition (see Box #12bii1-3 if needed).

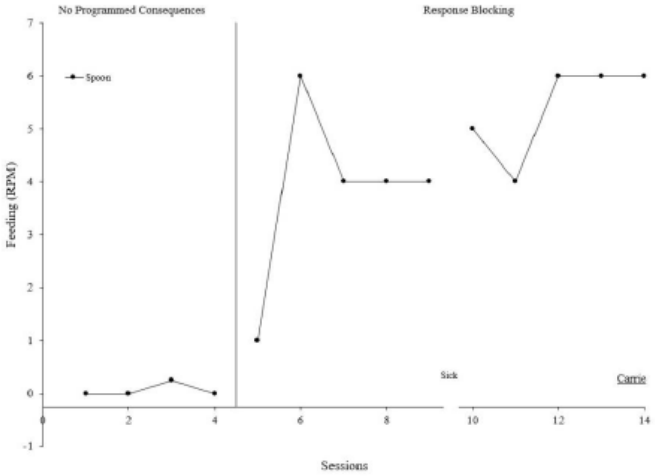
   ii. Highlight the text within the new text box and type why you broke your x-axis (e.g., Break, Sick).

   iii. Click on the grey outline of the text box.

   iv. Click "Home," located at the top, left of your Excel document.

      1. Above "Font," click the down arrow next to the font size textbox and click "10."

   v. Drag the text box so it is slightly above x-axis break on your graph.

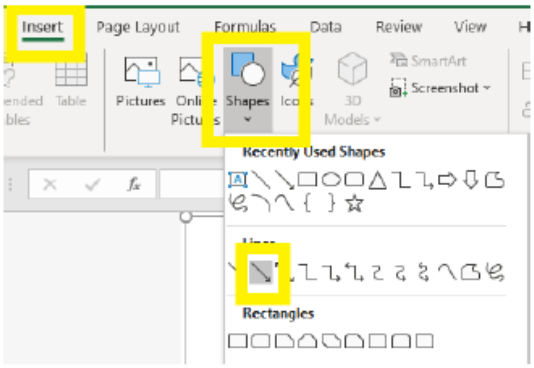


d. Add an arrow to help associate the descriptive text box to the location which you are describing.

   i. Click "Insert," located at the top, left of your Excel document.

      1. Above "Illustrations," click "Shapes." You may have to click "Illustrations" first.

         a. Under "Lines," click "Line Arrow" (this will appear when hovering over the correct icon).



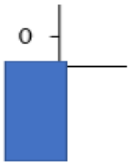
2. Click and hold just below your descriptive note and drag to where on the graph you want this note associated – let go of your click. The arrow should appear pointing to that location.

ii. Click "Shape Format," or "Format," located at the top, middle of your Excel document.

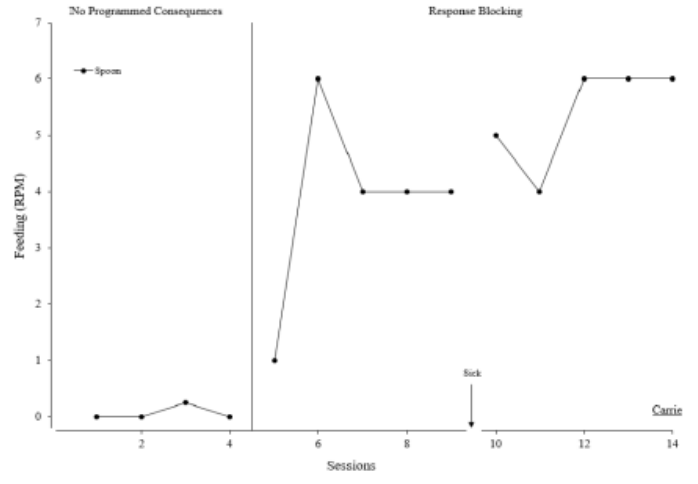
1. Above "Shape Styles," click "Shape Outline."
    a. Below "Theme Colors," click "Black, Text 1" (this will appear when hovering over the correct icon).
2. Above "Shape Styles," click "Shape Outline" again.
    a. Click "Weight."
        i. Click "1 pt."

16. Separate X- and Y-Axes.

a. Click "Insert," located at the top, left of your Excel document.
   i. Above "Illustrations," click "Shapes." You may have to click on "Illustrations" first.
      1. Under "Rectangles," click "Rectangle" (this will appear when hovering over the correct icon).
   ii. Click and hold just under and to the left of the 0 on the y-axis and drag until your rectangle covers the 0 of the x-axis and the any numbers less than 0 appearing on your y-axis.



b. Click "Shape Format," located at the top, center of your Excel document.
   i. Above "Shape Styles," click "Shape Fill."
      1. Below "Theme Colors," click "White, Background 1" (this will appear when hovering over the correct icon).
   ii. Above "Shape Styles," click "Shape Outline."
      1. Click "No Outline."

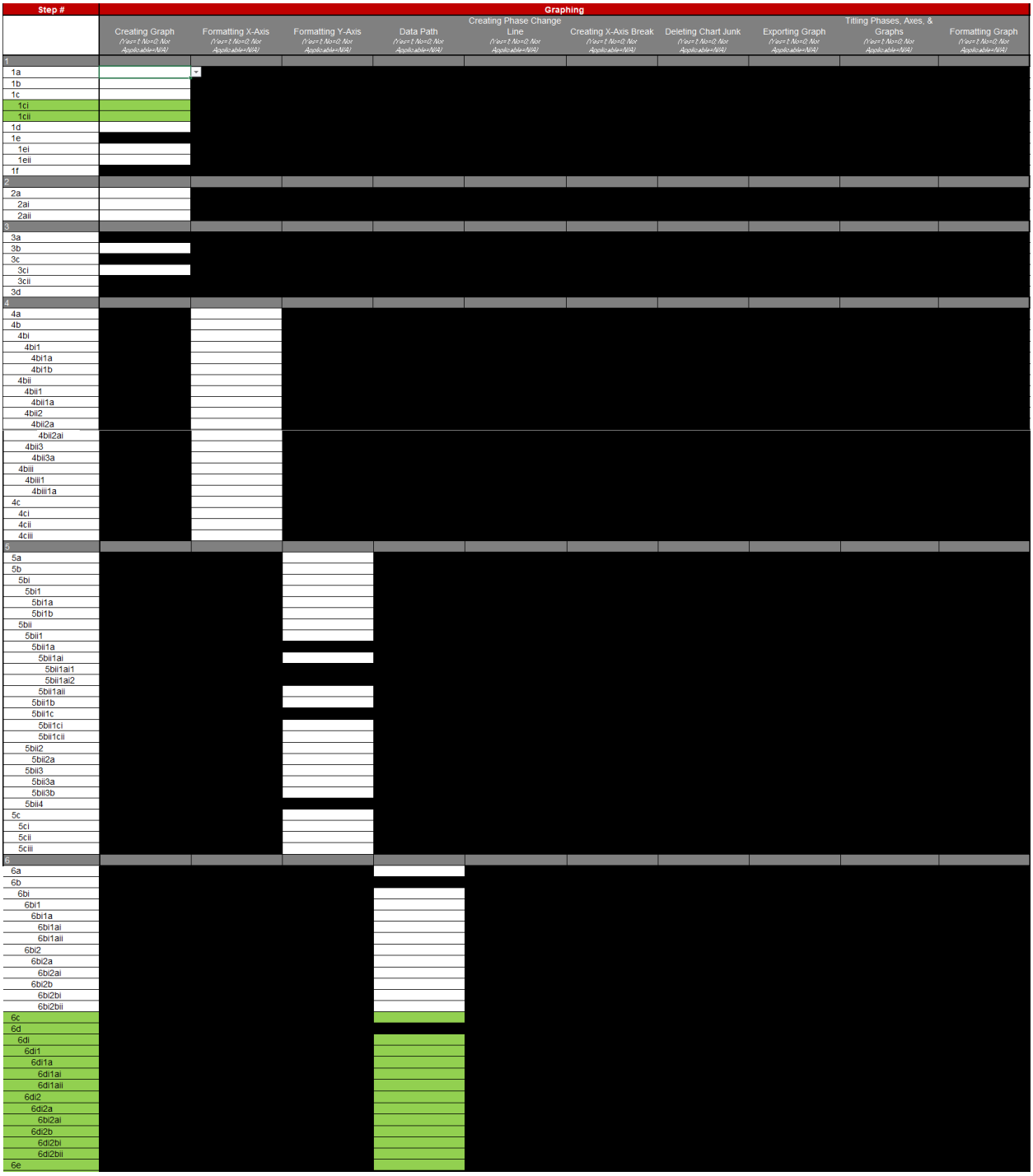


YOU ARE COMPLETE!

OPEN THE SESSION START & STOP PROMPT!
SAVE YOUR DOCUMENT!
Click "File," located in the top, left of your Excel document, then click "Save."

Appendix N

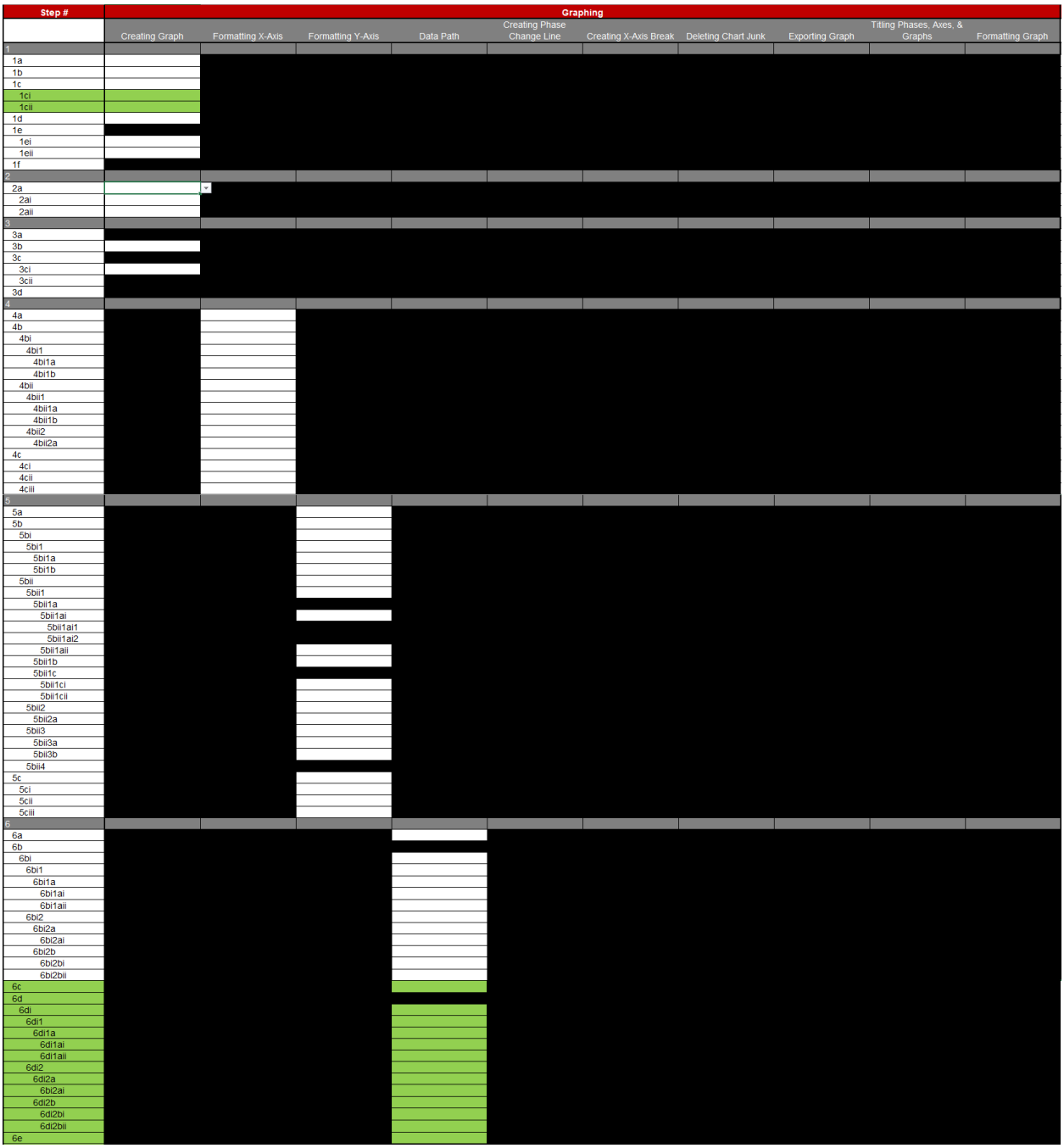
Sample Real-Time Data Collection Sheet (Dates)



Note. There were 205 real-time steps for scaling dates to the *x*-axis; Green cells represent generalization steps.

Appendix O

Sample Real-Time Data Collection Sheet (Sessions)



Note. There were 200 real-time steps for scaling sessions to the *x*-axis; Green cells represent generalization steps.

Appendix P

Sample Live-Excel Data Collection Sheet

Component	Live Excel
X-Axis	#DIV/0!
	#DIV/0!
Line	
Color: black	
Width: 1 pt.	
Axis	
Labels: best fit data	
Ticks: outside	
Font	
Font: Times New Roman	
Color: black	
Size: 12 pt.	
Y-Axis	#DIV/0!
	#DIV/0!
Line	
Color: black	
Width: 1 pt.	
Axis	
Labels: best fit data	
Ticks: outside	
Axis Cross: best fit data	
Decimals: accurate	
Font	
Font: Times New Roman	
Color: black	
Size: 12 pt.	
Data Path	#DIV/0!
	#DIV/0!
Topography 1	
Line	
Color: black	
Width: 1 pt.	
Marker	
Color: black	
Border Color: black	
Border Width: 1 pt.	
Broken Data Path	
Broken: phase change	
Topography 2	
Line	
Color: black	
Width: 1 pt.	
Marker	
Color: white	
Border Color: black	
Border Width: 1 pt.	
Broken Data Path	
Broken: phase change	
Topography 3	

Note. There were 86 live-Excel steps for scaling dates and sessions to the *x*-axis; Green cells represent generalization steps.

Appendix Q

Sample Permanent Product Data Collection Sheet

Component	Permanent Product
X-Axis	#DIV/0!
	#DIV/0!
Line	
Color: black	
Width: 1 pt.	
Axis	
Labels: best fit data	
Ticks: outside	
Font	
Font: Times New Roman	
Color: black	
Size: 12 pt.	
Y-Axis	#DIV/0!
	#DIV/0!
Line	
Color: black	
Width: 1 pt.	
Axis	
Labels: best fit data	
Ticks: outside	
Axis Cross: best fit data	
Decimals: accurate	
Font	
Font: Times New Roman	
Color: black	
Size: 12 pt.	
Data Path	#DIV/0!
	#DIV/0!
Topography 1	
Line	
Color: black	
Width: 1 pt.	
Marker	
Color: black	
Border Color: black	
Border Width: 1 pt.	
Broken Data Path	
Broken: phase change	
Topography 2	
Line	
Color: black	
Width: 1 pt.	
Marker	
Color: white	
Border Color: black	
Border Width: 1 pt.	
Broken Data Path	
Broken: phase change	
Topography 3	

Note. There were 75 permanent product steps for scaling dates and sessions to the *x*-axis; Green cells represent generalization steps.

Appendix R

Procedural Integrity Data Sheet

Participant: **Date:**

Session #: **Condition & Data Set:**

Proctor: **Reli observer:**

---

1. **All Materials Delivered:** Y N

2. **Appropriate Materials Delivered:** Y N

3. **Session Terminated Correctly:** Y N

CALCULATION: (# of Y's / # of total steps) X 100

Appendix S

Pre-Study Questionnaire

The Neidert Lab
Edna A. Hill Child Development Center
Applied Behavioral Science Department
1000 Sunnyside Avenue
Lawrence, KS 66045-7555

PRE-STUDY SOCIAL VALIDITY QUESTIONNAIRE

"Enhanced Written Instructions for Creating Publication-Quality, Single-Case Design Graphs in Microsoft Excel"

Instructions

You have been identified as an individual whose responsibilities include, or may include in the future, graphing of single-subject data. You have also given pre-consent to participate in the current study. Therefore, we would like to know more about your current or future position. **Please do not write your name for purposes of anonymity.** The primary researcher will contact you with whether or not you have been selected for participation following your submission of this pre-study questionnaire.

Questionnaire

Demographics

1. What is your age (in years)? _____

2. What is your highest educational degree? (circle one)

High School/GED	Some College	2-yr College
4-yr College/University	Master's	Doctoral

3. What is your current position*? (circle one)

RBT BCBA Line Therapist/Paraprofessional^ Teacher^ Other^

^Briefly describe your position: _____

**RBT: credentialed Registered Behavior Technician through the BACB BCBA: credentialed Board Certified Behavior Analyst through the BACB*
Line Therapist/Paraprofessional: you work 1:1 with children but do not currently hold a certification in behavior analysis
Teacher: lead or assistant in a classroom for children, adolescents, or adults
Other: anything not covered above (e.g., Clinical Supervisor, University Faculty, Researcher, Research Assistant)

Graphing Data

4. Does your current position require you to graph data?

Yes No

5. If you answered No to #4, do you foresee yourself having a position where you might be required to enter data electronically?

Yes No

6. If you answered Yes to #4, how are data graphed?

Pencil & Paper Microsoft Excel GraphPad Prism SigmaPlot Other: _____

7. Have you, in any capacity, used Microsoft Excel before for the purposes of graphing?

Yes No

-over-

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8. If you answered Yes to #7, were you responsible for creating graphs from input data?

Yes No

9. To your knowledge, have you ever been trained using self-directed training procedures, more specifically, enhanced written instruction (EWI)?

Yes No

Importance of Graphing (1 = low; 3 = moderate; 5 = high)

10. It is important for individuals to be able to graph data in order to efficiently make data-based decisions?

n/a 1 2 3 4 5

11. A formal training in entering and graphing data will help me with my current, or future, responsibilities as a professional?

n/a 1 2 3 4 5

Appendix T

Post-Study Questionnaire

The Neidert Lab
Edna A. Hill Child Development Center
Applied Behavioral Science Department
1000 Sunnyside Avenue
Lawrence, KS 66045-7555

POST-STUDY SOCIAL VALIDITY QUESTIONNAIRE

"Enhanced Written Instructions for Creating Publication-Quality, Single-Case Design Graphs in Microsoft Excel"

Instructions

You have now completed the current study in which enhanced written instructions (EWI) was implemented to help increase the skills required to create single-subject graphs in Microsoft Excel. We would like to know how you perceived these treatments in terms of effectiveness. Answering the following questions honestly and in detail should help us gain a better understanding of what you believe to be the pros and cons to EWI as a self-directed training procedure. **Please refrain from writing your name on this questionnaire to allow for anonymity.**

Questionnaire (1 = low/disagree; 3 = moderate/neutral; 5 = high/agree)

1. How effective were the individual components of EWI in helping you complete the study's procedures?
   a. Limited technical jargon

   1 2 3 4 5

   b. Pictures/diagrams

   1 2 3 4 5

   c. Brief explanations (additional information & note boxes)

   1 2 3 4 5

2. Do you think EWI is good self-directed training procedure to be implemented in similar situations such as yours (i.e., for individuals currently or likely to be required to enter and graph data)?

   1 2 3 4 5

3. EWI could be made better as a self-directed training procedure.

   1 2 3 4 5

4. Why is EWI, or why is EWI not, a good self-directed training procedure to be implemented in similar situation such as yours?

5. Do you think that EWI was effective in teaching you skills toward the creation and maintenance of graphs?

   1 2 3 4 5

6. EWI was relatively easy to follow

   1 2 3 4 5

-over-

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Applied Behavioral Science Department
1000 Sunnyside Avenue
Lawrence, KS 66045-7555

7. Did you observe your own behavior change?

1 2 3 4 5

8. What behavior changes did you observe? Did these changes make a difference in your graphing behavior?

9. How confident are you that you could now adequately, confidently, and independently complete similar procedures to those outlined within the study without the use of the study materials?

1 2 3 4 5

10. How likely are you to reference these materials again in the future?

1 2 3 4 5

11. Are you satisfied with the outcomes of EWI?

1 2 3 4 5

12. Why are you, or why are you not, satisfied with the outcomes of EWI?

13. How well would EWI work to increase similar skills in the future or with other individuals?

1 2 3 4 5

14. Why would EWI, or why would EWI not, work well to increase similar skills in the future or with other individuals?

15. Would you recommend EWI as self-directed training procedures to other individuals with similar responsibilities as yourself?

1 2 3 4 5

16. Why would you, or why would you not, recommend EWI as a self-directed training procedure to other individuals with similar responsibilities as yourself?

Questionnaire adapted from:

Gresham, F. M., & Lopez, M. F. (1996). Social validation: A unifying concept for school-based consultation research and practice. *School Psychology Quarterly, 11*(3), 204-227.