Description and Validation of a Computerized Behavioral Data Program: “BDataPro”

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Abstract BDataPro is a Microsoft Windows®-based program that allows for real-time data collection of multiple frequency- and duration-based behaviors, summary of behavioral data (in terms of average responses per min, percentage of 10-s intervals, and cumulative responses within 10-s bins), and calculation of reliability coefficients. The current article describes the functionality of the program. BDataPro is freely available for download from the authors’ institution websites.

Keywords Computerized data collection · Data analysis · Data collection validation · Observational data

Observing, recording, and quantifying behavior is fundamental to behavior-analytic practice and research. Computerized data collection programs are advantageous to behavior analysts as a means to obtain precise behavioral data while automating data analysis (Kahng & Iwata, 1998). The need for precise and efficient data collection tools has become particularly acute with the recent rise

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in the number of individuals with autism or developmental disabilities and rapid increase in Board Certified Behavior Analysts (BCBAs) that provide behavioral treatments (Boyle et al., 2011; Maenner & Durkin, 2010; Shook & Favell, 2008). Although many programs exist that allow computerized data collection, these programs can encumber users with both the costs of the software itself (often on a per user basis) and the equipment required for software operation. The purpose of this paper is to describe an observational data collection program that is readily adaptable for use in clinical or research environments and that can run on both modern and older Microsoft Windows® PC computers. BDataPro is the product of a long collaboration between the authors whose goal was to design a behavioral data collection and analysis program for the Monroe-Meyer Institute Center for Autism Spectrum Disorders and the Kennedy Krieger Institute's neurobehavioral programs. BDataPro has now been in use in these institutions' clinical and research programs for several years. The authors of BDataPro have shared it with numerous colleagues and with the publication of the current article, and are making it freely available (along with a detailed user manual and source code) to download.

BDataPro allows for precise measurement of behavior, storage and organization of electronic data files, and automated data analysis. Real-time data can be collected for multiple frequency- and duration-based behaviors. Following an observational session, summary statistics are automatically calculated for collected data (e.g., average responses per min, percentage of 10-s intervals, and cumulative responses within 10-s bins). The program also will quickly calculate reliability coefficients for two observers of a session (Hartmann, 1977). BDataPro is designed to occupy the middle ground between simplified data collection systems (e.g., paper and pencil, hand-held devices; see Kelly, 1977) and more comprehensive data collection systems that have integrated data analysis, graphing, video, and database features (Noldus et al., 2000). Given its accessibility and ease of use, BDataPro should be of value to both researchers and practitioners working independently or in larger organizations. What follows is an overview of the program's functionality and capabilities.

Data Collection and Analysis Program

BDataPro is a computer program written with Microsoft Visual Basic 6.0® that is designed to collect observational behavior data, generate summary data, and calculate reliability coefficients across observers. The program has been installed successfully across a range of windows operating systems including Windows XP®, Windows 7®, Windows 8®, and Windows 10®. Further, the program requires a relatively modest computer system in order to run (e.g., we ran the program on laptop computers with Pentium-2 processors and 512 k of memory).

The program's functionality is described with respect to (a) collection and organization of demographic and session information for the individual being observed; (b) customizable arrangement of the keyboard such that most keys can function to record either a discrete occurrence of a behavior (frequency) or an ongoing behavior (duration); and (c) the collection, storage, and analysis of frequency and/or duration of behaviors recorded.

Demographic and Session Information

Data files generated for each session begin with a header that contains demographic and session information. Information concerning the details of an observational session includes the following: name, record number (or other ID number), the primary researcher or clinician name, supervisor, date, time, location, and the conditions currently in effect.

Customizable Arrangement of Keyboard

A user specifies keyboard keys that are depressed to record each behavior of interest. A key is designated as either a frequency key, used to record the number of occurrences of a behavior when each occurrence is treated as an instantaneous event, or a duration key, used to record the duration of a bout of behavior. The program records the time of occurrence for each key press (relative to the beginning of the session with 1/10th of a second resolution). See Fig. 1 for a screenshot of the key assignment portion of the program.

Data Organization

The first time BDataPro is run on a computer, a folder called “BDataPro” is created on the local hard drive (C: Drive) into which a data file for each observational period (session) is stored. Prior to collecting data, a user is required to specify the name of the individual on which data are collected, an assessment name, and a condition name. A subfolder is then created within the BDataPro folder corresponding to the individual

Go back to main menu

Create a customized keyboard setup file (KSF).

Select client / participant:

To create a new KSF fill in the fields below.
To modify an existing KSF, select an item from the list to the right.

Modify an existing KSF:

Key Type: Key: Key description:

Active during Session? Active during Pause?

Frequency Keys					Duration Keys				
Key Type	Key	Description	Pause Enabled	Session Enabled	Key Type	Key	Description	Pause Enabled	Session Enabled
f	S	SIB	yes	yes	d	T	Tantrum	yes	yes

Enter KSF save name:

Fig. 1 Program screen when making a keyboard setup file

observed. Within the individual's folder, a subfolder is created corresponding to the assessment name, and within this assessment folder, a subfolder is created with the corresponding condition name. For example, if one were taking data on an individual's behavior at school when in class and during recess, one might name the assessment "School" while the condition names would be "Class" and "Recess." In this example, data taken during "Class" would be saved within the "School" folder in the "Class" subfolder. To summarize, a separate data file is generated for each observational period or session. Data files are saved to the computer hard drive within folders and subfolders corresponding of the name of the observed individual, name of the assessment, and name of the condition. Multiple assessment subfolders can be created for each individual while multiple condition subfolders can be created for each assessment.

Output and Summary Statistics

For each session, summary data are calculated and transferred into a Microsoft Excel© spreadsheet. The spreadsheet contains the following information: (a) total time in session, (b) total time each duration behaviors occurred, (c) number of bouts of each duration behavior, (d) percentage of intervals during which a duration behavior was recorded, (e) number of instances each frequency behavior occurred, (f) percentage of 10-s intervals in which a frequency behavior was recorded, and (g) responses per minute for each frequency behavior. See Fig. 2 for a screenshot of the data summary spreadsheet that is automatically generated. In addition, data are presented in terms of absolute and cumulative frequency (or time for duration behaviors) for each behavior as a function of successive 10-s intervals, data that can be used to generate cumulative records of responding (see Fig. 3).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2			Local summary for:	Session										
3			Frequency keys	1	2	3	5	8	9	6	7	d	h	f
4			Frequency	2	0	14	0	0	0	0	0	3	0	0
5			%Intervals	3.33	0	20	0	0	0	0	0	10	0	0
6			RPM	0.4	0	2.8	0	0	0	0	0	0.6	0	0
7														
8														
9			Duration Keys	g	w	e	s	o	u	ST	PT			
10			Time	0	213.8	0	0	151.8	0	300	0			
11			%Intervals	0	76.67	0	0	53.33	0	100	0			
12			%Session	0	71.27	0	0	50.6	0	100	0			
13														
14														
15														
16			Local summary for:	Pause										
17			Frequency keys	1	2	3	5	8	9	6	7	d	h	f
18			Frequency	0	0	0	0	0	0	0	0	0	0	0
19			%Intervals	0	0	0	0	0	0	0	0	0	0	0
20			RPM	0	0	0	0	0	0	0	0	0	0	0
21														
22														
23			Duration Keys	g	w	e	s	o	u	ST	PT			
24			Time	0	0	0	0	0	0	0	0			
25			%Intervals	0	0	0	0	0	0	0	0			
26			%Pause	0	0	0	0	0	0	0	0			

Fig. 2 Session data summary spreadsheet generated by BDataPro

Fig. 3 Graph of cumulative frequency in 10-s bins for a frequency key

Reliability Coefficients

The program will also calculate six types of inter-observer reliability for frequency behaviors and three types for duration behaviors. The types of reliability coefficients calculated are as follows: (a) Exact Interval Agreement, (b) Partial Interval Agreement, (c) Total Interval Agreement, (d) Occurrence Interval Agreement, (e) Non-occurrence Interval Agreement, and (f) Partial Minute Agreement. The formulas for each type of reliability coefficient are included in Appendix A.

The results of the reliability analysis are saved in a spreadsheet that contains the following information: (a) each primary and reliability data file analyzed, (b) the percentage of sessions that have an accompanying reliability file, (c) the individual session reliability calculations for each behavior, (d) the average reliability quotients for each behavior, and (e) a sheet providing the formula and an explanation for each type of reliability calculated. Figure 4 shows a screenshot of the summary reliability output generated.

Validation and Training

BDataPro was tested across different makes and models of PC computers equipped with Microsoft Windows® to ensure accuracy of timing, frequency and duration events, summary statistics, and reliability coefficients. Appendix B provides a description of how the program was tested and validated. In the event that the program is used in computing environments outside of the testing conditions (e.g., Microsoft Windows® emulators or software virtualization). Appendix B provides a moderately quick method (approximately 1 h) by which to test for correct program functioning. Given that the computing environment remains the same, the tests in Appendix B need only be run once.

1	A	B	C	D	E	F	G	H	I	J
2	Client:	test								
3	Assessment:	Demand Treatment Evaluation								
4	Primary Files:	183								
5	Reli Files:	77								
6	Percent with Reli:	42.08								
7										
8										
9										
10	Reli averaged across sessions									
11	Frequency Keys	EIA	PIA	TIA	OIA	NIA	PMA	# of primary files with key	# of reli files with key	% sessions with reli for key
12	1	99.94	99.96	99.98	97.62	99.98	99.96	183	77	42.08
13	2	99.72	99.76	99.78	66.44	99.78	99.23	183	77	42.08
14	3	97.86	98.6	99.16	71.64	99.02	97.63	183	77	42.08
15	4	98.77	98.97	99.16	72.61	99.09	97.39	183	77	42.08
16	7	97.71	98.25	98.9	52.37	98.49	96.84	183	77	42.08
17	0	99.96	99.96	99.96	0	99.96	100	183	77	42.08
18	8	89.91	90.8	91.62	72.69	88.35	90.67	183	77	42.08
19	9	94.46	95.08	95.65	70.77	94.47	93.22	183	77	42.08
20	5	92.92	93.49	94.07	73.35	92.96	93.58	170	68	37.16
21	6	97.95	98.17	98.38	68.21	98.15	97.45	159	65	35.52
22										
23	Duration Keys: Duration EIA intervals rounded to nearest second									
24	q	94.91	95.8				94.72	183	77	42.08
25	r	93.42	95.66				93.99	183	77	42.08
26	s	98.57	98.81				98.44	183	77	42.08
27	t	97.81	98				96.69	183	77	42.08
28	o	99.59	99.69				99.2	183	77	42.08
29	h	99.2	99.34				98.2	183	68	37.16
30	d	99.35	99.48				99.13	183	77	42.08
31	b	94.44	96.08				94.38	183	30	16.39
32	ST	91.86	94.3				92.39	183	77	42.08
33	PT	96.5	97.82				96.85	183	77	42.08
34										
35										
36										
37										
38										
39										

Fig. 4 Output produced by computing inter-observer reliability. *EIA* Exact Interval Agreement, *PIA* Partial Interval Agreement, *TIA* Total Interval Agreement, *OIA* Occurrence Interval Agreement, *NIA* Non-occurrence Interval Agreement, *RPMA* Responses per Minute Agreement

Behavioral data collection, however, requires more than an accurate data collection program. The importance of training data collectors to accurately record observations cannot be overstated. Established professional standards in the field of behavior analysis concerning data collection (Lerman et al., 2010; Repp et al., 1988) discuss the importance of developing objective operational definitions, training observers to criterion, and ongoing assessment of inter-observer agreement. Training procedures and operational definitions should always be reviewed carefully prior to beginning behavioral data collection.

Availability of BDataPro

It has become increasingly common across scientific fields to make programs used for data acquisition and analysis freely available. Providing free access to computer programs and code (open source) used in research reduces effort involved replication by removing the burden of redeveloping a program that already exists (Barnes, 2012; Ince et al., 2012). BDataPro has been made freely available in order to facilitate both clinical and research endeavors which involve behavior data acquisition and analysis. Source code for BDataPro and the program itself are freely available to download on the Behavior Analyst website (<https://www.kennedykrieger.org/BDataPro>).

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Compliance with Ethical Standards

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest The authors declare that they have no conflict of interest.

Appendix A

Reliability Calculation Formulas

Frequency Behavior Reliability Calculations

a. EIA—Exact Interval Agreement

1. Divide sessions into successive 10-s intervals.
2. An agreement is scored for an interval if both observers record the same number of responses (e.g., both recorded zero responses; both recorded three responses).
3. The total agreements and disagreement for a session is then put into the following formula:

$$(\text{Number of agreements} / (\text{Number of agreements} + \text{Number of disagreements})) \times 100.$$

b. PIA—Partial Interval Agreement

1. Divide sessions into successive 10-s intervals.
2. For each interval, the lower number of responses recorded is divided by the higher number. If both observers record zero responses, a ratio of 1.0 is substituted.
3. The ratios are summed and divided by the number intervals in the session and then multiplied by 100.

$$(\text{Sum of ratios} / \text{Number of intervals}) \times 100$$

c. TIA—Total Interval Agreement

1. Divide sessions into successive 10-s intervals.
2. For each interval, an agreement is scored if both observers record at least one response or if both record zero responses. A disagreement is scored if one observer records at least one response and the other records zero responses.
3. The total agreements and disagreement for a session is then put into the following formula:

$$(\text{Agreements} / (\text{Agreements} + \text{Disagreements})) \times 100.$$

d. OIA—Occurrence Interval Agreement

1. Calculated in the same manner as total agreement except that only intervals in which at least one response was recorded are included (i.e., if both observers recorded zero responses, that interval would be excluded).

$$(\text{Agreements} / (\text{Agreements} + \text{Disagreements})) \times 100$$

e. NIA—Non-occurrence Interval Agreement

1. Calculated in the same manner as total agreement except that only intervals in which at least one of the observers recorded zero responses are included (i.e., if both observers recorded at least one response in the interval, that interval would be excluded).

$$(\text{Agreements} / (\text{Agreements} + \text{Disagreements})) \times 100$$

f. RPMA—Responses per Minute Agreement

1. Divide sessions into successive 60-s intervals.
2. An agreement is scored for an interval if both observers record the same number of responses (e.g., both recorded zero responses; both recorded three responses).
3. The total agreements and disagreements for a session is then put into the following formula:

$$(\text{Number of agreements} / (\text{Number of agreements} + \text{Number of disagreements})) \times 100.$$

Duration Behavior Reliability Calculations

a. EIA—Exact Interval Agreement

1. Divide sessions into successive 10-s intervals.
2. An agreement is scored if both observers recorded exactly the same duration (rounded to the nearest 1 s) of the target response in that interval (e.g., both recorded 0 s; both recorded 3 s).
3. The formula for exact agreement is as follows:

$$(\text{Agreements} / (\text{Agreements} + \text{Disagreements})) \times 100.$$

b. PIA—Partial Interval Agreement

1. Divide sessions into successive 10-s intervals.

2. For each interval, the lower number of responses recorded is divided by the higher number. If both observers record zero responses, a ratio of 1.0 is substituted.
3. The ratios are summed and divided by the number intervals in the session and then multiplied by 100.

$$(\text{Sum of ratios} / \text{Number of intervals}) \times 100$$

c. PMA—Partial Minute Agreement

1. Divide sessions into successive 10-s intervals.
2. For each interval, the lower number of responses recorded is divided by the higher number. If both observers record zero responses, a ratio of 1.0 is substituted.
3. The ratios are summed and divided by the number intervals in the session and then multiplied by 100.

$$(\text{Sum of ratios} / \text{Number of intervals}) \times 100$$

Appendix B

Program Validation

BDataPro was tested in order to ensure that (1) the timing is accurate and stable, (2) frequency and duration event recording is accurate, (3) the summary statistics are accurate, (4) the reliability coefficients are accurate, and (5) the program functions consistently across different makes and models of Windows® PC computers.

Testing should occur under conditions similar to those under which the program will be used. For example, users of a data collection program may also have other programs running simultaneously (e.g., web browser and word processor). If other programs may be running at the same time as data collection, then these programs should also be running during testing. What follows is a description of several types of tests that ensure the program is working correctly.

Testing for Accurate Timing, Event Recording, and Data analysis

Accurate recording of behavior and its occurrence in time are fundamental for the collection and analysis of behavioral data. It is critical to confirm that program keeps track of time correctly and consistently. Timing should remain accurate over long periods, independent of how many events are recorded. This can be confirmed with two types of tests referred to here as the “extended timer” and the “events timer” tests. Tests of timing accuracy require a previously validated, independent, timing device (e.g., stopwatch) with which to compare program timing.

Extended Timer Test The extended timer test involves simply starting the data collection program timer and a stopwatch simultaneously. This test should be run for a period of time that exceeds the duration of observational periods for which the data collection program will likely be used. Both timers should indicate the same amount of time having passed at the end of the period.

Events Timer Test The events timer test is designed to ensure that entering events (i.e., pressing a frequency or duration key) does not alter timing accuracy. For this test, two computers equipped with the data collection program can be used and a session should be run that exceeds the likely duration of observations periods for which the program will be used. The data collection program is started on both computers at the same time. For one of the computers, numerous events are recorded while the other computer simply runs the program. Both timers should remain synchronized regardless of the number of events recorded.

Frequency and Duration Events Test This test is designed to examine whether the program output accurately reflects what frequency and duration events were actually entered (i.e., keystrokes). A known number of events should be recorded, across multiple frequency and duration keys, into a computer running BDataPro. The session summary data should correspond to the recorded events.

Summary Statistics Output Test The purpose of this test is to examine the accuracy of calculations of summary statistics across multiple duration and frequency keys. Specifically, this test ensures accuracy of records concerning the total time each duration key is activated, the number of duration key bouts, the percentage of intervals during which a duration key is active, the percentage of intervals each frequency key is pressed, and responses per minute for each frequency key.

Reliability Tests Calculation of inter-observer agreement by independent data collectors is a critical function of any observational data collection program. Examining the accuracy of calculated reliability coefficients should show that both agreement and disagreement of observations between two observers are correctly computed.

A straightforward method of ensuring that reliability between two observers whose data are in agreement is used to compare data from a two identical sessions in which multiple frequency and duration events were recorded. This test involves simply copying and relabeling a data file as a reliability file (simulating a data file generated from a second observer, but with known 100 % reliability). When these two files are compared, the program should indicate that all reliability coefficients are at 100 % agreement. Testing for accurate reliability calculations when observers disagree can be accomplished by comparing data files scored differently. Reliability coefficients for these two files are computed manually and compared to the program calculations. The manual calculations should correspond to those of the program.

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