An Empirical Evaluation of the Disequilibrium Model to Increase Independent Seatwork for an Individual Diagnosed with Autism

Art Dowdy¹ · Kenneth W. Jacobs²

Published online: 24 October 2018
© Association for Behavior Analysis International 2018

Abstract

This brief practice is an evaluation of work output predicted by Timberlake's (1980) disequilibrium model. Jacobs, Morford, King, and Hayes (2017) provided a downloadable, online tool using the disequilibrium model to assist practitioners in maximizing intervention outcomes. The disequilibrium model was used to predict the duration of independent seatwork for Marvin, a 17-year-old boy diagnosed with autism spectrum disorder. The disequilibrium model effectively predicted a work duration that Marvin was compliant with throughout the study. Practitioners should consider using the disequilibrium tool to select intervention parameters.

Keywords Disequilibrium model · Contingent activity · Compliance · Response deprivation · Autism

The disequilibrium approach (Timberlake, 1980), also known as the response deprivation hypothesis (Timberlake & Allison, 1974), defines reinforcement in terms of instrumental and contingent activities. For example, manding may be instrumental in producing access to toys for playing, where play is the contingent activity. If access to play were restricted, then manding for play would increase relative to its typical baseline level of occurrence. Restricted access to play is the “disequilibrium” that an individual works to reduce by engaging in additional instrumental responses such as manding. When manding produces access to a contingent activity such as play with toys, manding for toys is more likely to occur in the future. The disequilibrium approach provides practitioners with a tool to predict that an increase in manding will occur based on at least two conditions: (a) how much an individual usually engages in the contingent activity (e.g., play) and (b) how much we may be able to restrict that activity to produce increases in instrumental responding (i.e., manding).

Practitioners may find the disequilibrium approach useful because of its capability to identify reinforcers based on baseline measures of at least two activities (e.g., how often an individual engages in a play activity versus how often an individual engages in manding behavior). Furthermore, the disequilibrium approach allows practitioners to predict *how much* any given behavior will increase or decrease. The power to predict the magnitude of behavior change has utility for practitioners when selecting and arranging behavioral interventions (e.g., Farmer-Dougan, Langley, Gavin, & Berenbaum, 2017; Konarski, Johnson, Crowell, & Whitman, 1981; Timberlake & Farmer-Dougan, 1991). However, practitioners may be reluctant to use the disequilibrium approach because of its esoteric terminology (e.g., *instrumental* and *contingent activity*) and use of mathematical models to make predictions.

In an attempt to address the clinical boundaries of the disequilibrium approach, Jacobs, Morford, King, and Hayes (2017) provided a tutorial on its terminology and associated models for reinforcement and punishment. Additionally, they offered a Microsoft Excel spreadsheet to easily calculate the predictions based on the disequilibrium approach mathematical model developed by Heth and Warren (1978). Heth and Warren's mathematical model is a *disequilibrium model*, and the Excel spreadsheet uses it to calculate the predicted direction and magnitude of behavior change. The calculation is based on an individual's baseline levels of responding and the practitioner's choice of intervention parameters. Jacobs

This research study was completed at Melmark, Berwyn PA.

✉ Art Dowdy
dowdy@temple.edu

¹ Department of Teaching and Learning, Temple University, 1301 Cecil B. More Ave., Philadelphia, PA 19122, USA

² Department of Psychology/296, University of Nevada, Reno, NV 89557, USA

et al. (2017) provide instructions for the practitioner to input both instrumental and contingent values into the free, online tool (<https://osf.io/knf7x/>) in order to predict the desired intervention effects.

The purpose of this brief practice was to empirically evaluate the disequilibrium model's ability to predict the desired effects of an intervention using Jacobs et al.'s (2017) online Microsoft Excel spreadsheet. Given free-operant, paired-baseline measures of two behaviors, we designated one as instrumental and the other as contingent. Specifically, independent seatwork was designated as the instrumental activity that produced access to watching music videos on an iPad, the contingent activity. Our aim was to increase the duration of independent seatwork by restricting access to the iPad while also making iPad access contingent upon independent seatwork completion. In our study we addressed the following research questions:

1. To what extent does the disequilibrium model accurately predict instrumental activity?
2. What are the effects, in terms of clinical practice, for increasing independent seatwork using the disequilibrium model for an adolescent with autism spectrum disorder (ASD)?

Method

Participant, Setting, and Materials

Marvin was a 17-year-old male diagnosed with ASD, traumatic brain injury, and cerebral palsy. He lived in a residential treatment facility and attended school on the campus. Marvin could vocally communicate his wants and needs using full sentences. He had basic addition and subtraction skills and the ability to read and write sentences when viewing a model of the sentence. Materials used in the study included independent seatwork consisting of basic addition, subtraction, and sentence-copying worksheets. Marvin's teacher reported that whenever Marvin was asked to complete his independent seatwork, he would sit and talk to others in the classroom rather than complete the assigned independent work.

Response Measurement

Observers collected data on laptop computers using BDataPro™ (Bullock, Fisher, & Hagopian, 2017) for all sessions. Duration data were collected on independent seatwork engagement and iPad engagement. The dependent variable, independent seatwork engagement, was defined as the participant seated at his desk, oriented toward his work materials, and manipulating the work material in a functional manner.

iPad engagement was defined as the participant seated at his desk and oriented toward the iPad.

Reliability Data

Interobserver agreement was collected on both independent seatwork engagement and iPad engagement for 86% of baseline sessions and 71% of treatment sessions. Exact interval agreement (EIA) was collected for both independent seatwork engagement and iPad engagement. EIA was calculated by dividing sessions into successive 10-s intervals. Agreement was scored if both observers recorded exactly the same duration of the target response in that interval. Agreements were divided by agreements plus disagreements then multiplied by 100. For independent seatwork engagement, the mean duration agreement coefficient during baseline was 96.3% (range 92.4%–100%) and the mean duration agreement coefficient during treatment was 94.8% (range 91.2%–100%). For iPad engagement, the mean duration agreement coefficient during baseline was 94.3% (range 91.2%–100%) and the mean duration agreement coefficient during treatment was 93.8% (range 90.7%–100%).

General Procedures

Similar to Konarski, Crowell, Johnson, and Whitman (1982), we used the disequilibrium model in an attempt to increase the duration Marvin engaged in academic seatwork. His teacher reported that when asked to complete his independent seatwork, Marvin was often off task. During times when Marvin was asked to complete his independent seatwork, he either sat at his desk doing nothing or was distracted by talking to others in the classroom. For this reason, Marvin was selected for the study. Treatment effects were evaluated using an A-B-A-B reversal design. All sessions lasted 10 min.

During baseline, both independent seatwork and the iPad were placed on Marvin's desk equal distance away from where he sat and equal distance apart from one another. Prior to baseline sessions, a script was read to Marvin that said the following:

Hi, Marvin. Today you are going to work at your desk. During this time, I need for you to stay seated here until I say we can get up. On your desk is either seatwork that you can do independently or the iPad that you can play on. You can do whatever you want—the independent seatwork or play with the iPad, it's up to you—for as long as you want. The only rule is you have to stay in your seat and you can only work on one task at a time.

Immediately following the script, the session started. Baseline sessions lasted 10 min. The data collector recorded separate

durations for iPad engagement and independent seatwork engagement.

Following baseline phases, the Microsoft Excel spreadsheet developed by Jacobs et al. (2017) was used to determine the schedule requirements for treatment phases. First, we obtained the mean duration of independent seatwork and mean duration of iPad engagement across baseline sessions. Second, we inputted those values into the O_i and O_c columns in the spreadsheet. O_i stands for baseline levels of instrumental activity (independent seatwork), and O_c stands for baseline levels of contingent activity (iPad engagement). Third, we inputted duration values into the I and C columns, which represent the schedule requirements for instrumental (I) and contingent (C) activities. For example, an I/C ratio of 60:60 would mean that for 60 s of independent seatwork the participant would get 60 s of access to the iPad.

Figure 1 is a screenshot of the Excel spreadsheet with the means for O_i and O_c from the first baseline phase, as well as the different I and C values we considered for the first treatment phase. I and C values are the intervention parameters that a practitioner must choose based on contextual factors for which the disequilibrium model cannot account. The I and C values chosen for this brief practice were Option 2, highlighted in Fig. 1; 60 s of seatwork for 60 s of iPad engagement seemed most feasible given Marvin's average baseline levels of seatwork. Additionally, the 60:60 ratio has a relatively large predicted outcome of 284.38 s of instrumental activity shown in the rightmost column of Fig. 1. Options 1 and 3 result in a larger predicted outcome, but they come with certain risks. A 120-s instrumental requirement for Option 1 might be unachievable, and taking the iPad away after only 30 s of access within Option 3 might be disruptive. We refer readers to Jacobs et al. (2017) for the tutorial on how to use the Excel spreadsheet and for considerations on how to select the appropriate intervention parameters.

During treatment, a single clear bin containing independent seatwork was placed on Marvin's desk. Marvin was required to engage in independent seatwork in order to access the iPad. If Marvin met the schedule requirements, then two clear bins containing either independent seatwork or the iPad were

placed on Marvin's desk. Prior to treatment sessions, a script was read to Marvin that said the following:

Hi, Marvin. Today you are going to work at your desk. During this time, I need for us to stay seated here until I say we can get up. Just a reminder: the rules are you can only work on one task at a time and you should keep all of the materials in the bin if you're finished or not using them.

Based upon output from the disequilibrium equation, Marvin was required to complete independent seatwork (instrumental activity) for 1 min to access his iPad (contingent activity) for 1 min. During times when the iPad was placed on the desk, independent seatwork was not removed, so Marvin was free to engage with either activity. However, if Marvin engaged with independent seatwork during the presentation of the iPad, he was unable to use that time to satisfy the instrumental activity requirements—completion of 1 min of independent seatwork. The schedule requirements were not told to Marvin at any point during treatment. The sequence of 1-min access to the iPad for satisfying independent seatwork requirements occurred throughout the 10-min session duration.

Results and Discussion

Figure 2 shows the results of the independent seatwork engagement and iPad engagement for baseline and treatment sessions. During the initial baseline session, Marvin engaged in independent seatwork (315 s) for a greater duration compared to iPad (170 s) engagement. As baseline sessions were continued, Marvin began to engage with the iPad for greater durations, until he exclusively selected the iPad for the 10-min baseline session duration. Across sessions during the first treatment phase, Marvin engaged in independent seatwork for greater durations when compared to iPad engagement. When we returned to the baseline phase, Marvin exclusively selected the iPad to engage with during the entire session duration and did not engage in independent seatwork. During the final treatment phase, independent seatwork

Options	Baseline			Intervention			
	O_i	O_c	O_i/O_c	I	C	I/C	X_i Prediction
1	101.375	467.375	0.22	120	60	2.00	379.17
2	101.375	467.375	0.22	60	60	1.00	284.38
3	101.375	467.375	0.22	60	30	2.00	379.17
4	101.375	467.375	0.22	30	60	0.50	189.58

Fig. 1 Screenshot of the Microsoft Excel spreadsheet used to calculate the predicted instrumental outcomes based on baseline measures and the practitioner's choice of intervention parameters. Columns O_i and O_c contain the mean baseline durations in seconds for independent seatwork and iPad engagement, respectively. The I and C columns

contain the schedule requirements for seconds of instrumental activity (seatwork) required for seconds of access to the contingent activity (iPad). The X_i Prediction column contains the predicted instrumental activity (seatwork) in seconds

Fig. 2 Results of the A-B-A-B design in which treatment phases entailed 60 s of independent seatwork for 60 s of access to the iPad

increased and iPad engagement decreased when compared to baseline phases. The duration of independent seatwork presented at an overall greater duration than iPad engagement during the treatment analysis. These results suggest that we were able to successfully select parameters for treatment based upon baseline durations of instrumental and contingent activity using the disequilibrium model as a guide.

Figure 3 shows the outcomes predicted by Heth and Warren's (1978) model, calculated within the Excel spreadsheet developed by Jacobs et al. (2017), compared to the actual outcomes observed. Predicted independent seatwork and actual independent seatwork are represented by their mean durations for Treatment 1 and Treatment 2. For Treatment 1, the predicted duration was 284.38 s and the actual duration of seatwork observed was 341.23 s. Based on mean duration, Marvin spent 56.85 s more on independent seatwork than predicted. This outcome is not surprising because Marvin engaged in 315.7 s of independent seatwork in Session 1 of

baseline (Fig. 2). As for Treatment 2, the predicted duration was 297.83 s and the actual duration of seatwork observed was 285.30 s. Based on mean duration, Marvin's independent seatwork was only 12.53 s less than predicted. Although imperfect, the predictions of the disequilibrium model appear to be accurate enough to guide practitioners on which intervention parameters to select for the outcomes they may desire.

A limitation of this study is that the disequilibrium model was only employed for a single participant. We encourage future researchers and practitioners to replicate this method across additional participants. We empirically demonstrated that the disequilibrium model can predict intervention effects, but future research should consider using the model to identify the boundaries of instrumental activity output. For example, once initial parameters are successfully met by the participant, the disequilibrium model could be rerun to predict whether a longer work duration (i.e., instrumental activity) is feasible compared to the original model output. In conclusion, we

Fig. 3 Predicted independent seatwork and actual independent seatwork observed

were able to accurately predict instrumental activity using the disequilibrium model and were able to increase independent seatwork to a clinically significant duration for an adolescent diagnosed with ASD. We encourage practitioners to determine instrumental and contingent activity parameters using the disequilibrium model made available by Jacobs et al. (2017).

Implications for Practice

- Clinicians often have difficulty predicting the magnitude of intervention effects prior to completing treatment analysis.
- The disequilibrium model has the ability to accurately predict the effects of interventions.
- Jacobs et al. (2017) provide clinicians with a free, online, and intuitive tool for predicting intervention effects.
- Using the online tool, we were able to accurately predict intervention effects and carry out treatment for an adolescent male diagnosed with ASD.

Compliance with Ethical Standards

Conflict of Interest Art Dowdy declares he has no conflict of interest. Kenneth Jacobs declares he has no conflict of interest.

Ethical Approval All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

- Bullock, C. E., Fisher, W. W., & Hagopian, L. P. (2017). Description and validation of a computerized behavioral data program: “BDataPro”. *Behavior Analyst*, 40(1), 275–285. <https://doi.org/10.1007/s40614-016-0079-0>.
- Farmer-Dougan, V., Langley, M. D., Gavin, J., & Berenbaum, A. (2017). Disequilibrium as an alternative to internal states and affordance. *Behavior Analyst*, 40(1), 83–93. <https://doi.org/10.1007/s40614-017-0102-0>.
- Heth, C. D., & Warren, A. (1978). Response deprivation and response satiation as determinants of instrumental performance: some data and theory. *Animal Learning & Behavior*, 6(3), 294–300. <https://doi.org/10.3758/BF03209617>.
- Jacobs, K. W., Morford, Z. H., King, J. E., & Hayes, L. J. (2017). Predicting the effects of interventions: a tutorial on the disequilibrium model. *Behavior Analysis in Practice*, 10(2), 195–208. <https://doi.org/10.1007/s40617-017-0176-x>.
- Konarski, E. A., Crowell, C. R., Johnson, M. R., & Whitman, T. L. (1982). Response deprivation, reinforcement, and instrumental academic performance in an EMR classroom. *Behavior Therapy*, 13(1), 94–102. [https://doi.org/10.1016/S0005-7894\(82\)80052-X](https://doi.org/10.1016/S0005-7894(82)80052-X).
- Konarski, E. A., Johnson, M. R., Crowell, C. R., & Whitman, T. L. (1981). An alternative approach to reinforcement for applied researchers: response deprivation. *Behavior Therapy*, 12(5), 653–666. [https://doi.org/10.1016/S0005-7894\(81\)80137-2](https://doi.org/10.1016/S0005-7894(81)80137-2).
- Timberlake, W. (1980). A molar equilibrium theory of learned performance. *Psychology of Learning and Motivation*, 14, 1–58. [https://doi.org/10.1016/S0079-7421\(08\)60158-9](https://doi.org/10.1016/S0079-7421(08)60158-9).
- Timberlake, W., & Allison, J. (1974). Response deprivation: an empirical approach to instrumental performance. *Psychological Review*, 81(2), 146–164. <https://doi.org/10.1037/h0036101>.
- Timberlake, W., & Farmer-Dougan, V. A. (1991). Reinforcement in applied settings: figuring out ahead of time what will work. *Psychological Bulletin*, 110(3), 379–391. <https://doi.org/10.1037/0033-2909.110.3.379>.