

Using Mobile Technology to Reduce Engagement in Stereotypy:

A Validation of Decision-Making Algorithms

Isabelle Préfontaine, Marc J. Lanovaz, and Emeline McDuff

Université de Montréal

Catherine McHugh and Jennifer L. Cook

Monarch House

This paper was written in partial fulfillment of the requirements of the MS degree in Psychoeducation at the Université de Montréal by the first author. This research project was supported by a Canadian Graduate Scholarship and by a Graduate Scholarship from the Fonds de Recherche du Québec – Société et Culture to the first author, and by a grant from the Canadian Institutes of Health Research (# MOP – 136895) and a salary award from the Fonds de Recherche du Québec – Santé (# 30827) to the second author. We thank Sarah Huxley for her support with data collection, and Ted Hill, François-Olivier Leblanc and Misael Ntirushwa for their assistance with programming.

Correspondence concerning this article should be addressed to Marc J. Lanovaz, École de Psychoéducation, Université de Montréal, C.P. 6128, succursale Centre-Ville, Montreal, QC, Canada, H3C 3J7. Email: marc.lanovaz@umontreal.ca. Phone: 1 514-343-6111 #81774.

The final, definitive version of this paper has been published in *Behavior Modification*, 43/2, March 2019 published by SAGE Publishing, All rights reserved.

<https://doi.org/10.1177/0145445517739278>

### **Abstract**

We developed an iOS app, the iSTIM, designed to support parents of children with autism spectrum disorders (ASD) in reducing common repetitive vocal and motor behavior (i.e., stereotypy). The purpose of our study was to preliminarily test the decision-making algorithms of the iSTIM using trained university students to implement the assessments and interventions. Specifically, we examined the effects of the iSTIM on stereotypy and functional engagement in 11 children with ASD within alternating treatment designs. Using the iSTIM reduced engagement in stereotypy for 8 participants and increased functional engagement in for 4 of those participants. Our results indicate that the iSTIM may decrease engagement in stereotypy, but that some of the decision-making algorithms may benefit from modifications prior to testing with parents.

*Keywords:* autism, differential reinforcement, noncontingent access, stereotypy, technology.

## Using Mobile Technology to Reduce Engagement in Stereotypy:

### A Validation of Decision-Making Algorithms

A defining feature of autism spectrum disorders (ASD) is the presence of stereotyped, restricted, and unusual patterns of behaviors or interests (American Psychiatric Association, 2013). One of these behavioral patterns is referred to as stereotypy, which is generally characterized by repetitive and invariant behaviors that serve no apparent social function (Rapp & Vollmer, 2005). A recent systematic review indicated that approximately 88% of children with ASD engage in at least one form of stereotypy (Chebli, Martin, & Lanovaz, 2016). For example, children with ASD may engage in body rocking, hand flapping, object alignment, mouthing, and repetitive vocalizations (DiGennaro Reed, Hirst, & Hyman, 2012). Stereotypy displayed by children with ASD differs from typically developing children because the behavior is not adapted to the developmental context and social norms (Cunningham & Schreibman, 2008; Thelen, 1979).

Many studies have stressed the importance of reducing engagement in stereotypy because it may be perceived negatively by others, causing prejudice and reducing positive socialization opportunities (Goldman, et al., 2009; Jones, Wint, & Ellis, 1990; Lanovaz, Robertson, Soerono, & Watkins, 2013; MacDonald et al., 2007; Matson, Kiely, & Bamburg, 1997). Some parents may avoid public places and social settings, fearing the stigmatization associated with stereotypy displayed by their child. Moreover, engagement in stereotypy is associated with poorer expression of thoughts and speech comprehension, more limited abilities in self-caring, and lower levels of engagement in functional activities (Matson et al., 1997). Stereotypy may also interfere with socially appropriate behavior as well as learning (Koegel, Firestone, Kramme, & Dunlap, 1974; Lanovaz, Robertson et al., 2013). For example, researchers have shown that the

reduction of stereotypy may result in increases in functional play in children with ASD (Lang et al., 2010; Lang et al., 2009; Stahmer & Schreibman, 1992). Taken together, these results suggest that while children are engaging in stereotypy, they are less available to attend to natural learning opportunities.

Two of the interventions that have received the most empirical support to reduce engagement in stereotypy in children with ASD are noncontingent access to preferred stimuli and differential reinforcement (DiGennaro Reed et al., 2012). Noncontingent access is designed to reduce engagement in problem behavior by providing continuous or regular access to preferred items (e.g., music, toys, activities) that substitute or compete with the targeted behavior (Britton, Carr, Landaburu, & Romick, 2002; Carr, Severtson, & Lepper, 2009; Hansen & Wadsworth, 2015; Higbee, Chang, & Endicott, 2005; Lindberg, Iwata, Roscoe, Worsdell, & Hanley, 2003; Rapp et al., 2013; Roane, Kelly & Fisher, 2003; Saylor, Sidener, Reeve, Fetherston, & Progar, 2012). For example, Higbee, Chang, and Endicott (2005) provided noncontingent access to items that produced visual stimulation to reduce motor stereotypy (i.e., moving fingers in front of eyes) in a child diagnosed with ASD and severe intellectual disability. In a more recent example, Saylor et al. (2012) reduced vocal stereotypy in two children with ASD by playing music in the background. Noncontingent access has the advantage of ease in implementation because it does not require continuous attention from a parent. However, noncontingent access might be unsuitable in some contexts where the stimulation generated by the item would interfere with ongoing activities (Lanovaz et al., 2014).

Differential reinforcement involves delivering a preferred item either when the child engages in an alternative appropriate behavior or has not displayed stereotypy for a predetermined amount of time (Haring, Breen, Pitss-Conway, & Gaylord-Ross, 1986; Lanovaz,

Rapp, & Ferguson, 2013; Nuernberger, Vargo, & Ringdahl, 2013; Patel, Carr, Kim, Robles, & Eastridge, 2000; Rozenblat, Brown, Brown, Reeve, & Reeve, 2009). For example, Lanovaz, Rapp, and Ferguson (2013) reduced engagement in vocal stereotypy during television watching by providing edible items contingent on an alternative behavior (i.e., sitting). Alternatively, Rozenblat et al. (2009) provided edible items for the absence of vocal stereotypy to reduce engagement in vocal stereotypy for three children with ASD. In comparison to noncontingent access, differential reinforcement minimizes interference with ongoing activities; however, it is more complex to implement because it requires continuous and substantial attention from the parent that must deliver the reinforcer at a specific moment. Despite the effectiveness of the previous interventions to reduce engagement in stereotypy, many children with ASD and their families do not have access to these behavioral treatments due to the limited number of trained professionals, the long waiting lists associated with public services, the high cost of private services, or geographic isolation. One potential solution to address restricted accessibility may be to support parents who could use mobile technology to function as behavioral change agents for their child's stereotypy.

Mobile technology refers to “electronic equipment such as mobile phones and small computers that you can use in different places” (Mobile technology, 2017). In other words, mobile technology is by definition portable. Since the arrival of accessible mobile technology, many apps have been developed to extend psychological and behavioral treatments beyond clinical settings. For example, Heron and Smyth (2010) reviewed 27 apps designed to provide ambulatory treatment for different psychological or health issues (e.g. smoking cessation, anxiety, alcohol use). Their review indicated that mobile technology may be an effective modality to deliver interventions in applied settings. In an example specific to stereotypy,

Crutchfield, Mason, Chambers, Wills, and Mason (2015) used an Android-based app, the I-Connect, to teach self-management to two adolescents with ASD. Using the I-Connect reduced stereotypy in both participants when compared to baseline. That said, some children may be unable to use a self-management app on their own due to their age or to the severity of an associated intellectual disability. In these cases, practitioners are more likely to recommend parent-implemented interventions.

To this end, we developed the iSTIM (individual Stereotypy Treatment Integrated Modules), a four-module mobile app designed to support parents in reducing stereotypy. From an ethical standpoint, it is important to validate the decision-making algorithms embedded in the app to verify their effects prior to testing the app with parents. Thus, the purpose of our study was to examine the effects of trained personnel using the iSTIM on stereotypy and functional engagement in children with ASD.

## **Method**

### **Participants**

Eleven children with ASD between 3 and 10 years old participated in the study. To be included in the study, it was required that the participants be 12 years old or less, have a diagnosis of ASD (provided by an independent multidisciplinary team prior to their invitation to participate) and engage in high levels of stereotypy (i.e., 20% of the time or at least 12 times in an hour). We recruited the participants from three centers providing services to children with developmental disabilities in Québec and Ontario, Canada. To recruit participants, the therapists and educators in each centre solicited families of children who engaged in high levels of stereotypy for their permission to provide their contact information to the research team. Then, a

research assistant scheduled a meeting with the family and obtained informed consent. Table 1 reports the characteristics of each participant.

### **Data Collection**

We videotaped each session and measured the duration of targeted stereotypy and functional engagement for each participant using these recordings (see Table 2 for definitions used for measurement). A second research assistant measured interobserver agreement (IOA) for at least 25% of sessions for each participant and for each condition (i.e., baseline and intervention) using the block-by-block method with 10-s bins (Mudford, Taylor, & Martin, 2009). The block-by-block method involves dividing the observation period into equal-duration intervals (e.g., 10 s). For each interval, the lowest duration is divided by the highest duration and the result is multiplied by 100%. Then, the IOA is calculated by averaging all the intervals within each session. We present the mean IOA for each form and participant in the results section (see Table 3). To characterize the severity of autistic symptoms in our sample, the research assistant also completed the Childhood Autism Rating Scale – Second Edition (CARS2; Schopler, Van Bourgondien, Wellman, & Love, 2002) based on parental reports and observations of the child during the study.

### **individualized Stereotypy Treatment Integrated Modules (iSTIM)**

The iSTIM is a free iOS app developed by our research team. iOS apps can be installed on Apple® manufactured devices such as the iPhone, the iPad and the iPod Touch. Usually, these apps can be downloaded from Apple's app store, but the iSTIM is not currently available as we want to conduct further validations before disseminating it to the general public. It is available from the second author upon request for research purposes. Figure 1 provides examples of screenshots of the app for each of the four modules.

**Module 1.** The first module of the mobile app asked the research assistant a series of eight questions on the characteristics of stereotypy and the context in which stereotypy was targeted for reduction (see Appendix A for questions). These responses were used to make recommendations regarding data collection, preference assessment, and intervention procedures (see below). The recommendations were made by the iSTIM following the decision-making algorithms that we created (see Appendix A for decision-making algorithms). It is important to note that the iSTIM was designed to recommend interventions for forms of stereotypy that occurred at least 12 times per hour, were not physically harmful, and persisted in the absence of social reinforcement.

**Module 2.** The second module prompted the research assistant to collect baseline data on stereotypy using discontinuous methods of measurement (i.e. momentary time sampling or partial interval recording). Momentary time sampling involves recording an occurrence when the behavior is occurring at the end of an interval whereas partial interval recording involves recording an occurrence when the behavior occurs at least once during an interval (Meany-Daboul, Roscoe, Bourret, & Ahearn, 2007). Depending on the responses to the initial questions, the app recommended estimating either frequency or duration. That is, the iSTIM selected frequency if the research assistant reported that the occurrences had a consistent duration; otherwise, it selected the duration of the behavior. As recommended in previous research, partial interval recording was used to estimate frequency whereas momentary time sampling was used to estimate duration (Ciotti Gardenier, MacDonald, & Green, 2004; Meany-Daboul et al., 2007; Rapp et al., 2007; Rapp, Colby-Dirksen, Michalski, Carroll, & Lindenberg, 2008). One exception was for low frequency behaviors with short durations (less than 1 s), which were measured using partial interval recording.



The research assistant was instructed by the app to observe for 10 min. The 10-min period was divided into 20, 30-s intervals. During data collection, the device beeped at the end of each of the 20 intervals. For partial interval recording, the question, “Did stereotypy occur once or more since that last interval?” appeared when the device beeped, and the research assistant would select yes or no. For momentary time sampling, the device beeped and asked, “Is stereotypy occurring now?” To estimate frequency or duration, the number of positive responses was divided by 20 (i.e., the number of intervals) and multiplied by 100%. This module ended when the percentage remained between 20% and 80% for three consecutive observation periods or after a maximum of ten periods. If stereotypy fell below 20% for three consecutive sessions during momentary time sampling, the app switched to partial interval recording. These discontinuous data are estimates of frequency or duration, which are used by the app to make real-time decisions regarding the assessments and interventions. However, we only report the data collected on video recordings (as described in Data Collection section) in our results as the latter are more reliable and representative of the actual values. This continuous measurement system was not incorporated in the app due to its complexity.

**Module 3.** The research assistant was instructed to implement a preference assessment by the third module. The free-choice method (Roane, Vollmer, Ringdahl, & Marcus, 1998) was recommended to identify preferred stimuli for the noncontingent access procedure, with the exception of music or edible stimuli. The paired-choice method (Fisher et al., 1992) was recommended for all children who received the differential reinforcement intervention, as well as those whose preferred stimuli were music or edible items. The type of preferred stimuli recommended for each child also depended on the form of stereotypy. Music was recommended for children who engaged in vocal stereotypy (Rapp et al., 2013; Saylor et al., 2012), whereas

edible items were recommended for mouthing (Roane, Kelly, & Fisher, 2003; Simmons et al., 2003). For other types of stereotypy, the iSTIM recommended that the research assistant select age-appropriate toys and games.

The mobile app requested that the research assistant select six potential reinforcers based on the categories described previously (i.e., edible items, toys, music). During the free-choice assessment, the app prompted the research assistant to present the six items simultaneously. Then, the app beeped every 30 s for 10 min, presenting each time the six choices on the screen. The research assistant recorded which item the child was interacting with when the device beeped. The assessment was repeated once more. The most preferred item that was used as part of the intervention was the one selected for the most number of intervals. During the paired-choice assessment, the device prompted the research assistant to present the items in pairs. Each possible combination was presented once. During each presentation, the research assistant recorded which of the two items the child had selected (if any). The item selected most often was used as the preferred stimulus during the intervention.

**Module 4.** The final module supported the implementation of the intervention procedure based on the context and the form of the target stereotypy. Noncontingent access was always recommended for vocal stereotypy and mouthing. For other forms of stereotypy, noncontingent access was implemented only during play/free-time periods. Noncontingent access is typically the simplest intervention to implement, but it may be unsuitable for contexts in which the person must engage in other behaviors (e.g., completing tasks). In these cases, differential reinforcement was recommended by the iSTIM because it should also strengthen an appropriate behavior.

During noncontingent access, the child with ASD had continuous access to his or her preferred stimulus (as identified in Module 3) during the entire observation period. The iSTIM

also instructed the research assistant to prompt the child to engage in an alternative behavior (e.g., play, task, sit down) when he or she was unengaged for 5 consecutive seconds. If noncontingent access was ineffective, the research assistant conducted a second preference assessment and implemented noncontingent access with this new item. Note that this change was not implemented for one participant (i.e., Emile) due to his limited availability. If the intervention remained ineffective, we switched to differential reinforcement (see below). The termination criteria for Module 4 malfunctioned during the study. Thus, we used visual analysis to decide when to stop or change the intervention. The results of the current study were used to develop new modification and termination criteria for the next version of the app (see Discussion section).

During differential reinforcement, the device beeped once for data collection and twice for when the research assistant should intervene. Double beeps were presented on a 30-s variable interval schedule. When the device beeped twice, the research assistant provided the reinforcer to the child for approximately 15 s when the child was not emitting stereotypy and engaging in the functional alternative behavior, or otherwise prompted an appropriate alternative behavior. If functional engagement was prompted, then the research assistant provided the preferred stimulus as soon as both conditions were met again (i.e., no stereotypy and functional engagement).

## **Procedures**

We asked trained undergraduate and graduate students in educational psychology (i.e., the research assistants) to implement the procedures recommended by the app at home, at an early intervention clinic (Billy, Elliot, and Abby), or at school (Emile only). Given that the app was in its prototype phase, the research assistants manually validated all the decisions taken by the app. When there was a discrepancy between what the app suggested and the planned

algorithms, the research assistant followed the original planned algorithms and reported the bug to the programmer for correction. It is important to note that the research assistants always followed the planned decision-algorithms (as described in Appendix A).

**Preliminary assessment.** After consent was provided by the parents, a research assistant conducted at least three 1-hr observation sessions in contexts wherein the child was likely to display stereotypy. The purpose of the preliminary assessment was to (a) verify that the inclusion criteria were met and (b) collect sufficient information to respond to the questions from Module 1. After the three observation sessions were completed, the research assistant, together with the parent, identified the target stereotypy and the context of the intervention. The questionnaire was completed using the mobile app and the responses were recorded on a separate spreadsheet to manually check the decision-making algorithms.

**Baseline.** We conducted two to four 10-min baseline sessions per week (no more than one session per day) depending on the child's availability. During baseline, the research assistants used the second module to monitor the behavior in the targeted context. Although these data were used to make decisions for convenience, the data reported in our results are based on continuous measures from the video recordings.

**Preference assessment.** Following baseline, the research assistants conducted a preference assessment as instructed by the iSTIM (Module 3). The preference assessment was conducted twice. The research assistants recorded the selections during each assessment. The most preferred item was used as a preferred stimulus or reinforcer during the subsequent intervention.

**Intervention.** When the preference assessment was completed, the iSTIM moved to Module 4 (intervention phase). The conditions were the same as baseline, except that the

research assistants were prompted to implement either noncontingent access or differential reinforcement. During this phase, we alternated the intervention sessions with baseline sessions in a semi-random manner to examine the effects of using the iSTIM on both stereotypy and functional engagement in alternating treatment designs.

### **Results**

Table 3 depicts the means for stereotypy, functional engagement, and IOA for each condition and participant. The mean percentage of engagement in stereotypy was below 20% for four participants (Ben, Alia, Albert, and Emile). These participants nevertheless met our inclusion criteria and were included in our study as they engaged in stereotypy at least 12 times per hour.

Figure 2 presents the results of the participants who received noncontingent access only as an intervention ( $n = 6$ ). The data show a reduction in stereotypy for all participants, except for Ben (fifth panel). The results of Ben were inconclusive as baseline levels of stereotypy decreased to near-zero levels when we introduced the intervention. We observed the largest reductions for George (upper panel), Elliot (third panel) and Billy (fourth panel). Results for two of five participants showed improvements in functional engagement. Because of an error in the prompting procedure by the research assistant (i.e., she did not prompt play), the data for Alia's functional engagement in free play was not included in the results. The results of the participants who only received differential reinforcement ( $n = 3$ ) are displayed in Figure 3. Using the app reduced engagement in stereotypy and increased functional engagement for Bob (upper panel) and Henry (middle panel), but we did not observe clear differentiation between baseline and intervention for Albert (lower panel). The results for participants who received noncontingent access first and then differential reinforcement ( $n = 2$ ) are presented in Figure 4. Noncontingent

access did not reduce engagement in stereotypy, nor increase functional engagement for both participants. Differential reinforcement marginally reduced engagement in stereotypy towards the end for Emile (upper panel) and increased functional engagement in Dave (lower panel).

### **Discussion**

Our results indicate that using the iSTIM produced reductions in stereotypy for 8 of 11 participants and increases in functional engagement in 4 of those participants. Specifically, noncontingent access reduced stereotypy for five participants and increased functional engagement for two participants. Differential reinforcement decreased stereotypy for three participants and increased functional engagement for two of those participants. More importantly, the interventions never reduced or interfered with functional engagement. These results are consistent with prior research which has shown that noncontingent access and differential reinforcement may reduce engagement in stereotypy (DiGennaro Reed et al., 2012; Lanovaz et al., 2014). The effectiveness of noncontingent access may be explained by the preferred item substituting or competing with engagement in stereotypy whereas differential reinforcement reduced stereotypy by strengthening an alternative response. As expected, the interventions were not effective for all participants, which is also consistent with prior research. It should be noted that both noncontingent access and differential reinforcement may produce resistance to change, especially when implementing extinction (Nevin & Shahan, 2011). That said, these effects should be minimal in the treatment of stereotypy as it is generally impractical to implement extinction for automatically reinforced behavior.

To our knowledge, our study is one of the first to use mobile technology to reduce engagement in stereotypy. Crutchfield et al. (2015) examined the use of technology as an aid for self-management to reduce stereotypy, but the intervention was not adapted for parents or for

children who are unable to use such devices on their own. Our results further suggest that a mobile app with embedded decision-making algorithms can support the reduction of stereotypy while enhancing functional engagement. One of the unique features of this study is the differential reinforcement procedure, which is a hybrid between differential reinforcement of alternative behavior (the reinforcer is given when the target alternative behavior occurs) and differential reinforcement of other behavior (the reinforcer is given in the absence of the target problem behavior). In our procedure, the research assistant provided the reinforcer when the criteria for both types of schedule were met; that is, stereotypy was absent and the child engaged in functional appropriate behavior. The use of this conjunctive procedure may have been instrumental in reducing stereotypy while strengthening functional engagement during differential reinforcement.

Our results also suggest that multiple modifications may be required to improve the iSTIM before assessing the effects of parent implementation. First, we observed that implementing the differential reinforcement procedure using reinforcers other than edibles (e.g., toys) was complex and may be challenging for parents to execute effectively without in-person training. Thus, we propose using edibles as the only reinforcer option, which may be significantly easier to deliver for parents. Second, the termination criterion for baseline (i.e., Module 2; three consecutive points between 20% and 80%) initially led to excessively variable data trends. Instead, we recommend the criterion of three consecutive data points between 20% and 100%, in which (a) the points have no more than a 20% difference and (b) the overall trend is not decreasing.

Third, our results from the intervention module allowed us to develop modification and termination criteria. For noncontingent access, we propose that the iSTIM recommends

conducting four to six sessions as the effects were usually rapid. If no differentiation is detected after six sessions, the app should perform another preference assessment. The iSTIM should then implement noncontingent access with the new reinforcer for another four to six sessions. If still no differentiation is detected, the app should change the intervention to differential reinforcement for four to ten sessions as its effects can be longer to detect. The absence of differentiation during this final intervention should lead to a termination message suggesting that parents seek professional help. If the intervention is effective at reducing stereotypy, the app should teach parents to fade the intervention procedures. To determine whether the data paths are differentiated, we recommend integrating the dual-criteria method of visual analysis developed by Fisher, Kelley, and Lomas (2003) within the app. Finally, the next version should include interactive computer training, which would present video models prior to each module to support parents in learning the assessments and interventions (e.g., McCulloch & Noonan, 2013; Pollard, Higbee, Akers, & Brodhead, 2014). To further examine the validity of the results, the next step is to update the app based on the current results and conduct a study wherein the parents function as the behavior change agents.

Our study is limited insofar as our research protocol did not evaluate whether stereotypy was maintained by social reinforcement. As recommended by Querim et al. (2013), we conducted a series of no-interaction conditions (i.e., baseline sessions) to confirm that the behavior was maintained in the absence of social consequences (which suggests an automatic function), but we did not explicitly evaluate the effects of other social functions. Our anecdotal observations indicate that this limitation may explain why the intervention was less effective with some of the participants (e.g., Dave); in these cases, stereotypy may have been partly maintained by social reinforcers, which our interventions were not designed to reduce. Another



limitation is that we only targeted one form of stereotypy for each participant (i.e. the most prevalent). Previous studies have shown that an intervention targeted for one form of stereotypy may affect untargeted topographies (e.g., Lanovaz, Robertson et al., 2013; Rapp et al., 2013). Future researchers should consider monitoring multiple forms simultaneously, especially when the intervention does not appear to strengthen appropriate behavior. Finally, we did not measure treatment integrity for the research assistants because we had previously trained them to perform these procedures and they were following the iSTIM's instructions. As such, we assumed that each research assistant was implementing the procedures correctly. Due to this limitation, it is not possible to determine if there were some individual differences in the accuracy of implementation across research assistants that could explain our results. In the future, treatment integrity should be measured when the effectiveness of the iSTIM is assessed with parents.

### References

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). Washington, DC: American Psychiatric Association.
- Britton, L. N., Carr, J. E., Landaburu, H. J. & Romick, K. S. (2002). The efficacy of noncontingent access as treatment for automatically reinforced stereotypy. *Behavioral Interventions*, *17*, 93-103. doi: 10.1002/bin.110
- Carr, J. E., Severtson, J. M. & Lepper, T. L. (2009). Noncontingent access is an empirically supported treatment for problem behavior exhibited by individuals with developmental disabilities. *Research in Developmental Disabilities*, *30*, 44-57. doi: 10.1016/j.ridd.2008.03.002
- Chebli, S. S., Martin, V. & Lanovaz, M. J. (2016). Prevalence of stereotypy in individuals with developmental disabilities: a systematic review. *Review Journal of Autism and Developmental Disorders*, *3*, 107-118. doi: 10.1007/s40489-016-0069-x.
- Ciotti Gardenier, N., MacDonald, R., & Green, G. (2004). Comparison of direct observational methods for measuring stereotypic behavior in children with autism spectrum disorders. *Research in Developmental Disabilities*, *25*, 99-118. doi: 10.1016/j.ridd.2003.05.004
- Crutchfield, S. A., Mason, R. A., Chambers, A., Wills, H. P. & Mason, B. A. (2015). Use of a self-monitoring application to reduce stereotypic behavior in adolescents with autism: A preliminary investigation of I-Connect. *Journal of Autism and Other Developmental Disorders*, *45*, 1146-1155. doi: 10.1007/s10803-014-2272-x
- Cunningham, A. B. & Schreibman, L. (2008). Stereotypy in autism: The importance of function. *Research in Autism Spectrum Disorders*, *2*, 469-479. doi: 10.1016/j.rasd.2007.09.006
- DiGennaro Reed, F. D., Hirst, J. M. & Hyman, S. R. (2012). Assessment and treatment of stereotypic behavior in children with autism and other developmental disabilities: A thirty

- year review. *Research in Autism Spectrum Disorders*, 6, 422-430. doi:  
10.1016/j.rasd.2011.07.003
- Fisher, W. W., Kelley, M. E. & Lomas, J. E. (2003). Visual aids and structured criteria for improving visual inspection and interpretation of single-case designs. *Journal of Applied Behavior Analysis*, 36, 387-406. doi: 10.1901/jaba.2003.36-387
- Fisher, W. W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C. & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis*, 25, 491-498. doi:  
10.1901/jaba.1992.25-491
- Goldman, S., Wang, C., Salgado, M. W, Greene, P. E., Kim, M. & Rapin, I. (2009). Motor stereotypies in children with autism and other developmental disorders. *Developmental Medicine & Child Neurology*, 51, 30-38. doi: 10.1111/j.1469-8749.2008.03178.x.
- Hansen, B. D. & Wadsworth, J. P. (2015). Effects of an antecedent intervention on repetitive behaviors of a child with autism. *Child & Family Behavior Therapy*, 37, 51-62. doi:10.1080/07317107.2015.1000235
- Haring, T. G., Breen, C. G., Pitts-Conway, V. & Gaylord-Ross, R. (1986). Use of differential reinforcement of other behavior during dyadic instruction to reduce stereotyped behavior of autistic students. *American Journal of Mental Deficiency*, 90, 694-702.
- Higbee, T. S., Chang, S. & Endicott, K. (2005). Noncontingent access to preferred sensory stimuli as a treatment for automatically reinforced stereotypy. *Behavioral Interventions*, 20, 177-184. doi: 10.1002/bin.190

- Heron, K. E., & Smyth, J. M. (2010). Ecological momentary interventions: Incorporating mobile technology into psychosocial and health behaviour treatments. *British Journal of Health Psychology, 15*, 1-39. doi:10.1348/135910709X466063
- Jones, R. S. P., Wint, D. & Ellis, N. C. (1990). The social effects of stereotyped behavior. *Journal of Intellectual Disability Research, 34*, 261-268. doi: 10.1111/j.1365-2788.1990.tb01537.x
- Koegel, R. L., Firestone, P.B., Kramme, K.W. & Dunlap, G. (1974). Increasing spontaneous play by suppressing self-stimulation in autistic children. *Journal of Applied Behavior Analysis, 7*, 521-528. doi: 10.1901/jaba.1974.7-521
- Lang, R., O'Reilly, M., Sigafos, J., Lancioni, G.E., Machalicek, W., Rispoli, M., & White, P. (2009). Enhancing the effectiveness of a play intervention by abolishing the reinforcing value of stereotypy: A pilot study. *Journal of Applied Behavior Analysis, 42*, 889-894. doi: 10.1901/jaba.2009.42-889
- Lang, R., O'Reilly, M., Sigafos, J., Machalicek, W., Rispoli, M., Lancioni, G.E., Aguilar, J. & Fragale, C. (2010). The effects of an abolishing operation intervention component on play skills, challenging behavior, and stereotypy. *Behavior Modification, 34*, 267-289. doi: 10.1177/0145445510370713
- Lanovaz, M. J., Rapp, J. T., & Ferguson, S. (2013). Assessment and treatment of vocal stereotypy associated with television: A pilot study. *Journal of Applied Behavior Analysis, 46*, 544-548. doi: 10.1002/jaba.35
- Lanovaz, M.J., Rapp, J.T., Maciw, I., Pregent-Pelletier, É., Dorion, C., Ferguson, S. & Saade, S. (2014). Effects of multiple interventions for reducing vocal stereotypy: Developing a

- sequential intervention model. *Research in Autism Spectrum Disorders*, 8, 529-545. doi: 10.1016/j.rasd.2014.01.009
- Lanovaz, M. J., Robertson, K., Soerono, K. & Watkins, N. (2013). Effects of reducing stereotypy on other behaviors: A systematic review. *Research in Autism Spectrum Disorders*, 7, 1234-1243. doi :10.1016/j.rasd.2013.07.009
- Lindberg, J.S., Iwata, B.A., Roscoe, E.M., Worsdell, A.S. & Hanley, G.P. (2003). Treatment efficacy of noncontingent reinforcement during brief and extended application. *Journal of Applied Behavior Analysis*, 36, 1-19. doi: 10.1901/jaba.2003.36-1
- MacDonald, R., Green, G., Mansfield, R., Geckeler, A., Gardenier, N., Anderson, J. & Sanchez, J. (2007). Stereotypy in young children with autism and typically developing children. *Research in Developmental Disabilities*, 28, 266-277. doi: 10.1016/j.ridd.2006.01.004
- Matson, J.L., Kiely, S.L. & Bamburg, K.J. (1997). The effect of stereotypies on adaptive skills as assessed with the DASH-II and Adaptive Behavior Scales. *Research in Developmental Disabilities*, 18, 471-476. doi: 10.1016/S0891-4222(97)00023-1
- McCulloch, E. B., & Noonan, M. J. (2013). Impact of online training videos on the implementation of mand training by three elementary school paraprofessionals. *Education and Training in Autism and Developmental Disabilities*, 48, 132-141.
- Meany-Daboul, M. G., Roscoe, E. M., Bourret, J. C., & Ahearn, W. H. (2007). A comparison of momentary time sampling and partial-interval recording for evaluating functional relations. *Journal of Applied Behavior Analysis*, 40, 501-514. doi: 10.1901/jaba.2007.40-501
- Mobile technology. (2017). In *Cambridge Advanced Learner's Dictionary*. Retrieved from <http://dictionary.cambridge.org/dictionary/english/mobile-technology>

- Mudford, O. C., Taylor, S. A., & Martin, N. T. (2009). Continuous recording and interobserver agreement algorithms reported in the Journal of Applied Behavior Analysis (1995–2005). *Journal of Applied Behavior Analysis, 42*, 165-169. doi:10.1901/jaba.2009.42-165
- Nevin, J. A., & Shahan, T. A. (2011). Behavioral momentum theory: Equations and applications. *Journal of Applied Behavior Analysis, 44*, 877-895. doi: 10.1901/jaba.2011.44-877
- Nuernberger, J. E., Vargo, K. K. & Ringdahl, J. E. (2013). An application of differential reinforcement of other behavior and self-monitoring to address repetitive behaviour. *Journal of Developmental and Physical Disabilities, 25*, 105-117. doi : 10.1007/s10882-012-9309-x
- Patel, M. R., Carr, J. E., Kim, C. K., Robles, A. & Eastridge, D. (2000). Functional analysis of aberrant behavior maintained by automatic reinforcement: assessments of specific sensory reinforcers. *Research in Developmental Disabilities, 21*, 393-407. doi: 10.1016/S0891-4222(00)00051-2
- Pollard, J. S., Higbee, T. S., Akers, J. S., & Brodhead, M. T. (2014). An evaluation of interactive computer training to teach instructors to implement discrete trials with children with autism. *Journal of Applied Behavior Analysis, 47*, 765-776. doi: 10.1002/jaba.152
- Querim, A. C., Iwata, B. A., Roscoe, E. M., Schlichenmeyer, K. J., Ortega, J. V. & Hurl, K. E. (2013). Functional analysis screening for problem behaviour maintained by automatic reinforcement. *Journal of applied behavior analysis, 46*, 47-60. doi: 10.1002/jaba.26
- Rapp, J. T., Colby, A. M., Vollmer, T. R., Roane, H. S., Lomas, J., & Britton, L. N. (2007). Interval recording for duration event: A re-evaluation. *Behavioral Interventions, 22*, 319-345. doi: 10.1002/bin.239

- Rapp, J. T., Colby-Dirksen, A. M., Michalski, D. N., Carroll, R. A., & Lindenberg, A. M. (2008). Detecting changes in simulated events using partial-interval recording and momentary time sampling. *Behavioral Interventions, 23*, 237-269. doi: 10.1002/bin.269
- Rapp, J. T., Swanson, G., Sheridan, S., Enloe, K., Maltese, D., Sennott, L.,...Lanovaz, M. J. (2013). Immediate and subsequent effects of matched and unmatched stimuli on targeted vocal stereotypy and untargeted motor stereotypy. *Behavior Modification, 37*, 543-567. doi: 10.1177/0145445512461650
- Rapp, J. T. & Vollmer, T. R. (2005). Stereotypy I: A review of behavioral assessment and treatment. *Research in Developmental Disabilities, 26*, 527-547. doi: 10.1016/j.ridd.2004.11.005
- Roane, H. S., Vollmer, T. R., Ringdahl, J. E., & Marcus, B. A. (1998). Evaluation of a brief stimulus preference assessment. *Journal of Applied Behavior Analysis, 31*, 605-620. doi: 10.1901/jaba.1998.31-605
- Roane, H. S., Kelly, M. L. & Fisher, W. W. (2003). The effects of noncontingent access to food on the rate of object mouthing across three settings. *Journal of Applied Behavior Analysis, 36*, 579-582. doi: 10.1901/jaba.2003.36-579
- Rozenblat, E., Brown, J. L., Brown, A. K., Reeve, S. A. & Reeve, K. F. (2009). Effects of adjusting DRO schedules on the reduction of stereotypic vocalizations in children with autism. *Behavioral Interventions, 24*, 1-15. doi: 10.1002/bin.270
- Saylor, S., Sidener, T. M., Reeve, S. A., Fetherston, A., & Progar, P. R. (2012). Effects of three types of noncontingent auditory stimulation on vocal stereotypy in children with autism. *Journal of Applied Behavior Analysis, 45*, 185-190. doi: 10.1901/jaba.2012.45-185

Schopler, E., Van Bourgondien, M. E., Wellman, G. J., & Love, S. R. (2002). *Childhood Autism Rating Scale* (2nd ed.). Los Angeles, LA: Western Psychological Services.

Simmons, J. N., Smith, R. G., & Kliethermes, L. (2003). A multiple-schedule evaluation of immediate and subsequent effects of fixed-time food presentation on automatically maintained mouthing. *Journal of Applied Behavior Analysis*, *36*, 541-544. doi: 10.1901/jaba.2003.36-541

Stahmer, A.C. & Schreibman, L. (1992). Teaching children with autism appropriate play in unsupervised environments using a self-management treatment package. *Journal of Applied Behavior Analysis*, *25*, 447-459. doi: 10.1901/jaba.1992.25-447

Thelen, E. (1979). Rhythmical stereotypies in normal human infants. *Animal Behaviour*, *27*, 699-715. doi: 10.1016/0003-3472(79)90006-X



Table 1

*Participants' Characteristics*

Name	Age	CARS-2 T-score	Context	Stereotypy
George	4	57	Free play	Tearing
Billy	7	52	Free play	Vocal stereotypy
Elliot	6	57	Free play	Vocal stereotypy
Abby	8	67	Free play	Stereotypic object manipulation
Ben	5	34	Free play	Head banging Mouthing
Alia	10	47	Free play	Vocal stereotypy
Bob	7	36	Television watching	Repetitive play/pause
Henry	7	45	Homework	Repetitive throwing of pen caps
Albert	3	54	iPad play	Hand clapping
Emile	7	57	Homework	Vocal stereotypy
Dave	5	58	Free play	Vocal stereotypy

*Note.* Childhood Autism Rating Scale, Second Edition (CARS-2)

Table 2

*Behavioral Definitions*

Behavior	Definition
Hand clapping	Repetitive contacts of the hands together
Vocal stereotypy	Acontextual sounds or words produced by the vocal apparatus
Mouthing	Insertion of a body part in the mouth
Repetitive play/pause	Playing and pausing the television repetitively
Visual stimulation	Moving a piece of paper repetitively in front of the eyes
Tearing	Tearing papers and tissues in small pieces
Repetitive throwing of pen caps	Throwing pen caps repetitively on the floor
Stereotypic object manipulation	Repetitive rubbing of the hands on objects
Functional engagement	Using play or task materials in a manner consistent with their intended function or, for television watching, sitting on the couch, facing the television without touching the remote control

Table 3

*Means of Stereotypy, Functional Engagement, and Interobserver Agreement*

Name	Age	Stereotypy (%)			Functional Engagement (%)		
		Baseline	Intervention	IOA	Baseline	Intervention	IOA
George	4	82.7	16.1	93.5	3.5	64.7	94.6
Billy	7	31.1	2.0	90.2	53.3	68.3	88.9
Elliot	6	31.7	4.4	87.6	0.7	1.9	94.0
Abby	8	99.3	43.4	91.2	0.0	4.4	99.5
Ben	5	9.3	0.4	95.6	43.2	98.5	91.4
Alia	10	19.5	6.1	85.2	N/A	N/A	N/A
Bob	7	42.7	2.1	92.5	29.2	89.0	94.3
Henry	7	87.4	35.4	92.1	0.9	45.3	93.3
Albert	3	7.5	9.5	91.2	85.8	83.1	94.0
Emile	7	10.1	10.3	90.1	51.0	51.7	90.2
Dave	5	25.7	21.2	83.8	24.1	28.4	92.7

*Note.* Interobserver agreement (IOA)

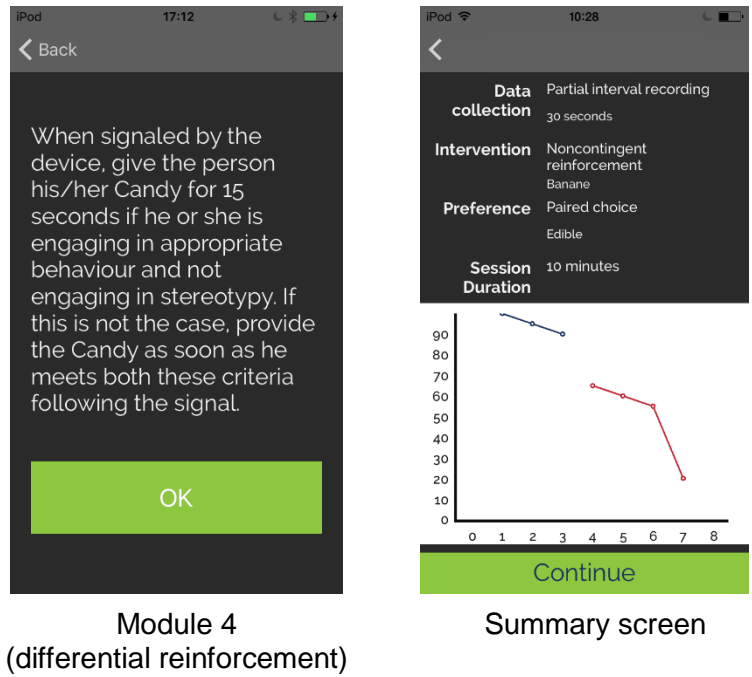
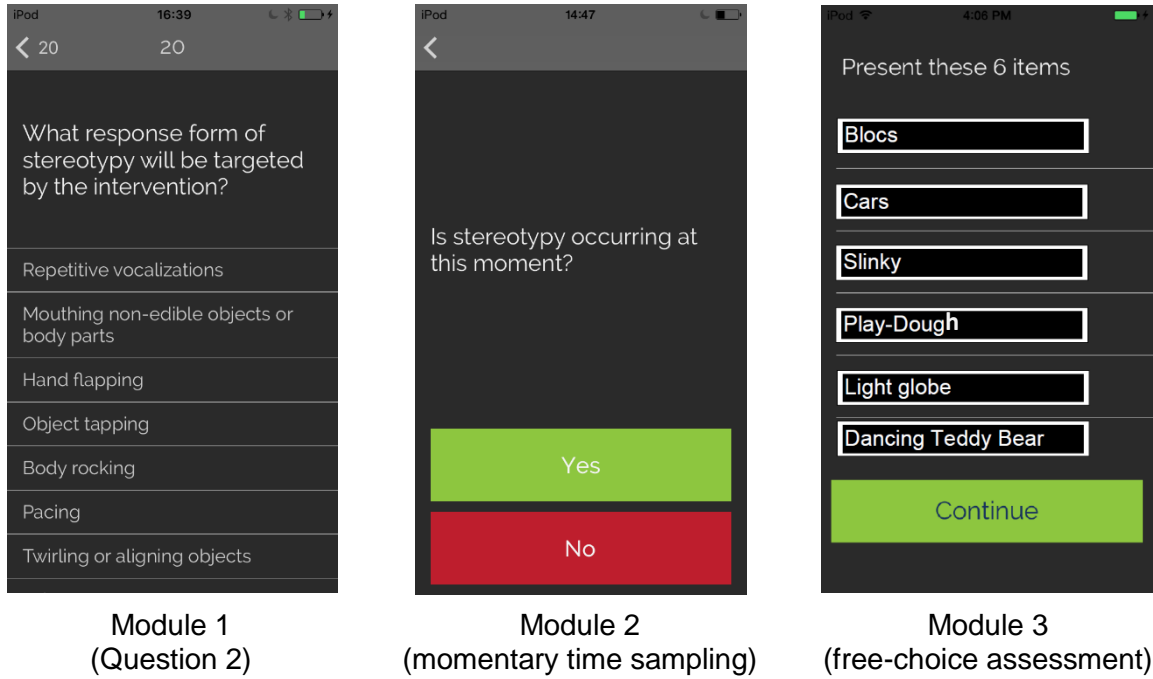


Figure 1. Screenshot examples for each module of the iSTIM

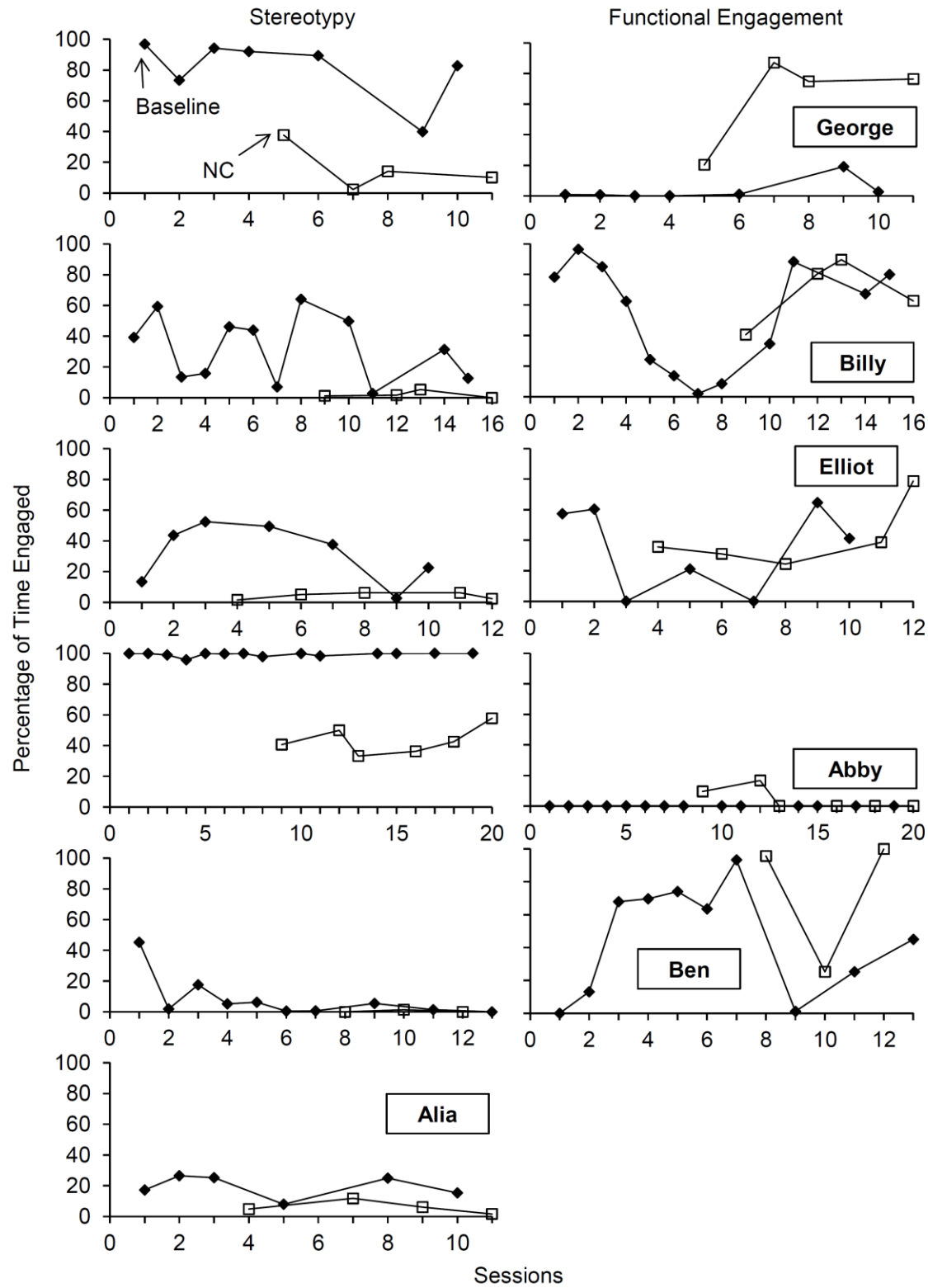


Figure 2. Percentage of time of engaged in stereotypy and functional engagement during baseline and noncontingent access (NC) conditions.

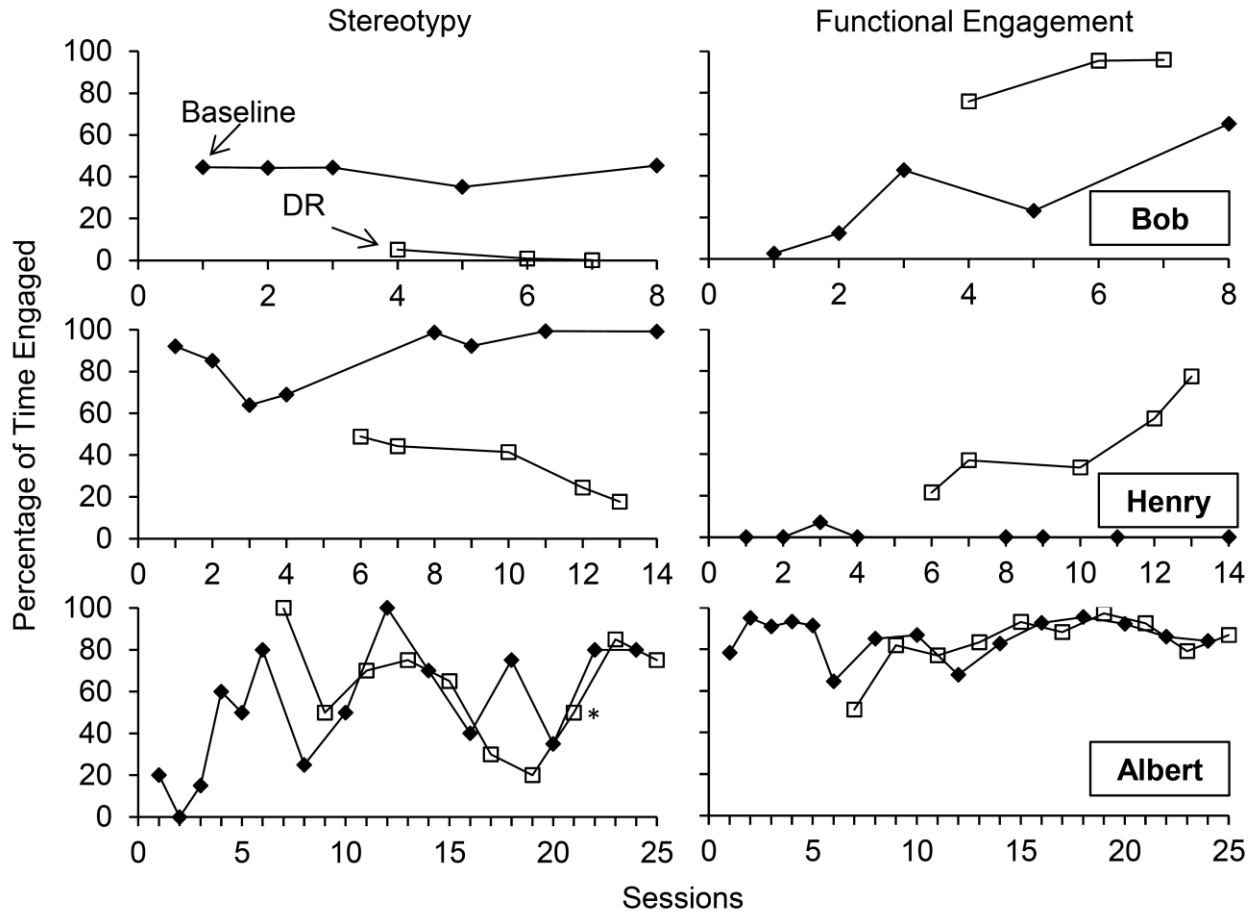


Figure 3. Percentage of time of engaged in stereotypy and functional engagement during baseline and differential reinforcement (DR) conditions. The asterisk denotes a change in reinforcer during the intervention.

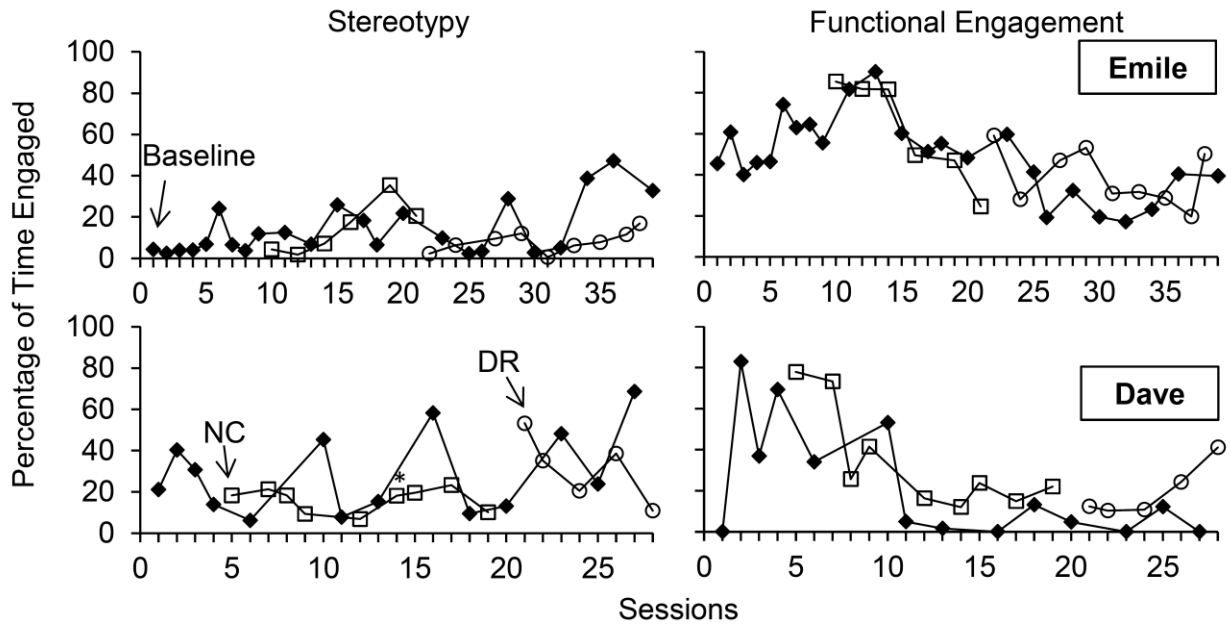


Figure 4. Percentage of time of engaged in stereotypy and functional engagement during baseline, noncontingent access (NC), and differential reinforcement (DR) conditions. The asterisk denotes a change in preferred stimulus during the intervention.