Comparing the Effects of Immediate vs. Delayed Differential Reinforcement of Zero Rate Behavior Schedules on Tic Suppression

Kristine T. Vo
Marquette University

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by

Kristine Vo, B.A.

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ABSTRACT
COMPARING THE EFFECTS OF IMMEDIATE VS. DELAYED DIFFERENTIAL REINFORCEMENT OF ZERO RATE BEHAVIOR SCHEDULES ON TIC SUPPRESSION

Kristine Vo, B.A.

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Persistent Tic Disorder and Tourette Disorder are a neuropsychiatric condition characterized by motor and or/ vocal tics. Treatment surrounding tics involves pharmaceutical or behavior therapy. Individuals seeking behavior therapy receive habit reversal training (HRT) or comprehensive behavioral intervention for tics (CBIT). Much research demonstrates the efficacy of HRT and CBIT, however, as these treatments often teach effective tic suppression skills, it may be useful to better understand the behavioral contingencies that most effectively lead to suppression. This research aims to compare different schedules of reinforcement on tic suppression. Two individuals diagnosed with Tourette's Disorder, ages 9-14, participated in this study. A multielement treatment design was used to compare three conditions, baseline (BL), immediate differential reinforcement of zero rate behavior (DRO-10s), and delayed differential reinforcement of zero rate behavior (delayed DRO). Tic frequencies were significantly higher during BL conditions compared to DRO-10s and delayed DRO across participants. Although DRO-10s and delayed DRO demonstrated robust decrease in tic frequency, the results between DRO conditions were undifferentiated. Self-reported urge to tic ratings decreased from pre-sessions rating in baseline sessions and increased following both DRO conditions. Only one participant reported a slight increase in urge to tic ratings following the initial baseline and one participant reported no change in self-reported urge to tic ratings in DRO10s condition. Urges precedes tics were reported to be aversive, and while best practices would not recommend utilizing DRO procedures as a method to produce tic suppression, both participants one trial preference assessment implies general reinforcing value for suppressing tics.

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Introduction

Tic disorders, such as Tourette Disorder (TD) and persistent (chronic) motor or vocal tic disorders, are neuropsychiatric conditions defined by the production of sudden, rapid, and nonrhythmic motor movements (motor tics) or vocal sounds (vocal tics) that persist for at least one year (American Psychiatric Association, 2013). The onset of tics typically occurs in children between 3 and 8 years of age (Knight et al., 2012). The prevalence of tic disorders is between .04% and 3.0%, and the diagnosis is more common in males (Mason et al., 1998; Zeitlin et al., 2001). Many individuals with tic disorders describe an accompanying aversive sensation that precedes tics and often occurs in the joints, muscles, and other parts of the body (Steinberg et al., 2010). Tics are thought to be negatively reinforced, as they temporarily terminate the aversive sensation, also known as the premonitory urge (Reese et al., 2014).

Tics are associated with impairment in physical and psychosocial domains. Repeated performance of tics may lead to musculoskeletal or neuropathic pain, tissue damage, and injury (Fusco et al., 2006). Pain from repeated motor movements can occur (Fusco et al., 2006), and tics also affect multiple aspects of the individual's social functioning. Fluctuation in tic frequency, duration, and intensity may impede one's ability to concentrate in class, interfere with task performance or completion, and disrupt reading fluency or handwriting activities (Packer, 2005). Children with tic disorders are more likely to experience a lower quality of life, are perceived less positively, experience more peer rejection than children without tics, and are more likely to be victims of bullying (Zinner et al., 2012).

Various treatment options exist for individuals with tic disorders. Pharmaceutical treatments, including alpha 2-adrengic agonists, antipsychotics, topiramate, and tetrabenazine (Cothros et al., 2019) are widely used. Although effective in reducing tics, long-term use of these medications can be associated with unfavorable side effects involving drug-induced movement disorders, weight gain, increased heart rate, and blood pressure, increase in prolactin, and QT prolongation (Pringsheim et al., 2019). Individuals often discontinue medication due to the side effects or may be unresponsive to pharmaceutical treatments (Deckersbach et al. 2006).

Behavioral treatments, including habit reversal training (HRT) and comprehensive behavioral intervention for tics (CBIT), also reduce tic severity. HRT, developed initially to treat tics, nervous habits, stuttering, and other habit disorders, includes nine primary techniques; four designed to increase awareness, one teaching a competing response, three for increasing motivation, and one to enhance treatment generalization (Woods & Miltenberger, 1995). The awareness techniques include response description, response detection, early warning training, and situation awareness (Woods & Miltenberger, 1995). After becoming aware that the tic(s) has or is about to occur, individuals use a competing response technique contingent on tics. A competing response involves doing a behavior that is (a) opposite of the tic, (b) possible to complete for at least 1 min, and (c) socially inconspicuous and can be easily completed during an ongoing activity (Azrin & Nunn, 1973). Lastly, using the generalization technique, individuals practice the procedures while imagining themselves in various high-risk (e.g., for tics) situations (Woods & Miltenberger, 1995).

HRT trains individuals to gain control over their tics by emitting an inhibiting response (e.g., competing response to the tic) in the presence of an urge (Azrin & Nunn, 1973; Piacentini & Chang, 2005; Viefhaus et al., 2020; Woods & Miltenberger, 1996). Peterson and Azrin (1994) and Piacentini and Chang (2005) evaluated and confirmed that HRT is effective in reducing tics. Other studies found that relative to control conditions, adults with tics had significantly fewer tics and reduced functional impairment following a course of HRT (Deckersbach et al., 2006; Wilhelm et al. 2003). Interestingly, Deckersbach et al. demonstrated that individuals who were less compliant in doing competing responses responded more poorly to HRT (Deckersbach et al., 2006). Although HRT has been successful in reducing tic severity, attempts have been made to further improve the therapeutic benefits of HRT via procedural modifications.

One example is comprehensive behavioral intervention for tics (CBIT). Researchers designed CBIT to reduce tics in children and adolescents (Piacentini et al., 2010). CBIT is composed of HRT, relaxation training, functional intervention, psychoeducation, and a behavioral reward program (Piacentini et al., 2010).

Functional intervention starts by identifying antecedent and consequences that influence tic expression (Piacentini et al., 2010). Antecedent events are those that occur prior to the occurrence of tics, and consequence events are those that occur immediately following tics. Examples of antecedents that may lead to tic occurrences include conversing with others, watching television, discussing topics related to tics, stress and anxiety, or specific environmental situations (Capriotti et al., 2015; Silva, et al., 1995). Therapeutically, clinicians and clients learn to identify tic-triggering antecedents and alter

them to reduce tics. For example, a decision may be made to rearrange seating conditions for students who tic frequently while sitting in front of the class.

Consequences that occur immediately following tics may also increase or decrease the likelihood of tics occurring again in similar contexts. For example, one common consequence of ticcing is the immediate removal of the premonitory urge, which can increase the future likelihood of tics occurring in the presence of subsequent urges. Other examples include tic-contingent social consequences, such as attention from family members, peers, or individuals in the community. Ticcing may also be positively reinforced by tic-contingent comfort. Based on a functional assessment, individualized behavioral strategies are developed to alter or reduce contact with consequences that exacerbate tics.

CBIT also includes a psychoeducation component that focuses on reducing stigma by teaching the patient about tic disorders. The behavioral reward program involves the patient earning points for attending session, completing homework assignments, and attempting or completing in-session activities. *However, the CBIT reward program does not directly reinforce the absence of tics or successful tic suppression*. Earned points are exchangeable for delayed backup reinforcers that are predetermined between the therapist, caregiver, and the patient (Woods et al., 2008). Although the therapists provide points during or at the end of session, earned points are exchanged for earned rewards with the caregiver outside of session.

Large trials have examined the efficacy of CBIT compared to supportive therapy. Piacentini (2010) and colleagues found that children randomized to the CBIT group exhibited a 7.6 decrease in the Yale Global Tic Severity Scale (YGTSS) Total Tic scores

following 10-weeks of treatment, compared to a 3.5-point decrease in the supportive therapy plus education group. This study demonstrated that 53% of CBIT patients were clinical responders compared to 19% of supportive therapy. By extension, this also indicates that 47% of the children did not respond to CBIT (Piacentini et al., 2010), suggesting further research should focus on enhancing CBIT's efficacy. One way to do so maybe to incorporate schedules of reinforcement that directly target tic-suppressing responses.

At its core, HRT involves teaching the patient to engage in a behavior (e.g., the competing response) that interrupts and prevents the tics from occurring. At the point of having a tic (i.e., in the presence of a premonitory urge), an individual makes a behavioral choice. They may choose to tic or to engage tic suppression behavior. Ticcing may result in an immediate negative reinforcer (e.g., the termination of an urge), whereas suppressing tics is reinforced by a more delayed and distal reinforcer (e.g., prevention of physical impairment and decreased social difficulties). Currently in CBIT, reinforcement for emitting a competing response is delivered for broadly defined treatment compliance, with the exception of generalized conditioned reinforcers in the form of therapist praise, reinforcers for successfully using the competing response or displaying tic reduction are not delivered directly or immediately. Nevertheless, a growing body of experimental work has evaluated the impact of differential reinforcement on tic suppression. Studies have shown that differentially reinforcing the absence of tics leads to a significant decrease in tic frequency (Capriotti et al., 2012; Himle et al., 2008; Woods & Himle, 2004).

Using Reinforcement Schedules to Strengthen Tic Suppression

The differential reinforcement of zero rate behavior (DRO) procedure is a contingency in which reinforcers are delivered following an interval without an occurrence of a defined undesirable behavior (Catania, 2013; Jessel & Ingavarsson, 2016; Mazaleski, et al., 1993). Importantly, no specific behavior is reinforced. Rather, only the absence of the target response is required to produce reinforcement (Poling and Ryan, 1982). Furthermore, it is crucial that reinforcers utilized in DRO procedures are stronger than those available for the undesirable behavior (Poling & Ryan, 1982; Repp & Deitz, 1976). DRO appears to be relatively common in the treatment of various forms of problem behavior including self-injurious (Mazaleski et al., 1993) and undesirable classroom behaviors (Repp et al., 1983). As applied to tics, Wagaman (1995) and colleagues first demonstrated the effectiveness of DRO procedures to suppress a vocal tic for a 9-year-old male utilizing a reversal treatment design. The results showed that the participant had variable tic frequency during baseline conditions and low to zero levels of tic expression across all DRO conditions.

In addition to the Wagaman (1995) study, a series of lab-based studies have tested the impact of DRO on tics. Using an alternating treatments design, Woods and Himle (2004) compared the effects of verbal instruction to suppress tics vs. DRO-enhanced instruction on tic reduction. The experiment included four participants, each of whom exhibited at least one tic. Each participant was exposed to five consecutive 5- min conditions. A token dispenser placed in front of the participants was controlled by the experimenter in the observation room. Participants were informed that the machine was a "tic detector" and had the ability to count tics. The first baseline condition involved the

therapist telling the participant the tic detector would count each tic occurrence and that they could tic as needed. No consequences were provided during the baseline condition. During the verbal instruction condition, the therapist told participants to sit in front of the tic detector and attempt to stop their tics from occurring. No consequences were provided for suppressing tics. In the DRO-enhanced instruction condition, participants were instructed to suppress their tics, and the tic detector delivered a token following 10s tic-free interval. At the end of the experiment, the participants exchanged the tokens for money. Overall, DRO-enhanced instruction resulted in a 76.3% decrease in tic frequency from baseline, compared to the 10.3% reduction found in the verbal instruction condition. The verbal instruction condition is analogous to the treatment approach taken in CBIT, in that during CBIT, the therapist provides similar instructions such as “do not tic and practice your competing response”, but there are no programmed consequences for successful suppression. Findings from Woods and Himle (2004) study suggest that adding the use of a DRO schedule in HRT may provide a way to enhance tic suppression. Subsequent studies have also tested the effects of DRO schedules and confirmed a robust reduction of tics in children with tic disorders.

Himle et al. (2008) compared the effects of DRO and noncontingent reinforcement (NCR) schedules on tic suppression. Four participants diagnosed with PTD, who each engaged in at least one tic per minute, were asked to sit on front of the “tic detector” and told the device would count the occurrences of tics and dispense tokens. Participants were told they could earn tokens during the study and that earned tokens could be exchanged for a small prize. During baseline, participants were instructed to sit alone in a small room, face the token dispenser, and tic as needed. No tokens were

dispensed during the baseline condition. The DRO condition was similar to baseline, except the participants were instructed to suppress all tics, and tokens were delivered following 10 seconds of no tics. During NCR, the therapist instructed the participants to suppress all tics, and tokens were delivered on a fixed-time (FT) schedule, regardless of performance. The experimenters used a multielement design to compare all conditions. After the initial baseline condition, the conditions were randomized and repeated three times throughout the study. Results showed a reduction in tic frequency during the DRO condition compared to baseline for 3 out of the 4 participants. Only one of the three participants demonstrated tic suppression during NCR. The fourth participant showed undifferentiated responding across baseline, DRO, and NCR. In summary, for three of the four participants, noncontingent reinforcement did not reliably suppress tics, suggesting that the DRO contingency was responsible for decreasing tic frequency.

Greene et al. (2015) extended earlier studies by comparing verbal instruction, DRO, and NCR in 21-school-aged children whose tics began within the prior six months of diagnosis. A computer program, TicTrainer was used to record the timing of each tic, track the 10s tic-free interval, and deliver tokens during reinforcement conditions. Each of the participants (ages 5-14 years with tics) completed two 5 min sessions of baseline, verbal instruction, DRO, and NCR respectively. During baseline, the participants were told to tic as needed, and that the tic detector would count each tic. There were no programmed consequences during baseline. The verbal instruction condition was like baseline except participants were instructed to suppress all tics. In the DRO condition, participants were instructed to suppress their tics, and the therapist delivered a token that would appear on the screen following each 10s interval without tics. In the NCR

condition, participants were told to suppress their tics; and a token was delivered regardless of tic occurrences. The delivery of reinforcement in the NCR condition was yoked to the time of token delivery in the DRO condition. For example, if a token was delivered at 1:23 during the first DRO condition, the experimenter would deliver a token at the same time during the NCR condition, regardless of tic occurrence (Greene et al., 2015). Following the initial exposure to each condition, the second presentation of the conditions was conducted in reverse order (baseline, NCR, DRO, and verbal instruction, respectively) to counterbalance and control for possible order effects. The participants demonstrated the greatest tic reduction during the DRO condition (M=2.67, SD=3.12) compared to baseline (M=4.37, SD=2.95). The participants also exhibited decreases during the verbal instruction (M= 3.41, SD=3.06) and NCR conditions (M=4.01, SD=5.62). This study again demonstrated that tic suppression was most successful when immediate reinforcers were provided contingent on the absence of tics.

Studies have also evaluated the effects of punishment procedures compared to differential reinforcement schedules on tic suppression. Capriotti et al. (2012) extended previous research and compared DRO to a punishment procedure. In this study, three of the four participants demonstrated a greater decrease in tic frequency during the DRO and response cost (RC) conditions compared to the baseline conditions. Although there were no reliable differences in tic suppression between DRO and RC, this study further suggests that positive reinforcement contingencies effectively reduce tics.

Prior studies all utilized resetting DRO procedures in which patients were provided a token following every n-seconds tic-free interval. Capriotti (2017) and colleagues expanded the utility of DRO by increasing the magnitude of reinforcers

contingent on each consecutive interval that elapsed. “Progressive amount” schedules have been shown to be more effective than fixed-amount schedules within substance use literature (Capriotti et al., 2017). Thus, Capriotti et al. (2017) compared the effects of progressive amount DRO (DRO-P) and fixed amount DRO (DRO-F) schedules on tic suppression using a multi-element design. Four adolescents with tic disorders were exposed to eleven, 6 min randomized sessions, which included three baseline conditions, four DRO-F conditions, and four DRO-P conditions. Following the eleventh session, a one trial preference assessment was conducted. Prior to the initial session, participants were told the tic detector could count each occurrence of a tic and were instructed to sit facing the tic detector for accurate monitoring. The researchers informed the participants that every 1000 points were worth $20, although all participants were rewarded $20 at the end of the experiment, regardless of performance. During the baseline condition, participants were told the tic detector would count their tics, and no points were available. During the DRO-P condition, DRO-10s was initially in effect and the magnitude was set at 6 points. The reinforcer incrementally increased by one point following each subsequent tic-free interval. For example, the participant earned 6 points following the first 10s tic-free interval and could earn 7 additional points following the consecutive 10s tic-free interval (total of 13 points). Contingent on an occurrence of a tic, the interval time and the magnitude of the reinforcer reset to 6 points. The participant would have to engage in 3, fixed-DRO intervals with the magnitude of 6 points before the value of the reinforcer reverted to the highest number of points previously attained. During both the DRO-F and DRO-P conditions, participants viewed their accumulated points on a monitor throughout session and a brief tone sound was delivered to indicate points had

been earned. The preference probe for baseline, DRO-F, and DRO-P involved the participants selecting a square that represented each condition. Following the preference probe, a 15-min extinction session was conducted.

Results of this study showed that three of the four participants demonstrated a reduction in tic frequency during DRO-F and DRO-P conditions compared to baseline. There was no difference in tic reduction between DRO-F and DRO-P. Although the DRO schedules of reinforcement resulted in similar reduction in tic frequency, three out of four participants indicated a preference for DRO-F. The other participant selected baseline and no participant indicated DRO-P as a preference. In summary, the DRO-F schedule effectively decreased tic expression and produced sustained tic suppression across participants. Additionally, it was the preferred schedule.

Comparison of DRO Schedules on Tic Suppression

Behavioral treatments including HRT and CBIT have evolved and been proven effective for individuals with tic disorders. However, various procedural changes may enhance treatment. Basic and applied research examining the effects of DRO on tic suppression suggests several reasons why the targeted use of such procedures have the potential to enhance HRT/CBIT efficacy. First, DRO schedules may allow the therapist to be more specific in the delivering reinforcers for a target response (e.g., the absence of tics over a given time interval) compared to CBIT, in which clients receive points for multiple behavior chains that are indirectly related to tic reduction, such as completing and turning in homework or participating in activities during session. Second, DRO may provide participants more practice opportunities to engage in tic suppressing behaviors

such as competing response with the therapist. Imbedding more practice opportunities to engage in tic suppression would promote longer sustained tic suppression and habituation to the premonitory urge. Finally, the immediate delivery of reinforcer may increase motivation to engage in tic suppressing behaviors. The programmed reinforcement within CBIT does not directly reinforce tic suppressing behavior, and reinforcers that are delivered are done so on a delayed schedule. More specifically, points are provided following the end of treatment session or the next appointment rather than an immediate delivery of reinforcers during treatment appointments. In general, integrating DRO into CBIT may lead to an increase in treatment responders and ultimately enhance CBIT. Nevertheless, before integrating DRO procedures into CBIT, further research on whether reward immediacy in DRO impacts tic reduction and whether delayed vs. immediate DRO schedules are preferred by patients should be evaluated. In the current study, we will evaluate whether DRO with immediate reinforcer delivery differs in efficacy from DRO in which reinforcers are delivered following a delay.

Furthermore, client's preferences on the DRO with or without reinforcer delay are of clinical importance. Obtaining such information may allow therapists to provide patients treatment that is consistent with patients wishes (Givens et al., 2007; Sidani et al., 2006; Sidani et al., 2009). Capriotti (2015) and colleagues demonstrated that participants showed a higher preference for a fixed schedule of reinforcement compared to a progressive schedule of reinforcement. Other studies including Lucyzinski and Hanley (2009) showed that more participants preferred differential reinforcement of an alternative behavior compared to NCR. Incorporating choices within treatment will identify more potent reinforcers for individuals (DeLeon et al., 2009; Fisher et al., 1992;

Hanley & Tiger, 2011). Whether immediate vs delayed delivery of reinforcement produces effective reduction in tics, a measure of preference may provide additional valuable information. This present study will compare the effectiveness of immediate DRO (DRO-10s) vs Delayed DRO schedules on tic suppression. Additionally, we will evaluate individuals self-reported urge to tic ratings and participant's preference between baseline, DRO-10s, and delayed DRO conditions.

Methods

Participants

Two participants were recruited through the Tic Disorders Clinic at Marquette University. Inclusion criteria were as follows: (1) ages 8-17; (2) positive for DSM-5 diagnosis of Tourette Disorder or Persistent Tic Disorder; (3) Yale Global Tic Severity Score (YGTSS; Leckman et al., 1989) $\geq$ 14 and < 30 OR $\geq$ 10 and < 20 if persistent tic disorder (for the total scores > 30); (4) exhibited at least one tic per minute during a 5 min observation or screening; (5) had not been taking any tic suppressing medication for at least 6 weeks; (6) had access to an internet connection with a minimum speed of 5 megabytes per second (Mbps); (7) was fluent in English. Exclusion criteria included (1) co-occurring disorders (as assessed on a structured clinical interview) that required immediate treatment (2) T-Score <37 on the Wechsler Abbreviated Score of Intelligence, second edition (WASI-II)-Vocabulary subtest (Wechsler, 2011); and (3) T-Score $\geq$ 80 on the inattention or hyperactivity/impulsivity scales of the Conners 3-Parent Short (C 3-PS; Conners, 2008).

Ryan. Ryan was a 9-year-old Caucasian male diagnosed with Tourette's Disorder. Ryan experienced tics since the age of 7. At the time of screening, Ryan indicated that he had 5 motor tics: facial tics, eye tics, two different nose tics, and a neck tic (Table 1). Prior to the study, Ryan had no behavioral or pharmaceutical treatment for his tics. A trained clinician conducted the Mini-Kid, diagnostic interview for DSM-IV psychiatric disorder, and found that Ryan only met the criteria for Tourette's Disorder.

Kayla. Kayla was a 14-year-old Caucasian female diagnosed with Tourette's Disorder. Kayla experienced tics since the age of 9. A total of 5 motor tics and 5 vocal tics were described during the screening (Table 1). She demonstrated a face scrunch tic, three different head tics, and an arm tic (Table 1). Her vocal tics involve a sniffing tic, gasping tic, and sounds or words (Table 1). Kayla indicated that she tried TicHelper, an 8-week online program that provided self-guided therapy and comprehensive information regarding tics and the types of treatments available for individuals experiencing tics. Other than TicHelper, Kayla had never received clinically guided behavioral or pharmaceutical treatment for her tics. The Mini-Kid was conducted and identified that Kayla met criteria for attention deficit hyperactivity disorder (ADHD), non-specified anxiety disorder, and depression. A follow up was conducted to assess whether Kayla was receiving treatment for non-tic related disorder. At the time of the study, The primary caregiver reported that Kayla was taking 50 mg of Sertraline for anxiety and depression, and receiving therapy for ADHD and anxiety during the time of the study.

Table 1. Participant's Tic Operational Definition

Participant	Tic	Definition
Ryan	Nose Scrunch	Scrunching the nose with furrowed eyebrows and eyes open
	Nose Touch	Touching or pinching the nose with arms, hands, or finger(s) once or multiple times without releasing the harms, hands, or finger from nose
	Eyebrow Lift	Raising both eyebrows up with or without widening the eyes
	Rapid Eyeblink	2 or more consecutive and fast blinks with a 2s offset
	Chin Downward	Moving chin downward directed towards the center of the upper chest
Kayla	Face Scrunch	Scrunching the nose and eyes with mouth puckered
	Side Head Tilt	Tilting the head to the left or the right with or without other vocal and motor tics
	Downward Head Tilt	Tilting head downward and chin tucked into the chest with or without other vocal and motor tics
	Arm Movement	Closing left or right hand into a fist and hitting the chest
	Chirp	Lips puckered while making chirp/bird sounds with head tic
	Gasp	Gasping air inward with head tic
	Sniff In	Sniffing in with head tic
	"Soup"	Saying the word "soup" with or without head tic
	"Upsie Daisy"	Saying the phrase "upsie daisy" with or without head tic

Materials

Parent Tic Questionnaire (PTQ; Appendix A).

The Parent Tic Questionnaire (PTQ) is a caregiver-report designed to measure the presence, frequency, and intensity of common motor and vocal tics over the past week (Chang et al., 2009). Frequency was rated on a scale of 1-4 with the description "constantly" (occurring all times during the day), "hourly" (at least once per hour), or "weekly" (few tics or less a week) (Chang et al., 2009). Parents would rate intensity of tics on the same 1-4 scale with the description "mild" (weak twitch), "noticeable to others," "very noticeable to others and may be painful" (Chang et al., 2009). The subscale score for motor tics (range=0-112) and vocal tics (range 0-112) are summed to yield the total tic severity score (range= 0-224). Research evaluated PTQ internal consistency across two-week evaluation with twenty children diagnosed with Tourette's Disorder and persistent tic disorder. Studies showed that the PTQ had high internal consistency with the motor tic severity score of (a= .72 and .82), vocal tic severity score of (a=.83 and .87), and total tic severity score of (a=.86 and .90) (Chang et al., 2009). The PTQ was compared to the results from the golden-standard measuring tool for tic severity and found strong correlation with motor severity score (r=.66 and .70), vocal tic severity score (r=.45 and .53), and total tic severity score (r=.65 and .62) (Chang et al., 2009). Psychometric testing demonstrated that the PTQ is the first parent-reported tool to demonstrate high test re-test reliability, convergent validity, and shown to be a valuable tool to administer in conjunction with other assessments. (Chang et al., 2009).

Yale Global Tic Severity Scale (YGTSS; Appendix B)

The YGTSS was completed by a trained clinician following a semi structured interview about symptoms in the prior week (Leckman et al., 1989). The presence of tics is recorded on a "Tic Inventory" form, which is used as a guide to rate the severity of motor tics and phonic tics along five different dimensions: number, frequency, intensity, complexity, and interference. A six-point ordinal scale (0-5) is used to score each of the five dimensions separately for motor and phonic tics. For the number dimension, the rating scale is scored from 0 (no tics) to 5 (multiple discrete tics and less than two orchestrated patterns of complex or sequential tics). Frequency is scored from 0 (none, meaning no evidence of specific tic behavior) to 5 (always, specific tic behaviors are present virtually all the time, and tic-free intervals are difficult to identify). Intensity is scored from 0 (absent) to 5 (severe intensity. Complexity is rated from 0 ("simple" tics) to 5 (severe "lengthy" displays or utterances involving unusual, inappropriate behaviors) (Leckman et al., 1989, p. 257). Interference is rated from 0 (none) to 5 (severe, when tics are present, they frequently disrupt ongoing actions or communication)" (Leckman et al., 1989, p. 572). The ratings for phonic tics and motor tics are summed and provide a total tic severity score (range, 0-50). A separate impairment rating focuses on the impact tics had on the individual over the previous week. Domains of potential impairment include the various impacts on self-perception and self-esteem, relationships with family members, social and peer relationships, and the ability to perform in academic or occupational settings (Leckman et al., 1989). An impairment rating is given on a 0 (none) to 50 (severe, tics associated with extreme difficulties on multiple aspects of the individual's life and disrupts social ties) point scale. Leckman et al. (1989) evaluated inter rater reliability across three raters for 20 participants and found that the intraclass

correlation coefficients (ICC) values were significant with motor tics (ICC= .78), phonic tics (ICC= .91), total tic scores (ICC=.84), overall impairment rating (ICC=.80), and global severity score (ICC=.85) (Leckman et al., 1989). Leckman (1989) and colleagues evaluated convergent validity of the YGTSS by comparing the global score to other studies and assessments with similar dimensions. The convergent validity showed that the YGTSS correlated well to the Tourette Syndrome Global Scale (TSGS; Shapiro, 1984) with motor tics (r= .86), phonic tics (r=.91), and total tics (r= .90) (Leckman et al., (1989). YGTSS has shown to be a resourceful measuring tool for clinicians to monitor individuals' tics and guide treatment decisions.

The Mini International Neuropsychiatric Interview—Kid (MINI-Kid)

The MINI-Kid is a standardized 30 min diagnostic interview for DSM-IV psychiatric disorders in children and adolescent (Sheehan et al., 2010). The assessment has strong interrater and test-retest reliability for psychiatric diagnoses in children between the ages of 6 and 17, except for dysthymia. A high correspondence between the MINI-Kid and other diagnostics was demonstrated for any mood disorder, anxiety disorders, substance use disorder, attention-deficit hyperactivity disorder or behavioral disorder, and eating disorders (k=.56-.87). The MINI-Kid was be conducted by a trained clinician and the primary experimenter during the screening (Sheehan et al., 2010).

Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II)

The WASI-II (Wechsler, 2011) is 15-30 mi assessment of general intelligence for individuals between the ages of 6 and 90 years old. The WASI provides a score for both Perceptual Reasoning (PR) and Verbal Comprehension (VC) which assesses knowledge, verbal concept formation, and visual stimuli. This assessment is widely utilized to obtain

an estimate of IQ score and cognitive functioning for individuals evaluated by psychiatrists. For this experiment, we only obtained the vocabulary subset of the assessment as a proxy for IQ.

Conners 3- Parent Short (C 3-PS)

The C 3-PS is a parent-rated assessment to measure inattention, hyperactivity/impulsivity, learning problems or executive functioning, aggression, and peer relations of adolescents (Conners, 2008). Parents rate the frequency of behavior in the past month across 6 items using a scale from 0 (not at all true) to 3 (very much true). The raw score is converted to a T-Score based on age and gender. Individuals with a T-Scores $\geq$ 80 may present concerns related to hyperactivity/impulsivity and inattention (Conners, 2008). A trained clinician administered the C 3-PS during the screening visit.

Training Procedures

A clinician with previous experience observing tics trained the study observers. Training in tic identification occurred by (a) providing didactic instruction about observation procedures, (b) demonstrating how to define tics from pre-recorded video exemplars, and (c) having observers practice identifying tics based on the definitions provided for the pre-recorded exemplars. Following training, the study observers watch two 15 min video of a trained clinician engaging in motor and vocal tics. The trained clinician confirmed whether the trainee's observations were correct. If incorrect, the trained clinician assisted in redefining the operational definition of each tic and having the trainee rescore the training video. The trainees did not have to retrain nor rescore videos. The trainees obtained interrater observer reliability of at least 80% with the trainer on each of the practice video. A frequency within interval coding system was

calculated for each tic in the training video. The score is calculated by dividing the number of agreements by the number of agreements plus disagreements. Trainee 1 received a score of 87.6% and 100%, trainee 2 received a score of 95.7% and 80%, and trainee 3 received a score of 87.5% and 94%.

Interrater Reliability (Appendix C)

A primary observer scored the occurrence of tics for each participant and these data were utilized for evaluating outcomes. A secondary observer scored 100% of the same sessions to calculate inter observer agreement (IOA). The primary observer recorded each session, communicated the start of session by counting down (e.g., "3, 2, 1, and start") and recorded tic occurrences using the TicTrainer Program. The program automatically timestamped when the primary experimenter detected tics. These timestamps were transferred to a frequency within interval coding scheme and yielded an overall dependent variable of frequency of tics.

After the study completion, IOA data were obtained. The primary experimenter discussed the predetermined operational definitions and showed an example of each target tic from the recordings. The secondary observer then watched each recorded session. While watching the recorded videos, the secondary observer took data using a frequency-within interval coding system for each targeted tic. Following completion, the secondary observer's data were compared with the primary experimenter's data. IOA was calculated by dividing number of agreements to the number of agreements plus disagreements per interval between both observers. Then, the percent agreement of each cell was computed and divided across 30 cells for the average for the respective condition. IOA was required to be at least 80% for 3 sessions of each condition (baseline,

DRO-10s, and delayed DRO). If the observers did not meet the criteria, the primary experimenter would observe the disagreements and assess if the observers needed to be retrained. Following retraining, the observers would re-score videos that did not meet criteria. This occurred for occurred for two baseline sessions for participant 1.

Treatment Integrity (Appendix D)

A secondary experimenter also assessed treatment integrity to ensure that the primary experimenter implemented the experiment according to the written procedures. The secondary experimenter was trained on the study protocol, as well as how to identify tics. The primary experimenter was observed providing instructions and conducting the respective conditions. A binary measure assessed the delivery of simple instructions (e.g., Did the researcher display a white virtual background during baseline condition? Yes/No). To determine the accuracy of reinforcer delivery during 5-min DRO-10s and delayed DRO conditions, a percentage of correct delivery was calculated. Correct delivery of reinforcer was defined as a token delivered within 1s contingent on 10s of tic-free interval using a secondary timer. Incorrect delivery of a reinforcer was defined as (a) token delivery prior to the 10s interval with or without tics (e.g., token is delivered within 5s of the 10s interval), (b) token delivery following >1s delay of 10s tic-free interval (e.g., token is delivered following a 3s delay of the 10s tic-free interval), or (c) false positives (e.g., the experimenter pressed “tic detected” which resets the 10s interval and result in no token delivery following 10s of tic-free interval). The secondary observer took treatment integrity data during at least 33.3% portion of the experiment. Treatment integrity was scored for at least one session of baseline, DRO-10s, and delayed DRO condition. The primary experimenter had to obtain a binary treatment fidelity score of at

least 95% and at least 80% accuracy of reinforcer delivery across DRO conditions. For incorrect token delivery, the observer identified whether it was an error of omission (i.e., the primary experimenter did not provide a token following 10s tic free interval) or an error of commission (i.e., the primary experimenter provided a token when tics occurred). Binary measures were calculated by total number of correct steps implemented over the total number of steps. Accuracy of reinforcer delivery was calculated by the total number of correct token delivery divided by the number of correct token delivery plus incorrect token delivery.

Setting and Apparatus

Eligible participants completed the experiment via Microsoft TEAMS. The researcher conducted the study in a quiet session room on secured Wi-Fi network to ensure internet access between the participant and the experimenter. Participants were observed in their own homes and instructed to have no distractors when the experiment was conducted. Participants were provided with individual to access Microsoft Teams meeting.

TicTrainer Program (Appendix E)

Before the experiment, the researcher registered the participant on a web-based program, TicTrainer (Black et al., 2017; Black & Black, 2018), which functioned as a "tic detector" used in previous tic suppression studies (Woods & Himle, 2004; Himle et al., 2008; Capriotti et al., 2012). The participant had a nonidentifying "user" account. The primary experimenter logged into the "user" account and share the display with the participant over Microsoft Teams. When logged in, the participant would only see the TicTrainer user page. For baseline conditions, the participant saw a blank screen with a

highlighted instruction, “free to tic.” In DRO conditions the screen had the instructions “don’t tic,” however, only the DRO-10s condition had tokens appear underneath the instructions. During delayed DRO condition, a blank screen with the instruction “don’t tic” was displayed over Microsoft teams. At the end of each delayed DRO condition, the participant was told how many tokens they had earned. The trainer account allowed the researcher to start and end session, administer reinforcers for successful tic suppression and press a button indicating the presence or absence of tics as they occurred in session.

Procedures (Appendix F)

This study protocol was approved by the IRB (Approval number HR-4000). At the beginning of the Microsoft TEAMS meeting, the primary researcher reviewed and obtained consent and assent forms through Qualtrics. Following consent and assent process, participants were assessed for study eligibility. Participants who were recruited and was deemed eligible from another study participated in the secondary screening. During the secondary screening, the primary experimenter asked the participant to list and describe the number of tics they have experienced within the last month. Following the description, the experimenter created operational definitions and then set a 5 min duration timer to observe frequency of tics. During the 5 min observation, the primary researcher talked to the participant about their interest and took data on frequency of tics. Participants were eligible to participate in the study if they engaged in at least one tic per minute during the 5 min observation.

Participants recruited from the tic clinic were informed about the study via phone call. The experimenter scheduled a 2-hour meeting via Microsoft Teams to complete the primary and secondary screening for eligibility. A trained clinician conducted the YGTSS

and the WASI. The primary experimenter conducted the Mini-Kid and the C3-PS. The primary caregiver was provided a link to complete the demographic form and the PTQ. Following the assessments, the primary experimenter conducted the 5 min observation and recorded frequency of tics. The trained clinician and the primary experimenter analyzed the information obtained from the screening and determined study eligibility.

During the screening, followed similar procedures of obtaining list of tics and the description of each tic. These operational definitions were used later in both the administration of the study and scoring data. Tics that appeared during the study but had not been operationally defined from the outset, were not targeted. During the study, only one participant exhibited tics that were not listed or described by the participant during the screening. The primary experimenter observed Kayla engage in two different tics that were not defined throughout the study. The nontargeted tics were, (1) mouth movement- shifting lower mouth side to side with mouth closed; and (2) popping sound- making popping sound by smacking lips together. These tics were not scored.

A multielement design was used to evaluate the effects of DRO-10s and delayed DRO on tic suppression and changes in urge rating (post rating minus pre rating). Three conditions were compared, including baseline, DRO-10s, and delayed DRO. Consistent with previous research, each condition was 5 min in duration. This experiment consisted of 3 baseline sessions, 3 DRO-10s sessions, and 3 delayed DRO sessions. At the beginning of the study, the primary experimenter informed the participants that they have an opportunity to earn a prize at the end of the study. A prize may be exchanged from tokens. Additionally, the more tokens earned, the bigger the prize the participant received. The primary experimenter also informed the participant that a self-reported urge

to tic rating using a scale (ranging from 0 to 100) will be obtained at the start of each session and the end of each session. The primary experimenter ensured that each participant understood that the urge to tic is the aversive sensation or "the feeling" that precedes tics. Each participant was exposed to one baseline session prior to DRO-10s and delayed DRO. Following the initial baseline condition, all participants were exposed to each condition (baseline, DRO-10s, and delayed DRO) at least three times but no more than four in random order. Each condition was associated with a colored virtual background. Following the last session, the primary experimenter conducted a one-trial participant preference assessment and debriefed the participant. The primary experimenter informed the participant that the magnitude of the prize was pre-determined before the study began and the purpose of the statement was to observe whether the participant would sustain longer tic suppression when tokens were earned.

The secondary observer was seated behind the primary experimenter and took treatment integrity data using pen and paper. The participant did not see the secondary observer in the camera view. The primary experimenter and the secondary observer agreed upon operational definitions before conducting the experiment.

Baseline. The primary experimenter displayed a white background with an instruction "free to tic" highlighted in green on Microsoft Teams. Tokens did not appear on the screen. The primary experimenter told the participant that the experimenter would observe the targeted tics and obtain an urge rating using a scale from (0-100). Following the urge rating, the experimenter instructed the participants, "you are free to tic as needed." The experimenter asked the participants to repeat the instructions and began the 5-min session. During baseline, the experimenter counted each targeted tic using the

TicTrainer program. The experimenter did not program any consequences for suppressing tics. Following 5 min, the experimenter ended the session and obtained another urge rating (0-100). A 2-min break was offered to the participant.

DRO-10s. The experimenter displayed a yellow background and shared their screen with the participant. The display contained the user's TicTrainer account which had the instruction "don't tic" highlighted in red on a plain white background. Before the primary experimenter provided instructions, an urge rating was obtained. The experimenter instructed the participant, "do everything you can to stop your tics. After a few seconds of no tics, tokens will appear on your screen." After the participant repeated the instructions, the experimenter began the session. Following every 10 s without tics, the TicTrainer program automatically displayed a token on the participant's screen. Contingent on targeted tics, the primary experimenter pressed the button "tic detected" on the TicTrainer program, and the TicTrainer internal timer reset to 0. At the end of session, the experimenter obtained an urge rating and provided a 2-min break.

Delayed DRO. The experimenter changed their background to blue and shared a blank screen with the instruction "don't tic." The experimenter obtained an urge rating from (0 to 100) and provided instructions to try everything they could to stop their tics, and to look forward to a reward at the end of the session. No other specific instructions were provided. Participants earned a token following 10-s interval without tics; however, the tokens did not appear on the participant's screen. Instead, the experimenter told the participant how many tokens they earned at the end of each delayed DRO session. Following observed tics, the experimenter pressed the "tic detected" button and the 10-s interval reset. At the end of each delayed DRO conditions, the experimenter obtained an

urge rating (0-100) and told the participant how many tokens they had earned for holding back tics.

Participant Preference. At the end of the study, the experimenter conducted a one-trial participant preference assessment. The experimenter displayed three different 2 x 2 colored squares. The colored squares corresponded to the colors associated with each condition (white, yellow and blue). The primary experimenter prompted the participant to state the rules of each condition associated with each colored square. If the participant correctly stated the rules for each condition, the primary experimenter asked the participant to pick which condition was most preferred and explain why. If the participant did not answer correctly, the experimenter provided a series of prompts to assist answering the question (e.g., “during that time, did you receive tokens?” “When did you receive tokens?”). Ryan was the only participant that needed the series of prompts to state the rules for two conditions condition. When the primary experimenter asked Ryan to state the rules for baseline, Ryan correctly stated that he was free to tic when the background was white. When the primary experimenter asked Ryan to state the rules for DRO-10s and delayed DRO, Ryan incorrectly stated the rules. The primary experimenter asked Ryan if he received tokens and followed up with the question about when tokens were delivered. Ryan answered correctly to both initial prompts for DRO-10s and delayed DRO. Ryan was asked to restate the rules for all the conditions prior to being asked to state which one was most preferred and why. Kayla correctly stated the rules for baseline, DRO-10s, and delayed DRO during the first opportunity.

Results

Screening Results

Ryan. Ryan received a t score of 52 on the WASI-II, indicating that that his vocabulary skills were within the average range compared to same-age peers. He received a T-score of 56 for inattention and a t score of 66 for hyperactivity/impulsivity on the C3-PS, indicating that he did present concerns related to hyperactivity/impulsivity and inattention. Ryan's caregiver completed the PTQ, and a trained clinician conducted the YGTSS. He received a score of 32 on the PTQ, a YGTSS total tic score of 23 and impairment score of 15.

Kayla. Kayla received a score of a raw score of 62 on the WASI-II, indicating that her vocabulary skills were higher than average compared to same-age peers. Kayla received a T-score of 73 for inattention and a T-score of 69 for hyperactivity and impulsivity on the C3-PS, indicating that there was parent reported inattention symptoms that aligns with the clinical concern. Kayla's caregiver completed the PTQ, and a trained clinician conducted the YGTSS with the participant during the screening. Kayla received a score of 35 on the PTQ, a YGTSS total tic score of 37 and an impairment score of 30.

Interobserver Agreement

Ryan. Ryan's mean interobserver agreement was 81% (range, 77% to 86%) for baseline, 89.6% (range, 88% to 91%) for DRO-10s, and 88% (range, 79% to 100%) for delayed DRO.

Kayla. Kayla's mean interobserver agreement was 80% (range,77 % to 83%) for baseline, 88% (range, 85% to 94%) for DRO-10s, and 90% (range, 80% to 98%) for delayed DRO.

Treatment Integrity

Ryan. During baseline, the primary experimenter received a score of 85% for treatment fidelity. For DRO-10s, the primary experimenter received a binary score of 100% for simple instructions and 86% for accuracy of reinforcer delivery. During the delayed DRO condition, the primary experimenter received a score of 100% for simple instructions and 93% for correct delivery of reinforcers. Errors in binary measures include asking the participant to repeat instruction in baseline, three errors of omission in DRO-10s, and one error of omission in the delayed DRO condition.

Kayla. During baseline, the primary experimenter received a treatment fidelity score of 100%. During the DRO-10s condition, the primary experimenter received a binary score of 100% for simple instructions and 96% for accuracy of reinforcer delivery. Lastly, the primary experimenter received a score of 100% for binary measures and 96% for correct delivery of reinforcer during the delayed DRO condition. Errors in reinforcer delivery includes one error of omission during DRO-10s and one error of commission in the delayed DRO condition.

Comparison of BL, DRO-10 s, and Delayed DRO

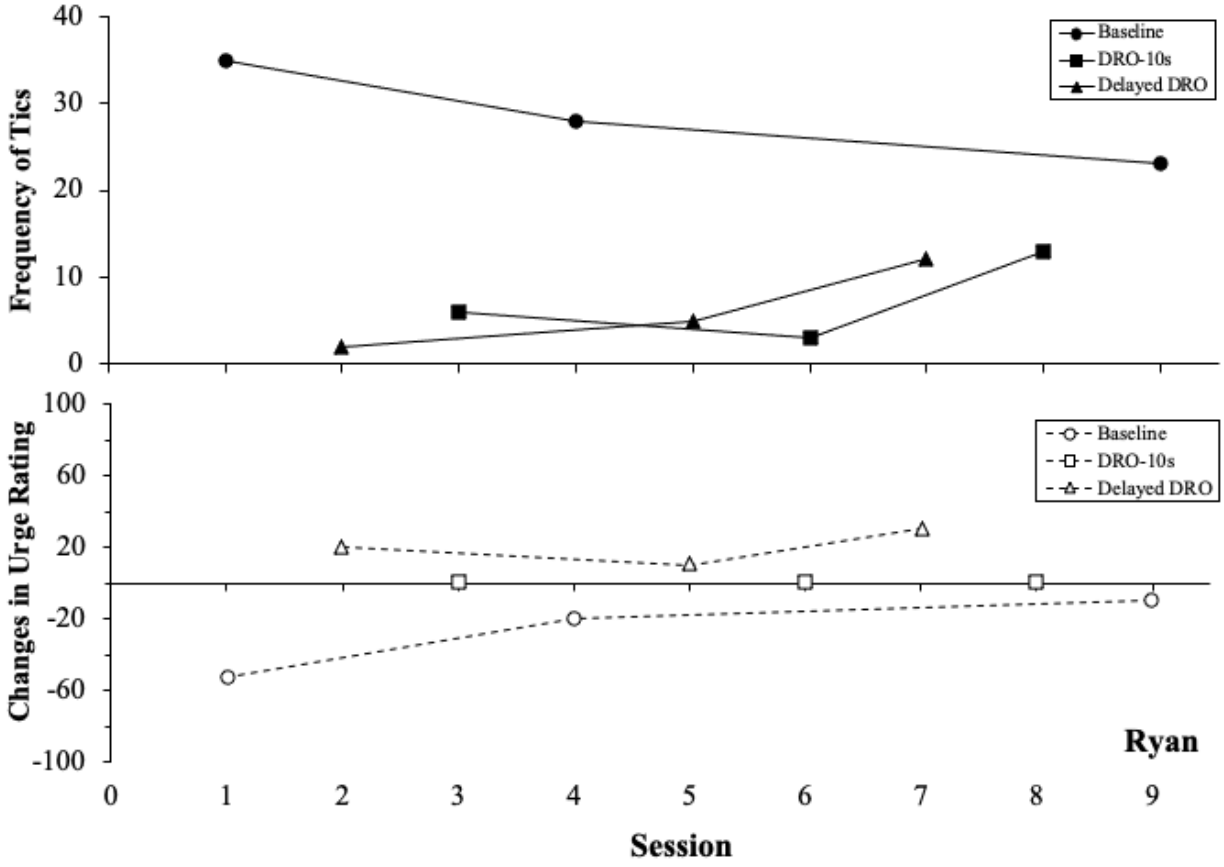
Ryan. Figure 1 shows the result of Ryan's data. Results of the multielement design for tic suppression are presented in the top panel and changes in urge rating in the bottom panel. Across all baseline sessions, tic frequency remained at high levels, however an overall decreasing trend in tics were observed. The mean frequency of tics during baseline was 28.6. When delayed DRO was introduced, tic frequency significantly decreased and remained at lower levels. However, a slight increasing trend in tic frequency was observed. The mean frequency of tics during delayed DRO was 6.3.

Similar to delayed DRO, tic frequency remained at low levels and a slight increasing trend was observed during DRO-10s. The mean frequency of tics during DRO-10s was 7.3. Although both delayed DRO and DRO-10s led to a significant reduction in tic frequency, the results between DRO conditions were undifferentiated.

The changes in urge ratings are graphed the difference between the post-session self-reported urge to tic ratings and by the pre-session self-reported urge to tic ratings. Across all baseline sessions, Ryan's self-reported urge to tic ratings decreased in the post rating from the pre-prating. Following the initial baseline session, urge to tic rating significantly decreased from the pre-session urge to tic ratings. The mean changes in urge rating for baseline was -27.6. Following delayed DRO, Ryan's self-reported urge to tic rating increased across the sessions and demonstrated an overall increasing trend in urges following suppression. The mean changes in urge rating for delayed DRO was +20. Following DRO-10s, Ryan exhibited no changes in urge rating from pre-session self-reported urge ratings. Across all DRO-10s, Ryan self-reported urge to tic rating was an average of 46.6 (range, 40 to 50). Overall, baseline sessions demonstrated a reduction in urge following free to tic condition. Self-reported urge to tic ratings increased across all delayed DRO conditions and did not change across all DRO-10s condition.

Following the forced trial exposure, a one trial preference assessment was conducted to identify participant's preference for any of the conditions. Following acknowledgment of all the rules per condition, Ryan indicated that DRO-10s was most preferred due to the immediacy of token delivery.

Figure 1. Multielement Treatment Design of Baseline, DRO-10s, and Delayed DRO



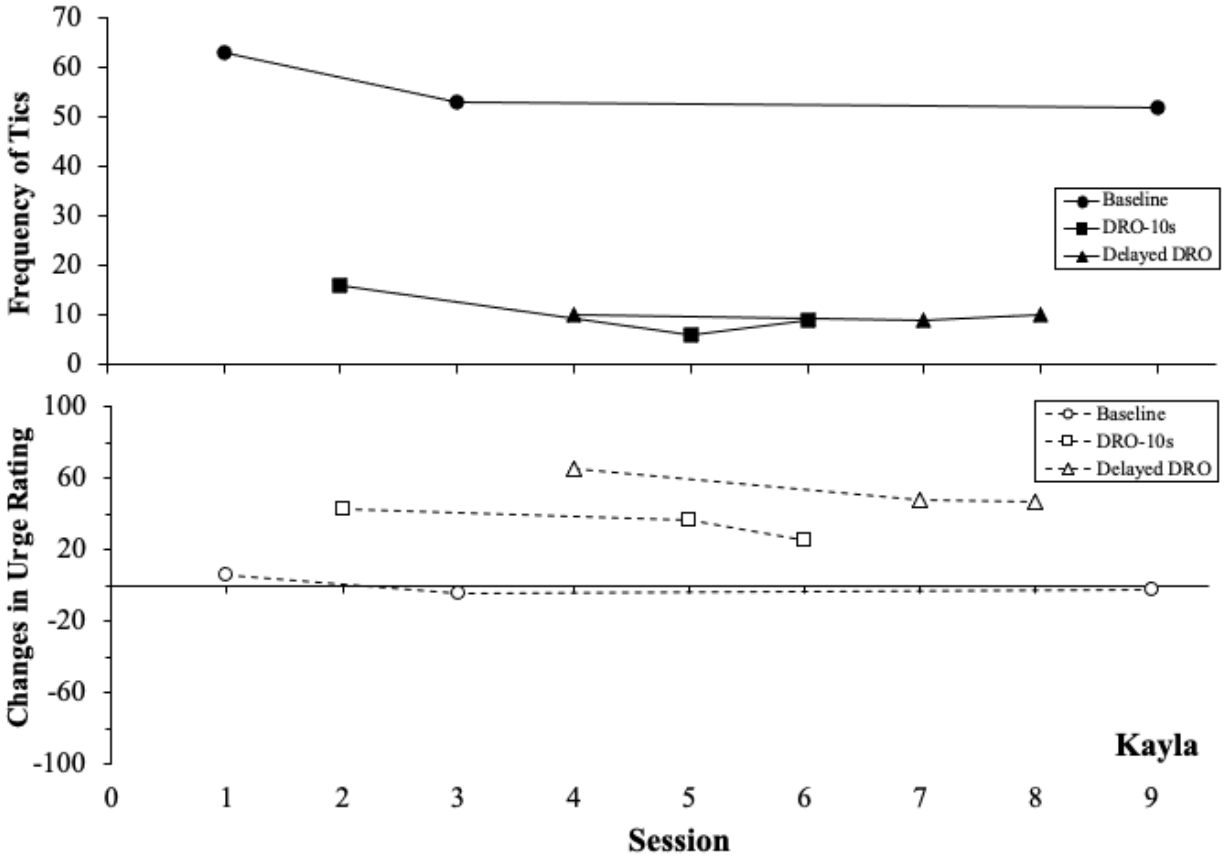
Note. The top panel demonstrates the frequency of tics during baseline, immediate differential reinforcement of other behavior (DRO-10s) and delayed differential reinforcement of other behavior (Delayed DRO) across 9 sessions. The bottom panel demonstrates the changes in urge rating from post session minus pre session across baseline, DRO-10s, and delayed DRO.

Kayla. Figure 2 shows Kayla's data. The top panel displays the frequency of tics in baseline, DRO-10s, and delayed DRO conditions across sessions. The bottom panel shows changes in self-reported urge ratings following baseline, DRO-10s, and delayed DRO conditions. Across all baseline sessions, high levels and stable responding of tic frequency were observed. The mean frequency of tics during baseline was 56. When DRO-10s was introduced, a significant reduction in tic frequency was observed. Across all DRO-10s, tic frequency remained at low level and stable responding. The mean frequency of tics during DRO-10s was 10.3. Delayed DRO also resulted in low levels and stable responding of tic frequency. DRO conditions led to a significant reduction in overall tic frequency and undifferentiated results between DRO-10s and delayed DRO.

Kayla's demonstrated similar correspondence between changes in urge rating and the frequency of tics across baseline, DRO-10s, and delayed DRO with exception to the initial baseline data. In subsequent baseline sessions, Kayla's self-reported urge to tic rating decreased by an average of -2.3 from the initial urge to tic ratings. Across DRO-10s condition, the changes in self-reported urge to tic rating significantly increased following the initial urge ratings and remained at moderate levels. The mean frequency of changes in urge rating across DRO-10s was +34.6. The changes in urge ratings following delayed DRO was higher than DRO-10s; however, an overall decreasing trend was observed. The mean changes in urge ratings following delayed DRO was +53.3. In general, Kayla demonstrated that following free to tic conditions, a decrease in self-reported urge rating was observed. Additionally, changes in urge ratings were much higher in delayed DRO compared DRO-10s.

Lastly, the one trial preference assessment was conducted to identify the preferred condition. Following Kayla's demonstration of acknowledgement of each condition, Kayla stated that DRO-10s was most preferred. Kayla indicated that DRO-10s was easier to endure while managing her tics.

Figure 2. Multielement Treatment Design of Baseline, DRO-10s, and Delayed DRO



Note. The top panel demonstrates the frequency of tics during baseline, immediate differential reinforcement of other behavior (DRO-10s) and delayed differential reinforcement of other behavior (Delayed DRO) across 9 sessions. The bottom panel

demonstrates the changes in urge rating from post session minus pre session across baseline, DRO-10s, and delayed DRO.

Discussion

The purpose of this paper was to compare the effects of an immediate DRO schedule to a delayed DRO schedule on tic suppression. This study also measured changes in participants self-reported urge to tic ratings when exposed to baseline, DRO-10s, and delayed DRO. Lastly, this paper identified individuals' preference following a forced trial exposure to baseline, DRO-10s, and delayed DRO. Across both participants, a clear reduction in tics were observed in DRO-10s and delayed DRO, compared to baseline, demonstrating that DRO schedules enhance tic suppression. This research also demonstrated an overall impact on urge to tic ratings following periods of tic suppression. Lastly, this study found a consistent preference for the immediate DRO condition.

The robust impact of DRO on tic suppression found in this study is consistent with Woods and Himle (2004), who found that differential reinforcement produced a significant reduction in tics compared to baseline and verbal instruction to suppress tics across all four participants (Woods & Himle, 2004). The result of this study also align with Himle et al. (2008) who found a reliable tic reduction in the DRO condition compared to baseline and NCR for three of the four participants, suggesting that contingency for suppressing tics had significant impact. The participant that did not respond to DRO was also a non-responder to the NCR condition. Although there was no significant difference between DRO-10s and delayed DRO, this is also consistent with Capriotti et al. (2012) who evaluated roles of operant contingencies on tic suppression

and found that DRO did not reliably produce greater tic suppressing affects compared to RC. This study expanded upon previous literature by utilizing DRO derived from Woods and Himle procedures and comparing the effects of an immediate DRO to delayed DRO, which has been used in Woods and Himle (Woods and Himle, 2004; Himle et al., 2008; Capriotti et al., 2012; & Greene et al., 2015).

With respect to the effects of DRO on urge ratings, baseline sessions resulted in a decrease in self-reported urge to tic ratings, whereas self-reported urge to tic ratings stayed stable or increased following DRO-10s and delayed DRO conditions. Combined, these results suggest that urges worsen following periods of withholding tics but diminish when tics are allowed to occur freely. The self-reported urge ratings were found to be consistent with the urge and stress ratings obtained by Capriotti et al. (2012) and colleagues. An urge and stress thermometer were presented on a 9-point scale only at the end of each condition. Capriotti (2012) and colleagues found a robust difference in urge and stress ratings in the DRO and RC condition compared to baseline; however, there were no reliable difference in urge and stress ratings in the DRO and RC condition. This study extended upon Capriotti et al. (2012) by evaluating self-reported urge to tic ratings prior to and following each session.

Preference for an immediate DRO compared to delayed DRO and baseline was reliable across participants. This finding is consistent with Capriotti et al. (2017), who evaluated individuals' preference for DRO-F and DRO-P and found that three of the four participants chose DRO-F and one participant chose baseline over DRO-P. This study combined with Capriotti et al. (2017) still suggests an overall preference for DRO over baseline. Research have suggested explanations for preferring suppressing tics even if

urges worsen. First, suppressing tics result in natural reinforcing consequences such as avoiding negative attention in a form of teasing, reacting to tics, bullying, etc. (Woods and Himle, 2004; Conelea et al., 2008). Additionally, suppressing tics and habituation to urge may result in avoidance of pain and injury such as headaches, neck pain, tissue damage, etc. Others may prefer suppressing tics because it leads to conditioned positive reinforcers. Ryan and Kayla reported that they preferred DRO-10s because of the immediate token delivery. More specifically, Kayla indicated that the immediate token delivery, or DRO-10s condition, allowed for time to go by faster and make tic suppression more manageable.

The findings of this current study may have important clinical implications for the treatment of tics. Individuals with Tourette's Disorder or persistent tic disorder reported a direct functional relationship between urges and tics. More specifically, individuals with tics reports an aversive sensation that precedes tics and is temporarily alleviated following the production of tics. Meanwhile, withholding tics also leads to an increase in urge intensity. This implies the importance of teaching individuals to habituate to urges and the skills to be successful at maintaining tic suppression. One way to teach individuals to habituate to urges and suppress tics may be under differentially reinforcing suppressed tics condition. The results of this study would suggest that delayed DRO is the best condition to teach individuals to habituate to urges, in which the higher self-reported urge ratings would provide optimal practice opportunities to successfully manage premonitory urges. However, both participants indicated a higher preference for immediate DRO. Providing immediate token delivery for periods of no tics may be more motivating and compelling to successfully suppress tics instead of tic expression. While

rewards are programmed within CBIT, DRO is currently not integrated within behavioral treatment for tics. Thus, this research suggests clinicians to manipulate the environment that establishes the reinforcing value for suppressing tics over the urge to complete tics.

It is important to consider that this study only included two participants. To strengthen the findings, future research should include larger samples and expand to include older individuals with tics. Other limitations of the study are worth noting. First, this study was conducted via Microsoft TEAMS. There were connectivity issues that occurred during the study and periods where the primary experimenter did not observe tics. Additionally, the position of the camera restricted the primary experimenter to observe tics that are only exhibited from the individual's chest to the top of their head. Motor tics that occurred below the chest were not targeted during this study. Future research should replicate this study with participants in person and include all possible tics exhibited by the participant for more accuracy. Although this study demonstrated that immediate positive reinforcement for tic-free periods were more preferred compared to delayed DRO and baseline, this study only included a one-trial preference assessment. Future research should conduct multiple preference assessment for reliability measures. Third, strategies for suppressing tics were not provided during the study. Future research should compare DRO on tic suppression when provided a strategy to stop tics versus having no strategy to suppress tics. Lastly, a token was provided on a DRO 10-s schedule without exhibited tics. Future research may compare other schedules (e.g., variable DRO schedule vs a fixed DRO schedule) to compare the relative impact on tic suppression and premonitory urges.

In summary, this study suggests that DRO should be integrated in treatment package for multiple reasons. First, it may be less aversive to experience the urge than to contact the social consequences of ticcing. This treatment may be socially significant because it can improve individual's self-esteem, relationship with peers, performance in academic task, and physical health. Second, it may teach individuals to habituate to premonitory urge and decrease the aversiveness overtime. While this may have positive implication, much research can be done to identify best practicing conditions for any individuals with tics.

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Comparing the Effects of Immediate vs. Delayed Differential Reinforcement of Zero Rate Behavior Schedules on Tic Suppression

APPENDIXES

Kristine Vo, B.A.

APPENDIX A

PARENT TIC QUESTIONNAIRE

For each of the tics listed below, please mark "YES" or "NO" as to whether or not your child has had the tic in the past week.

For each tic you mark as "YES", please mark how **FREQUENTLY** the tic occurred over the past week, according to the following:

C onstant, almost all the time during the day
H ourly, at least once per hour
D aily, at least several times per day
W eekly, just a few times or less

Under **INTENSITY**, rate how intense you believe the tic felt to your child over the past week. For example, if it was very mild, like a weak twitch, that would be a "1". A much more forceful tic that would be very noticeable to others and may even be painful would be rated as a "3" or even higher. Any tic that would be obviously noticeable to others should be rated as at least a "2".

Motor Tics	**Present**		**Frequency**				**Intensity**
	Yes	No	C	H	D	W	(1 - 4)
	1	***0***	***4***	***3***	***2***	***1***	
Eye Blinking	□	□	C	H	D	W	_____
Eye rolling/darting	□	□	C	H	D	W	_____
Head Jerk	□	□	C	H	D	W	_____
Facial Grimace	□	□	C	H	D	W	_____
Mouth/Tongue Movements	□	□	C	H	D	W	_____
Shoulder Shrugs	□	□	C	H	D	W	_____
Chest/stomach tightening	□	□	C	H	D	W	_____
Pelvic Tensing Movements	□	□	C	H	D	W	_____
Leg/Feet Movements	□	□	C	H	D	W	_____
Arm/Hand Movements	□	□	C	H	D	W	_____
Echopraxia (copying another's gestures)	□	□	C	H	D	W	_____
Copropraxia (obscene gestures)	□	□	C	H	D	W	_____
Other Motor Tics _____	□	□	C	H	D	W	_____

Complex Motor Combinations (multiple tics at once)	□	□	C H D W	_____

_____

_____

Office Use Only:

Sum of Motor Tic Scores: _____
Sum of Vocal Tic Scores: _____
Sum of All Scores (Motor + Vocal): _____

PARENT TIC QUESTIONNAIRE

FREQUENCY: Constant: almost all the time during the day, Hourly: least once per hour, Daily: at least several times per day, Weekly: just a few times or less

INTENSITY: Mild: 1, Obvious to others: 2, Very noticeable or painful: 3 or higher.

Vocal Tics	**Present** Yes ***1***	No ***0***	**Frequency** C ***4*** H ***3*** D ***2*** W ***1***	**Intensity** (1 - 4)
Grunting	□	□	C H D W	_____
Sniffing	□	□	C H D W	_____
Snorting	□	□	C H D W	_____
Coughing	□	□	C H D W	_____
Animal Noises	□	□	C H D W	_____
Syllables	□	□	C H D W	_____
Words	□	□	C H D W	_____
Phrases	□	□	C H D W	_____
Echolalia (repeating vocalizations of others)	□	□	C H D W	_____
Coprolalia (obscene words)	□	□	C H D W	_____
Blocking/stuttering	□	□	C H D W	_____
Other	□	□	C H D W	_____

Other Vocal Tics _____	□	□	C H D W	_____
Complex Vocal Combinations (multiple tics at once)	□	□	C H D W	_____

Office Use Only:

Sum of Motor Tic Scores: _____
Sum of Vocal Tic Scores: _____
Sum of All Scores (Motor + Vocal): _____

APPENDIX B

Y G T S S

Yale Global Tic Severity Scale

Rater: _____

YGTSS SUMMARY – COMPLETE AFTER ADMINISTRATION

	Number	Frequency	Intensity	Complexity	Interference	Total
Motor						
Vocal						
Total						

IMPAIRMENT

MOTOR TIC SYMPTOM CHECKLIST (Check motor tics present during **past week**.)

• **Simple Motor Tics** (Rapid, Darting, "Meaningless"):

o Eye blinking
o Eye movements
o Nose movements
o Mouth movements
o Facial grimace
o Head jerks/movements
o Shoulder shrugs
o Arm movements
o Hand movements
o Abdominal tensing
o Leg, foot, or toe movements
o Other (describe):

o Other (describe):

•**Complex Motor Tics** (Slower, "Purposeful"):

o Eye movements
o Mouth movements
o Facial movements or expressions
o Head gestures or movements
o Shoulder movements
o Arm movements
o Hand movements
o Writing tics
o Dystonic postures
o Bending or gyrating
o Rotating
o Leg or foot or toe movements
o Blocking
o Tic related compulsive behaviors (touching, tapping, grooming, evening-up)
o Copropraxia
o Self-abusive behavior
o Paroxysms of tics (displays), duration ___ seconds
o Disinhibited behavior (describe):*
o Other (describe):

PHONIC TIC SYMPTOM CHECKLIST (Check phonic tics present over the **past week**.)

•**Simple Phonic Symptoms** (Fast, "Meaningless" Sounds):

o Sounds, noises (circle: coughing, throat clearing, sniffing, or animal or bird noises)

o Other (list):

_____

_____

•**Complex Phonic Symptoms** (Language: Words, Phrases, Statements):

o Syllables (list)

_____

o Words (list)

_____

o Coprolalia (list)

_____

o Echolalia
o Palalalia
o Blocking
o Speech atypicalities (describe)

_____

o Disinhibited speech (describe)*

_____

* Do not include disinhibitions in ratings of tic behaviors

NUMBER	**Motor**	**Phonic**	
None	o	o	**0**
Single tic	o	o	**1**
Multiple discrete tics (2-5)	o	o	**2**
Multiple discrete tics (>5)	o	o	**3**
Multiple discrete tics plus as least one orchestrated pattern of multiple simultaneous or sequential tics where it is difficult to distinguish discrete tics	o	o	**4**
Multiple discrete tics plus several (>2) orchestrated paroxysms of multiple simultaneous or sequential tics that where it is difficult to distinguish discrete tics	o	o	**5**

FREQUENCY	**Motor**	**Phonic**	
NONE No evidence of specific tic behaviors	o	o	**0**
RARELY Specific tic behaviors have been present during previous week. These behaviors occur infrequently, often not on a daily basis. If bouts of tics occur, they are brief and uncommon.	o	o	**1**
OCCASIONALLY Specific tic behaviors are usually present on a daily basis, but there are long tic-free intervals during the day. Bouts of tics may occur on occasion and are not sustained for more than a few minutes at a time.	o	o	**2**

FREQUENTLY Specific tic behaviors are present on a daily basis. tic free intervals as long as 3 hours are not uncommon. Bouts of tics occur regularly but may be limited to a single setting.	o	o	**3**
ALMOST ALWAYS Specific tic behaviors are present virtually every waking hour of every day, and periods of sustained tic behaviors occur regularly. Bouts of tics are common and are not limited to a single setting.	o	o	**4**
ALWAYS Specific tic behaviors are present virtually all the time. Tic free intervals are difficult to identify and do not last more than 5 to 10 minutes at most.	o	o	**5**

INTENSITY	**Motor**	**Phonic**	
ABSENT	o	o	**0**
MINIMAL INTENSITY Tics not visible or audible (based solely on patient's private experience) or tics are less forceful than comparable voluntary actions and are typically not noticed because of their intensity.	o	o	**1**
MILD INTENSITY Tics are not more forceful than comparable voluntary actions or utterances and are typically not noticed because of their intensity.	o	o	**2**
MODERATE INTENSITY Tics are more forceful than comparable voluntary actions but are not outside the range of normal expression for comparable voluntary actions or utterances. They may call attention to the individual because of their forceful character.	o	o	**3**
MARKED INTENSITY Tics are more forceful than comparable voluntary actions or utterances and typically have an "exaggerated" character. Such tics frequently call attention to the individual because of their forceful and exaggerated character.	o	o	**4**
SEVERE INTENSITY Tics are extremely forceful and exaggerated in expression. These tics call attention to the individual and may result in risk of physical injury (accidental, provoked, or self-inflicted) because of their forceful expression.	o	o	**5**

COMPLEXITY	**Motor**	**Phonic**	
NONE If present, all tics are clearly "simple" (sudden, brief, purposeless) in character.	o	o	**0**
BORDERLINE Some tics are not clearly "simple" in character.	o	o	**1**
MILD Some tics are clearly "complex" (purposive in appearance) and mimic brief "automatic" behaviors, such as grooming, syllables, or brief meaningful utterances such as "ah huh," "hi" that could be readily camouflaged.	o	o	**2**
MODERATE Some tics are more "complex" (more purposive and sustained in appearance) and may occur in orchestrated bouts that would be difficult to camouflage but could be rationalized or "explained" as normal behavior or speech (picking, tapping, saying "you bet" or "honey", brief echolalia).	o	o	**3**
MARKED Some tics are very "complex" in character and tend to occur in sustained orchestrated bouts that would be difficult to camouflage and could not be easily rationalized as normal behavior or speech because of their duration and/or their unusual, inappropriate, bizarre or obscene character (a lengthy facial contortion, touching genitals, echolalia, speech atypicalities, longer bouts of saying "what do you mean" repeatedly, or saying "fu" or "sh").	o	o	**4**
SEVERE Some tics involve lengthy bouts of orchestrated behavior or speech that would be impossible to camouflage or successfully rationalize as normal because of their duration and/or extremely unusual, inappropriate, bizarre or obscene character (lengthy displays or utterances often involving copropraxia, self-abusive behavior, or coprolalia).	o	o	**5**

INTERFERENCE	**Motor**	**Phonic**	
NONE	o	o	**0**
MINIMAL When tics are present, they do not interrupt the flow of behavior or speech.	o	o	**1**
MILD When tics are present, they occasionally interrupt the flow of behavior or speech.	o	o	**2**
MODERATE When tics are present, they frequently interrupt the flow of behavior or speech.	o	o	**3**
MARKED When tics are present, they frequently interrupt the flow of behavior or speech, and they occasionally disrupt intended action or communication.	o	o	**4**
SEVERE When tics are present, they frequently disrupt intended action or communication.	o	o	**5**

IMPAIRMENT (Continuous Scale)		
NONE	o	**0**
MINIMAL Tics associated with subtle difficulties in self-esteem, family life, social acceptance, or school or job functioning (infrequent upset or concern about tics vis a vis the future, periodic, slight increase in family tensions because of tics, friends or acquaintances may occasionally notice or comment about tics in an upsetting way).	o	**1 0**
MILD Tics associated with minor difficulties in self-esteem, family life, social acceptance, or school or job functioning.	o	**2 0**
MODERATE Tics associated with some clear problems in self-esteem family life, social acceptance, or school or job functioning (episodes of dysphoria, periodic distress and upheaval in the family, frequent teasing by peers or episodic social avoidance, periodic interference in school or job performance because of tics).	o	**3 0**
MARKED Tics associated with major difficulties in self-esteem, family life, social acceptance, or school or job functioning.	o	**4 0**
SEVERE Tics associated with extreme difficulties in self-esteem, family life, social acceptance, or school or job functioning (severe depression with suicidal ideation, disruption of the family (separation/divorce, residential placement), disruption of social tics - severely restricted life because of social stigma and social avoidance, removal from school or loss of job).	o	**5 0**

APPENDIX C

Inter Observer Reliability Datasheet

Operational Definitions	
Motor tics (M):	Vocal tics (V):

Tic Occurrences						
M — *V*	**00-09s**	**10-19s**	**20-29s**	**30-39s**	**40-49s**	**50-59s**
0 s						
1 min						
2 min						
3 min						
4 min						
5 min						

APPENDIX D

Participant ID: **Researcher:** **DC:** **Condition:** **Session:** **Date:**

Treatment Integrity Sheets		
The researcher showed the instructions on the participant's screen N/A	Yes	No
The researcher changed their background to the color of the condition N/A (BL-white; DRO-10s- yellow; delayed DRO-blue)	Yes	No
The researcher read the instructions to the participant. N/A The participant repeated the instructions	Yes	No
The researcher set up the secondary timer for 5 minutes N/A	Yes	No
The researcher obtained an urge rating (0-100) N/A (Before and after each condition)	Yes	No
The researcher counted down and start session N/A (TicTrainer and secondary timer)	Yes	No
The researcher counted down and end session N/A (TicTrainer and secondary timer)	Yes	No
Total:		

Reinforcement

Correct delivery of reinforcement: +

The researcher provided a token at the end of 10 s tic-free interval within 1s

Incorrect delivery of reinforcement: -

Error of omission (O): The researcher did not provide a token following 10 s tic free interval

Error of commission (C): The researcher provided a token when tics occurred

+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C
+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C
+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C	+ - O C

Tic Detected

Tally the frequency of targeted tics. (small number of tics/big number of tics *100)

Total:

APPENDIX E
Therapist Software Set Up Instructions

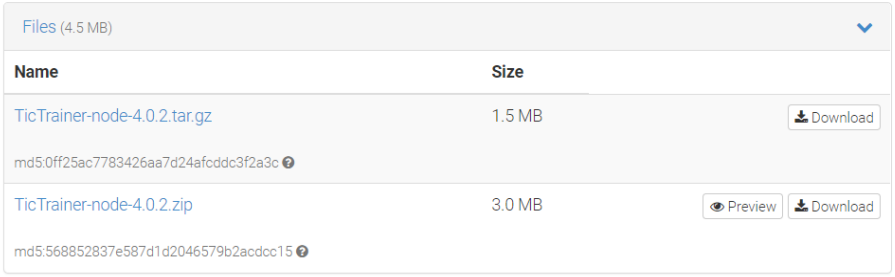
Node.js Installation:

1. Download the program Node.js at https://nodejs.org/en/download/
   - Click on the Windows Installer or macOS Installer icon to download:

2. In the bottom left corner of your screen the Node.js file will be downloading. Once it is ready, click on the file.
3. The Node.js Setup file will open and ask a series of questions. For the following, click on…
   - "Next"
   - "I accept the terms in the License Agreement", then "Next"
   - "Next"
   - "Next"
   - "Next"
   - "Install"
4. Allow the file to make changes to the computer.
5. Once Node.js has been successfully installed, click "Finish".

TicTrainer® Software Download:

1. Go to https://zenodo.org/record/3990474#.YFoDdq9KhPY
2. Scroll down to the files tab:

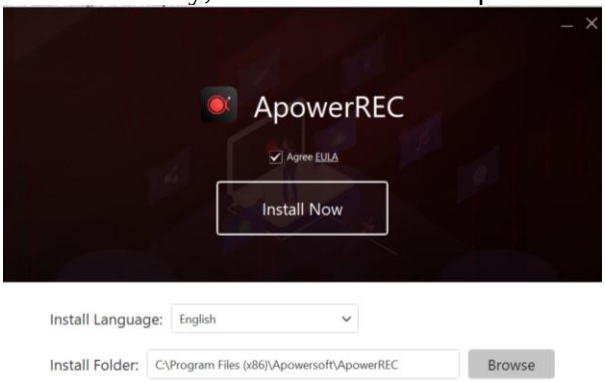


3. Click the "Download" tab for "TicTrainer-node-4.0.2.tar.gz".
4. In the bottom left corner of your screen the TicTrainer-node-4.0.2.tar.gz file will be downloading. Once it is ready, click on the file, and move it to your desktop.

ApowerREC® Software Download:

1. Go to https://www.apowersoft.us/screen-recording
2. Click the green tab that says "Download NOW".

3. In the bottom left corner of your screen, the ApowerREC® file will be downloading. Once it is ready, click on the file to open it. The figure below will appear on your screen.



4. Click “Install Now”.
5. After installation, a new tab will open with instructions for purchasing the app.
6. Click on the ApowerREC® Software Launcher icon on the bottom of your screen.
7. It will state, “Installed Successfully”; click the blue tab “Open Now”.
8. The program is ready for use.

Creating a TicTrainer® Account

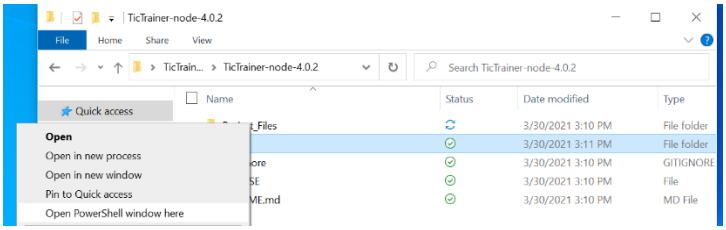
Extracting the TicTrainer® Folder:

1. Open the TicTrainer® folder on the desktop.
2. Right click on the folder “TicTrainer-node-4.0.2”.
3. Click on “extract all”.
4. Click on “extract”.
5. Continue from new extracted folder.

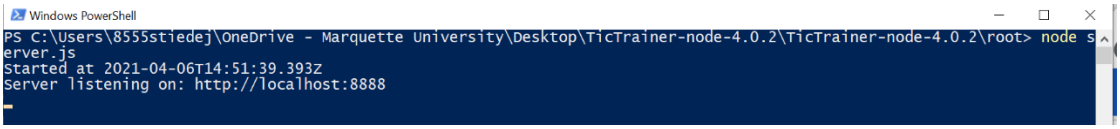
Steps 1-4 will only need to be done once

Running the Node.js Server:

1. Hold shift and right click on the “root” folder.
2. Click on “Open PowerShell window here”.



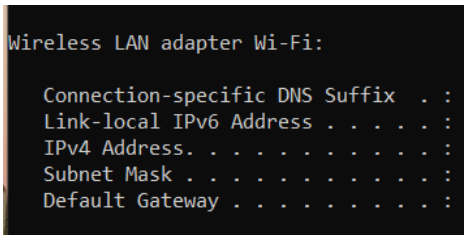
3. Type “node server.js” after the file name and press enter.
4. The following prompt will appear: “Server listening on: http://localhost:####”



5. Make note of the port number listed after the local host; it will be a series of four numbers.
6. The Node.js server is now running. Minimize the tab, but DO NOT close it.

Finding IP Address:

1. Using the search bar of the computer, find the app *Command Prompt*
2. Type in "ipconfig" – This will result in a series of text.
3. Find the line stating "Wireless LAN adapter Wi-Fi:"



- Underneath, find the line "IPv4 Address. . . . . : #.#.#.#" and make note of it.

Adding Account File to Computer:

1. Open TicTrainer® folder on the desktop.
2. Click on the "root" folder.
3. Click on the "account" folder.
4. Click on the "admin_data" folder.
5. Left click the TAD file and drag it into this folder.
6. Using a search engine, type in the IPv4 Address, add a colon, add the port number from the Node.js server, add a forward slash, and type admin
   - An example would be 10.160.9.180:8888/admin
7. In the "Admin ID" box, type **a0**
8. In the "Password" box, type **admin-password**
9. Click "authenticate".
10. Click on the "Manage Admin Accounts" icon.
11. Under the "Register Admin Password", create a password, and then create an account.
12. Your new username and password will appear on the screen; make note of these.

Making a Child's TicTrainer® Account:

1. Type in the IPv4 Address, add a colon, and add the port number from the Node.js server.

- An example would be 10.160.9.180:8888

2. On the TicTrainer® website, click "Register".
3. Click on "User".
4. Fill out the required information and create an account for the child.

5. Their new username and password will appear on the screen; make note of these.

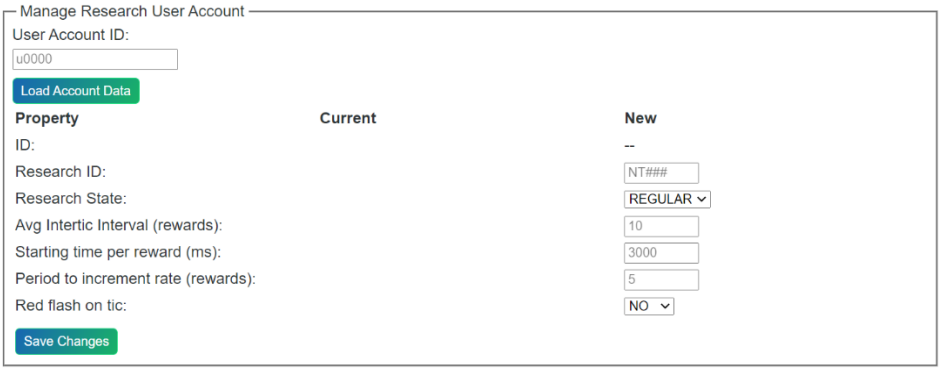
✓ **Two user ID accounts must be made for each child because one is needed for each admin computer used. They must be made on the admin computer being used.**

Connecting the Child's Account to the Admin Account:

1. Type in the IPv4 Address, add a colon, add the port number from the Node.js server, add a forward slash, and type admin.

- An example would be 10.160.9.180:8888/admin

2. Login to the admin account on the TicTrainer® website.
3. Click on "Manage Research Users".
4. Under "User Account ID", type in the child's user ID.



5. Click "Load Account Data".
6. Edit any TicTrainer® session information if necessary.
7. Save changes.

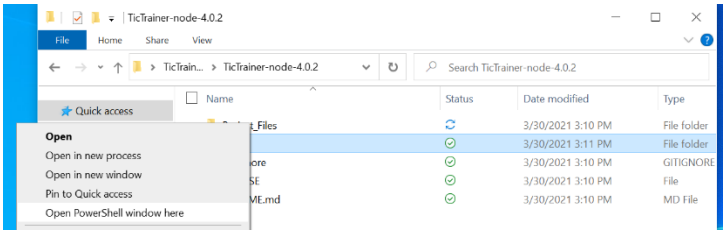
Enhanced Reward Task Script

Starting a TicTrainer® Session as a Therapist

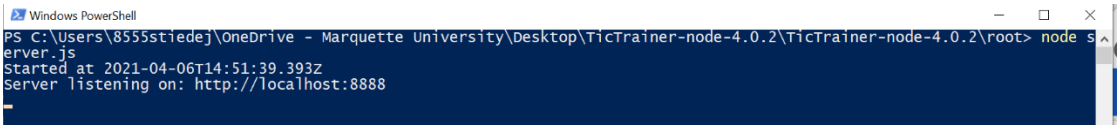
Running the Node.js Server:

1. Open the TicTrainer® folder on the desktop.
2. Hold shift and right click on the "root" folder.

3. Click on “Open PowerShell window here”.



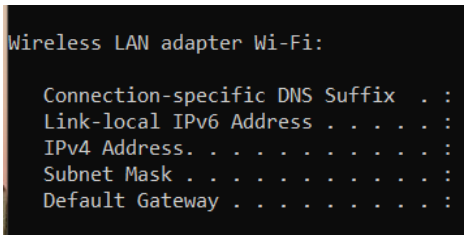
4. Type “node server.js” after the file name and press enter.
5. The following prompt will appear: “Server listening on: http://localhost:####”



6. Make note of the port number because it is needed to share a TicTrainer® session. This number will not change between sessions. The port number in the example above is 8888.
7. The Node.js server is now running. Minimize the tab, but DO NOT close it.

Finding IP Address:

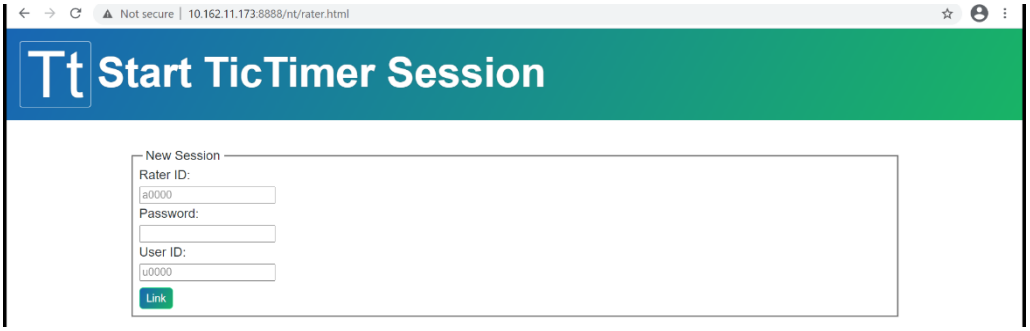
1. Using the search bar of the computer, find the app *Command Prompt*
2. Type in “ipconfig” – This will result in a series of text.
3. Find the line stating “Wireless LAN adapter Wi-Fi:”



4. Underneath, find the line “IPv4 Address. . . . . : #.#.#.#”
5. Write down the IPv4 Address number. This number will change each session.

Before the TicTrainer® Session:

1. Click the Microsoft Teams link
    a. You will be using the same Microsoft Teams link that the therapist uses for each session.
2. Start Google Chrome. Then, using a search engine, type in the IPv4 Address, add a colon, add the port number from the Node.js server, add a forward slash, type nt, add a forward slash, and then rater.html.
    a. An example would be 10.160.9.180:8888/nt/rater.html
3. This will take you to the TicTrainer® website where you can start a new session.

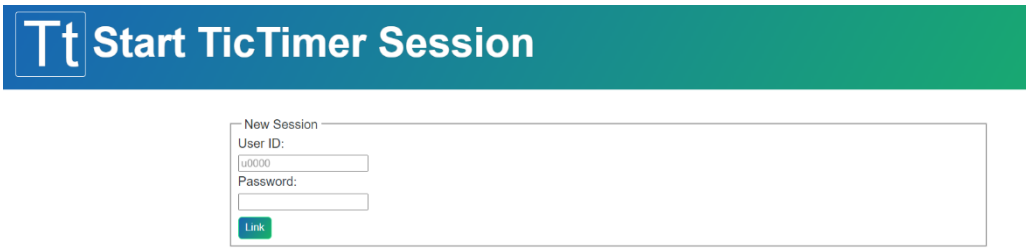


2. Wait to enter the Rater ID and Password until you have provided the child with instructions.

Start the Child's Session on TicTrainer®:

a. Start a new window on Google Chrome. Using a search engine, type in the IPv4 Address, add a colon, add the port number from the Node.js server, add a forward slash, type nt
   - An example would be 10.160.15.187:8888/nt

b. This will take you to the TicTrainer® website where you can join a session.



c. Separate the Rater's tab and the child's tab. Put them side by side on your screen.

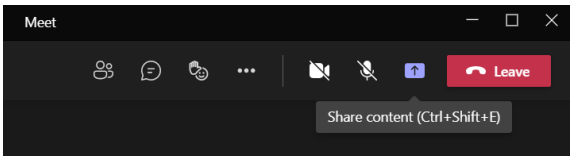
d. Place the Microsoft Teams tab over the child's tab. The Microsoft Teams tab should be side by side with the Rater's tab and in front of the child's tab.
   - ➔ **Do NOT minimize the child's tab at any point as this will stop sharing the window with the child.**

e. Wait for the child to join the Teams meeting.

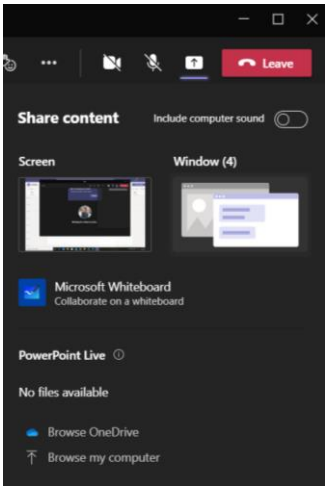
Once the Child Joins the Teams Meeting:

1. Once the child joins, use the script from protocol to provide the child instructions

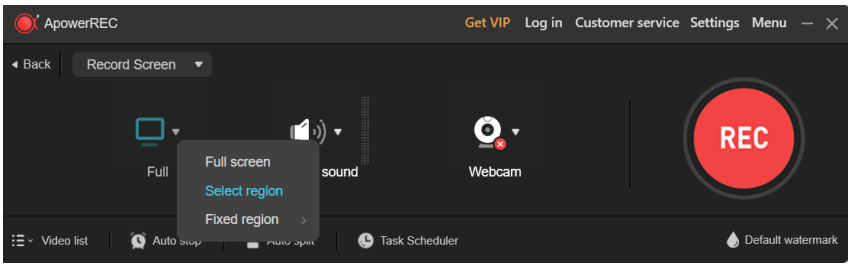
2. If the child communicates understanding, click on the "Share content" button in the upper right hand corner of the screen.



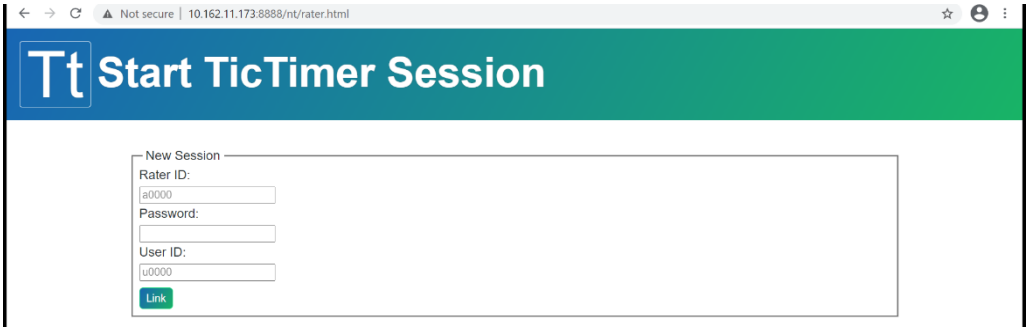
3. Click on the “Include computer sound” button, click on “Window”, and select the window for the child’s TicTrainer® session to share.



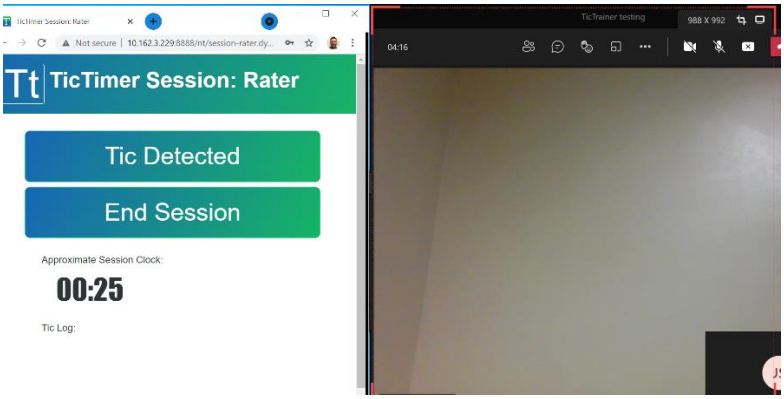
4. Turn off your camera.
5. Open ApowerREC® app and click on “Full” under “Record Screen”.
6. Click on “Select Region”.

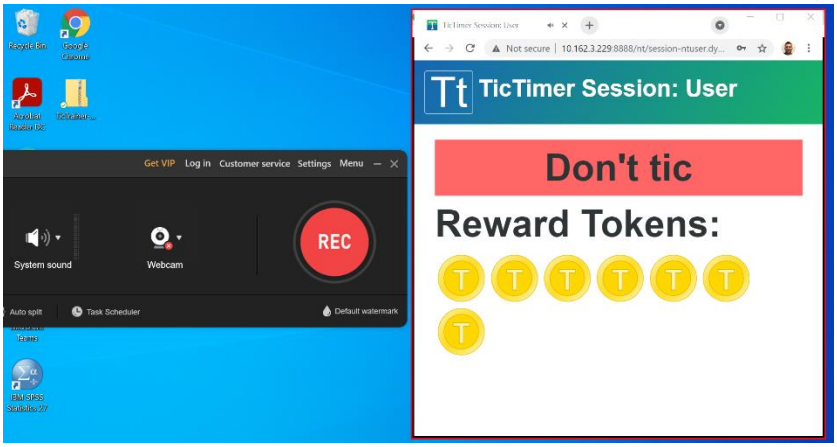


7. Using the red lines as your boundaries, crop the window over the video of the child.
8. Click Record.
9. Drag the Rater’s tab over the ApowerREC® tab.
10. Enter the child’s user ID and password and click “Link”.
    a. Place the Microsoft Teams video over the child’s TicTrainer® tab again.
11. Then, go to the tab with the Rater ID and password.



12. Type in your Rater ID and Password.
13. Type in the child's TicTrainer® User ID.
14. Click "Link".
15. Finally, tell the child that you are about to start the 5-minute
    → Before starting the TicTrainer® session, make sure the Microsoft Teams video of the child is placed over the child's TicTrainer® tab and is being recorded. Also, the Rater's TicTrainer® tab is next to the Microsoft Teams video and is placed over the ApowerREC® tab.





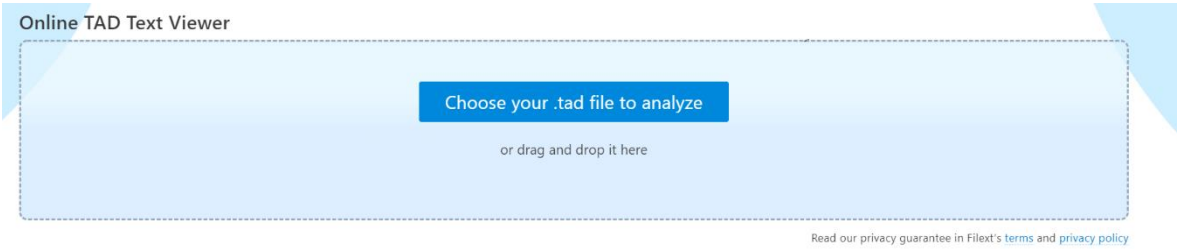
16. Click on the "DRZ" icon while stating you are starting the session.
    a. Once the "DRZ" icon is selected, the session has started.

<u>During the TicTrainer® Session:</u>

1. Click on the “Tic” icon anytime the child performs a target tic.
2. After 5 minutes, the TicTrainer® program will stop the session.

Retrieving Data from TicTrainer® Session:

1. Open the TicTrainer® File on your desktop.
2. Click on the “root” folder.
3. Click on the “session” folder.
4. Click on the “archive” folder.
5. Find the session you are looking for using the time and date provided.
6. Decrease the size of the tab, but do not fully minimize it.
7. Go to https://filext.com/file-extension/TAD
8. Left click the session file from the TicTrainer® file and drag it onto the “Online TAD Text Viewer” website, so it can be viewed.



9. View the file and click on the “Print” option.
10. Save the file as a PDF to the participant’s folder.

APPENDIX F

Comparison of DRO Procedures

Tic Suppression- Checklist

Eligibility Checklist

1. 8-17 years old
2. Meet the DSM 5 diagnostic criteria for TD or PTD
3. YGTSS less than or = to 14 and < 30
4. The participant must have at least 1 tic per min. (TO: 30 min)
5. The participant has not been taking any tic medication for at least 6 weeks
6. Have access to internet
7. Fluent in English
8. No co-occurring disorders that will require immediate attention
9. Wechsler abbreviated score of intelligence
10. > 80 score on the C-3 PS
11. Obtain consent form
12. Obtain assent form

Pre-Experiment Checklist

1. Open MicrosoftTeams and share link to the participant
2. Check virtual background colors
3. Ensure audio and camera is working
4. Log into "administrator" TicTrainer account
5. Create an account or log into the "user" TicTrainer account
6. Reinforcer is ready (check if token delivery is working)
7. Open APowerREC
8. Prepare session cards. Each session card should be labeled:
    a. Participant ID_Condition_Session#_Date (Participant 001_BL_Session 1_9.7.2021)
9. Open PowerPoint for baseline and delayed DRO instructions
10. Secondary timer is ready
11. Instructions for each condition is prepped
12. Treatment integrity datasheet
13. Experiment Datasheet

During Session Checklist

1. Record session
2. Show session card
3. Start secondary timer and TicTrainer session simultaneously
4. Secondary researcher is taking treatment integrity
5. Stop recording

Post Experiment Checklist

1. Debrief each participant and provide $10 gift card
2. Label recorded videos according to the session card
3. File all recorded videos in a password protected folder
4. Graph data
5. Assign videos for IOA

APPENDIX G

Comparison of DRO Procedures

Tic Suppression

Protocol

Primary DV: Frequency of motor and vocal tics. ▫ The primary and secondary experimenter will operationally define observable tics. Secondary DV: Urge rating (0-100) ▫ Before and after each condition One-trial preference assessment	**Materials:** ▫ Laptop ▫ Microsoft Teams ▫ APowerREC ▫ TicTrainer Program ▫ YGTSS Tics Description ▫ Treatment Integrity Datasheet ▫ PowerPoint (Baseline and delayed DRO condition)	**Necessary Experimenters:** **Primary Experimenter**: The primary experimenter will be responsible for conducting all the conditions with each participant. The primary experimenter will use the Tic Timer program during the experiment **Secondary Experimenter**: The secondary experimenter will be responsible for taking treatment integrity data on the primary experimenter.

General Procedures

1. This study will require 3 participants. A total of 10 individuals will be recruited (includes individuals who are deemed ineligible following screening and drop out).
2. Student PI of protocol #3837 will call individuals from waitlist group and inform individuals a study
3. If individuals are interested in participating in the study, the Student PI from study protocol #3837 will ensure that consent was provided to give access to data collected during screening.
    a. After obtaining consent, the student PI of this study will obtain consent and assent from the parent/guardian of the child participant and the child participant.
    b. The researcher will conduct an additional 5-minute observation. This measurement assesses whether tics are exhibited once per minute.
4. If individuals called directly from the clinic, the student PI from this study will go through the consenting and assenting process through Qualtrics
    a. Following consent/assent, a trained clinician and researcher associated with study will conduct screening assessment.
    b. Following determining edibility for the study, a five minute observation will be conducted to assess for tics exhibited once per minute.
        i. Note: second assessment may take up to 10 minutes (this includes data collection).

5. The researcher and the secondary observer will determine the tics that will be targeted during the study
    a. **Note: only observable tics via Microsoft TEAMS will be targeted. The researcher may target vocal tics and motor tics from the chest to the top of their head.**
6. Following the operational definition, the researcher will provide introduction description:
    a. *During this study, I will be observing your _____tic(s) for 5 min at a time. For those 5 min, I will give you different instructions in the beginning. I will let you know when I will begin recording and starting the session. During the time of the study, please stay seated in front of the camera where I can see you and please do not have any distractors around you. After each session, I will provide you a 2 min break to get some water or whatever you need. In this study, you will have the opportunity to earn tokens and the more tokens you earn, the bigger the prize you will get at the end of the experiment. Before we start, do you have any questions for me?*
7. The researcher will run an initial baseline session
8. Following the initial baseline phase, the researcher will randomize baseline, DRO-10s, and delayed DRO until the participant has experienced as few as 3 and as many as 4 (refer to step 7 for criteria).
9. The secondary observer should take treatment integrity for **one** session in each condition (baseline, DRO-10s, and delayed DRO) while the primary researcher is conducting the session.
    a. If treatment integrity is low, the primary researcher will conduct one additional session
        i. Criteria for *binary measure is 95%* (e.g., simple instruction)
        ii. Criteria for *reinforcer delivery is 80%* (e.g., token delivery after 10s of tic free interval)
        iii. The primary researcher will not rerun more than 1 session for each condition.
    b. The secondary observer will total the treatment integrity score during the 2 min break.

Baseline Procedure

1. The researcher will share their screen with the participant
    a. The participants screen will be a blank PowerPoint slide with the instructions “Free to Tic”
2. The researcher will change their background to a **white** background
3. The researcher will obtain an urge rating (0-100)
    a. *“On a scale from 0-100, how intense are your urge to tic? 0 meaning ‘not at all’ to 100 ‘very much”*
4. The researcher will provide the instructions to the participant:
    a. *“For the next 5 min, I will be monitoring your tics. During this time, you are free to tic as needed. Please stay in front of the monitor where I can see you. Do you have any questions for me before we start?”*

   b. The researcher will ask the participant to repeat the instructions
   c. The researcher will not move on till the participant repeats the instructions
5. The researcher will set a secondary timer for 5 min.
6. The researcher will press record
   a. *"I am going to start recording now"*
   b. Show the session card: Participant #_Condition_Session #_Date
   c. Start session on TicTimer by saying "3, 2, 1… start"
7. During baseline condition, the experimenter will:
   a. Click the "tic detected" button within 1s on the TicTimer when the targeted tics are exhibited.
8. Following 5 min, the researcher will end the session:
   a. *"End session in 3, 2, 1 stop"*
9. The researcher will obtain an urge rating (0-100)
   a. "On a scale from 0-100, how intense are your urge to tic? 0 meaning 'not at all' to 100 'very much"
10. The researcher will provide a 2 min break set up for the next condition
   a. "We just completed one of the sessions. At this time, you may take a 2 min break to go to the bathroom, get some water, or you may just sit there"

DRO-10s Procedure

1. The researcher will share their screen with the participant
   a. The participant will see the TicTimer program with the instructions "Don't Tic"
2. The researcher will change their background to a **yellow** background
3. The researcher will obtain an urge rating (0-100)
   a. "On a scale from 0-100, how intense are your urge to tic? 0 meaning 'not at all' 100 'very much"
4. The researcher will provide the instructions to the participant:
   a. "For the next 5 min, I will be monitoring your tics. During this time, do everything you can to stop your tics. After a few seconds of not ticcing, you will earn a token. The token will appear on your screen along with a chime sound. Be sure to stay seated in front of the monitor. Do you have any questions before we start?"
   b. The researcher will ask the participant to repeat the instructions
   c. The researcher will not move on until the participant repeats the instructions
5. The researcher will set up a secondary timer for 5 min
6. The researcher press record
   a. "I am going to start recording now"
   b. Show the session card: Participant #_Condition_Session #_Date
   c. Start session on TicTimer by saying "3, 2, 1… start"
7. During the DRO-10s condition, the experimenter will:
   a. Click "tic detected" button within 1s on the TicTimer program when the targeted tics are exhibited.
   b. Ensure that a token is delivered within 1s following 10s of no targeted tics, TicTimer will automatically deliver token on the participant screen.

i. If tokens were not delivered within 1s following 10s of no targeted tics, the therapist will timestamp in which the error occurred.

8. Following 5 min, the researcher will end the session:
    a. *"End session in 3, 2, 1 stop"*
    b. The researcher will tell the participant how many tokens they have earned. The researcher may count the total tokens or retrieve data via TicTimer Tad files.
        a. *"In this session, you've earned __ tokens!"*
9. The researcher will obtain an urge rating (0-100)
        b. *"On a scale from 0-100, how intense are your urge to tic? 0 meaning 'not at all' 100 'very much"*
11. The researcher will provide a 2 min break set up for the next condition
    a. *"We just completed the session. At this time, you may take a 2 min break to go to the bathroom, get some water, or sit there"*

Delayed DRO Procedure

1. The researcher will share their screen with the participant
    a. The participant will see a blank PowerPoint slide with the instructions "Don't Tic"
2. The researcher will change their background to a **blue** background
3. The researcher will obtain an urge rating
    a. *"On a scale from 0 to 100, how intense do you have an urge to tic? 0- not at all, 100- very much"*
4. The researcher will provide the instructions to the participant:
    a. *"For the next 5 min, I will be monitoring your tics. During this time, do everything you can to stop your tics. I will tell you how many tokens you earned at the end of session. Please be sure to stay seated in front of the monitor where I can see you. Do you have any questions before we start?"*
    b. The researcher will ask the participant to repeat the instructions
    c. The researcher will not move on until the participant repeats the instructions
5. The researcher will set up a secondary timer for 5 min
6. The researcher will press record:
    a. *"I am going to start recording now"*
    b. Show the session card: Participant #_Condition_Session #_Date
    c. Start session on TicTimer by saying "3, 2, 1… start"
7. During the delayed DRO condition, the experimenter will:
    a. Click "tic detected" button within 1s on the TicTimer program when the targeted tics are exhibited. Tokens are not shown to the participant
    b. Ensure that a token is delivered within 1s following 10s of no targeted tics, TicTimer will automatically deliver token on the participant screen.
        i. If token was not delivered within 1s following 10s of no targeted tics, the therapist will timestamp in which the error occurred.
8. Following 5 min, the researcher will end the session:
    a. *"End session in 3, 2, 1 stop"*

9. The researcher will show how many tokens the participant earned by sharing the "user" window. The researcher will tell total amount of token by counting the tokens or by retrieving data from Tad files.
    a. *"For this session, you earned ___tokens!"*
10. The researcher will obtain an urge rating (0-100)
    a. *"On a scale from 0-100, how intense are your urge to tic? 0 meaning 'not at all' 100 'very much'"*
11. The researcher will show the participant earned tokens at the end of the session.
    a. The researcher will use TicTrainer Tad files to obtain data.
12. The researcher will offer a 2 min break and set up for the next condition
    a. *"We just completed the session. At this time, you may take a 2 min break to go to the bathroom, get some water, or sit there*

Preference Assessment

1. Record and show session card: Participant #_Preference Assessment_Date
2. The researcher will display a PowerPoint slide with 3 colored boxes (2x2 in) that correspond to each condition (white, yellow, blue)
3. The researcher will instruct the participant:
    a. "When I changed my background to white, what were you expected to do?
        i. The researcher will wait 10s for a response. Following a correct response, the researcher will provide praise and move on to the next question
        ii. Following an incorrect response, the researcher will provide a vocal prompt.
            1. *Did you receive any tokens during the 5 min?*
            2. *When did you earn the tokens?*
            3. *When I had the white background, you were instructed to sit for 5 min, and you were free to tic as needed.*
    b. "When I changed my background to yellow, what were you expected to do?"
        i. The researcher will wait 10s for a response. Following a correct response, the researcher will provide praise and move on to the next question
        ii. Following an incorrect response, the researcher will provide a vocal prompt.
            1. *Did you receive any tokens during the 5 min?*
            2. *When did you earn the tokens?*
            3. *When I had the yellow background, I told you to do everything you can to stop your tic and tokens appeared on your screen.*
    c. "When I changed my background to blue, what were you expected to do?
        i. The researcher will wait 10s for a response. Following a correct response, the researcher will provide praise and move on to the next question
        ii. Following an incorrect response, the researcher will provide a vocal prompt.

1. *Did you receive any tokens during the 5 min condition?*
2. *When did you earn the tokens?*
3. *When I had the blue background, you were told to do everything you can to stop your tics and the reward came later. After 5 min, I showed you how much tokens you earned for stopping your tic.*

4. Following the description, the researcher will instruct the participant to pick one
    a. "Now that you told me the rules for each color, which experience do you like the best?
    b. "Why did you like ____ the best?"

End of the Experiment (debrief)

"That was the end! Thank you for participating in the study. At the beginning of the study, I told you that the more tokens you earn, the bigger the prize you will receive. However, the amount of the gift card was set before the study began. The reason why we said that you could earn a bigger prize by the number of tokens you earned was that we wanted to see whether that would influence you to stop your tics. You did a great job, and I would like to give you a $10 Amazon gift card for your participation! The Amazon gift card will be emailed/mailed to the address your parent provided during the consent process. As of right now, do you have any questions for me?

As of right now, do you have any questions for me?

If you think of questions later, please feel free to contact us at any time. The contact information is listed at the bottom of your assent/consent form. If there isn't anything else, I hope you have a good rest of your day!"

APPENDIX H

Comparison of DRO Schedules
Tic Suppression
Experiment Datasheet

Urge Rating (0-100)

Baseline			
Sessions:	**1**	**2**	**3**
Before			
After			

DRO-10s			
Sessions:	**1**	**2**	**3**
Before			
After			

Delayed DRO			
Sessions:	**1**	**2**	**3**
Before			
After			

Preference Assessment: "I would like to know out of the three activities, which one was your favorite. Before we do that, I would like for you to tell me what each of the activities we did.

- When I changed my background to white, what were you expected to do? (Pause, refer to protocol)
- When I changed my background to yellow, what were you expected to do? (Pause, refer to protocol)
- When I changed my background to blue, what were you expected to do? (Pause, refer to protocol)

Out of these three activities, which activity was your favorite. You can also tell me the color that matched the activity (pause for answer). Why did you prefer _____? "

- ❑ Baseline- White
- ❑ DRO-10s- Yellow
- ❑ Delayed DRO- Blue