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COMPARING FIXED-AMOUNT AND PROGRESSIVE-AMOUNT SCHEDULES OF REINFORCEMENT FOR TIC SUPPRESSION

by

Matthew R. Capriotti

A Dissertation Submitted in

Partial Fulfillment of the

Requirements for the Degree of

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ABSTRACT

COMPARING FIXED-AMOUNT AND PROGRESSIVE-AMOUNT SCHEDULES OF REINFORCEMENT FOR TIC SUPPRESSION

by

Matthew R. Capriotti

The University of Wisconsin-Milwaukee, 2015

Under the Supervision of Bonita P. Klein-Tasman

Chronic tic disorders (CTDs) involve motor and/or vocal tics that cause substantial distress and impairment. Existing behavioral interventions for CTDs have comparable efficacy to pharmacological treatments but still leave many individuals with significant tic symptoms and impairment. One approach to improving existing treatments involves conducting pre-clinical laboratory research to evaluate procedures that may be attractive candidates for applied treatment research. Reinforcing tic suppression via differential reinforcement of other behavior (DRO) procedures produces decreases in tic frequency of ~80% in youth with CTDs; however, a more robust reduction may be needed to affect durable clinical change. The present study compared the effects of a novel, progressive-amount DRO schedule for tic suppression and a standard DRO schedule representative of that used in previous research. Five youth with CTDs were exposed to periods of baseline, traditional/fixed-amount DRO (DRO-F), and progressive-amount DRO (DRO-P). Both DRO schedules decreased tic rate and inter-tic interval duration. However, no systematic differences between the two DRO schedules were observed on measures of tic occurrence, premonitory urge strength, or subjective stress. The DRO-F schedule was generally preferred to the DRO-P schedule. The DRO-P procedure did not yield more desirable effects than the DRO-F schedule. Basic and applied implications of this study and future directions for CTD treatment development research are discussed.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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“Every good scientist is half B. F. Skinner and half P. T. Barnum.”

~Principal Skinner, *The Simpsons*

History and Background

Chronic tic Disorders (CTDs) such as Tourette Syndrome (TS) were first identified in the 15th century Malleus Maleficiarum**,** a guide for the identification and prosecution of suspected witches and sorcerers. Since that time, these disorders have piqued the curiosity of both laymen and scholars. Consistent with the cultural zeitgeist, gross classification of CTDs has changed greatly over history. In medieval Europe, tics were taken originally to be a sign of Satanic possession and eradicated through exorcism or execution. With the development of physical medicine in the 19th century, TS came to be viewed as a medical disease of the nervous system. The famous French physicians Armand Trousseau and Jean-Marc Gaspar Itard included case studies of patients with tics in their seminal writings on clinical medicine.

In 1885, Gilles de la Tourette, a student of Charcot's, published a comprehensive case series of nine patients with multiple motor and vocal tics (de la Tourette, 1885; Finger, 1994). Following the publication of this landmark work, the disorder it described was named "Gilles de la Tourette Syndrome" which soon began to appear in its shortened form as "Tourette Syndrome." From Tourette's seminal work, TS came to be considered as a psychological symptom often related to hysteria, and brought on by so-called nervous disorders (Kushner, 2000). This view continued throughout the first half of the 20th century, wherein it was most often viewed through a psychoanalytic lens.

In the 1970s, evidence emerged that antipsychotic medications (e.g., haloperidol) could produce significant reductions in tic symptoms (Connell et al., 1967, Ford & Gottlieb, 1969; Shapiro & Shapiro, 1968). With these advances, a contemporary biological model of CTD etiology and treatment came into favor among researchers and clinicians, and the utility of other psychotropic medications was further explored (for a review see Scahill et al., 2006).

Concurrently, research also emerged demonstrating that environmental factors play an important role in determining the expression of CTD symptoms, and treatment studies showed that efficacious non-pharmacological treatment was possible with behavior therapy (Azrin & Nunn, 1973; Cook & Blacher, 2007). Today, tics are seen as biologically–based neurological symptoms that are heavily influenced by the patient's environment.

Prevalence and Course

In modern times, tic disorders are regarded as childhood-onset neurobehavioral conditions marked by the continuous presence of motor and/or vocal tics (American Psychiatric Association [APA], 2013). Specific diagnoses depend on the nature and chronicity of tics. When an individual exclusively experiences motor or vocal tics that occur for one year or longer, a diagnosis of Persistent (chronic) motor tic disorder or chronic vocal tic disorder, respectively, is conferred. A diagnosis of TS is given when multiple motor tics and at least one vocal tic are present over a period of one year or longer (APA, 2013).

Although sometimes thought to be a rare phenomenon, systematic research has revealed that tics are quite common among children. A large-scale epidemiological study (Costello et al., 1996) found that as many as 20% of children exhibit one or more tics for at least a month at some point in their development. Most of these individuals experience complete remission of tics without treatment and do not experience them chronically. However, some experience a more chronic and problematic course.

Community-based studies indicate that between 0.4 and 3.8% of children meet diagnostic criteria for a CTD (Robertson, 2008). Onset most often occurs in the late-preschool or early-elementary years, with a mean age of 5.6 years (Bloch & Leckman, 2009; Leckman et al., 1998). For children with a CTD, tics increase in number throughout the school-age years, and tend to

progress in a superior-to-inferior fashion, starting with simple facial movements and progressing to more complex movements involving areas of the trunk and/or limbs (Leckman et al., 1998). Tics generally increase in number and severity from onset to early puberty and tend to peak around ages 10-12 (Leckman et al., 1998). Throughout late adolescence and into adulthood, symptoms abate substantially for a majority of patients. A longitudinal study (Leckman et al., 1998) of 42 children found that a majority (57%) of individuals diagnosed with TS in childhood experience only minimal symptoms as adults. Nonetheless, a significant minority report moderate (27%) or severe (11%) symptoms into adulthood.

Phenomenology of Tic Expression

Temporal Dynamics. By definition, individuals with CTDs experience tics frequently throughout their day-to-day lives (APA, 2013). However, research indicates that tics are not distributed evenly across time; they tend to occur in bouts, wherein several tics occur in quick succession and are followed by a relatively long tic-free interval. Additionally, tic severity waxes and wanes over longer time frames, with affected individuals experiencing "good days" and "bad days" embedded in a context of "good weeks" and "bad weeks." This pattern seems to be governed partially by non-linear motor output processes coded in the basal ganglia (Peterson & Leckman, 1998). However, it has also been noted that a variety of environmental factors are associated with tic exacerbation (for a review see Conelea & Woods, 2008a), which has led some to view variability in tic frequency across contexts as stemming from operant processes (e.g., stimulus control; Woods, Walther, Bauer, Conelea, & Kemp, 2009).

Premonitory Urges. Although tics are the defining symptom of CTDs, the so-called "premonitory urges" that precede them are also highly relevant to the experience of affected

individuals. These urges are aversive somatosensory experiences that precede tics and temporarily subside following tic occurrence. Premonitory urges onset, on average, three years after the tics themselves (Leckman, Walker, & Cohen, 1993). Reasons for this gap are unclear. Some authors (e.g., Banashewski, Woerner, & Roethel, 2003; Leckman et al., 1993) have suggested that the delayed emergence of the urges is due to the fact that general interoceptive abilities are not fully developed during the modal ages of tic onset. Others have surmised that these urges become increasingly salient over time due to frequent, repeated encounters with aversive consequences for ticcing, noting data that show a link between premonitory urge severity and a history of experiencing negative consequences for ticcing (Capriotti, Espil, Conelea, & Woods, 2013; Woods, Piacentini, Himle & Chang, 2005).

Once present, these urges are described as uncomfortable and bothersome, sometimes even more so than physical tic symptoms themselves (Kane, 1994; Leckman et al., 1993). Although uncomfortable, some have suggested that these urges may be beneficial to patients, as they can serve as cues to engage in tic suppressing behaviors (Woods et al., 2008). However, research has generally not supported this claim. Indeed, premonitory urges lead individuals to experience tics as "semi-voluntary" and partially controllable (Koller & Biary, 1989), but do not appear to aid patients' efforts to suppress their tics (Banashewski et al., 2003; Ganos et al., 2012). In fact, research suggests that premonitory urges function as negative reinforcers whose presence actually promotes and maintains tics (Capriotti et al., 2014; Himle, Woods, Conelea, Bauer, & Rice, 2007). This evidence is paralleled by studies that have found *positive* correlations between premonitory urge severity and tic severity (e.g., Crossley, Seri, Stern, Robertson, & Cavanna, 2014; Capriotti et al., 2013; Woods et al., 2005).

Impact of Tics on Functioning. Individuals with CTDs experience negative tic-related sequalae in physical, social, academic, occupational, romantic, and other domains. CTDs are costly both to affected individuals, in terms of treatment costs and reduced quality of life, and to the societies in which they live, in terms of decreased productivity (Cutler, Murphy, Gilmour, & Heyman, 2009; Conelea et al., 2011, Storch et al., 2007; Dodel et al., 2010). Social impairment is seen in both children and adults with CTDs, and often involves social rejection, teasing and bullying, increased self-consciousness and avoidance of social situations (Conelea et al., 2011; Conelea et al., 2013). This avoidance can decrease school or work attendance in youth and adults, respectively (Conelea et al., 2011; Conelea et al., 2013). Affected individuals frequently report experiencing social reactions to ticcing from family members, peers, and strangers (Himle et al., 2014). Many individuals with CTDs also report that their tics lead to difficulty in completing academic tasks and household chores, playing sports, and engaging in recreational activities (Conelea et al., 2011; Conelea et al., 2013; Himle et al., 2014). Although a comprehensive review of tic-related impairment is beyond the scope of the present discussion, it is clear that individuals with CTDs often experience significant functional impact.

Comorbidity

Tic disorders often co-occur with other forms of psychopathology. The majority of youth with CTDs also meet diagnostic criteria for at least one other Axis-I psychiatric condition, with attention deficit hyperactivity disorder (ADHD) and obsessive-compulsive disorder (OCD) being the most common. Large epidemiological studies indicate that between 50%-75% of youth with a CTD also meet diagnostic criteria for ADHD (Comings & Comings, 1987; Freeman et al., 2000; Kadesjo and Gillberg, 2000; Khalifa & von Knorring, 2003; Scahill, Bitsko, Vissner, & Blumberg, 2009). Estimates of the prevalence of OCD among youth with TS range from 10%-

38% across these same studies. Additionally, some other studies (e.g., Khalifa & von Knorring, 2003; Gorman et al., 2010) have found elevated rates of depression and other externalizing behavioral disorders (e.g., oppositional defiant disorder, conduct disorder) among youth with CTDs.

In a recently-conducted multi-site randomized controlled trial of behavior therapy for CTDs (Piacentini et al., 2010). 26% of included children met criteria for ADHD, 19% for OCD, reflecting lower rates of cormobidity than noted in previous studies. Also of note; Piacentini et al. found no notable elevations in oppositional defiant disorder (ODD; 6%) or depression (0%); but did find relatively high rates of generalized anxiety disorder (20%) and social phobia (21%). In the Avon Longitudinal Study, a prospective population-based health study, lower rates of comorbidity were also seen, relative to many previous studies with clinical samples. Among youth who met stringent criteria for a CTD diagnosis, 14% had comorbid ADHD and 9% had comorbid OCD (Scharf, Miller, Mathews, Ben-Shlomo, 2012). One possible explanation for these disparate results is that youth with CTD and comorbid Axis-I disorders are less likely to seek treatment, especially pharmacological treatment, than their counterparts without these co-occurring conditions. This is consistent with research suggesting that comorbid conditions are responsible for substantial impairment and lowered quality of life among youth with CTDs (Conelea et al., 2011; Storch et al., 2007). As such, studies using clinical samples ascertained from TS specialty clinics that focus on psychopharmacological intervention may report inflated rates of comorbidity due to ascertainment bias. In sum, although estimates of comorbidity rates vary across studies, it is clear that youth with CTDs are more likely to experience certain other forms of psychopathology, especially ADHD and OCD, than their tic-free counterparts.

Assessment and Treatment of CTDs

Differential Diagnosis. Often, Children with CTDs first present to their pediatrician with parental concerns about unusual, apparently purposeless, movements and/or vocalizations. If the child's presentation is typical, pediatricians may recognize the symptoms upon the first visit and diagnose the movements as tics. When the clinical picture is less clear the pediatrician may refer to a neurologist, to ensure that the movements are rightly classifiable as tics, as opposed to symptoms other types of disordered movements, such as choreas and stereotypies. Differential diagnosis of movement disorders is complex, involving careful observation of the movements and the patient's description of phenomenology (Tolosa, Koller, & Gershanik, 1997). Tics can generally be differentiated from other movement disorders based on these factors, but some complex tics may be harder to separate from compulsions associated with OCD. In this case, the movements may be classified as compulsions if preceded by somatic signs of anxiety (e.g., increased heart rate, sweating, clamminess) and/or a feared consequence if the behavior is not performed, and as tics if preceded by a somatosensory premonitory urges in the absence of somatic aspects of anxiety and feared consequences (Miguel et al., 1995).

After tics are identified, a specific tic disorder diagnosis is conferred based on the nature and duration of tics. For the year following initial onset of the first tic, a diagnosis of Provisional Tic Disorder (formerly Transient Tic Disorder; APA, 2000; 2013) is given, regardless of the nature of the tics. For individuals with two or more different tics, a CTD diagnosis is made when multiple motor and/or vocal tics have been present for one year or longer . If only motor or vocal tics have ever been present, then a diagnosis of Provisional (Chronic) Motor Tic Disorder or Provisional (Chronic) Vocal Tic Disorder is conferred. If multiple motor tics and at least one vocal tic have been noted since initial tic onset, a diagnosis of TS is given.

Symptom Assessment. As with any clinically targeted phenomenon, it is important to assess tic symptoms comprehensively before, during, and after treatment to track treatment progress. One foundational piece of assessment involves careful observation of tics that occur during the assessment appointment. If symptoms do not occur spontaneously, it may be useful to encourage the patient to imitate their tics. However, tics are highly variable across contexts, particularly those that involve observation by others (Piacentini et al., 2006) and tic-related conversation (Woods, Watson, Wolfe, Twohig, & Friman, 2001). As a result, it is necessary to obtain information regarding the tics in a variety of settings outside of the assessment session itself. Various tools exist for conducting multimodal, multi-informant assessment of tic symptoms. These include the "gold-standard" Yale Global Tic Severity Scale (YGTSS; Leckman et al., 1989), a multidimensional clinician-rated measure of tic severity based on an interview about with the patient and his/her parents about past-week tic symptoms. Several validated self- and parent-report scales also exist for assessing tic severity (Chang, Himle, Tucker, Woods, & Piacentini, 2009; Gaffney, Sieg, & Hellings, 1994; Walkup, Rosenberg, Brown, & Singer, 1992; Wilhelm et al., 2012). Premonitory urge severity may be assessed in children and adults using the Premonitory Urges for Tics Scale (PUTS; Woods et al., 2005).

Treatment.

Pharmacological Interventions. Several medications are commonly used to treat TS, including traditional (e.g., haloperidol) and atypical (e.g., risperidone) neuroleptics and alpha-adrenergic agonists (e.g., clonidine, guanfacine; Scahill et al., 2006). Haloperidol, pimozide, and risperidone are the only medications with solid empirical support for use in treating TS (i.e., that have been shown to be superior to placebo in at least two randomized controlled trials; Gilbert & Jankovic, in press). In clinical trials, average symptom reduction from

these medications has ranged from 32% to 66%. However, these medications carry significant and undesirable side effects (e.g., weight gain, sedation, cognitive dulling, blurred vision, electrocardiographic changes, dry mouth, constipation, acute dystonia, and urinary retention) that cause many to discontinue use (Scahill et al., 2006; Swain, Scahill, Lombroso, King, & Leckman, 2007). Thus, although antipsychotics are efficacious in reducing tic symptoms, side effects limit their acceptability and thus potentially their effectiveness in real-world clinical practice.

Nonpharmacological Interventions. A variety of nonpharmacological treatments for CTDs have been designed, implemented, and tested. Efficacy has been shown to vary widely across studies, depending on the intervention used. Cook & Blacher (2007) determined that only one nonpharmacological treatment, habit reversal training (HRT) qualified as a "well-established treatment" based on the criteria set forth by the APA (Chambless et al., 1998; Cook & Blacher, 2007). Additionally, exposure and response prevention was designated as a "probably efficacious" treatment, based on the results of a single randomized controlled trial (Verdellen et al., 2004). Below, these treatments are reviewed along with various other modalities that may be regarded as "experimental therapeutics."

Habit Reversal Training (HRT). HRT (Azrin & Nunn, 1973) is a multicomponent treatment package designed to treat tics in outpatient settings. The core of HRT involves sequential application of three treatment components to each tic targeted. The first component, awareness training, is designed to teach the patient to detect occurrences of tics and accompanying premonitory urges. During the second component, competing response training, patients are trained to engage in a behavior that is physically incompatible with the targeted tic (i.e., a competing response) for one minute or until the premonitory urge is no longer present,

contingent upon the occurrence of the tic or urge. The third component, social support, is designed to promote the use of the competing response outside of session. In this component, a parent or significant other is asked to provide praise contingent upon noticing the patient using the competing response and to deliver a prompt to use the competing response if the target tic occurs and the patient does not appear to be using the competing response.

Recently, researchers have developed an expanded version of HRT called Comprehensive Behavioral Intervention for Tics (CBIT; Woods et al., 2008). CBIT's acute treatment phase consists of eight weekly one-hour sessions followed by several "booster" sessions delivered in the subsequent months. CBIT adds several components to the core HRT package based on research findings that have emerged since HRT's development in the early 1970s. One of these added components is functional assessment and intervention, which attempts to identify and counteract tic-exacerbating factors in the patient's environment. Identification of these factors occurs via an interview with the patient (and parent, if the patient is a youth) to identify both environmental antecedents and consequences that are present when tics are exacerbated. Based on the results of this assessment, the clinician makes recommendations designed to minimize contact with tic-exacerbating antecedents and eliminate potentially reinforcing consequences of ticcing (e.g., escape from academic demands, provision of social attention).

CBIT also includes a relaxation training component, given that patients often indicate that their tics increase in the presence of anxiety (for a review see Conelea & Woods, 2008a). Thus, relaxation training is used as a stress-management tool, to manipulate a potential tic-exacerbating antecedent (i.e., anxiety) as opposed to a stand-alone treatment for tics. Finally, CBIT includes a psychoeducational component, in which patients and their families are presented with information regarding the phenomenology, course, causes, and impact of CTDs. Weekly

homework assignments are also included to facilitate use of new skills outside of session. For tics targeted with HRT, patients are instructed to use the competing response throughout their daily lives, and also to schedule planned practice times focused on using the exercises and self-monitoring the number of tics that occur.

As indicated by Cook and Blacher's (2007) review, a relatively large literature of methodologically sound studies supports the efficacy of HRT for treating CTDs. To date, eight randomized controlled trials have found HRT/CBIT (six HRT, two CBIT) superior to both wait-list and active-treatment controls (e.g., supportive therapy, massed negative practice; Azrin, Nunn, & Frantz, 1980; Piacentini et al., 2010). A meta-analytic review of "pure" HRT studies (i.e., excluding the CBIT trials) found a large effect size across trials (d=0.8; Bate, Malouff, Thorsteinsson, & Bhullar, 2011). Most recently, the efficacy of CBIT was compared to a treatment consisting of psychoeducation and supportive therapy in two separate multi-site randomized controlled trials for youth and adults (Piacentini et al., 2010; Wilhelm et al., 2012). Among those assigned to receive CBIT, 53% of pediatric patients and 37% of adult patients demonstrated a clinically significant reduction in tics. In contrast, only 18% of pediatric patients and 6% of adult patients in the psychoeducation and supportive therapy condition demonstrated clinically significant gains. Additionally, CBIT's effects were durable, with 87% of children and 80% of adults who initially responded to CBIT continuing to exhibit significant gains at six-month followup. Finally, CBIT proved to be largely free of adverse side effects, which occurred at low rates nondifferentially across the two treatments. In contrast, some positive treatment "side effects" were noted in the pediatric CBIT trial (Woods et al., 2011), as youth who responded to CBIT also displayed decreased rates of disruptive behavior, anxiety, obsessive-compulsive symptoms and family strain at six-month follow-up.

Exposure and Response Prevention (ERP). ERP is a behavioral intervention with well-established efficacy in the treatment of anxiety disorders, especially OCD (Foa, Franklin, & Kozak, 1998). More recently, ERP has been adapted to treat CTDs. As applied to OCD, ERP involves that patient "exposing" themselves to anxiety-eliciting stimuli and situations while refraining from engaging in compulsive behavior that would function to reduce their discomfort. Over time, patients who participate in ERP experience decreased anxiety in the anxiety-eliciting situations as they continually decrease the frequency of their compulsive behavior (Craske et al., 2008; Foa & Kozak, 1986). In the treatment of CTDs, ERP involves exposing patients to premonitory urges for prolonged periods of time, while coaching them to suppress their tics (Hoogduin, Verdellen, & Cath, 1997; Verdellen et al., 2004). Parallel to findings for ERP for OCD, over time, patients with CTDs report decreased premonitory urge strength and tic severity (Verdellen et al., 2004; Verdellen et al., 2008).

ERP appears to be a promising treatment for CTDs, but few data are available on its efficacy. One case series showed clinically significant gains in four individuals with CTDs, but this study was limited as it was an open uncontrolled trial (Hoogduin et al., 1997). Subsequently, Verdellen and colleagues (2004) conducted a randomized controlled trial comparing ERP to HRT and found substantial reductions in average tic severity from pre- to post-treatment, with comparable outcomes for both treatments. However, methodological limitations of this study (i.e., disparate amount of treatment time across conditions and exclusion of a social support component from the HRT intervention) limit the interpretability of findings on the relative efficacy of the two treatments.

Self-Monitoring. Self-monitoring involves asking a patient to record a specific target behavior (here, tic occurrence) throughout the day. Clinicians may use

self-monitoring to increase a client's awareness of a target behavior as it occurs in real time or to call their attention to the amount of behavior that is occurring. Research indicates that self-monitoring can facilitate behavior change by a) increasing the patient's awareness of the target behavior and subsequently promoting attempts to abstain from it and/or b) by arranging for an aversive event (i.e., recording the behavior, which is likely to occasion negative affect) to follow the behavior, thus punishing the action (Nelson & Hayes, 1981).

Because self-monitoring is usually included as part of a multi-component treatment package (e.g., Varni, Boyd, & Cataldo, 1978; Woods et al., 2008), little is known about the effects of self-monitoring as a monotherapy. However, two studies provide relevant data. In one, two children's tics were treated with self-monitoring and overcorrection, with self-monitoring being taught first, and overcorrection (i.e., a competing response) added later (Ollendick, 1981). During the self-monitoring only phase, tics decreased from baseline levels for one of the two children treated. Another study conducted a component analysis of major habit reversal elements and found that, for one of the three participants, a combination of self-monitoring and awareness training (see next section) significantly decreased tic frequency (Woods, Miltenberger, & Lumley, 1996). Based on this extremely limited evidence, it appears plausible that self-monitoring may have desirable effects in some cases.

Massed Negative Practice. In massed negative practice (MNP), patients are instructed to repeatedly perform their tics for scheduled periods each day. The aim of MNP was to facilitate "reactive inhibition" which would serve to suppress tic occurrence. MNP showed early promise in several case studies (e.g., Nicassio, Liberman, Patterson, & Ramirez, 1972; Tophoff, 1973) However, in a randomized controlled trial (Azrin, Nunn, & Frantz, 1980), MNP produced only negligible symptom reduction and proved inferior to the intervention to the

comparison condition (habit reversal training). Given the state of the evidence on MNP, it is not currently regarded either as an established evidence-based treatment or as a promising treatment (Cook & Blacher, 2007).

Contingency Management Procedures. Contingency management (CM) involves directly arranging operant consequences to promote desirable behavior change. Some previously tested CM interventions for CTDs have attempted to use positive reinforcement to promote the non-occurrence of tics. For instance, Wagaman, Miltenberger, and Williams (1995) provided token reinforcers contingent upon tic-free intervals to reduce a vocal tic in a school-aged boy. This produced robust decreases in tic frequency both during sessions and in non-treatment contexts. Similar procedures have demonstrated efficacy in other single-case reports (e.g., Doleys & Kurtz, 1974; Varni et al., 1978; Watson & Sterling, 1998). Additionally, a large literature of non-treatment studies show that these differential reinforcement procedures engender immediate tic reduction for a large majority of individuals (e.g., Capriotti, Brandt, Ricketts, Espil, & Woods, 2012; Conelea, Woods, & Brandt, 2011; Conelea & Woods, 2008b; Himle et al., 2007; Himle & Woods, 2005; Woods & Himle, 2004; Woods et al., 2009). However, differential reinforcement as a treatment for tics has not been evaluated in the context of larger-scale, controlled studies incorporating multiple participants. At present, there is not sufficient evidence supporting the efficacy of differential reinforcement as a stand-alone treatment, however, the results of the studies discussed above suggest that these procedures may be useful in some cases.

Other CM interventions have involved presentation of aversive stimuli (e.g., noxious odors, mild electric shock) contingent on tic occurrence. In these procedures, treatment consists of a series of training sessions the patient contacts the punishment contingency for ticcing. Two

uncontrolled case studies of these procedure report significant tic reduction (Alexander et al., 1973; Knepler & Sewall, 1974), but also potential for severe levels of patient dissatisfaction (Alexander et al., 1973). Given these results, and data from laboratory studies showing that more "mild" response-cost punishment procedures produce comparable effects to differential reinforcement procedures (Capriotti et al., 2012), the use of punishment procedures in treatment is not advisable.

Relaxation. Based on the understanding that tics are generally exacerbated in the presence of negative affect (e.g., stress, anxiety; Conelea & Woods, 2008b), some researchers have attempted to use relaxation training as a monotherapy for CTDs. This treatment involves teaching patients to recognize physical and cognitive signs of anxiety and engage in techniques such as controlled diaphragmatic breathing, progressive muscle relaxation, and guided imagery upon noticing that they are in an anxious state (Turpin & Powell, 1984; Woods et al., 2008). It is well established that engaging in these behaviors bring about a decrease in physiological markers of anxiety, as well as subjective levels of anxiety (Pawlow & Jones, 2002). When used as a monotherapy, relaxation training has been found to have negligible effects on tic severity (Bergin, Waranch, Brown, Carson, & Singer, 1998; Peterson & Azrin, 1992; Turpin & Powell, 1984). However, because anxiety/stress appears to interfere with effortful suppression of tics (Conelea Woods, & Brandt, 2011), relaxation training may be useful as an adjunctive treatment component, as is done in CBIT (e.g., Woods et al., 2008).

Existing Treatments: Strengths and Limitations. Over the past 40 years, scientists have developed efficacious pharmacological and nonpharmacological treatments for CTDs. The studies reviewed above demonstrate the ability of modern treatment tools to produce robust, long-lasting changes in tic symptoms. However, despite these important advances, substantial

barriers still stand between many patients and symptom relief. As discussed earlier, pharmacological interventions are often effective, but can carry side effect profiles that inhibit utilization. Likewise, HRT/CBIT, recently established as a recommended standalone first-line treatment or as an adjunct to pharmacotherapy (Cook & Blacher, 2007; Steeves et al., 2012; Verdellen et al., 2011), is far from a panacea. Only about 50% of patients receiving HRT/CBIT improve significantly. Clearly, there is a need to improve upon existing treatment options leaving open the possibility that adjunctive components to existing interventions and/or new behavioral treatments could be more efficacious.

One suggested avenue for improving behavior therapy's efficacy involves modifying treatments to increase their consistency with basic principles surrounding the replacement of existing habitual behaviors with novel habit repertoires (Capriotti & Woods, 2013). Along these lines, it is useful to consider the extent to which the format and structure of HRT/CBIT maximizes new learning of tic suppression/competing response use. According to existing protocols (e.g., Azrin & Nunn, 1973; Woods et al., 2008), reinforcement for competing response use is to be provided by therapists in session, by significant others (often parents) in the home via the social support component, and by general improvements in life functioning brought about by reduced tic frequency. However, the extent to which competing response use is actually reinforced remains unclear. No published studies have investigated the extent to which these putatively reinforcing outcomes (e.g., therapist praise, parental praise, nonoccurrence of social consequences previously produced by tics) occur during HRT and/or function as reinforcers. Additionally, research suggests that adding social support to a package of "awareness training + competing response training" does not enhance treatment efficacy (Flessner et al., 2003; Woods et al., 1996). In summary, although HRT/CBIT does include steps aimed at reinforcing

competing response use (thereby promoting clinical change), it does not ensure that this reinforcement is delivered with sufficient frequency, quality, and consistency to affect behavioral change as would be expected based on the habit learning literature. Thus, one avenue to improving behavior therapy for CTDs involves developing adjunctive interventions that ensure tic suppression is consistently reinforced.

Reinforcing Tic Suppression

Research clearly shows that behavioral consequences are essential for establishing novel habitual repertoires (Yin & Knowlton, 2006). Nevertheless, the delivery of reinforcing consequences alone is not enough. Reinforcing stimuli can be delivered according to certain patterns, or schedules, which will have differential impacts on the extent to which the target behavior is acquired and maintained (Ferster & Skinner, 1957). Not only is the schedule of reinforcement an important factor in establishing habitual responding, but also frequent, repeated pairings between the stimulus, response, and reinforcer are essential. This process has been called "overtraining" and has been shown to promote habit learning (Colwill & Rescorla, 1986).

Can Tic Rate Be Modified by Operant Consequences? Much evidence suggests that programmed reinforcement can be used to alter habitual patterns of ticcing in a laboratory setting. Many studies (Capriotti et al., 2012; Capriotti et al., 2014; Conelea & Woods, 2008b; Conelea, Brandt, & Woods, 2011; Himle et al., 2007; Himle & Woods, 2007; Himle, Woods, & Bunaciu, 2008; Woods et al., 2005; Woods et al., 2009; Woods & Himle, 2004) have shown that tic frequency can be reduced by arranging systematic schedules of reinforcement for tic suppression within the "tic detector paradigm," a schematic of which is shown in Appendix A. In this experimental paradigm, the subject is seated at an apparatus composed of a large box fitted with a webcam and is told that the apparatus is a "tic detector" that can monitor and count tics. In

actuality, an experimenter observes the subject from behind an observation mirror, records tics, and controls experimental events. During reinforced suppression conditions, a point or token (said to be exchangeable for a prize or money after the session) is delivered following each *n*-second interval in which no tics occur.

In the original study using this paradigm, Woods and Himle (2004) compared the effects of verbal instructions to suppress tics with and without a supporting reinforcement contingency for suppressing tics. Four children were exposed to alternating periods of free-to-tic baseline, "verbal instruction" to suppress (VI), and verbal instruction plus differential reinforcement of tic suppression (VI+DRO). Prior to the VI condition, the experimenter told the child to suppress his/her tics for the duration of the upcoming condition, and no contingencies were programmed for ticcing during the condition proper. Prior to the VI+DRO condition, similar instructions were given to suppress tics, and a token (said to be exchangeable for a small amount of money) was delivered from the box following every 10-s tic-free interval. Relative to baseline, modest reductions in tic frequency (M=10%) were seen during VI conditions. In contrast, robust decreases (M=76%) were seen during VI+DRO condition. These data suggest that (a) providing verbal instructions to suppress tics is not sufficient to produce reductions in tic frequency and (b) operant consequences are necessary to produce significant tic suppression. Many subsequent studies using the tic suppression paradigm have replicated the core finding of this study, demonstrating the combination of verbal instructions and a supporting DRO contingency reliably reduces tics to sub-baseline levels (Capriotti et al., 2012; Capriotti et al., 2014; Conelea & Woods, 2008; Conelea, Brandt, & Woods, 2011; Himle et al., 2007; Himle & Woods, 2005; 2008; Woods et al., 2005; Woods et al., 2009).

Another study (Himle et al., 2008) evaluated the contribution of the tic-token contingency to the response-decreasing effects seen in the original study. Subjects underwent alternating periods of baseline, reinforced tic suppression (identical to the VI+DRO conditions described above), and noncontingent reward (NCR conditions; in which children were instructed to suppress their tics, but a token was delivered every 10s, independent of tic occurrence). For three of the four children studied, tic rates were lower during the "token-contingent" reinforced suppression conditions than during NCR conditions. No relationship was noted between tic rate and condition type for the fourth subject. These results showed that a contingent relationship between tic non-occurrence and reinforcing outcomes is necessary to produce tic reductions via an operant approach.

Researchers have also investigated whether tics are sensitive to response-cost punishment procedures, in which the occurrence of a target response results in the loss of a reinforcer. Capriotti and colleagues (2012) exposed four subjects to alternating 5-min periods of free-to-tic baseline, differential reinforcement of tic suppression, and response cost. During the differential reinforcement conditions, a token appeared on a computer monitor following each 5-s tic-free interval; if a subject abstained from ticcing during the entirety of a condition, he/she could earn 60 tokens. In response cost conditions, 60 tokens were displayed at the onset of the condition and one disappeared each time a tic occurred. Both types of contingencies reliably reduced tics to sub-baseline rates, but no differences in tic rates were seen across response-cost and differential reinforcement conditions. Likewise, no differences were seen between response cost and differential reinforcement conditions in global, retrospective ratings of stress and premonitory urge strength. However, for some subjects, elevations were seen in stress when comparing

periods of tics suppression (supported by either reinforcement or response cost) to baseline conditions.

Taken together, the data from these studies suggest that tics are sensitive to at least two types of operant consequences: positive reinforcement and negative punishment. In the case of positive reinforcement, it appears that the contingent nature of the tic-reinforcer relationship is responsible for the rate-decreasing effects produced by positive reinforcement procedures, as opposed to a more general effect associated with providing monetary rewards per se.

What are the phenomenological "side effects" of operantly-induced tic suppression? Research on tic suppression has also aimed to investigate the interplay among tic expression, tic suppression, and various phenomenological experiences relevant to CTDs. These have included both specific tic-related phenomenological experiences (i.e., premonitory urges) and the more general state of "stress."

Premonitory Urges. First-person accounts (e.g., Bliss, Cohen, & Freedman, 1980; Kane, 1994; Patrick, 1905) have long suggested that premonitory urges are highly aversive experiences that can be relieved temporarily by ticcing. This description led some (e.g., Evers & van der Wetering, 1994; Himle et al., 2007) to posit that the urge functions as a negative reinforcer[1] that maintains ticcing. As such, premonitory urge strength would be expected to increase during periods of tic suppression. Himle and colleagues (2007) evaluated this possibility by comparing ratings of premonitory urge strength during periods of baseline and reinforced tic

[1]In precise operant terms, the urge may be more accurately classified as a reflexive motivating operation than as a negative reinforcer, as it represents a general perceived state subserved by physiological changes, as opposed to a readily definable physical stimulus (Michael, 1993; Moore, 2008). However, by definition, reflexive establishing operations are those whose own removal functions as a reinforcing event (Michael, 2000). Therefore, for the sake of concision, the premonitory urge is referred to as behaving with the function of a negative reinforcer.

suppression. The order and structure of conditions in this study was nearly identical to their 2005 study, except that subjects rated the strength of premonitory urges every 30s during each condition. For three of five subjects, average urge ratings were reliably higher during reinforced suppression conditions than during free-to-tic baselines. These results indicated that, for a majority of individuals, premonitory urges increase during periods of tic suppression, consistent with a negative reinforcement conceptualization.

Subsequent research has produced mixed findings on the relationships between ratings of urge strength and tic suppression. Three studies have failed to find differences between urge ratings during suppression and baseline conditions (Capriotti et al., 2012; Conelea et al., 2011; Woods et al., 2009). However, in these studies, urge strength was assessed via a single, global rating collected following condition offset, as opposed to averaging ratings collected frequently throughout the condition itself (cf. Himle et al., 2007). Another study that used in-condition ratings to assess urge strength (Capriotti et al., 2014) replicated Himle and colleagues (2007) findings, and also provided additional lines of evidence consistent with the notion that premonitory urges function as negative reinforcers. Further, data from this study also indicated that urge strength progresses in a hyperbolic fashion throughout periods of tic suppression, initially increasing and then plateauing after a period of 1-2 minutes (Cotter et al., 2011).

Stress. One study has evaluated the effects of engaging in a "stressful" task (i.e., computing math problems) on tic expression and suppression (Conelea, Woods, & Brandt, 2011). This study exposed children to four different conditions: free-to-tic baseline, reinforced tic suppression, baseline + math computation, and reinforced suppression + math computation. Results indicated no difference across baseline conditions with and without a concurrent "stressful" task; however, subjects displayed more tics during the suppression + mental math

condition than the reinforced suppression "only" condition. The authors interpreted this finding as indicating that exposure to stressors does not exacerbate tics directly, but rather that it may interfere with individuals' attempts to suppress tics

Empirically Evaluating Concerns Related to Therapy. Other tic suppression studies served as laboratory analogues designed to empirically evaluate concerns relevant to the use behavior therapy for CTDs. For instance, Himle and Woods (2005) used the tic detector paradigm to test the "tic rebound" hypothesis, which predicts that, immediately following a period of suppression, tic rates will "rebound" to levels above and beyond normal levels (Leckman et al., 1986). To evaluate this they exposed children to alternating periods of free-to-tic baseline (A) and reinforced tic suppression (B) using a hybrid alternating treatments/withdrawal (ABABA) design. In this case, the rebound hypothesis predicts that tic rates would be higher during the second and third iterations of the baseline condition than during the first. However, tic rates did not differ significantly between these "post-suppression" baselines and the initial baseline condition; in fact, tic rates were somewhat lower (17%) in post-suppression baseline conditions than during initial baselines. Several other studies (e.g., Capriotti et al., 2012; Himle & Woods, 2005; Woods & Himle, 2004) have provided additional data inconsistent with the tic-rebound hypothesis.

Another study (Conelea & Woods, 2008b), explored whether youth with CTDs could suppress tics while concurrently engaged in an attention-demanding task. Subjects were exposed to periods of baseline, reinforced tic suppression, and "reinforced tic suppression plus distraction." During the last condition type, children completed an auditory continuous performance task (CPT) while the reinforcement contingency for tic suppression was active. Results indicated that concurrent engagement in the CPT did not interfere with tic suppression;

however, subjects performed slightly less well on the CPT when suppressing tics than during a pre-experimental administration in which no contingencies were placed on ticcing. These results indicate that distraction does not interfere with tic suppression, but, without significant practice, attempts to suppress tics may interfere with concurrent task performance.

Finally, one study of tic suppression addressed concerns about potential tic-exacerbating effects of stimulant medications prescribed for attention deficit hyperactivity disorder. Lyon and colleagues (2010) used a crossover design to compare the effects of methylphenidate on tic rates during baseline and suppression reinforcement conditions. Overall, they found that tics occurred at a lower rate when subjects had taken methylphenidate than when they had taken placebo. However, tic rates were comparable during reinforced suppression conditions across drug and placebo days. Thus, this study demonstrated no adverse effects of a single-dose stimulant on tic symptoms, and may have indicated some beneficial effects.

Summary. Data from these tic suppression studies provide strong evidence that tics can readily come under the control of operant consequences. Additionally, they show that certain suspected side effects (e.g., rebound, marked interference with other tasks) do not occur, and that suppression can be achieved across a wide range of patients (e.g., varying in age, comorbid diagnoses, tic topography and severity, medication status). As discussed above, one shortcoming of existing behavior therapies is that they do not ensure that tic suppression is consistently reinforced. Based on these factors, providing organized practice with reinforced tic suppression is an appealing avenue for treatment development.

However, current operant techniques for creating tic suppression are suboptimal in some regards. In previous studies, a substantial minority of children (~25%) did not demonstrate a decrease in tics when a typical fixed-interval differential reinforcement contingency was

arranged. Additionally, among children who do show reliable reinforcement effects, tic rates rarely decrease to near-zero levels. The reason for this may be gleaned from the basic learning literature's principle of "momentary maximizing," which states that when an organism is presented with two competing response alternatives, it will allocate its responding to the alternative that yields the greatest payoff (i.e. probability of reinforcement) at that moment in time (Shimp, 1966). This principle has been supported by many basic learning studies of concurrent choice (MacDonall, Goodell, & Juliano, 2006; Shimp, 1966; Todorov, Souza, & Bori, 1993).

Tic Suppression: A Concurrent Operant View

The tic detector paradigm can be thought of as presenting two distinct response alternatives (i.e., ticcing or suppressing tics) between which a subject can choose. Research indicates that, as an individual successfully suppresses tics, the motivation to tic (i.e., premonitory urge) increases in strength (Cotter et al., 2011). Meanwhile, under the kinds of differential reinforcement schedules used in the studies above, the motivation to suppress (i.e., the magnitude of reinforcement) remains constant. As a result, many situations arise in which the reinforcement contingency supporting tic suppression may not compete with reinforcement for ticcing (i.e., reduction of the urge). For instance, if an individual is exposed to a differential reinforcement of other behavior (DRO)-10s schedule for tic suppression and suppresses his tics successfully for 60s, then the motivation to tic (i.e., urge strength) at second 61 is likely much stronger than it was at second 0. Ticcing would produce escape from the premonitory urge, which functions as a potent reinforcer (Capriotti et al., 2014; Evers & van der Wetering, 1993; Kane, 1994), since the urge should be relatively strong at this point in time. Meanwhile, the momentary "cost" of ticcing would be only a 1-s delay in reinforcer delivery. Thus, in this

situation, the subject would be expected to "maximize" his/her momentary access to reinforcement by ticcing. Through this process, the DRO schedule does decrease the rate of ticcing, but also yields momentary situations in which ticcing is favored over tic suppression. That is, it does not facilitate learning to engage in tic suppression in the presence of strong urges. Consistent with the predictions of momentary maximizing theory, evidence from tic suppression studies suggests that such DRO schedules may not robustly replace the tic habit with one of tic suppression, but rather encourage efficient alternation between behavioral repertoires (Conelea, Bauer, Woods, & Kemp, 2008). Additionally, evidence from a treatment trial of behavior therapy for CTDs (Verdellen et al., 2004; 2008) suggests that the increased tic frequency during attempted suppression is associated with poorer clinical outcomes, likely due to impaired development of the tic-suppressing habit.

From a momentary matching perspective, one solution to this issue would be to increase the magnitude of reinforcement for tic suppression as premonitory urge strength increases. Unfortunately, no robust biomarker for the premonitory urge phenomenon has been established, thus preventing the use of direct measurement of urge strength. Previous research has used self-reports of urge strength to assess the construct; however, using a contingency linking reinforcer magnitude with the level of urge reported would be expected to influence urge reporting in and of itself.

Progressive-Amount Schedules: A Potential for Improvement? Given the barriers to design the schedule around urge strength directly, one strong alternative would be to adapt schedules shown effective in reducing other target behaviors that are motivated by establishing operations which change in a similar manner across time. One instructive example is in the area of substance abuse. Just as premonitory urges increase in strength during initial periods of

sustained tic suppression, urges to engage in substance use increase shortly following substance use and across initial periods of continuous abstinence. Recognizing a similar challenge in providing adequate reinforcement to compete with these increasing urges to engage in substance use, Roll, Higgins, and Badger (1996) developed a reinforcement schedule that provided increases in reinforcement magnitude with continued abstinence from engaging in the target behavior (here, cigarette smoking). In the context of voucher-based contingency management for smoking cessation, they compared the effects of "progressive-amount" reinforcement schedules to those of a fixed-amount schedule typical of previous contingency management research (e.g., McCaul, Stitzer, Bigalow, & Liebson, 1984). In this program, subjects received monetary vouchers contingent upon providing a sample negative for carbon monoxide (which are a validated indicator of smoking abstinence) several times daily. Participants were assigned either to a no-voucher control group, or one of the two voucher reinforcement groups. In the fixed-amount voucher condition, subjects received a voucher with a value of $9.80 for each CO-negative reading. For subjects in the progressive-amount group, base voucher value was $3 for the first negative sample and increased $.50 for each consecutive negative sample (e.g., $3.50 for the second, $4.00 for the third, and so on). Every third consecutive negative sample resulted in a $10 bonus, in addition to the base voucher for that sample. Submitting a positive sample (or failing to provide a sample at a scheduled time) resulted the base voucher amount resetting to $3; then, after three consecutive negative samples at the $3 level, the base voucher amount reverted to the highest amount obtained previously and continued incrementing. Importantly, the total amount earnable was equal across the fixed- and progressive-amount conditions, such that reinforcement schedule type was dissociated from total reinforcer amount.

Results of this study indicated comparable numbers of CO-negative samples submitted for both the progressive and fixed groups. However, a higher percentage of subjects in progressive group than in the fixed group showed continuous abstinence across all five study days. Additionally, individuals in the progressive group were less likely to resume smoking (as evidenced by submission of a CO-positive sample) after submitting three consecutive CO-negative samples. Both voucher conditions were superior to the no-voucher control condition on all outcome measures assessed. Thus, this study indicated that progressive-amount schedules were more effective than fixed-amount schedules in engendering sustained abstinence from cigarette smoking.

Although Roll et al.'s (1996) study demonstrated differences in the effects of the progressive- and fixed-amount schedules, it did not elucidate the features of the progressive-amount schedule that were key in providing its advantages. It was not clear whether the incrementing voucher amount, the reset contingency, or a combination of the two were necessary to produce superior outcomes to those seen with fixed-amount schedules. To evaluate this question, Roll and Higgins (2000) conducted a follow-up study, again in the context of cigarette smoking cessation. Using a within-subjects design, they compared the effects of vouchers delivered on a fixed-amount schedule, a progressive-amount schedule with a reset contingency, and a progressive-amount schedule without a reset contingency; they also included a no-voucher control condition. Results replicated Roll and colleagues' (1996) study in that: (a) all voucher conditions produced greater rates of abstinence than the no-voucher control; and (b) there was no difference in number of negative samples between any of the three voucher conditions. However, participants in the progressive-reset condition had longer periods of sustained abstinence, on average, than those in the progressive-no-reset or fixed groups. No difference in average duration

of continuous abstinence was seen between progressive-no-reset and fixed groups. The results of this study suggest that the inclusion of the voucher amount reset contingency is necessary to produce outcomes above and beyond those yielded by fixed-amount schedules.

In summary, research in the context of substance abuse has indicated that progressive-amount schedules may be more effective than fixed-amount schedules in promoting continuous abstinence from a target behavior. These findings have been useful in forming the backbone of many effective contingency management interventions for substance abuse (Dallery & Glenn, 2005; Higgins, Silverman, Heil, & Brady, 2007). Several functional similarities between ticcing and substance abuse support the exploration of the utility of progressive-amount schedules in facilitating tic reduction. First, the motivating operations governing the two behaviors are quite similar in terms of their temporal dynamics. Just as the strength of premonitory urges increases during initial periods of sustained tic suppression, the strength urges to engage in substance use also increases shortly following substance use and across initial periods of continuous abstinence (Budney, Moore, Vandrey, & Hughes, 2003; McGregor et al., 2005). In both cases, engaging in the targeted behavior provides a brief reduction in the strength of the motivating operation, which subsequently increases once again from that point on. Second, both have been shown to be highly malleable by differential reinforcement of other behavior techniques. Finally, a wealth of neurocognitive research signals overlap in neurobiological and cognitive factors underlying both tics and substance abuse. Both are known to be associated with abnormal dopaminergic activity in the mesolimbic cortical structures (e.g., the basal ganglia, putamen, caudate), proposed by some to amount to a “reward deficiency syndrome” common to both classes of problematic behavior (Blum et al., 1996; Wanat, Willuhn, Clark, & Phillips, 2009). Given these functional similarities between substance abuse and tics, it is reasonable to assume that schedules of

reinforcement useful in promoting abstinence from substance use might also be useful in promoting increases in tic suppression.

Purpose of the Current Research

Based on this rationale, to the current pre-clinical study compared a DRO-P schedule for tic suppression with a DRO-F schedule representative of FI schedules in previous research on tic suppression. The primary aim of this study was to compare the effects of DRO-P and DRO-F schedules of reinforcement on tics. Based on previous research, the following primary hypotheses were made:

1. Tic rates will be lower during DRO-F and DRO-P conditions than in BL conditions.
2. Median duration of inter-tic-intervals will be greater during both DRO-F and DRO-P conditions than in BL conditions.
3. Median duration of inter-tic-intervals will be greater during DRO-P conditions than during DRO-F conditions.

We also made several secondary hypotheses related to other aspects of the study:

4. Ratings of urge strength will be higher during DRO-P and DRO-F conditions than during BL conditions.
5. Ratings of stress will be higher for DRO-P and DRO-F conditions than during BL conditions.

The following were undertaken as exploratory aims of the study:

1. Testing the acceptability of each schedule. Subjects' responses on Likert-type measures evaluating the ease of use, perceived utility, and acceptability for DRO-P and DRO-F conditions will be explored.

2. Evaluating behavioral preference from DRO-F versus DRO-P schedules via a forced-choice paradigm.
3. Evaluating potential moderators of differential performance on, and preference for, DRO-F versus DRO-P schedules, including age, Axis-I comorbidity, executive functioning (as measured by the BRIEF), tic severity (as measured by the YGTSS), and premonitory urge severity (as measured by the PUTS).
4. Evaluating tic rate throughout a 15-min extinction period following repeated exposure to reinforcement for tic suppression.

Method

Subjects and Recruitment

After the study protocol was approved by the University of Wisconsin-Milwaukee Institutional Review Board, six youth and their parent(s) were recruited (via print advertisements and patient flow through the UWM Tic Disorders Specialty Clinic), provided informed consent/assent, and initiated the screening process. During screening, it was discovered that Subject 02 was under nine years of age, so the assessment was discontinued. Some subjects (SOR04 and SOR05) completed the present study within the context of the baseline assessment of a larger clinical trial for pediatric TS. All other subjects completed the study as a standalone experiment. All subjects met diagnostic criteria for TS. Table 1 contains data on other descriptive demographic and clinical characteristics of subjects, and Table 2 contains quantitative measures of their neuropsychological functioning.

Subjects were screened for eligibility according to the following criteria: (1) generally healthy males or females of ages $9 \leq$ and ≥ 17; (2) a diagnosis of Tourette Syndrome, Chronic Motor Tic Disorder or Chronic Vocal Tic Disorder; (3) a Yale Global Tic Severity Score (YGTSS) total tic severity score $\geq$14 and <35 if diagnosed with TS OR $\geq$10 and<20 if diagnosed with CTD; (4) exhibits at least one tic per minute during the initial six-min baseline condition; (5) intellectual functioning in the low-average range or above as indicated by a score ≥ 75 on the Wechsler Abbreviated Scale of Intelligence (WASI); (6) no significant suicidal ideation at present, reflected by a score < 9 on the MINI-Kid suicidality index; (7) no history of behavioral treatment for tics; and (8) not currently taking a neuroleptic medication. Exclusion criteria were the presence of a psychotic disorder, substance use disorder, or autism spectrum disorder (parent-reported) will be excluded. Children with other comorbid conditions were included if they meet

all other eligibility requirements. Children on non-neuroleptic psychotropic medications were included if on a stable dosage for ≥ 6 weeks. Children on stimulant medications were included, so long as (a) they had adhered to their medication regimen for the past three days, and (b) they had not taken a dose within 10h of the onset of the first experimental condition, if taking an extended-release formulation, or within 6h, if taking an instant-release formulation.

Measures and Apparatus

Demographics Form (Appendix B). A parent-report measure was used to collect demographic information, treatment history, current medication status, and medical/psychiatric history for each subject.

Mini International Neuropsychiatric Interview – Kid (MINI-Kid). The MINI-Kid (Sheehan et al., 2010) is a brief structured diagnostic interview completed by the parent and child, and designed to assess for 27 Axis-I psychiatric disorders.

Wechsler Abbreviated Scale of Intelligence (WASI). The WASI is a psychometrically acceptable measure of intellectual functioning for individuals age 6 to 89 years (The Psychological Corporation, 1999). We will used the two-subtest WASI estimate of IQ.

Yale Global Tic Severity Scale (YGTSS; Appendix C). The YGTSS is a clinician-administered rating scale assessing tic severity. Separate scores are generated for motor and vocal tics (range: 0-25 each), which are added to yield a total tic severity score (range: 0-50). The YGTSS has good internal consistency, inter-rater reliability, and convergent and divergent validity (Leckman et al., 1989).

Behavior Rating Inventory of Executive Function (BRIEF). The BRIEF is a questionnaire designed to assess for executive function and dysfunction in children and

adolescents' daily lives. Respondents rate the applicability of each of 86 items to their child's behavior according to a three-point scale. The parent-report form was used in the present study. Individual item scores are summed and converted to age- and gender-normed t-scores for two indices (Behavioral Regulation and Metacognition), which combine to form a Composite index. Higher scores on the BRIEF reflect greater difficulties with executive dysfunction. The BRIEF has demonstrated good test-retest reliability and internal consistency, as well as good convergent, discriminant, and predictive validity (Gioia, Isquith, Guy, & Kenworthy, 2000).

Manipulation Check (Appendix D). Before each condition, an experimenter provided the child instructions for the upcoming condition including a description of the contingencies in operation. The experimenter asked the child to repeat the instructions and summarize the programmed contingency. If the child did so correctly, the experimenter acknowledged the response was correct and left the room. The condition began at this point. In the event of an incorrect response(s), the experimenter re-explained the instructions and reinforcement contingency; then, the experimenter again asked the child to repeat the questions not correctly answered the first time. This continued until the subject correctly responded to all questions for the upcoming condition.

Immediately after each condition ended, the experimenter asked the subject questions to evaluate his/her understanding of and compliance with the instructions for the just-terminated condition. The experimenter recorded the subject's responses, but provided no feedback as to their correctness.

Schedule Acceptability Scale (Appendix E). The Schedule Acceptability Scale is an ad hoc measure assessing various dimensions of acceptability including attentional strain, perceived control of tics, ease, and subjective discomfort. Using a likert-type scale, child subjects rated

various statements regarding these different aspects of acceptability for each reinforcement schedule.

Experimental Design

Pre-Experimental Assessment. Subjects and their parents underwent an initial assessment to determine if they met inclusion/exclusion criteria for participation in the experiment. After providing informed consent/assent, both the parent and child participated in interviews for the MINI-Kid and YGTSS. Children also completed the WASI, and parents completed the Demographics Form. A Masters-level therapist with supervised training in administration and interpretation of all study measures, administered, scored, and interpreted all measures.

Main Experiment. After completing the pre-experimental assessment, subjects were exposed to 11, six-minute conditions in a multielement design. Each subject was exposed to three baseline conditions (BL), four fixed-amount differential reinforcement of other behavior (DRO-F), and four progressive-amount differential reinforcement of other behavior (DRO-P) conditions. The first condition was always a BL condition, and subsequent conditions were presented in pseudorandom order with counterbalancing across subjects. Each condition type was associated with a unique background color on the experimental display. Prior to the first DRO condition of either type, children were told that every 1000 points they earned was worth $2, although in actuality all subjects were paid $20 post-experiment regardless of performance.

The present experiment employed the tic detector paradigm to measure tics using direct observation while minimizing reactivity to observation (see Appendix A, Woods & Himle, 2004). At the beginning of the experiment, subjects were told the experimental apparatus was equipped with a software program capable of detecting the occurrence of their tics. They were instructed to

sit facing the apparatus with their hands away from their face during all experimental conditions, so that the "tic detector" could accurately monitor their tics. Immediately prior to the onset of each condition, the experimenter read instructions (Appendix D) describing the contingencies in place for the upcoming condition, conducted a pre-condition manipulation check, and exited the room. Conditions began shortly (<30s) thereafter, as signaled by a tone audible to the subject. For the duration of the condition, the words "TIC DETECTOR ON" appeared in the bottom right corner of the screen. Meanwhile, the experimenter monitored the subject via a one-way mirror and a live video feed from a webcam mounted on top of the apparatus' computer monitor. Upon the occurrence of a tic, the experimenter pressed a key on a keyboard connected to the computer supporting the experimental apparatus, which created a timestamped record and, when applicable, reset the DRO contingency. Immediately following the offset of each condition, the experimenter re-entered the experimental room, prompted the subject to provide global, retrospective ratings of premonitory urge and stress during the previous condition (using the Urge and Stress Thermometer measures, respectively), and to conduct a post-session manipulation check to ensure that the subject had complied with the instructions given prior to condition onset.

BL Conditions. During BL conditions, no contingencies were programmed for ticcing. Subjects were told that the tic detector will be powered on and counting their tics, but that ticcing would not affect their point total.

DRO-P Conditions. During DRO-P conditions, a progressive-amount, resetting DRO 10-s schedule of reinforcement was in effect. Reinforcer delivery, consisting of an incrementing of the point count and brief tone, occurred following each 10s tic-free interval. Reinforcer magnitude was six points initially and increased by one point for each *consecutive* tic-free

interval elapsed. In the event of a tic, the timer reset and the reinforcer magnitude reverted to six. From this point, the reinforcer magnitude was fixed at six points until three consecutive tic-free intervals elapsed. After this had occurred, the magnitude reset to the highest amount attained previously in that condition and resumed incrementing by one point for each consecutive tic-free interval. The text "Point Count:" followed by the number of points earned in the current condition was displayed in the center of the monitor. Additionally, when applicable the availability of a bonus for completing the upcoming interval without ticcing was indicated on the screen. If subjects suppressed tics continuously throughout the condition, they would have earned 1086 points in total. To equate rule-governance across conditions, subjects were told that 1080 points were earnable.

DRO-F Conditions. During DRO-F conditions, a fixed-amount, resetting DRO 10-s schedule of reinforcement was in effect; 30 points were delivered following each 10s tic-free interval. Reinforcer delivery consisted of the point count incrementing by 30 and a brief tone sounding. The DRO timer was reset immediately upon the occurrence of a tic. Throughout the condition, the text "Point Count:" followed by the number of points earned in the current condition will be displayed in the center of the monitor. In the event that a subject emitted no tics throughout the entire condition, 1080 points were earnable.

Forced-choice Preference Assessment/Resistance to Extinction Condition. Following the termination of the 11th condition, subjects were instructed to select a final fifteen-minute condition from among the three types to which they were exposed (BL, DRO-F, and DRO-P). The experimenter explained the choice paradigm to the subject and left the room after the subject reflected comprehension on the manipulation check. Then, the subject was presented with three squares, each colored to match the background screen color of one of the three experimental

conditions. Additionally, each square contained a brief description of the contingencies that had been in effect. The subject selected a schedule type for the upcoming condition by selecting a square using the arrows on the keyboard and pressing the enter key. After the subject selected the condition, a 15-min extinction condition began, in which no programmed contingencies were in place, but the background was illuminated the color previously correlated with the selected condition. The subject's selection was used as a behavioral index of preference, and tic data from this condition were used to conduct exploratory analyses of resistance to extinction.

Interobserver Agreement (IOA). Output files indicating the number and timing of tics throughout the experimental session were used as the primary measure of tic occurrence. The head-on video stream of the subject during experimental conditions was recorded and later reviewed by a trained coder (i.e., secondary rater) who was blind to study hypotheses. The coder was provided the operational definition of each tic topography used by the experimenter. The coder then viewed the video and recorded the occurrence of each tic by pressing a button on the keyboard, which generated a timestamp accurate to the nearest hundredth of a second. Partial-interval IOA coefficients were then calculated across the two records for four of five subjects. IOA was not calculated for one subject (03) because his face and body were not consistently within view of the camera due to failure to consistently comply with directions to face the camera directly. Mean IOA was 85% (range: 79%- 86%).

Independent Variable Integrity. Review of output files indicated that 100% of reinforcers were delivered within 1s of their scheduled delivery time. All subjects passed all post-condition manipulation checks with one exception: After the first BL condition, SOR01 indicated that the instructions were to suppress tics and that she had been attempting to do so. The experimenter provided feedback as to the correct instructions, and re-administered the

condition. Only data from the re-administration of this condition are included in study analyses. Due to experimenter error, stress and urge ratings were not collected for Subject 01. Subject 04's mother requested that the experiment be suspended after the seventh experimental condition, stating a desire to get her daughter to bed (it was 7:30 PM on a weeknight) and return to complete the experiment at a later date. When asked directly, she stated no concerns with the experimental protocol. This subject was lost to contact after this session. As a result, she did not complete conditions seven through 11, the Schedule Acceptability Scales, or the forced-choice trial and subsequent extinction component. All other subjects completed all study tasks within a single session.

Results

Tests of Primary Hypotheses

It was hypothesized that tic rates would be lower during DRO-F and DRO-P conditions than in BL conditions. To test this prediction, tic rates were plotted across conditions for each subject (Figure 1). For four of five subjects, tic rates were reliably lower during DRO-F and DRO-P conditions than during BL conditions. For one subject (04), tic rate was reliably lower than BL conditions during DRO-P conditions, but not DRO-F conditions. Overall, these data are consistent with Hypothesis 1. Additionally, the total numbers of reinforcers earned across DRO-F and DRO-P conditions were compared for each subject (Table 3). All subjects earned a higher number of reinforcers in DRO-F conditions than in DRO-P conditions.

Hypotheses 2 and 3 related to the effects of each schedule of reinforcement on median inter-tic intervals (ITIs). It was hypothesized that the median ITIs would be higher for DRO-F and DRO-P conditions than for BL conditions (Hypothesis 2), and that median ITIs would be higher during DRO-P conditions than during DRO-F conditions (Hypothesis 3). To evaluate these hypotheses, the timestamp of each tic recorded was subtracted from the tic that preceded it using output from the experimental session. No ITI was calculated for the first tic during each condition, as there was no record of the tic that preceded it. The median ITI within each condition was calculated and plotted these across sessions for each subject (Figure 2). When fewer than two tics occurred in a condition, the median ITI duration was graphed as 601s.

Median ITI duration was reliably higher during DRO-F and DRO-P conditions than during BL conditions for only one subject (01) throughout all conditions. Data for the other three subjects showed that median ITI durations were generally higher than during BL, but differences were less robust. One subject (03) showed this pattern across the first seven experimental conditions, but showed less differentiation during the final four conditions. Another subject (06)

showed differentiation in the direction of Hypothesis 2 during conditions four through 11, but not during conditions one through three. Subject 05 showed substantially longer median ITI duration for DRO-F conditions than for BL conditions during the second half of the experiment, but this pattern was not seeing during the first half; median ITI duration did not differ systematically between BL and DRO-P conditions for this subject. Finally, SOR04 showed no systematic differences in median ITI duration. No subject showed reliable differences in median ITI. duration between DRO-F and DRO-P conditions. Taken together, these findings are partially consistent with Hypothesis 2 and inconsistent with Hypothesis 3.

Given that the findings surrounding Hypothesis 3 were inconsistent with previous research, factors that may have contributed to these disparate findings were explored. One possible reason for failure to find differences between schedules related to this hypothesis was that we examined median ITI duration to operationalize "sustained abstinence" from ticcing. In contrast to this approach, previous studies in substance use (Roll et al., 1996; Roll & Higgins, 2000) used a group design and examined number of patients achieving sustained abstinence for the course of the study. Because the present study included very few instances in which subjects refrained from ticcing for an entire condition, using this as a definition of "sustained" tic suppression would have created inadequate range in the outcome variable. However, no prior studies were available to provide guidance as to the duration at which tic suppression could be considered "sustained" (and clinically meaningful), versus relatively transient, As such, a parametric approach to evaluating various cutpoints was used, and the number of instances of "sustained" tic suppression were explored, with data combined across all DRO-F and DRO-P conditions. An instance of sustained tic suppression was defined as an inter-tic interval greater than a given duration (*t*). Eleven duration-based cutpoints were established ideographically for

each subject. The first was the mean ITI observed across all BL conditions for that subject. Cutpoints two through seven were multiples of the mean BL ITI duration (2x-10x). The eleventh cutpoint was 60s, as this is the duration for which patients are instructed to engage in the competing response in HRT/CBIT (Azrin & Nunn, 1973; Woods et al., 2008). For all subjects, the 10x BL ITI cutpoint was less than 60s. Data were not re-analyzed for Subject 01, as she achieved near-perfect tic suppression during both DRO condition types, and therefore few ITIs were available for analysis.

Results of these analyses are shown in Figure 3. At less stringent cutpoints, each subject showed differences in instances of sustained tic suppression observed. However, few differences between schedules were seen at more stringent cutpoints (i.e., above 7x mean BL ITI duration). For the 1x-5x cutpoints, Subjects 03 and 05 showed more sustained tic suppression for DRO-F than for DRO-P. However, no differences between schedules were observed for these subjects on the 6x-10x and 60s cutpoints. Subjects 04 and 06 showed an inverse pattern, with higher frequencies of sustained tic suppression under DRO-P schedules than DRO-F schedules. For Subject 04, these differences persisted for the 1x-7x cutpoints, but did not survive at higher-duration cutpoints. For Subject 06, differences were sustained through the 1x-10x cutpoints, but were not observed at the 60s cutpoint. Results of this analysis provide another line of evidence suggesting that the DRO-P schedule did not engender more sustained tic suppression than the DRO-F schedule, contrary to Hypothesis 3.

Schedule Acceptability. We evaluated the acceptability of DRO-F and DRO-P schedules both via behavioral preference (i.e., the condition selected in the forced-choice trial) and via self-report (i.e., responses to items on the Schedule Acceptability Scale). Three of four subjects chose DRO-F on the forced-choice trial, and one (06) chose BL. Responses on the Schedule

Acceptability Scale are depicted on an item-by-item basis across subjects in Figure 4. Three of four subjects (03, 05, and 06) rated the DRO-F schedule as more acceptable than the DRO-P schedule on a majority of items. SAS responses and forced-choice trial responses generally corresponded well within subjects. Two subjects (03 and 05) rated the DRO-F schedule as more acceptable than the DRO-P schedule on most items, and these individuals also selected the DRO-F schedule in the forced-choice trial. One subject (01) rated the two schedules comparably and selected the DRO-F schedule. The subject who chose a BL condition on the forced-choice trial (06) indicated agreement that he would like to receive a therapy centered around using either of the two treatments. Also, during the post-condition manipulation check for condition seven, he remarked spontaneously, "This is so cool, not even about the $2, its cool to be able to stop tics for that long." Thus, his choice of a non-DRO condition does not appear to indicate that he found the DRO schedules to be wholly unacceptable.

Ancillary Measures.

Urge Ratings. Figure 5 depicts post-condition urge ratings across conditions for the four subjects for whom these were collected. For each subject, urge ratings were reliably higher for DRO conditions than for BL conditions. Urge ratings did not differ systematically between DRO-F and DRO-P conditions for any subject. One subject (05) demonstrated decreases in urge ratings during DRO conditions with repeated exposure to the contingencies, consistent with the possibility that this individual habituated partially to these urges throughout the experiment.

Stress Ratings. Figure 6 shows post-condition stress ratings across conditions for each subject. Three of four subjects for whom ratings were available reliably reported higher stress during DRO conditions than during BL conditions. Data from one subject (05) showed a similar pattern in the first half of the experiment, but reported comparable stress ratings for all three conditions

in the second half of the experiment. For no subject did stress ratings differ systematically between DRO-F and DRO-P conditions.

Responding Under Extinction. Figure 7 shows extinction data for the two subjects who chose a DRO schedule during the forced-choice trial. Subject 01 and 04 were not included in these analyses because they did not complete the post-forced-choice condition, and Subject 06 was not included because he chose to complete a BL condition.

Both subjects (03 and 05) showed increases in tic frequency throughout the extinction session. For the first 12 mins of extinction, Subject 03 ticced at a rate below that seen in both his most recent BL condition and his most recent DRO-P condition. Then, his tics increased beyond this BL rate for two of the final three minutes. For the first five mins of extinction, Subject 05 ticced at a rate similar to that seen during his most recent DRO; his rate of ticcing then accelerated and approximated or exceeded his most recent BL rate for mins 8-15.

Moderators of DRO-F versus DRO-P performance and preference. Differences in performance DRO-F and DRO-P schedules were anticipated per study hypotheses. However, all four subjects showed no systematic differences between DRO-F and DRO-P schedules on any outcome variable related to tic frequency, premonitory urge ratings, or stress ratings. Additionally, all subjects expressed preference for the DRO-F schedule over the DRO-P schedule. Because no systematic differences across subjects were observed in relation to these outcome variables, it was not possible to conduct meaningful analyses of variables which may have moderated performance on and/or preference for DRO-F versus DRO-P schedules.

Discussion

In this study, the effects of two schedules of reinforcement for tic suppression were evaluated, one commonly-used (DRO-F) and one relatively novel (DRO-P). Findings were partially consistent with a priori study hypotheses. Relative to a baseline control condition, each DRO schedule decreased tic rate below baseline (Hypothesis 1) and generally increased median ITI duration (Hypothesis 2). Ratings of stress and premonitory urge strength were also higher during DRO conditions than during BL conditions. Contrary to a Hypothesis 3, no reliable differences in tic rate or median ITI duration were observed between the two DRO schedules. Finally, the DRO-F schedule appeared to be somewhat more preferred by subjects than the DRO-P schedule.

Although findings were not consistent with the predictions that DRO-P schedule would engender greater tic suppression than the DRO-F schedule, some possible reasons for the lack of differences can be offered. First, it is possible that the magnitude of reinforcement used in this study was too small to produce differences in responding. Although the precise mechanisms through which DRO-P conditions reduce behavior are unclear, their efficacy is thought to hinge on the combination of escalating nature of reinforcement (for continued abstinence from the target behavior) and response-cost-like reinforcer magnitude reset contingency (for engaging in the target behavior; Roll & Higgins, 2000). If the discrepancy in value between the “progressed” reinforcer amount and the minimum amount (to which the magnitude would reset in the event of a tic) is not sufficient, the unique features of the DRO-P schedule may not, in fact, facilitate enhanced reductions of the target behavior.

It is also possible that the relative effects of DRO-F and DRO-P schedules depend on the nature of the target response and the subject's ability to detect it. Previous research showing

greater reductions in behavior with DRO-P schedules than DRO-F schedules occurred in the context of cigarette smoking. Cigarette smoking is a behavior of which typically developing adults are aware (i.e., they would be able to indicate, in real time, when they are engaging in the target behavior and when they are not). Additionally, cigarette smoking involves a fairly complex chain of precurrent responses, such as taking a cigarette and lighter into one's hands, putting the cigarette in one's mouth, and lighting it. In contrast, ticcing has no necessary behavioral precursors nor does it require ancillary materials. Many individuals who present with TS cannot detect when their tics occur. Few formal studies have evaluated the extent to which treatment-naive patients are aware of their tics as they occur in real time, but deficits in this area are common enough that awareness training has long been included as a formalized component of behavior therapy for TS (Azrin & Nunn, 1973). Additionally, although tics are often preceded by premonitory sensations, these are not present for every tic topography in individuals who do report urges (Leckman et al., 1998). Further, many pediatric patients report that they do not always happen before each instance of a tic (Woods et al., 2005), and even when present, they are not correlated with the ability to suppress tics (Ganos et al., 2012). Based on these considerations, one empirically-testable explanation for our failure to find differences predicted in Hypothesis 3 is that the effects of DRO schedules may depend on individuals' awareness of the target response. Means to experimentally explore this possibility are suggested in the *Future Directions* subsection.

The DRO schedules produced sizeable decreases in tic rates, but their effects on median ITI durations were less robust. Molecular analyses revealed that, during DRO conditions, ITI distributions were still positively skewed, although less so than during BL conditions. Additionally, although the median ITI durations under DRO schedules were still short, a large

number of relatively short ITIs (indicative of sustained tic suppression) were observed during DRO conditions, relative to BL conditions (Figure 3). Relatively long ITIs are indicative of capacity for more prolonged tic suppression, which, in turn, may facilitate habituation to premonitory urges (Verdellen et al., 2007). As such, research aimed at identifying conditions that promote longer ITIs (i.e., periods of sustained tic suppression) could be of great clinical import.

Although the two DRO schedules had very similar effects on tics, we did find differences in subjects' preferences for the two DRO schedules. In the forced-choice trial, three of four subjects selected DRO-F, one selected BL, and none selected DRO-P. This indicates that, although effortful, reinforced tic suppression was more preferred than simulated "no treatment" (i.e., BL) conditions. On a self-report measure, three of four subjects generally rated the DRO-F schedule as more preferable than the DRO-P schedule. These three subjects also rated a hypothetical treatment involving repeated exposure to the DRO-F schedule as more preferable than one employing the DRO-P schedule. Thus, as administered in the context of this study, the DRO-P schedule was less preferred than the DRO-F schedule.

It is important to consider certain methodological features of our assessment of treatment acceptability when interpreting these results. For instance, we used a single, three-stimulus trial to assess behavioral preference for each of the conditions. Thus, it can only be preferred that the chosen condition was the *most* preferred at that time. It is unknown whether subjects who chose the DRO-F condition would have chosen the DRO-P condition if it were presented pairwise with the BL condition. Additionally, one subject (06), demonstrated behavioral preference for the BL condition, despite self-reporting high interest in receiving treatment involving either DRO schedule. It is possible that relatively transient motivating operations affected by extended

exposure to contingencies in the experimental context (e.g., satiation to the reinforcer, fatigue from repeated tic suppression) affected this individual's forced-choice preference.

These mitigating factors aside, possible reasons for DRO-P being less preferred than DRO-F are apparent. The most basic explanation may be that each subject earned substantially more reinforcers during DRO-F conditions than DRO-P conditions. Therefore, it would be unsurprising that subjects would prefer the condition in which they obtained the most monetary reinforcement. An additional possibility is that the resetting reinforcer magnitude feature of the DRO-P schedule may have been experienced as aversive. Indeed, verbally savvy individuals such as those who served as subjects in the present study could experience this procedure could be experienced as similar to a negative punishment contingency, in which engaging in the target response results in the removal of reinforcers.

The results of the present study also expand on prior research examining the phenomenological correlates of reinforced tic suppression (i.e., ratings of premonitory urge strength and stress). For three of four subjects, urge ratings were reliably higher during reinforced suppression conditions than during BL conditions; Subject 04 showed a similar pattern but differences were less robust. This is consistent with previous research showing that premonitory urges increase in strength during periods of reinforced tic suppression (Capriotti et al., 2014; Himle et al., 2007). No differences in urge ratings were seen between DRO-F and DRO-P conditions. This is unsurprising, given that the DRO-P contingency failed to produce enhanced tic suppression, which would be expected to, in turn, lead to greater temporary increases in urge strength (Himle et al., 2007).

Similarly, three of four subjects reported increased stress during both DRO conditions, relative to baseline. This is consistent with previous research showing that modest increases in

stress may occur for some individuals during reinforced tic suppression (Capriotti et al., 2012). Interestingly, two subjects showed decreases in stress ratings during reinforced tic suppression as the experiment progressed and they were repeatedly exposed to the contingencies. Subject 05 showed clear decreases across time for both DRO-F and DRO-P s. Subject 06 showed decreases in stress ratings over time for DRO-F conditions, but not DRO-P conditions. Another subject (04) showed mild increases in stress during DRO conditions throughout the six experimental conditions she completed. Subject 03 showed robust and reliable increases in stress during both DRO conditions throughout the entire experiment; this individual also chose the DRO-F condition in the forced-choice trial, suggesting that these increases in stress were not sufficiently aversive to result in a preference shift. Overall, the present findings indicate that tic suppression may initially be stressful for treatment-naive youth with TS. However, they also suggest that stress surrounding tic suppression is (a) often short-lived in many cases when suppression is practiced repeatedly, and (b) generally not great enough to deter patients from opting to engage in tic suppression in the future.

Limitations

The present study was subject to a number of methodological limitations which should be considered in interpreting its results. First, subjects were exposed to an interspersion of the two DRO schedules within the context of a multielement design. This design, while useful for comparing multiple conditions in a relatively rapid session, leaves open the possibility that multiple treatment interference may have influenced outcomes; that is, exposure to one DRO schedule may have influenced responding under the other DRO schedule. Therefore, it is possible that repeated exposure to each DRO schedule alone (e.g., in the context of a withdrawal design, or via a between-groups design) would have yielded greater differentiation between the

two schedules, or that tic suppression may have improved more rapidly during repeated exposure to one DRO schedule versus the other.

Our assessment of the acceptability of schedules used in the present study, although novel, was also subject to certain limitations. We used a single, three-option trial to assess subjects' behavioral preference among the three schedules. Thus, present findings speak only to which schedule was *most* preferred, not to specific pair-wise preferences for one schedule over another. For instance, for the three subjects who chose DRO-F in the forced-choice trial, it is unknown whether they preferred DRO-P to BL. Also, by assessing preference at the end of session, it is possible that satiation to the reinforcer and/or fatigue may have influenced forced-choice trial responding. Assessing preference at multiple timepoints is generally recommended in applied behavioral research and practice (Hanley, 2010), and future research should aim to do so.

The discrepancy in total reinforcers earned across conditions is also an important factor to consider when interpreting the results of the present study. The total number of reinforcers *earnable* for perfect tic suppression was equated across conditions, but, due to the nature of the schedules, individuals with imperfect tic suppression (including all subjects in this study) earned fewer reinforcers in DRO-P conditions than in DRO-F conditions. Additionally, poorer tic suppression was associated with concomitant increases in the discrepancy in reinforcers earned across schedule types. Comparable effects on tic rate were seen across schedules, suggesting that DRO-P schedules engendered more efficient tic suppression in terms of effects per reinforcer delivered. However, given the absence of empirical data on reinforcer magnitude and tic suppression, it is difficult to draw strong inferences about these differences.

A final consideration relates to the within-subject design and small sample size of this study. Although well-controlled within-subject designs have good internal validity and allow for

demonstration of generalizability across subjects (Barlow, Nock, & Hersen, 2009), larger sample sizes are necessary to answer certain questions pertinent to the present experiment. For instance, the design of the present study did not allow for analyses aimed at identifying subject-specific factors that may moderate tic suppression (e.g., age, IQ, comorbidity).

Contributions of the Present Study

Progressive-Amount Schedules of Reinforcement. The present findings contribute to the nascent literature on DRO-P schedules of reinforcement. This is the first report of using DRO-P schedules to target a behavior other than drug use. Whereas previous research use found that DRO-P schedules reduced adults' drug use to a greater extent than DRO-F schedules, the present study found no differences in the effects of these two schedules on tics in youth with TS. Several possible explanations for these divergent findings exist, as discussed above. An additionally possibility is that the effectiveness DRO-P schedules may be moderated by certain traits and other repertoires particular to the individual subject/patient. For instance, DRO-P schedules may be more effective for individuals who discount delayed rewards less steeply (i.e., are more tolerant to delayed gratification). Within the context of the DRO-P used in the present study, subjects could obtain either an immediate reinforcer (urge reduction; Capriotti et al., 2014) for ticcing, or a more delayed reinforcer (points, the value of which incremented as the delay increased). Thus, it may be that tolerance to delay facilitates enhanced performance in DRO-P schedules. Along these lines, the effects of DRO-P schedules may also be age-dependent, as delay tolerance is known to increase throughout childhood and adolescence, as prefrontal cortical structures, which subserve capacity to tolerate delays, mature (Green, Fry, & Myerson, 1994). It is also worth noting that general intellectual level may relate to these abilities, as some studies

(e.g., Wilson, Mitchell, Musser, Schmitt, & Nigg, 2011) have found that apparent correlates of delay discounting may reflect second-order correlations explained primarily by IQ.

This was also the first study to report on patient acceptability of DRO-P schedules in relation to DRO-F schedules. In general, DRO-P schedules appeared to be somewhat less preferred than DRO-F schedules. As discussed above, this could have been due to differences in number of reinforcers obtained across conditions, certain features of the schedules themselves (e.g., the magnitude-reset contingency of the DRO-P may have been experienced as aversive), and/or other factors. Additionally, it may be that certain subject-specific factors such as age, personality, co-occurring psychopathology, and/or intellectual functioning modulate preference for DRO-F versus DRO-P schedules.

Tic Suppression. This study expands the literature on tic suppression in a number of ways. First, the present findings support the generality of tic suppression to schedules of positive reinforcement beyond the fixed-amount DRO schedules used in previous research. Second, this was the third study to report on subjective stress experienced during tic suppression, and the first to find that tic suppression increased ratings of stress across majority of subjects. Previous studies had either used a group approach and found no statistically significant differences in stress ratings during DRO- versus BL conditions (Conelea et al., 2011), or found reliable increases in stress for some subjects, but not others (Capriotti et al., 2012). Third, this study adds to the literature suggesting that premonitory urges increase during periods of tic suppression, consistent with the notion that the removal of these urges is a negative reinforcer central to tic maintainence. A majority of subjects in the present study reliably reported higher urge ratings for DRO conditions (when tics occurred at a relatively low rate) than for BL conditions (wherein tics occurred at a higher rate). This is consistent with findings of some previous studies (Capriotti et

al., 2012; Capriotti et al., 2014; Himle et al., 2007), and runs counter to a number of other studies that found no such differences (Conelea & Woods, 2008; Conelea et al., 2011; Specht et al., 2013; Woods et al., 2009).

Fourth, this was the first study to formally evaluate the social validity and patient acceptability of reinforced tic suppression procedures. Previous research had falsified claims about deleterious effects of tic suppression (e.g., the tic rebound hypothesis; Himle & Woods, 2005), but had not investigated subjects' subjective evaluations of tic suppression procedures. The present study provides the first indication that most youth with TS prefer to engage in reinforced tic suppression rather than a no-suppression baseline. Additionally, it provides preliminary data on subjects' subjective phenomenological experiences of reinforced tic suppression.

Fifth, this is the first study specifically to evaluate extinction effects related to reinforced tic suppression explicitly. Woods and colleagues (2009) found that average tic rates were lower in the presence of a stimulus previously correlated with a DRO schedule for tic suppression than in the presence of control stimuli. However, this study aggregated data across three, five-min extinction probes, thus precluding more molecular analyses. The present study provided preliminary analyses of this sort with data from two subjects exposed to a single, 15-min extinction condition. Although preliminary, results indicated that tic rates were relatively low during early phases of the extinction condition, and gradually accelerated toward baseline rates as the condition progressed. This pattern is generally consistent with extinction effects seen for a multitude of target behaviors (Mazur, 2013). Due to the very small sample size and use of a single extinction session, it was not possible to determine whether extinction bursts beyond BL rate occurred systematically. Clinically, this findings suggests that tics may at first be appear to

be reduced in the presence of stimuli previously present during tic suppression, but these effects are likely to be short-lived without systematic programming for maintenance of their control (e.g., by repeated reinforced practice of tic suppression in their presence).

Future Directions.

DRO-P Schedules. This study was the first to evaluate DRO-P schedules outside of the context of substance use and results were inconsistent with those of previous experiments. The present findings suggest that social validity/treatment acceptability may be a concern when using these schedules in certain contexts. However, due to the multitude of differences between this study and previous experiments on DRO-P schedules, only very cautious interpretations can be made. Additional experimental research is needed to identify, (a) subject-specific and schedule-parametric factors that modulate the efficacy of DRO-P schedules, and (b) factors that affect subjects' self-reported and behaviorally expressed preference for DRO-P schedules. This line of inquiry seems well-suited to a bench-to-bedside translational approach. For instance, initial studies could utilize human operant laboratory approaches to parametrically manipulate features potentially important to the above questions. Then, once influential factors have been identified, analogous studies could be run evaluating DRO-P schedules in the context of clinical intervention. These applied studies would determine whether basic findings would be replicated when used in less controlled, naturalistic contexts.

Basic TS Psychopathology Research. As indicated above, the present findings relate closely to the experimental literature on tic suppression. This study attempted to improve the degree of tic suppression observed under DRO-F schedules (used widely in previous research), by evaluating a novel schedule, DRO-P. Contrary to empirically-derived hypotheses, no clear, systematic benefits were seen for DRO-P relative to DRO-F. As such, it appears incrementing reinforcer

magnitude according to a DRO-P schedule may not be an advisable approach to enhancing tic suppression. However, a multitude of possible avenues for creating better tic suppression remain.

One attractive possibility involves varying the timing of reinforcer delivery by using a variable-interval (VI) schedule. VI schedules are known to engender steady patterns of behavior, whereas fixed-interval (FI) schedules (such as the 10s DRO used in the present study) are known to promote a "scallop-like" pattern of pre-reinforcer behavioral acceleration and post-reinforcer behavioral deceleration (Ferster & Skinner, 1957). Applied to tic suppression, FI scalloping would result in a pattern in which suppression occurs during the interval required for reinforcement, but is unlikely to occur reliably immediately after reinforcer delivery, thus preventing prolonged periods of tic suppression. Basic research on VI schedules suggests that they would engender more consistent and sustained tic suppression. However, given that some studies have found atypical patterns of FI and VI responding in verbally-competent individuals (Lowe, Beasty, & Bentall, 1983), this extension should not be assumed without empirical investigation. As such, a direct comparison of FI and VI schedules for tic suppression appears to be indicated.

Additionally, analysis of the present data was limited due to a lack of empirical support for defining "sustained" tic suppression in a meaningful way. In short, it is not known what duration of tic suppression, relative to baseline tic occurrence, is necessary to produce durable changes in tic and urge severity. Twohig and colleagues (2001) parametrically varied competing response duration in a study of HRT for nail-biting and found that a 1-min duration produced superior outcomes to shorter durations. No differences in outcomes were seen between for one-min and three-min durations. However, nail-biting and ticcing are behaviors may differ significantly in terms of their neurological substrates and behavioral functions. Future research

should parametrically manipulate duration of tic suppression (e.g., by varying the interval required to obtain reinforcement) and evaluate effects on tic symptoms and urges. This would inform future treatment development research by providing an empirically-supported target duration for tic suppression.

Applied TS Treatment Development Research. Although the present study was pre-clinical in nature, its results may inform applied treatment development research. This study aimed to identify a schedule more apt to produce sustained tic suppression and, in turn, habituation to urges. Although no reliable differences were seen between schedules in terms of tic occurrence and urge ratings, the goal of generating procedures that enhance effects on these variables remains an important one for treatment development. Future laboratory research as described above may generate more promising procedures for testing in applied treatment-development research.

Findings of the present study also set the stage for future research on the social validity of potential treatments involving computer-mediated tic suppression. Procedures in the present study (and previous studies of tic suppression) were well-tolerated and did not produce observable or subject-reported adverse effects. However, patient ratings of schedule acceptability in the present study could generally be described as "fair" for both DRO schedules. All subjects indicated being at least "somewhat" comfortable during tic suppression under both schedules (as defined by ratings of 3/7-5/7 on SAS items). All subjects indicated feeling that they could "somewhat" control their tics under both DRO schedules and feeling "somewhat" comfortable doing so. Subjects reported difficulty with sustaining attention to the tic-suppression task, with three of four reporting ratings of 3/7 or lower for at least one DRO schedule.

Future research should evaluate whether feelings of comfort and perceived control over tics increase with repeated practice of reinforced tic suppression. If these do not increase spontaneously with repetition, modifications that directly aimed at these phenomenological facets may be pursued. For instance, strategies about how to suppress tics (e.g., competing responses) may be taught. Teaching relaxation strategies such as diaphragmatic breathing and/or progressive muscle relaxation could also be useful in increasing feelings of comfort during tic suppression. Concerns about sustaining subjects' attention to the task may be address by procedural modifications. The procedures used in the present study involved an austere environment and portrayal of schedule-related stimuli, to control for potential effects of extraneous environmental stimuli. However, in application, a more enriched environment could facilitate subjects' ability to sustain attention to the task for a longer time. One approach to enriching the environment could involve changes to the stimulus display. For instance, the schedule could be presented in the context of a videogame wherein the goal was to earn the most points possible. Another strategy might involve providing concurrent access to toys, music, television, or other leisure items. However, these sources of stimulation could plausibly interfere with tic suppression; future research would need to address this concern before ancillary environmental enrichment can be programmed into novel suppression-based treatments.

Although the results of the present study do not strongly recommend DRO-P schedules as a superior alternative to previously used schedules of reinforcement for tic suppression, the importance of research aimed at developing improved techniques for facilitating efficient tic suppression remains high. This project represents only one effort of many possibilities along these lines, and it demonstrates how a translational approach can be used to test potential modifications before bringing them to scale in clinical trials. Research on behavior therapy for

TS broadly, and tic suppression-based treatments specifically, is burgeoning, and continued investigation along these lines holds the promise to yield more effective and accessible treatments for individuals affected by TS.

Table 1. Demographic and clinical background data.

Subject ID	Age	Gender	Comorbidity	Medications
01	16y 5m	F	ADHD, ODD, Mood Disorder NOS	None
03	10y 7m	M	OCD	None
04	9y 11m	F	Separation Anxiety, ADHD	clonidine
05	15y 0m	M	None	none
06	15y 0m	M	GAD, Panic, OCD, ADHD	sertraline atomoxetine methylphenidate

Table 1. Demographic and clinical background data on included subjects. F=Female; M=Male; ODD=oppositional defiant disorder; NOS=not otherwise specified; GAD=Generalized Anxiety Disorder; Panic=Panic Disorder.

Table 2. Quantitative clinical and neuropsychological subject profiles.

Subject ID	YGTSS Severity	YGTSS Impair	PUTS	WASI	BRIEF Behavioral Regulation t-score (%ile)	BRIEF Metacognition t-score (%ile)
01	34	25	25	109	55 (70)	64 (88)
03	27	20	22.5*	141	49 (54)	62 (85)
04	25	20	14	104	57 (80)	55 (73)
05	22	20	31*	98	52(68)	68 (96)
06	31	30	23	118	57 (77)	48 (47)

Table 2. TS-specific symptom and neuropsychological measures. Asterisk denotes no response recorded on one item, in which case total score was calculated by interpolation by using modal response on all other items.

Table 3. Reinforcers Earned by Condition Type

Subject ID	DRO-F	DRO-P
01	4140	3252
03	2970	1212
04	1860	426
05	3450	1698
06	4140	3400

Table 3. Total number of reinforcers earned throughout the experiment during DRO-F and DRO-P conditions for each subject.

Figure 1. Tics per minute across conditions

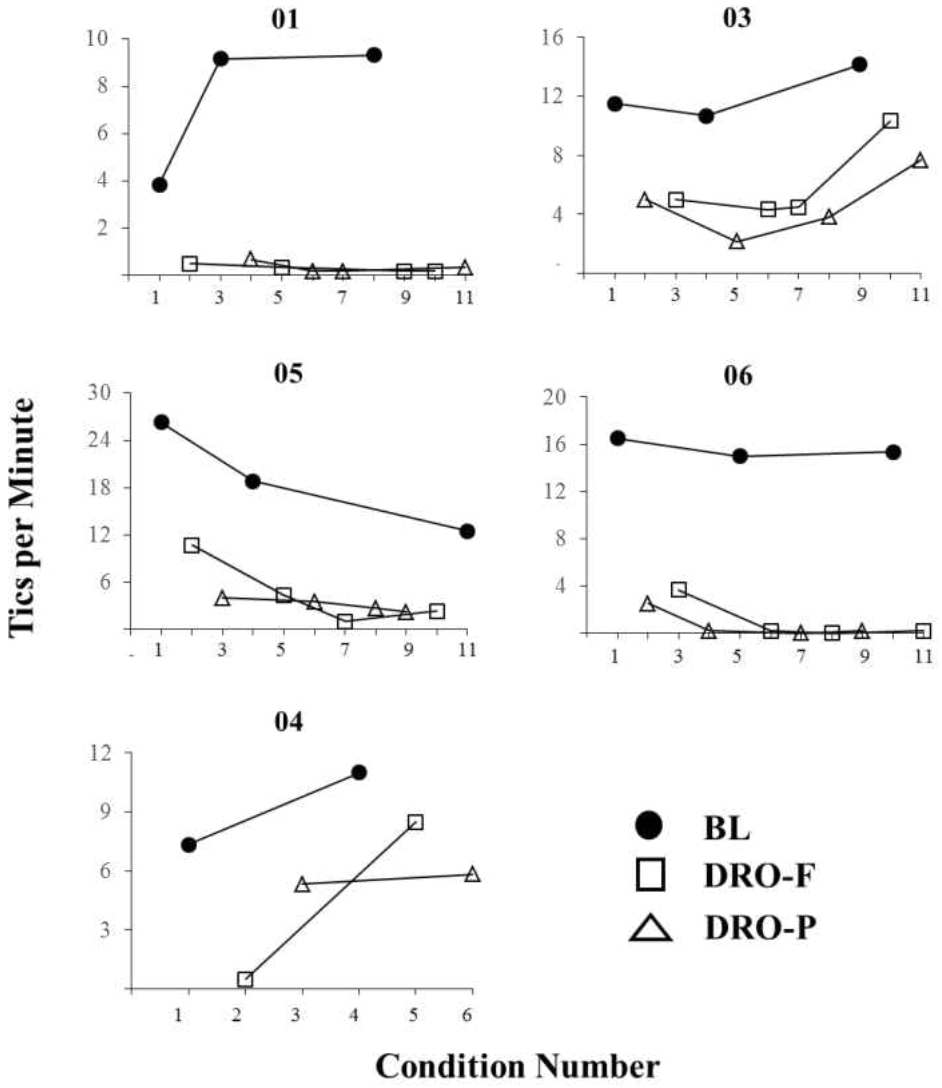

Figure 1. Tics per minute across conditions for each subject. Note that y-axes are scaled differently across subjects.

Figure 2. Median Inter-tic Interval Duration across Conditions

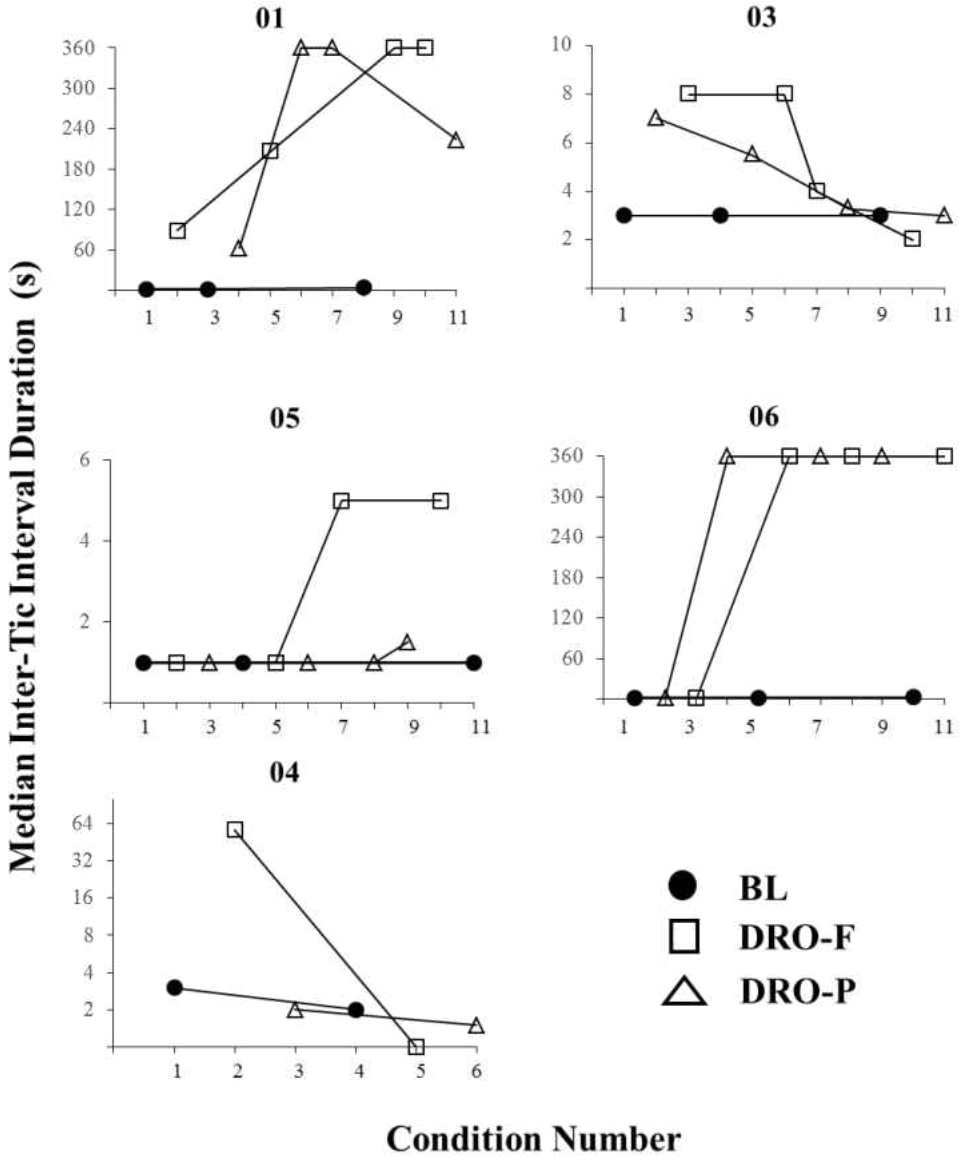

Figure 2. Median ITI durations across conditions for each subject. Note that y-axes are scaled differently across subjects.

Figure 3. Instances of Sustained Tic Suppression by Schedule Type

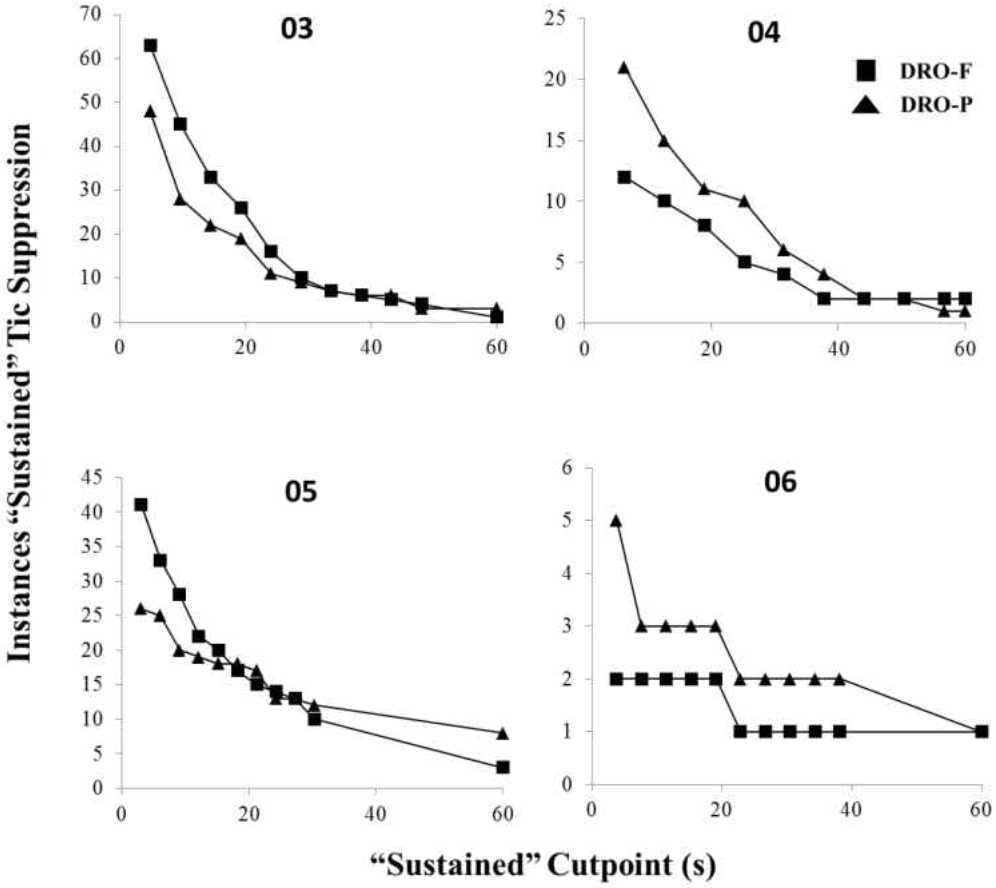

Figure 3. Instances of sustained tic suppression observed under DRO-F and DRO-P. X-axis displays cutoff time for an instance of suppression to be considered "sustained" and y-axis displays number of sustained episodes of tic suppression observed at each cutpoint for each schedule type. Data from all four conditions of each DRO were collapsed into a single data set for these analyses. Note that y-axes are scaled differently across subjects.

Figure 4. Subject-reported Acceptability of DRO Schedules

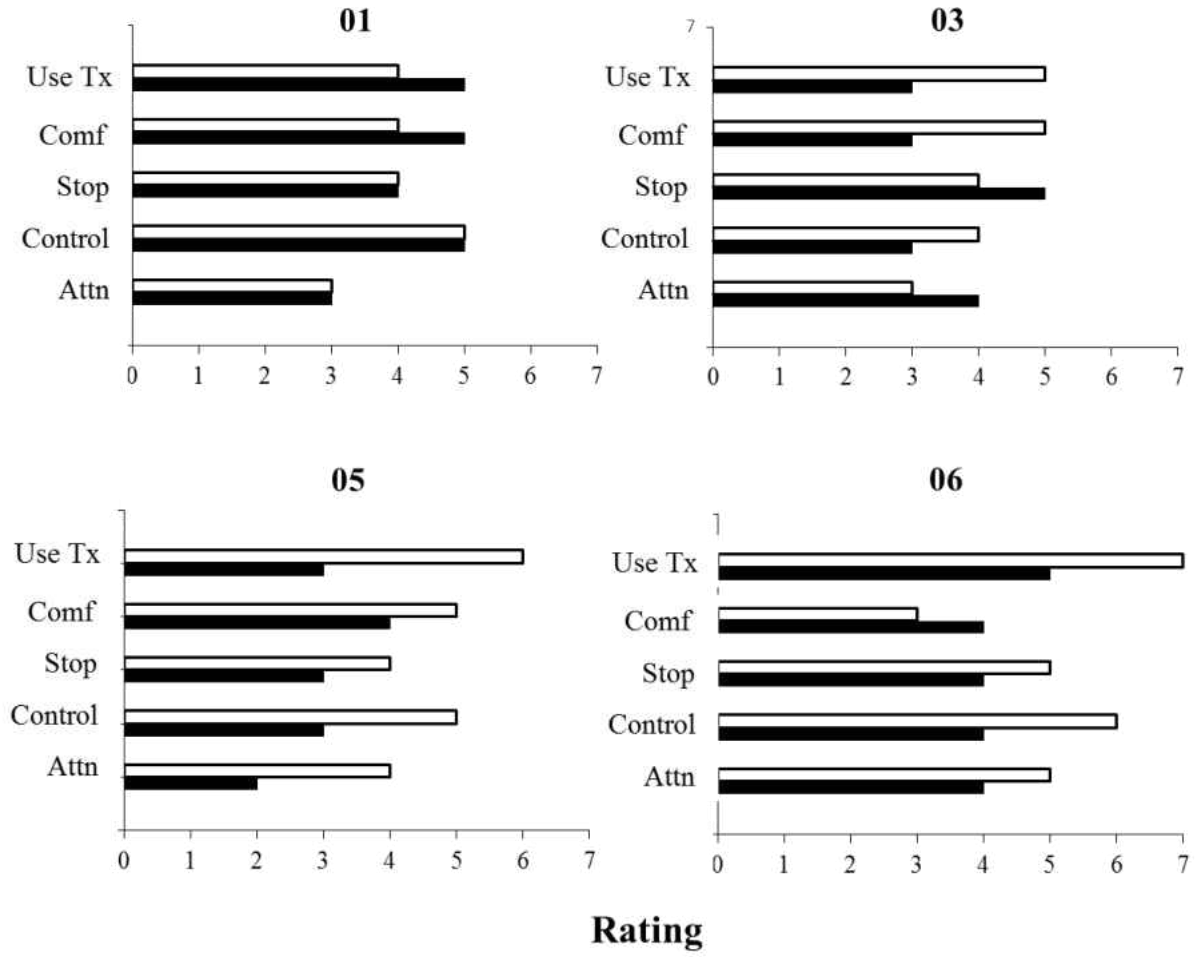

Figure 4. Subject's ratings of individual items on the schedule acceptability scale for DRO-F (open bars) and DRO-P (filled bars) schedules. Comf=comfort; Attn=attention. See Appendix E for full item phrasing.

Figure 5. Premonitory Urge Strength Ratings across Conditions

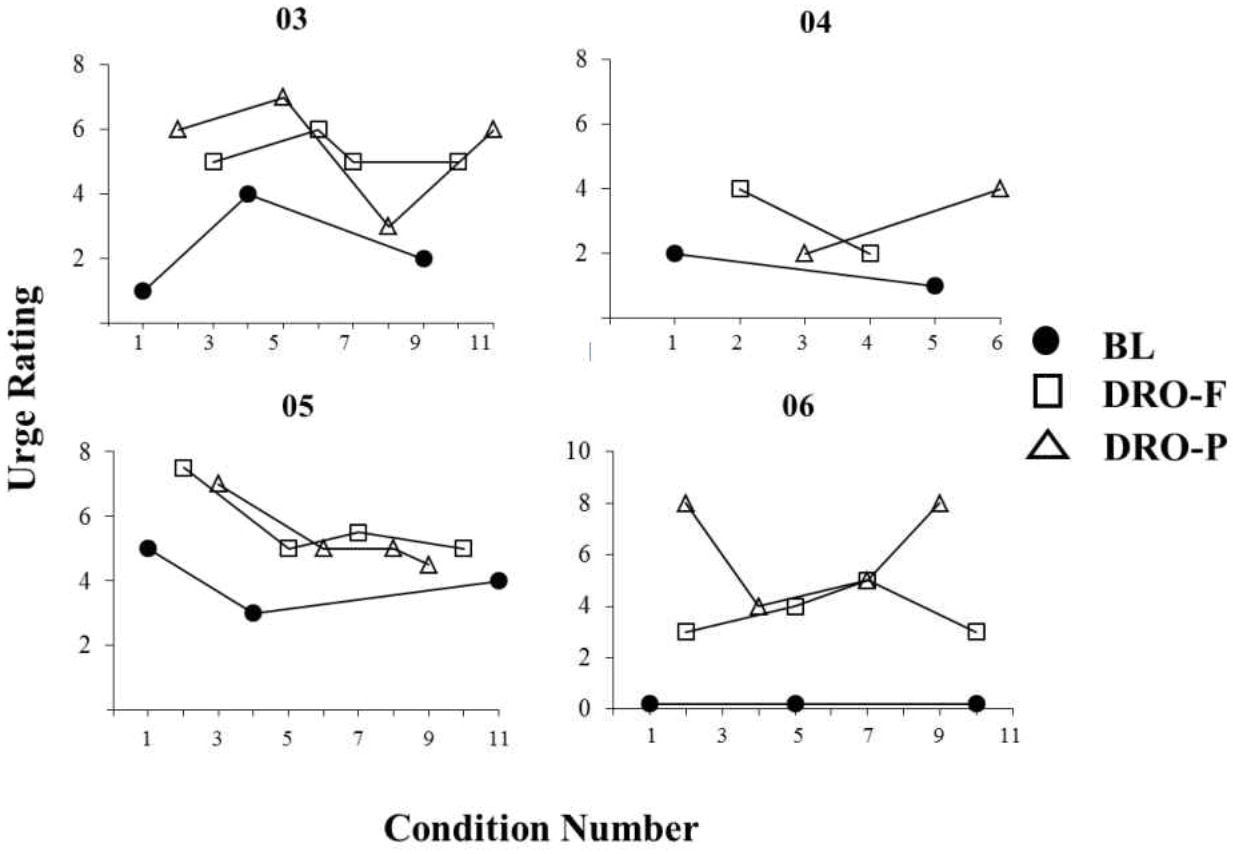

Figure 5. Post-condition ratings of urge strength across conditions for each subject. Urge ratings not collected for subject 01 due to experimenter error.

Figure 6. Stress Ratings across Conditions

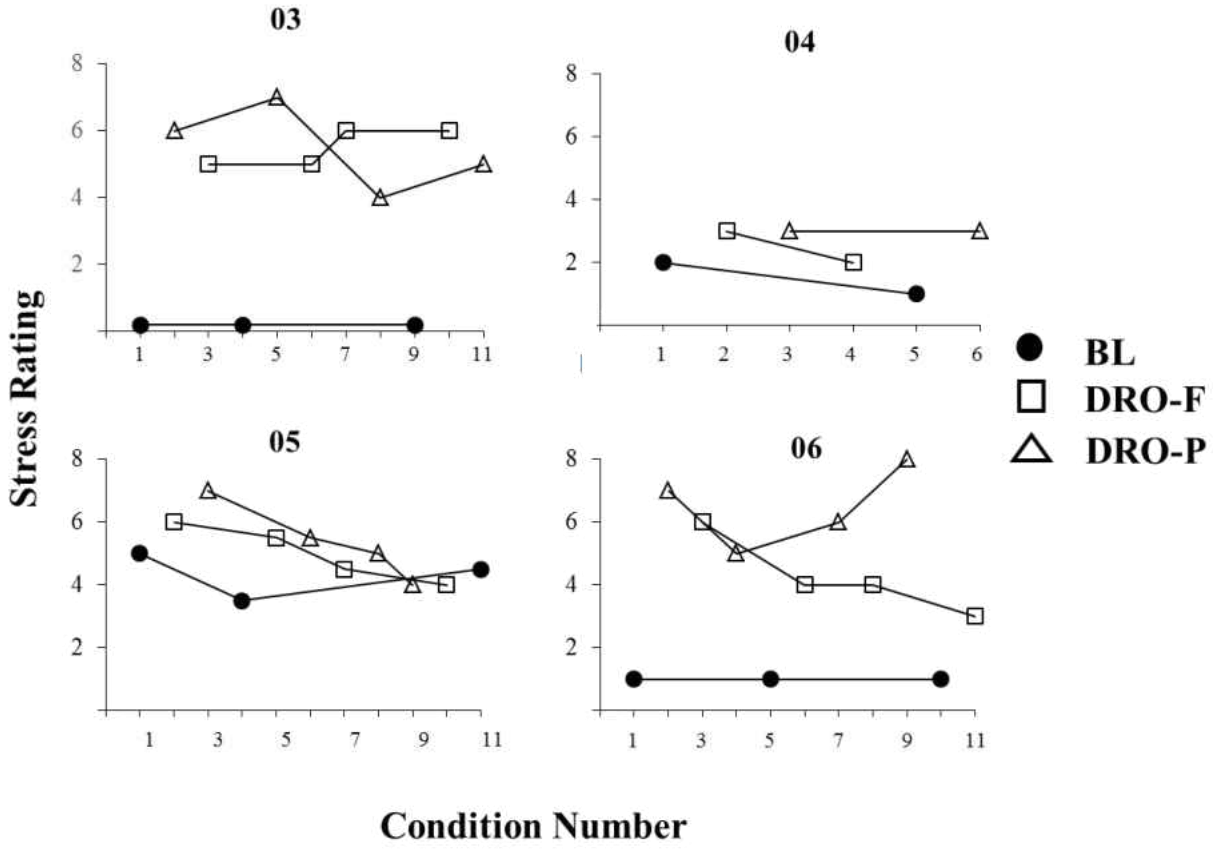

Figure 6. Post-condition ratings of stress during conditions for each subject. Stress ratings not collected for subject 01 due to experimenter error.

Figure 7. Tic Rate During Extinction

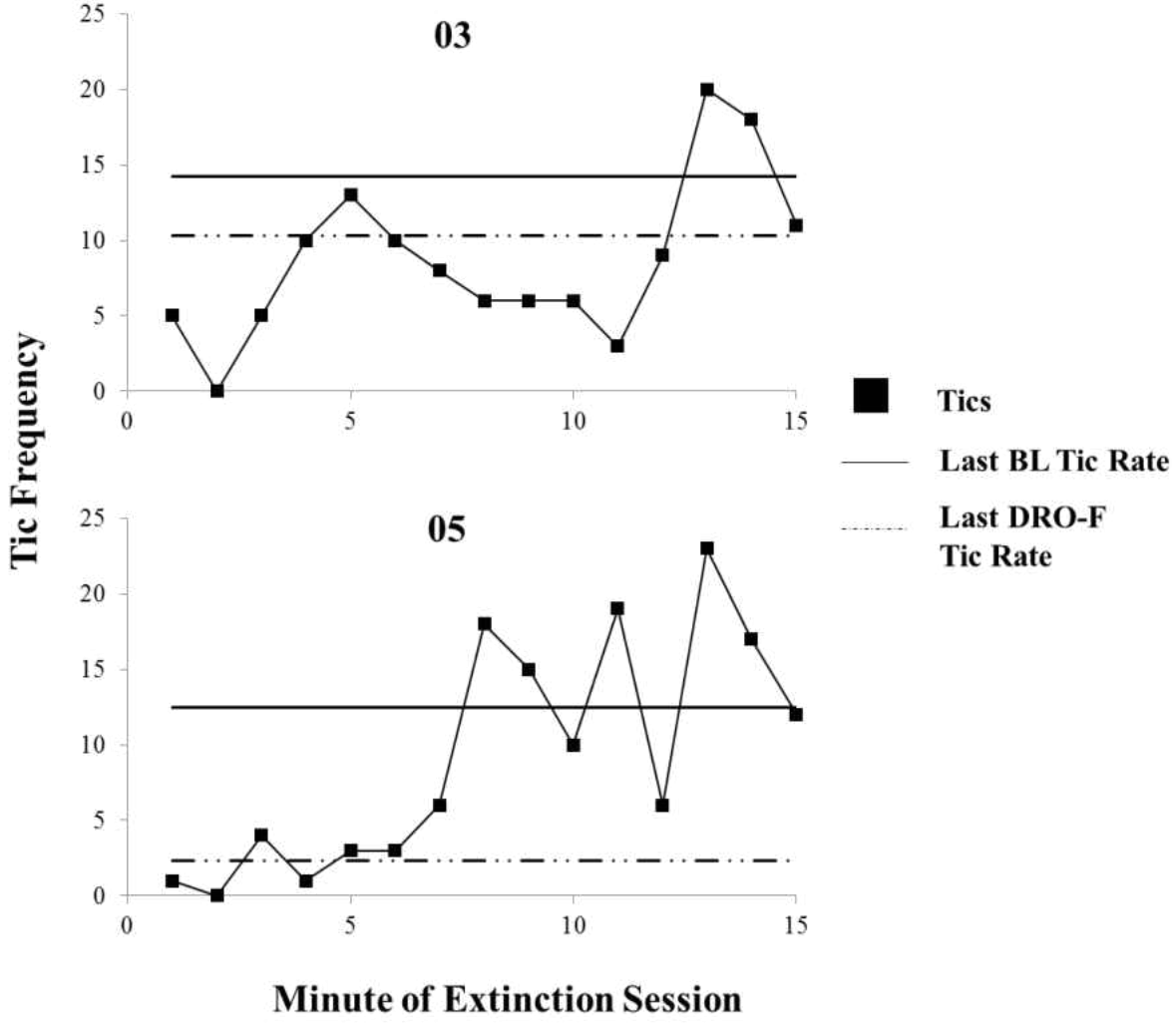

Figure 7. Minute-by-minute plot of tics during 15-min extinction session for two subjects. Horizontal lines depicting average tic rates during most proximal BL and DRO-F conditions shown for reference.

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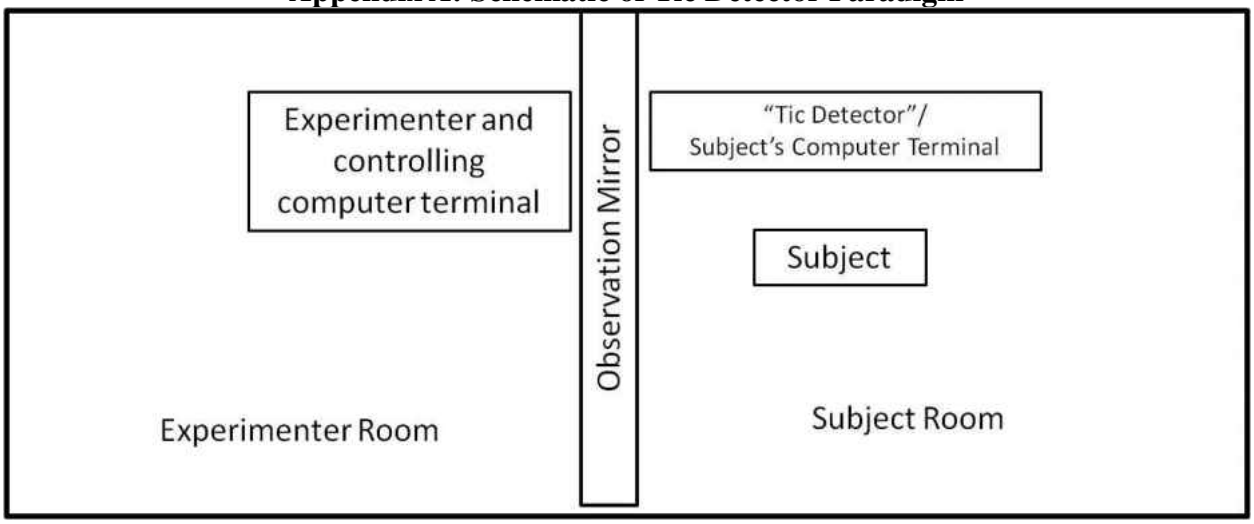
Appendices

Appendix A: Schematic of Tic Detector Paradigm



Appendix B: Background Form

Childhood OCD, Anxiety, and Tourette's Disorder
Background Information Sheet

Participant ID # :_____ Today's Date: _____

Child's Age: __ __ (yrs) __ __ (mos)

Ethnicity: || Caucasian (1) || African-American (2) Latino (3) Asian/Pacific Islander (4)
|| Native American (5) || Mixed (6), please describe: _____
|| Other (7), please describe: __

Biological Parents:

Mother: Age: _____ Occupation:_____
Father: Age: _____ Occupation:_____

Step Parents (if applicable):

Mother: Age: _____ Occupation:_____
Father: Age: _____ Occupation:_____

The child lives with: || Both Biological or Early Adoptive Parents (1)
|| Single Parent: Please note: || Mother (2) or || Father (3)
|| Mother and step-father (4)
|| Father and step-mother (5)
|| Equal time with separated/divorced parents (6)
|| Relatives who are not parents (7);
describe:_____
|| Foster family (8)
|| Treatment Facility (9):
(type):_____
|| Other
(0):_____

Current marital status of biological parents:

Married	||No (0)	|| ||Yes (1)
Separated/Divorced	||No (0)	|| Yes (1)
Mother remarried	||No (0)	||||Yes (1)
Father remarried	||No (0)	|| Yes (1)
Widowed	||No (0)	|| Yes (1)

Custodial parents' education (Highest level completed):	Mother	Father
1. Eighth Grade – no High School (1)	| |	
2. High school diploma or equivalent (GED) (2)	| |	| | | |
3. Technical/trade school or some college (3)	| |	| | | |
4. Junior/Community college graduate (A.A.) (4)	| |	| |
5. College graduate or equivalent (B.A., B.S.) (5)	| |	| | | |
6. Post graduate/Professional degree (M.A., Ph.D., M.D., J.D.) (6)	| |	| | | |

Estimated Annual Gross Family Income: \| \| $20,000 or less (1) $20,001 - $40,000 (2)

\| \| $40,001 - $60,000 (3) \| \| $60,001 - $80,000 (4)

\| \| $80,001 - $100,000 (5) \| \| $100,000+ (6)

Child's siblings (list ages):

	age	age	age	age
Full brothers:				
Full sisters:				
Half-brothers:				
Half sisters:				
Step brothers				
Step sisters				

Current School: \| \| Public (1) \| \| Private (2) \| \| Home Studies (3) \| \|Not in School (4) \| \| Other (5)

Grade:_____

Has child ever attended resource, remedial, or special classes in the past? \| \| \|No (0) \| \| \|Yes (1)

If yes, describe:_____

Has child ever repeated a grade? \| \| \|No (0) Yes (1) If yes, describe:_____

Current School Performance: Failing (1) | | Below Average (2) | | Average (3) | | Above Average (4)

Psychiatric History:

Has your child ever been hospitalized because of a behavioral, emotional, or psychiatric problem?
| | | |No | |Yes If yes, Child's age:
Reason:_____

Has your child ever been **diagnosed** as having the following symptoms or disorders? | |Yes | | No

Symptom/Disorder	**Onset Age**	Treatment Received
. _ _ Obsessive Compulsive Disorder (OCD)		⍰ Therapy + other (6) ⍰ Medication + other (5) ⍰ Medication + Therapy (4) ⍰ Medication (3) ⍰⍰Therapy (2) ⍰⍰Other (1) ⍰⍰None (0) Describe: _____
2. _ Other Anxiety Disorder _____		⍰⍰Therapy + other (6) ⍰ Medication + other (5) ⍰ Medication + Therapy (4) ⍰ Medication (3) ⍰ Therapy (2) ⍰⍰Other (1) ⍰⍰None (0) Describe: _____
. _ _ Tourette's Disorder or other Motor/Vocal Tics		⍰ Therapy + other (6) ⍰ Medication + other (5) ⍰ Medication + Therapy (4) ⍰ Medication (3) ⍰⍰Therapy (2) ⍰⍰Other (1) ⍰⍰None (0) Describe: _____
. _ _ Violent Behavior: _____		⍰⍰Therapy + other (6) ⍰ Medication + other (5) ⍰ Medication + Therapy (4) ⍰ Medication (3) ⍰⍰Therapy (2) ⍰⍰Other (1) ⍰⍰None (0) Describe: _____
5. _ Attention Deficit/ Hyperactivity Disorder (ADD/ADHD): _____		⍰⍰Therapy + other (6) ⍰ Medication + other (5) ⍰ Medication + Therapy (4) ⍰ Medication (3) ⍰⍰Therapy (2) ⍰⍰Other (1) ⍰⍰None (0) Describe: _____
. _ Eating Disorder: _____		⍰⍰Therapy + other (6) ⍰ Medication + other (5) ⍰ Medication + Therapy (4) ⍰ Medication (3) ⍰⍰Therapy (2) ⍰⍰Other (1) ⍰⍰None (0) Describe: _____
. _ _ Alcohol or Drug Abuse _____		⍰⍰Therapy + other (6) ⍰ Medication + other (5) ⍰ Medication + Therapy (4) ⍰ Medication (3) ⍰⍰Therapy (2) ⍰⍰Other (1) ⍰ None (0) Describe: _____

Medical History:

Has your child ever had any strep infections: ☐No (0) ☐Yes (1)
If so, how many times? _____
Please list up to 3 most recent strep infection episodes:

Age of strep infection episode	Did OCD/Tics symptoms worsen during the strep infection episode?	**Treatment for the strep infection**
	Yes (1) No (0) N/A (2)	
	Yes (1) No (0) N/A (2)	
	Yes (1) No (0) N/A (2)	

Other Recent Medical Illnesses (past 3 years)

Illness	Date	**Treatment**

Medication History:

Please provide information about all medications that your child is currently taking:

Current Medications	**Date started (mo/yr)**	**Current Dose**

Please provide information about medications that your child has taken for psychiatric problems in the past:

Past Medications	**Date started (mo/yr)**	**Date stopped (mo/yr)**	Final Dose

Have any other family members had psychiatric / emotional problems? | | No | | Yes
If yes, please list relationship to child and problem experienced below:

Relative	OCD	Tics/ Tourette's	Anxiety	Depression	Drugs/ Alcohol	Schizophrenia	Other
Mother – biological							
Father - biological							
Sister: Age ____							
Sister: Age ____							
Brother: Age ____							
Brother: Age ____							
Pat. Grandmother							
Pat. Grandfather							
Mat. Grandmother							
Mat. Grandfather							
Other Relative: _____							

Any Family History of Sydenham's Chorea or Rheumatic Fever? No (0) | | Yes (1)
If yes, describe:

_____

Appendix C: Yale Global Tic Severity Scale

ID #: qqq

Y G T S S

Yale Global Tic Severity Scale

Yale Child Study Center

October 1992 version

NAME:	TODAY'S DATE : / /
RATER:	

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	0	0	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.	0	0	1
MILD INTENSITY Tics are not more forceful than comparable voluntary actions or utterances and are typically not noticed because of their intensity.	0	0	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.	0	0	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.	0	0	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.	0	0	5

COMPLEXITY	Motor	Phonic	
NONE If present, all tics are clearly "simple" (sudden, brief, purposeless) in character.	0	0	0
BORDERLINE Some tics are not clearly "simple" in character.	0	0	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.	0	0	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).	0	0	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").	0	0	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).	0	0	5

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

Appendix D: Instructions and Manipulation Check Questions

Instructions for Experimental Conditions

Before all conditions:

"This camera on the monitor in front of you is hooked up to a computer program called The Tic Detector. The Tic Detector works like an Xbox Kinect: it can monitor movements and the count how many tics you have. Because the tic detector will be focused on you, it is really important that you do not leave your chair or turn away from the machine. Also, keep your hands in your lap or on the arms of the chair. Don't put your hands over your face."

Instructions for BASELINE:

"For the next 6 minutes we are going to have you just sit in this chair. The tic detector will be on, but try to ignore it and feel free to tic as much or as little as you need to. These are the tics that the tic detector will be counting [review list of child's tics from YGTSS]. Stay seated in the chair with your hands in your lap or on the armrests."

> *Let's review. What do we want you to do for the next 6 minutes? I will be back in 6 minutes. Do you have any questions?"*

Instructions for DRO-F condition:

"For the next 6 minutes, the tic detector will count your tics, and for every 10 seconds that you don't tic, you will get 30 points and the computer will make a sound. [If first DRO condition of either type, also say: At the end of the day, we will count your points and you will be able to exchange them for money]. If you don't tic at all during the whole time, you will earn 540 points total. Remember, because the tic detector will be focused on you, it is really important that you do not leave your chair or turn away from the machine. Also, keep your hands in your lap or on the arms of the chair. Remember, stay seated in the chair with your hands in your lap or on the armrests. Again, you will get a point for every 10 seconds you go without having a tic, but if you do have a tic the timer will start over and you will not get a point."

Do you understand the instructions?

Are you supposed to try to stop your tics?

How do you get a point?

What happens if you have a tic?

Instructions for DRO-P condition

"For the next 6 minutes, the tic detector will count your tics, and for every 10 seconds that you don't tic, you will get a points. This time, every time in a row that you stop your tics for 10s, the number of points you earn will get bigger. For example, you could get 6 the first time, 7 the second time, 8 the third time, and so on. Also, for every three times in a row that you go 10s without having a tic, you will get a ten-point bonus. If you do have a tic, the timer will reset and you will go back to earning 6 points each time you go 10s without a tic. Then, once you go 30s without a tic, go back to earning the highest amount you had during the block. So, if you got up to earning 8 points, then had a tic, then went 30s without ticcing, you'd go back to earning 8 points, then 9 points, and so on. If you don't tic at all during this block of time, you will earn 1080 points total.

Remember, you can try to stop your tics any way that you want, except you can't hold your face with your hands. Because the tic detector will be focused on you, it is really important that you do not leave your chair or turn away from the machine. Also, keep your hands in your lap or on the arms of the chair. Remember, stay seated in the chair with your hands in your lap or on the armrests. I will be back in 6 minutes. Do you have any questions?"

Do you understand the instructions?

Are you supposed to try to stop your tics?

How do you get points?

What happens if you have a tic?

As you go longer and longer without a tic will you get more points each time, or the same amount of points each time?

Post-Condition Manipulation Check

Participant #_____ Date:_____

Condition (Circle): BL DRO-F DRO-P

What were the instructions I gave you for the last section?

Were you supposed to be trying to stop your tics during the last section?

Were you trying to stop your tics during the last section?

For the DRO-F and DRO-P only:

How did you get your points?

As you went longer without a tic did you: get more points, the same amount of points, or fewer points?

If you had a tic, did the point total: stay the same the next time, or go back to 6?

Appendix E: Schedule Acceptability Scale

PART A: DRO-F

Subject ID #_____ **Date _____**

Instructions: Please think about what it was like when you tried to stop your tics during this study. Please answer the following questions as completely and as honestly as possible. Answer each question by circling the number that best fits how you feel about the answer. There is no right or wrong answer.

Think about the [DRO-F screen background color] condition, where you always got one point for stopping tics.

	Not at all			Somewhat			Very Much
1. How hard was it to pay attention during the [color] condition? *reverse scored*	1	2	3	4	5	6	7
2. How much control did you feel you had over your tics when the screen was [color]?	1	2	3	4	5	6	7
3. How easy was it to stop your tics when the screen was [color]?	1	2	3	4	5	6	7
4. How comfortable were you did you feel when the screen was [color]?	1	2	3	4	5	6	7
5. How much would you like to use a treatment that taught you how to stop your tics like you did when the screen was [color]?	1	2	3	4	5	6	7

Part B: DRO-P

Subject ID #_____ **Date _____**

Instructions: Please think about what it was like when you tried to stop your tics during this study. Please answer the following questions as completely and as honestly as possible. Answer each question by circling the number that best fits how you feel about the answer. There is no right or wrong answer.

Think about the [DRO-P screen background color] condition, where the amount of points you got every 10 seconds without tics increased as you went longer without a tic.

	Not at all			Somewhat			Very Much
1. How hard was it to pay attention during the [color] condition? *reverse scored*	1	2	3	4	5	6	7
2. How much control did you feel you had over your tics when the screen was [color]?	1	2	3	4	5	6	7
3. How easy was it to stop your tics when the screen was [color]?	1	2	3	4	5	6	7
4. How comfortable were you did you feel when the screen was [color]?	1	2	3	4	5	6	7
5. How much would you like to use a treatment that taught you how to stop your tics like you did when the screen was [color]?	1	2	3	4	5	6	7

CURRICULM VITAE

Matthew Richard Capriotti

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PERSONAL INFORMATION

Office Address:	University of California San Francisco Department of Psychiatry 401 Parnassus Avenue, Box 0984 San Francisco, CA 94143-0984
Office Phone:	(415) 476-7816
Email:	Matthew.Capriotti@ucsf.edu

EDUCATION

2015 (anticipated)	Ph.D., University of Wisconsin-Milwaukee, Milwaukee, WI Major: Clinical Psychology Minor: Behavior Analysis
2014-2015	Predoctoral Internship (APA-Accredited). University of California San Francisco, Clniical Assessment and Intervention Cluster, San Francisco, CA.
2011	M.S., University of Wisconsin-Milwaukee, Milwaukee, WI Major: Clinical Psychology
2010	B.S., University of Florida, Gainesville, FL Major: Psychology, emphasis in Behavior Analysis
2010	B.A., University of Florida, Gainesville, FL. Major: Spanish

AWARDS AND HONORS

2013	Midamerican Association for Behavior Analysis Student Research Paper Competition Winner
2013, 2011	Graduate Student Travel Award, University of Wisconsin-Milwaukee
2012	University of Wisconsin-Milwaukee Graduate Psychology Research Award

2011	Distinguished Graduate Student Fellowship, University of Wisconsin-Milwaukee
2011	Chancellor's Graduate Student Award, University of Wisconsin-Milwaukee
2010	Elected Phi Beta Kappa, University of Florida Chapter
2008	Anderson Scholar, University of Florida
2006	National Merit Scholar
2006	Robert C. Byrd Scholar, University of Florida

PROFESSIONAL AFFILIATIONS

2010 – present	Association for Behavioral and Cognitive Therapies
2008 – present	Association for Behavior Analysis International
2010 – 2013	Midamerican Association for Behavior Analysis

GRANT ACTIVITY

Grants Funded

John and Lynn Schiek Grant Fund. "Acquisition of Responding to Perithreshold Discriminative Stimuli." 8/1/2011- 7/31/2013. Principal Investigator. (Funded; $2000).

John and Lynn Schiek Grant Fund. "The Effects of Contingency Management for Medication Adherence in Sickle Cell Disease". 8/1/2012-5/31/2014. Co-Principal Investigator. (Funded; $2000).

Other Grant Writing Experience

National Institutes of Health. (F31). "Developing a Reinforcement-Based Behavioral Intervention for Youth with Chronic Tic Disorders." Principal Investigator. Submitted 08/07/2012. Round 1 Score: 33 (28^{th} percentile). Not resubmitted due to relocation of key personnel.

REFEREED PUBLICATIONS (N=11)

Capriotti, M. R., Brandt, B. C., Ricketts, E. J., Espil, F. M., & Woods, D. W. (2012). Comparing the effects of reinforcement and response-cost contingencies on tic suppression. *Journal of Applied Behavior Analysis, 45,* 251-263.

Capriotti, M. R., Espil, F. M., Conelea, C. A., & Woods, D. W. (2013). Environmental factors as potential determinants of premonitory urge severity in youth with Tourette syndrome. *Journal of Obsessive-Compulsive and Related Disorders, 2,* 37-42.

Ricketts, E. J., Bauer, C. C., van der Fluit, F., **Capriotti, M. R.**, Espil, F. M., Snorrason, I…, & Woods, D. W. (2013). Behavior therapy for stereotypic movement disorders in typically functioning children: A clinical case series. *Cognitive and Behavioral Practice, 20,* 544-555.

Capriotti, M. R., Brandt, B.C., Turkel, J. E., Lee, H.-J., & Woods, D. W. (2014). Negative reinforcement and premonitory urges in Tourette syndrome: An experimental evaluation. *Behavior Modification, 38,* 276-296.

Himle, M. B., **Capriotti, M. R.**, Hayes, L. P., Josyula, K., Woods, D. W., Scahill, L.,…, & Piacentini, J. (2014). Variables associated with tic exacerbation in children with chronic tic disorders. *Behavior Modification, 38,* 163-183.

Houghton, D. C., Compton, S. N., Twohig, M. P., Saunders, S. M., Franklin, M. E., Neal-Barnett, A., Ely, L. J., **Capriotti, M. R.,** & Woods, D. W. (2014). Measuring the role of psychological inflexibility in trichotillomania. *Psychiatry Research, 220,* 356-361.

Espil, F. M**.**, **Capriotti, M. R.,** Conelea, C. A., & Woods, D. W. (2014). The role of parental perceptions of tic frequency and tic intensity in predicting tic-related functional impairment in youth with chronic tic disorders. *Child Psychiatry and Human Development, 45,* 657-665.

Capriotti, M. R., Himle, M. B., & Woods, D. W. (2014). Behavioral treatments for Tourette syndrome. *Journal of Obsessive-Compulsive and Related Disorders, 3,* 415-420.

Houghton, D. C., **Capriotti, M. R.**, Conelea, C. A., & Woods, D. W. (2014). Sensory aspects of Tourette syndrome including premonitory urges: Their role in symptom formation and treatment. *Current Developmental Disorders Reports, 1,* 245-251.

Capriotti, M.R., Ely, L. J., Snorrason, I., & Woods, D. W. (in press). Acceptance-enhanced behavior therapy for excoriation (skin-picking) disorder: A case series. *Cognitive and Behavioral Practice.*

Capriotti, M. R., Piacentini, J., Himle, M. B., Ricketts, E. J., Espil, F. M., Lee, H.-J., Turkel, J. E., & Woods, D. W. (in press). Assessing environmental consequences of ticcing in youth

with chronic tic disorders: The Tic Accommodation and Reactions Scale. *Children's Health Care*

NONREFERREED PUBLICATIONS (N=4)

Book Chapters

Capriotti, M. R., Espil, F. M., & Woods, D. W. (2012). Behavioral therapy. In J.T. Walkup, J. Mink, & K.S. McNaught (Eds). *A Family's Guide to Tourette Syndrome.* (pp. 135-144). Tourette Syndrome Association: Bayside, NY.

Capriotti, M. R., & Woods, D. W. (2013). Cognitive-Behavioural therapy. In D. Martino & J. Leckman (eds.) *Tourette Syndrome.* Oxford University Press: New York, NY.

Capriotti, M. R., Espil, F. M., & Woods, D. W. (2013). Tourette Syndrome and Tic Disorders. In J. Smits (Ed). Cognitive Behavioral Therapy: A complete reference guide. Wiley-Blackwell Publishers: New York, NY.

Encyclopedia Entry

Capriotti, M. R. & Woods, D. W. (2013). Habit reversal. In F. Volkmar (Ed). *Encyclopedia of Autism Spectrum Disorders.* Springer: New Haven, CT.

MANUSCRIPTS IN PROGRESS (N=3)

Capriotti, M. R., Johnson, R. A., Turkel, J. E., Espil, F. M., & Woods, D. W. (under review) Comparing fixed- and progressive-amount schedules of reinforcement for tic suppression in youth with Tourette syndrome.

Houghton, D. H., **Capriotti, M. R.**, De Nadai, A., Acceptance Enhanced Behavior Therapy Project Workgroup, & Woods, D. W. (in prep). Defining treatment response in trichotillomania: Signal detection analysis of two popular measures of hair pulling severity.

Brabson, L., Brown, J., **Capriotti, M. R.,** Ramanujam, K., Himle, M. B., Nicotra, C. M., …, & Specht, M. W. (in prep). Patterned changes in urge ratings with tic suppression.

CONFERENCE PRESENTATIONS (N=25)

* undergraduate co-author mentored by Capriotti

Capriotti, M. R., & Dallery, J. (2009, April). *An extension of the matching law to multiple schedule behavior in rats.* Poster presented at the University of Florida Department of Psychology Undergraduate Research Symposium.

Capriotti, M. R., & Dallery, J. (2009, May) *An experimental analysis of multiple schedule behavior in rats: Does the matching law apply?* Poster presented at the annual meeting of the Association for Behavior Analysis International Annual Convention, Phoenix, AZ.

Capriotti, M. R., Woods, D.W., Franklin, S. A., Conelea, C. A. (2010, November).*The role of tic severity in family functioning of families with children with chronic tic disorders.* Poster presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, San Francisco, CA.

Franklin, S. A., Snorrason, I., **Capriotti, M. R.**, & Woods, D. W. (2010, November). *Experiential avoidance in pathological skin picking: The acceptance and action questionnaire for skin picking*. Poster presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, San Francisco, CA.

Snorrason, I., **Capriotti, M. R.**, Franklin, S. A., & Woods, D. W. (2010, November). *Negative affect and pathological skin picking: the meditational role of experiential avoidance*. Poster presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, San Francisco, CA.

Capriotti, M. R., Brandt, B. C., & Woods, D. W. (2011, October). *Evaluating a common academic accommodation for youth with chronic tic disorders via a laboratory analogue.* Poster presented at the annual meeting of the Midamerican Association for Behavior Analysis, Chicago, IL.

Capriotti, M. R., Brandt, B.C., *Wissing, A.A., *Rebitski, R.M., & Woods, D.W. (2011, May). *Comparing the effects of response cost and DRO contingencies on tic suppression*. Poster presented at the annual meeting of the Association for Behavior Analysis International, Denver, CO.

Capriotti, M. R., Espil, F. M., *Wissing, A. A., Conelea, C. A., & Woods, D. W. (2011, November). *More than a feeling: Premonitory urge severity as a unique predictor of anxiety, depression, and avoidance in youth with chronic tic disorders.* Poster presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, Toronto, Canada.

Himle, M. B., Graham, L., **Capriotti, M. R.**, Wilhelm, S. Deckersbach, T., Specht, M., Walkup, J., Scahill, L., Sukholdolsky, D., Peterson, A., Villerreal, R., Chang, S., Flacks, L., Piacentini, J. (2011, November). *Function-based assessment in Tourette syndrome: Results from the Comprehensive Behavioral Intervention for Tics Trial*. Poster presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, Toronto, Canada.

Espil, F. M., **Capriotti, M. R.**, *Johnson, J. A., Conelea, C. A., & Woods, D. W. (2011, November). *Assessing the relative contributions of tic frequency and tic intensity to functional impairment in youth with chronic tic disorders*. Poster presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, Toronto, Canada.

Espil, F. M., **Capriotti, M. R.**, Ricketts, E. J., Conelea, C. A., & Woods, D. W. (2011, November). *Self-reported medication use and outcome in a community sample of children with chronic tic disorders*. Poster presented at the Tic and Impulse Control Disorders Special Interest Group meeting at the annual meeting of the Association for

Behavioral and Cognitive Therapies, Toronto, Canada.

*Cotter, S. P., **Capriotti, M. R.**, Brandt, B.C. & Woods, D. W. (2011, November). *Habituation to premonitory urges in Tourette syndrome: A controlled laboratory evaluation*. Poster presented at the Tic and Impulse Control Disorders Special Interest Group meeting at the annual meeting of the Association for Behavioral and Cognitive Therapies, Toronto, Canada.

Capriotti, M. R., Brandt, B. C., & Woods, D. W. (2012, May). Temporal dynamics of urge-to-tic ratings and escape-maintained responding during tic suppression. In Douglas W. Woods (Chair), *Translational Behavior Analytic Research in Tourette Syndrome: From Bedside to Bench and Back.* Presentation delivered at the 38th annual meeting of the Association for Behavior Analysis International, Seattle, WA.

Capriotti, M. R., *Spaeth, D. M., Brandt, B. C., Turkel, J. E., Bauer, C. C., Lee, H. J., & Woods, D. W. (2012, November). *Eyeblink rate during suppression of non-ocular tics: Evidence of a biobehavioral mechanism?* Poster presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, National Harbor, MD.

Capriotti, M. R., Espil, F. M., Bauer, C. C., Ely, L. J., Neal-Barnett, A., & Woods, D. W. (2012, November). *Evaluation sources of potential selection bias in a trial of behavior therapy for trichotillomania in adults*. Poster presented at the Tic and Impulse Control Disorders Special Interest Group meeting at the annual meeting of the Association for Behavioral and Cognitive Therapies, National Harbor, MD.

Espil, F. M., **Capriotti, M. R.,** Ricketts, E. J., Bauer, C. C., Neal-Barnett, A., & Woods, D. W. (2012, November). *Minority recruitment of individuals with trichotillomania: Preliminary findings from a randomized controlled trial.* Poster presented at the Tic and Impulse Control Disorders Special Interest Group meeting at the annual meeting of the Association for Behavioral and Cognitive Therapies, National Harbor, MD.

Espil, F. M., **Capriotti, M. R.**, Conelea, C. A., & Woods, D. W. (2012, November). *Treatment delay as a predictor of functional impairment in youth with chronic tic disorders.* Poster presented at the 46th Annual convention of the Association for Behavioral and Cognitive Therapies, National Harbor, MD.

Ricketts, E. J., Bauer, C. C., van der Fluit, F., **Capriotti, M. R.**, Espil, F., Snorrason, I., Ely, L. J., Walther, M. R., & Woods, D. W. (2012, November). *Behavior therapy for stereotypic movement disorder in a typically developing children: A clinical case series.* Poster presented at the 46th Annual convention of the Association for Behavioral and Cognitive Therapies, National Harbor, MD.

Capriotti, C. D., **Capriotti, M. R.,** & Brenske, S. M. (2013, May). *Use of precision teaching techniques in the rehabilitation of a bilingual male with brain injury.* Poster presented at the annual meeting of the Association for Behavior Analysis International.

Capriotti, M. R., Ricketts, E. J., Espil, F. M., Lee, H-J., Piacentini, J. C., & Woods, D. W. (2013, November). *Assessing environmental consequences of ticcing in youth with Tourette syndrome.* In J. A. Richey (Chair). Repetitive behaviors across the disorders: A transdiagnostic framework. Symposium presented at the 47th Annual convention of the Association for Behavioral and Cognitive Therapies, Nashville, TN.

Capriotti, M. R., Brandt, B. C., Turkel, J. E., Lee, H-J., & Woods, D. W. (2013, November). *Negative reinforcement and premonitory urges in youth with Tourette syndrome: An experimental evaluation.* In Joseph McGuire (Chair). *Updates in the phenomenology of Tourette disorder: New directions for treatment.* Symposium presented at the 47th Annual convention of the Association for Behavioral and Cognitive Therapies, Nashville, TN.

Capriotti, M. R., Bauer, C. C., Turkel, J. E., Brandt, B. C., Lee, H-J., & Woods, D. W. (2013, November). *Exploring potential mechanisms of change in behavior therapy for Tourette syndrome*. Poster presented at the 47th Annual convention of the Association for Behavioral and Cognitive Therapies, Nashville, TN.

Capriotti, M. R., Piacentini, J., Himle, M. B., Ricketts, E. J., Espil, F. M., Lee, H.-J., Turkel, J. E., & Woods, D. W. (2014, April). *Functional assessment of tics in the outpatient mental health clinic: Strategies, tactics, and research findings.* In Carla Lagorio (Chair) *Symposium 1*. Symposium presented at the Wisconsin Association for Behavior Analysis Roadshow, Eau Claire, WI.

Capriotti, M. R., Himle, M. B., Conelea, C. A., Specht, M. W., & Woods, D. W. (2014, November). *Quantitative analysis of the temporal dynamics of tics during rest and reinforced tic suppression*. Poster presented at the 48th Annual convention of the Association for Behavioral and Cognitive Therapies, Philadelphia, PA.

Capriotti, M. R., Houghton, D. C., Conelea, C. A., Woods, D. W., Tourette Syndrome Association Behavioral Sciences Consortium, Tourette Syndrome Impact Project Workgroup. (2014, November). *Understanding relationships among premonitory urge severity, tic severity, and non-tic dimensions of psychopathology in youth with tic disorders.* Symposium presented at the 48th Annual convention of the Association for Behavioral and Cognitive Therapies, Philadelphia, PA.

CLINICAL EXPERIENCE

University of California San Francisco, San Francisco, CA
Langley Porter Psychiatric Institute
Predoctoral Clinical Psychology Fellow

- July 2014-present
- Primary Supervisor: Linda Pfiffner, Ph.D.
- Provide clinical services through a psychiatric hospital within a major academic medical center. Rotations include(d):
  - Hyperactivity, Attention, and Learning Problems Clinic
    - Co-lead parent management training and child skills groups as behavior therapy for youth with ADHD.
    - Conduct clinical and psychoeducational assessments for youth referred for concerns surrounding, attention, learning, and behavior problems.
    - Provide supervisory consultations to school social workers implementing behavioral interventions for ADHD through a Department of Education-funded project
  - Obsessive-Compulsive and Related Disorders Youth Intensive Outpatient Program
    - Conduct clinical assessments for children and adolescents with OCD and related disorders
    - Provide individual cognitive-behavior therapy (primarily exposure and response prevention) for youth with OCD and related disorders
  - Adolescent Dialectical Behavior Therapy (DBT) Program
    - Co-lead weekly multifamily DBT skills groups for teenagers with Borderline Personality Disorder and their families
    - Participate in weekly DBT consultation team meetings with other treatment providers
  - Emergency Department
    - Provide consultative assessments and treatment recommendations for individuals who present to the UCSF Emergency Department with emergent psychiatric issues
  - Adult Inpatient Unit
    - Serve as primary therapist for adults hospitalized for acute psychiatric problems. Primary modalities included supportive therapy and brief, skills focused cognitive-behavior therapy.
    - Coordinate disposition planning and case management services
    - Lead family meetings with patients' primary support network to provide psychoeducation and coordinate post-discharge care
  - Adult Psychiatry Clinic
    - Provide weekly individual therapy for adults with various presenting problems on an outpatient basis.

Rogers Memorial Hospital, Milwaukee, WI
Child and Adolescent Day Treatment Unit
Student Psychotherapist

- August 2013-May 2014
- Conducted diagnostic assessments and provided psychotherapy (individual and

group) to children and adolescents (ages 6-17) with diverse diagnoses in a day treatment program. Presenting problems included attention deficit hyperactivity disorder, oppositional defiant disorder, conduct disorder, depression, generalized anxiety, social phobia, post-traumatic stress disorder, selective mutism, and encopresis. Primary theoretical approach was cognitive-behavioral, with integration of other perspectives as appropriate.

- Supervisor: Nancy Goranson, Psy.D.

University of Wisconsin-Milwaukee Psychology Clinic, Milwaukee, WI

Clinical Services Experience

Student Psychotherapist

- February 2012-May 2014
- Primary therapist for children, adolescents, and adults seen in generalist and specialized outpatient psychotherapy clinics. Patient diagnoses in generalist clinic included major depression, anxiety disorders (including OCD), personality disorders, body-image concerns, and adjustment disorder. Specialty clinic patient diagnoses included chronic tic disorders, trichotillomania, skin picking (excoriation) disorder, and obsessive-compulsive disorder.
- Supervisors: Douglas W. Woods, Ph.D., Gwynne O. Kohl, Ph.D., Shawn P. Cahill, & Robyn Ridley, Ph.D.

Student Assessor

- April 2011-September 2013
- Conducted supervised psychoeducational assessments with children, adolescents, and adults in an outpatient clinic and at a local public school.
- Supervisors: Bonita Klein-Tasman, Ph.D., Han Joo Lee, Ph.D.

Supervisory Experience

Student Clinical Supervisor

First- and Second-Year Assessment Practica.

- August 2012-May 2013
- Performed live and videotaped observations of twelve graduate students conducting assessments (which involved clinical interviews, psychological tests, and providing feedback to clients), providing individual supervision for trainees, leading biweekly didactic sessions, and attending "supervision of supervision" meetings with a licensed psychologist.
- Supervisors: Bonita Klein-Tasman, Ph.D., Han Joo Lee, Ph.D

Behavior Therapy and Research Lab, University of Wisconsin-Milwaukee, Milwaukee,WI

Psychotherapist

"Acceptance Enhanced Behavior Therapy for Trichotillomania." (R01MH080966; Woods, PI).

- October 2012-December 2013

- Provided behavior therapy and supportive therapy to adults with trichotillomania as part of a federally-funded randomized controlled trial
- Supervisors: Douglas Woods, Ph.D., Shawn Cahill, Ph.D.

Psychotherapist

Piloting Web-Based Videoconference-Delivered Behavior Therapy for Children with Tourette Syndrome" (F31 MH096375; Woods, PI).

- February 2012-September 2012
- Provided behavior therapy to youth with Tourette syndrome (age 9-15) via videoconferencing as part of a federally-funded pilot randomized controlled trial
- Supervisor: Douglas Woods, Ph.D.

Clinical Evaluator

Acceptance Enhanced Behavior Therapy for Trichotillomania. (R01MH080966;Woods, PI).

- October 2011-December 2012
- Conducted multimodal assessments with adults with trichotillomania as part of a federally-funded randomized controlled trial
- Supervisors: Douglas Woods, Ph.D., Martin E. Franklin, Ph.D.

Clinical Evaluator

Psychosocial Intervention for Young Children with Chronic Tics" (funded by the Tourette Syndrome Association; Piacentini, PI).

- Period Worked: December 2011-August 2013
- Assisted in development of treatment protocol and assessment battery. Conducted multimodal assessments with children with Tourette syndrome (ages 5-8) and their parents.
- Supervisors: John Piacentini, Ph.D., Douglas Woods, Ph.D.

Behavior Analysis Research Clinic, University of Florida, Gainesville, FL

Behavior Therapist

- August 2009-May 2010
- Provided in-home applied behavior analysis therapy to preschool-aged children with autism
- Supervisors: Cara Phillips, M.S., BCBA; Jeanne Donaldson M.S., BCBA

North Florida Evaluation and Treatment Center, Gainesville, FL

Undergraduate Student Extern

- August 2008-December 2008
- Shadowed counselor at forensic psychiatric facility for adults. Conducted brief mental status examinations with patients.
- Supervisor: Robert Morton, M.A.

TEACHING EXPERIENCE

Instructor

Child Psychology (PSYCH260, Online section). University of Wisconsin-Milwaukee, Fall 2013- Spring 2014. Foundation-level course for ~100 students per semester majoring in psychology, education, and other disciplines related to child development.

Teaching Assistant

Introduction to Psychology (PSY 2012). University of Florida, Spring 2010. Introductory-level class with 150 undergraduate students. Lead review sessions and assisted with preparation of course materials.

Introduction to Psychology (PSYCH 101). University of Wisconsin-Milwaukee, Spring 2011. Introductory-level class with ~300 undergraduate students. Planned and lead five weekly discussion sections related to course lecture content.

Personality Psychology (PSYCH 205). University of Wisconsin-Milwaukee, Fall 2010. Foundation-level class with ~300 undergraduate students. Planned and lead five weekly discussion sections related to course lecture content.

Psychological Statistics (PSYCH 210). University of Wisconsin-Milwaukee, Spring 2014. Foundation-level statistics class with ~150 students. Planned and lead three weekly discussion sections to review course lecture content. Lead three weekly lab question to practice statistical applications using computer software (SPSS).

Conditioning and Learning (PSYCH 514) University of Wisconsin-Milwaukee, Fall 2013. Capstone-level class with 20 advanced undergraduate students. Lead animal laboratory component of the course, in which students ran behavioral experiments with rats, presented results, and discussed relevant literature in a seminar model.

First-Year Clinical Psychology Practicum (PSYCH 801). University of Wisconsin-Milwaukee, Fall 2012-Spring 2013. Graduate-level practicum with six doctoral students in clinical psychology. Planned and lead didactic sessions related to psychodiagnostic, personality, and psychoeducational assessment. Supervised clinical interviews and testing sessions and provided related feedback to students.

Second-Year Clinical Psychology Practicum (PSYCH 801). University of Wisconsin- Milwaukee, Fall 2012. Graduate-level practicum with eight doctoral students in clinical psychology. Co- lead didactic sessions related to psychodiagnostic, personality, and psychoeducational assessment. Supervised

clinical interviews and testing sessions and provided related feedback to students.

Guest Lecturer

"Behavior Therapy for Tourette Syndrome." In Introduction to Behavior Analysis (Instructor: Meagan Gregory, Ph.D.). Florida Institute of Technology. October 18, 2012.

"Exposure Therapy." In Introduction to Conditioning and Learning (Instructor: Shawn Cahill, Ph.D.). University of Wisconsin-Milwaukee. October 15, 2012.

"Learning." In Introduction to Psychology (Instructor: Katie Ports, M.S.). University of Wisconsin-Milwaukee. February 15, 2011

PROFESSIONAL SERVICE

Student Representative (University of Wisconsin-Milwaukee) to the Association for Behavior Analysis International, October 2011-present.

Departmental Representative (Psychology) to Graduate Student Advisory Council at the University of Wisconsin-Milwaukee, September 2012-present.

Student Representative. University of Wisconsin-Milwaukee Clinical Psychology Diversity Workgroup. December 2012-February 2014.

Student Representative. Psychology Department Behavior Analysis Faculty Search Committee, University of Wisconsin-Milwaukee. December 2013-March 2014.

Ad Hoc Reviewer

*denotes mentored reviews

Education and Treatment of Children, 2014
School Psychology Quarterly, 2014*
Journal of Attention Disorders, 2014*
Behavior Modification, 2013*, 2010*
Journal of Obsessive Compulsive and Related Disorders, 2012*, 2014
Journal of Neural Transmission, 2010*
Child and Family Behavior Therapy, 2010*
Behavioral Interventions, 2010*

REFERENCES

Available upon request.