*COMPARING THE EFFECTS OF DIFFERENTIAL REINFORCEMENT OF
OTHER BEHAVIOR AND RESPONSE-COST CONTINGENCIES ON TICS
IN YOUTH WITH TOURETTE SYNDROME*

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Tics are rapid, repetitive, stereotyped movements or vocalizations that arise from neurobiological dysfunction and are influenced by environmental factors. Although persons with tic disorders often experience aversive social reactions in response to tics, little is known about the behavioral effects of such consequences. Along several dimensions, the present study compared the effects of two treatments on tics: response cost (RC) and differential reinforcement of other behavior (DRO). Four children with Tourette syndrome were exposed to free-to-tic baseline, DRO, RC, and quasibaseline rebound evaluation conditions using an alternating treatments design. Both DRO and RC produced substantial decreases in tics from baseline levels. No differential effects of DRO and RC contingencies were seen on self-reported stress or in the strength of the reflexive motivating operation (i.e., premonitory urge) believed to trigger tics, and neither condition produced tic-rebound effects. Implications of these findings and directions for future research are discussed.

Key words: differential reinforcement, response cost, tics, Tourette syndrome

Tourette syndrome (TS) is a childhood-onset neurobehavioral condition marked by the presence of multiple motor and vocal tics for 1 year or longer (American Psychiatric Association [APA], 2000). Many individuals with TS also report private events that occur prior to the tics. These urges are described as salient somatosensory discomfort that temporarily diminishes when a tic is performed (Leckman, Walker, & Cohen, 1993). From a behavioral perspective, the urge can be considered to be a reflexive motivating operation (MO), and tics can be seen as being maintained by automatic negative reinforcement (Evers & van de Wetering, 1994; Himle, Woods, & Bunaciu, 2008; Woods, Piacentini, Himle, & Chang, 2005).

Research overwhelmingly suggests that TS has a biological origin, stemming from disruptions in movement-regulation functions mediated by the basal ganglia (Mink & Pleasure, 2003). However, environmental factors have been shown to influence tic exacerbation and attenuation both under laboratory conditions (Conelea & Woods, 2008a; Himle & Woods, 2005; Himle et al., 2008; Woods & Himle, 2004) and in natural environments (Conelea & Woods, 2008b; Silva, Munoz, Barickman, & Friedhoff, 1995). Based on the understanding that behavioral factors affect tic maintenance, behavioral interventions for TS have been developed, tested, and proven to be efficacious (Cook & Blacher, 2007; Piacentini et al., 2010). Nonetheless, there is room to improve these behavioral treatments. Such improvement may be accomplished by developing a more comprehensive understanding of the behavioral processes that influence tics.

Tics can be suppressed to a greater extent than other disordered movements such as tremors and dystonias (Koller & Biary, 1989; Meidinger et al., 2005). Over the past several

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years, researchers have explored factors that control the behavior of tic suppression.¹ In these studies, provision of small monetary rewards on differential reinforcement of other behavior (DRO) schedules has been shown to reduce tics more effectively than verbal instructions alone (Conelea & Woods, 2008a; Himle & Woods, 2005; Himle *et al.*, 2008; Woods & Himle, 2004). Although informative, the exclusive use of DRO contingencies in these studies limits their external validity, because real-world efforts to suppress tics also can be maintained by avoidance of social punishment and associated stimuli and contexts (e.g., teasing from peers, stares from strangers, requests to stop ticcing; Conelea & Woods, 2008b).

The relative effects of positive reinforcement and punishment on tics are unclear, but there are reasons to believe that these two processes could differentially affect tic frequency, stress, MO (i.e., premonitory urge) strength, and the postcontingency return of tics. Although punishment procedures have been used successfully to reduce tics (Varni, Boyd, & Cataldo, 1978), the extent to which such procedures confer untoward side effects (e.g., increases in subjective experiences of stress and urges to tic) is unknown. Indeed, much has been written about the tendency of punishment and other forms of aversive control to produce increases in the intensity of anxiety, stress, and other aversive private events (e.g., Sidman, 1989). Anxiety and stress have been implicated as tic-exacerbating factors (Leckman *et al.*, 1993), and experimental evidence suggests that the tic-reducing effects of the aversive contingency may be partially or fully offset by the tic-exacerbating effects of anxiety (Conelea, Brandt, & Woods, 2011).

This increase in stress, however, is not the only aversive private event that may accompany

punishment for tics; the provision of aversive consequences theoretically could intensify the MO (urge) that establishes the tic as reinforcing. When tics regularly produce aversive events, the somatosensory phenomena that precede them may acquire a conditioned aversive function (Woods *et al.*, 2005). Thus, a pattern of increasing MO (urge) aversiveness may emerge with repeated exposure to punishment. The present study provides an empirical evaluation of this possibility.

If punishment does increase the strength of MOs for ticcing, then a temporary increase in tics may follow a period of tic suppression maintained by aversive control. Indeed, this tic-rebound phenomenon has been consistently noted as a possibility in the scientific literature on TS (Burd & Kerbeshian, 1987; Jankovic, 1997; Leckman *et al.*, 1986; Marcks, Woods, Teng, & Twohig, 2004). However, to date, no studies have found reliable patterns of rebound following tic suppression (Himle & Woods, 2005; Himle, Woods, Conelea, Bauer, & Rice, 2007; Woods & Himle, 2004). Nevertheless, because studies of rebound always have utilized reinforcement contingencies to establish suppression, it is possible that the MOs (urges) for ticcing were not increased to the necessary levels during the suppression procedures to produce rebound effects.

In the absence of data on the effects of any type of aversive consequence on tics, ethical considerations preclude the evaluation of aversive social consequences. Thus, the present study evaluated the effects of an RC procedure, a putative analogue to naturally occurring aversive contingencies, in the context of a controlled laboratory experiment. The purpose of the present study was to compare the effects of (a) an RC analogue, (b) a DRO procedure commonly used in previous research on tic suppression, and (c) a no-suppression baseline condition on tic rate, subject-reported urge severity, subject-reported stress level, and tic rebound.

¹ The term *tic suppression* is used herein and elsewhere in the tic disorders literature to refer to behaviors that an individual emits when attempting to stop the occurrence of tics. This should not be confused with suppression of behavior as a punishment process, as often discussed in the behavior-analytic literature.

Table 1
Demographic and Diagnostic Information for Subjects

Subject	Age	Tic diagnosis	YGTSS total	YGTSS motor	YGTSS vocal	Comorbid diagnoses	Medications
Alex	9	TS	21	16	5	GAD	None
Bryan	10	TS	30	12	18	None	Clonidine Fluoxetine
Carl	11	TS	25	15	10	None	None
David	13	TS	33	20	13	None	Guanfacine Olanzapine

Note. TS = Tourette syndrome, GAD = generalized anxiety disorder.

METHOD

Subjects

We recruited subjects through the Tic Disorders Specialty Clinic at the University of Wisconsin–Milwaukee. Children were included if they (a) met the APA (2000) criteria for chronic tic disorder or TS, (b) scored ≥ 80 on the Wechsler Abbreviated Scale of Intelligence (WASI; Psychological Corporation, 1999), (c) had a Yale Global Tic Severity Scale (YGTSS; Leckman, Riddle, Hardin, & Ort, 1989) severity score of ≥ 14 , (d) ticced at least once per minute while alone (as determined by tic frequency during the first baseline condition), (e) had not received prior behavior therapy for their tics, and (f) did not meet diagnostic criteria for attention deficit hyperactivity disorder (ADHD), oppositional defiant disorder, or conduct disorder, as indicated by a severity rating of ≥ 5 (≥ 6 for ADHD) on the respective modules of the Anxiety Disorders Interview Schedule IV (ADIS; Silverman & Albano, 1996).

We recruited six children for the study, but excluded one for failing to meet diagnostic criteria for a chronic tic disorder or TS and another for not ticcing once per minute during the initial baseline condition. Ultimately, four children served as subjects in the study. All were Caucasian boys who resided in the upper midwestern region of the United States. Table 1 shows additional demographic and diagnostic information on these individuals.

Materials

Yale Global Tic Severity Scale (YGTSS). The YGTSS is a structured clinician-rated scale used to assess tic severity. This measure has excellent internal consistency and interrater reliability (Leckman et al., 1989). Clinicians rate motor and vocal tics along several dimensions (number, frequency, intensity, complexity, and interference; range, 0 to 5 each). The sum of these ratings represents a total tic severity score (range, 0 to 50) with separate motor and vocal severity scores (range, 0 to 25 each). The normative mean for the total tic severity is 17.5 ($SD = 1.7$; Storch et al., 2005).

Urge and stress thermometers. The urge thermometer and stress thermometer measures used in the present study were adaptations of the 9-point “feelings thermometer” rating scale used to rate anxiety during administration of the ADIS (Silverman & Albano, 1996). Each measure was used to obtain separate ratings for stress and urge to tic after the termination of each condition. Each scale was presented on a stimulus card that contained nine drawings of thermometers, numbered from 0 to 8, with constantly ascending shading (from right to left) and qualitative anchors (*not at all*, *a little bit*, *some*, *a lot*, and *very, very much*). Before the initial baseline, the child was given instructions (adapted from the ADIS manual) on how to use the scale to report urge. The child practiced reporting urge using hypothetical situations until he responded within predetermined ranges for practice items. A similar introduction and

set of practice activities was then conducted for the stress thermometer instrument. Psychometric data on these measures are not available, but previously published studies on tic suppression (e.g., Himle et al., 2007) and other childhood disorders (e.g., Layne, Bernat, Victor, & Bernstein, 2009) have employed these and similar measures.

Setting and Apparatus

During experimental conditions, the subject was seated in a room (3 m by 3 m), facing a table that contained a computer monitor (31 cm by 23 cm) and a large box fitted with a Web camera. No recreational materials were concurrently available, nor was it possible for the subject to operate the computer for nonstudy purposes. Experimenters located behind a one-way mirror in an adjacent room controlled delivery and removal of tokens (pictures of Canadian pennies that were displayed on the computer monitor). The subject was told that each token earned would be exchangeable for a small amount of money after the session, and that the box with the Webcam was a "tic detector" that had been programmed to detect the tics they had reported during the initial assessment interview.

Data Collection and Analysis

Two trained observers, blind to condition, worked in conjunction with the experimenters who had conducted the experimental session to create operational definitions of each tic on which contingencies had been placed. The two observers scored the video recordings for targeted tics, indicating the occurrence of each tic by pressing a key on a computer that generated a time stamp for each occurrence of a tic. Observers were to record nontargeted tics using a separate input key, but none were seen for any subject.

Observer data were grouped into 10-s bins and scored according to a frequency-within-interval method. Interobserver agreement was calculated for each 10-s bin by obtaining the

number of tics recorded by each observer during each 10-s bin, dividing the smaller of these two numbers by the larger, and multiplying the quotient by 100%. These values for individual bins were averaged to generate interobserver agreement measures for each subject. Across all subjects, interobserver agreement averaged 86% (range, 75% to 92%). Data obtained from the blind coding process were analyzed using standard visual inspection procedures (Barlow, Nock, & Hersen, 2009).

Procedure

Parental consent and child assent were obtained prior to beginning the study. The informed consent document indicated to parents that their child would receive a \$20 gift card after completion of the study. The child assent form indicated that it would be possible to earn tokens worth five cents each during the study. In fact, all children received the \$20 gift card regardless of the number of tokens earned. The parental consent document indicated that children would be observed and videotaped from behind a one-way mirror. The child assent form did not disclose this information, although children were informed of this during a postexperimental debriefing. We used this deception to ensure that tokens would function as reinforcers and to minimize reactivity to observation (Piacentini et al., 2006). The study protocol was approved by the University of Wisconsin–Milwaukee Institutional Review Board.

After a trained clinician administered the WASI, ADIS, and YGTSS, subjects completed 13 experimental conditions (5 min each), presented in an alternating treatments design. The 5-min duration was based on previous research indicating that average tic rates obtained from 5-min observations were similar to those obtained from longer observation periods (Himle et al., 2006). The experiment began with a baseline condition and then cycled between positive reinforcement, baseline rebound evaluation, and response-cost conditions

with counterbalancing across subjects. Alex did not complete the final baseline rebound evaluation condition due to experimenter error. Each condition is detailed below. Immediately following the termination of each condition, the experimenter entered the room, conducted an independent variable integrity check, requested stress and urge ratings for the just-finished condition, and read the instructions for the next condition. Subjects completed all tasks in a single clinic visit and completed all conditions sequentially during the visit.

Baseline. In baseline (Condition 1 for all subjects), the computer monitor was on but displayed only a solid black background with no text or tokens. Before the condition, the experimenter obtained stress and urge-to-tic ratings from the subject and then gave instructions for the upcoming condition. Specifically, the experimenter told the child that he would be left alone for 5 min, during which time he was “free to tic as little or as much as” he wanted to and that no tokens could be earned. The experimenter also told the child that (a) the tic detector had been programmed to detect the tics discussed during the intake assessment, (b) it would count them during the condition, and (c) it was important to remain seated and face the apparatus. The experimenter asked the child to repeat the instructions for the condition, left the room, and the condition began immediately.

Baseline rebound evaluation (BL:RE). BL:RE conditions (Conditions 3, 5, 7, 9, 11, and 13) were identical to baseline conditions, except that no rating of present level of stress or urge to tic was requested before the onset of the condition. BL:RE conditions are labeled differently than the first baseline condition because they may have been influenced by carryover effects (i.e., tic rebound) from immediately preceding conditions in which RC or DRO contingencies were in place.

Differential reinforcement of other behavior (DRO). Prior to DRO conditions, the experimenter instructed the subject to suppress his tics

and stated that after every tic-free 5-s interval, a token would appear on the screen. The experimenter did not provide instruction on how to suppress tics. Similar to the baseline condition, the subject was asked to repeat the instructions for the upcoming condition. The experimenter then left the room, initiating the start of the condition. Experimenters monitored tics and delivered tokens according to a resetting DRO 5-s schedule, meaning a token was shown on the screen immediately after each 5-s period in which the subject displayed none of the tics discussed at interview. No contingencies were placed on other tics or sudden movements.

Response cost (RC). During RC conditions, a fixed-ratio 1 schedule of negative punishment was in effect. Prior to the start of the condition, the experimenter instructed the subject to suppress his tics, and indicated that the condition would begin with many tokens on the screen, but one would disappear each time the subject ticced. Again, no instructions were provided on how to suppress tics. The experimenter asked the child to repeat the instructions, exited the room, and the condition began. At the beginning of the condition, 60 tokens were shown on the computer monitor. This initial number of tokens was equal to the maximum number of tokens that could be earned in each DRO condition, thus equating the potential net reward gain across the two different suppression-contingent conditions. The experimenters monitored tics and operated the token-loss contingency from the adjacent room behind the mirror. As in the DRO conditions, the contingency was imposed only on tics reported in the intake interview. The condition was to be terminated if the child lost all 60 tokens before 5 min had passed, but this did not occur for any subject.

Independent variable integrity checks. As noted previously, an experimenter described the contingencies that would be in operation during the upcoming condition immediately before each condition. The child was then asked to repeat the instructions. If the child correctly summarized the contingencies placed on tics

for the upcoming condition, the experimenter acknowledged that the response was correct and left the room. The condition began at that point. If the child initially provided an incorrect description of the instructions, the experimenter said, "Not quite; listen again," repeated the instructions for the condition, and asked the child to repeat the instructions again. This procedure was repeated until the child provided an accurate description of the instructions.

Immediately following the termination of each condition, the experimenter asked the child several questions to evaluate his comprehension of and compliance with the instructions for the just-completed condition. The experimenter recorded the child's response but provided no feedback. After each condition, the experimenter asked the subject "What were the instructions I gave you for this last condition?," "Were you supposed to be trying to stop your tics during the last condition?," and "Were you trying to stop your tics during the last condition?" For DRO and RC conditions, the experimenter also asked "How did you earn [lose] tokens in the last condition?"

Debriefing. After completion of all conditions, experimenters debriefed subjects regarding the nature of the experimental format. Children learned that the tic detector was not operational and that contingencies had been controlled by experimenters from behind a one-way mirror. The experimenter gave the child a \$20 gift card and informed him that the amount of this card had not in fact been dependent on the number of tokens earned during the study (i.e., the amount earned in tokens across all conditions was always less than \$20). All subjects provided postexperimental written assent to use the recording for data analysis.

RESULTS

Effects of DRO and RC Contingencies on Tic Rate

Responses per minute of tics across each condition for each subject are displayed in Figure 1. Three of the four subjects (Alex, Carl,

and David) demonstrated clear, reliable decreases in tic frequency compared to the initial baseline condition and subsequent BL:RE conditions during both DRO and RC conditions. No subject demonstrated reliable differences in tic rates between DRO and RC conditions. Two subjects (Alex and Carl) showed large reductions in tics in both DRO and RC conditions. Alex displayed 10.6 tics per minute in the initial baseline condition and a mean of 1.6 tics per minute during suppression conditions (range, 0.6 to 2.8). Carl exhibited 3.4 tics per minute in the initial baseline condition and a mean of 0.4 tics per minute during suppression conditions (range, 0 to 1.2). Both displayed fewer tics in all suppression-contingent conditions than in the initial baseline and subsequent BL:RE conditions. DRO and RC contingencies produced less pronounced tic-decreasing effects for David. David exhibited 1.6 tics per minute in the initial baseline condition and a mean of 0.8 tics per minute during suppression conditions (range, 0.4 to 1.8). In the first suppression condition to which he was exposed (RC), David ticced at a higher tic rate than in the initial baseline condition. In all subsequent suppression sessions, David ticced less than in the initial baseline condition and five of the six BL:RE conditions.

Bryan's data did not demonstrate convincing control of tics by programmed contingencies. He displayed 2.2 tics per minute in the initial baseline and a mean of 0.9 tics per minute in all subsequent suppression conditions (range, 0.2 to 1.4). Although Bryan had fewer tics during all DRO and RC conditions than in the initial baseline condition, his tic rates during several subsequent BL:RE conditions were comparable to those during DRO and RC conditions.

Effects of DRO and RC Contingencies on Urge and Stress Ratings

Idiosyncratic fluctuations in urge ratings were seen throughout the experiment for each subject, but none of the four subjects exhibited a robust difference between DRO and RC conditions (see Figure 2). Furthermore, for all but one subject

Figure 1. Tics per minute across conditions for each subject. Note that y axes are scaled differently to fit the range of the y variable for each subject. BL = baseline; BL:RE = baseline rebound evaluation; DRO = differential reinforcement of other behavior; RC = response cost.

(Carl), urge ratings were not reliably higher during DRO and RC conditions compared to the baseline condition, suggesting that suppression in general did not systematically increase the severity of the urge to tic. Similarly, no robust differences were seen in self-reported stress levels during DRO and RC conditions (Figure 3). However, for two of the four subjects (Alex and Carl), stress ratings may have been slightly higher during DRO than during baseline, BL:RE, and RC conditions.

Evaluation of Tic-Rebound Effects

In general, rebound effects (defined as BL:RE conditions in which tic rates were higher than in the initial baseline condition for that subject) were not seen following DRO or RC conditions (see Figure 1). Three of the four subjects (Alex,

Bryan, and David) did not show rebound effects when all suppression conditions were considered together, and their tic rates during post-DRO and post-RC BL:RE conditions did not differ systematically. One subject (Carl) did display postsuppression tic rates that may have been indicative of a mild rebound effect, especially after the first two suppression conditions (DRO and RC). These effects diminished with subsequent repeated exposure to the experimental setting and programmed contingencies. Carl did not display a robust difference in tic rate between BL:RE conditions that followed DRO conditions and BL:RE conditions that followed RC conditions.

Independent Variable Integrity Checks

The number of tokens obtained in DRO and RC conditions did not differ ($M_{DRO}=55.6$,

Figure 2. Urge ratings across conditions for each subject. BL = baseline; BL:RE = baseline rebound evaluation; DRO = differential reinforcement of other behavior; RC = response cost.

$M_{RC}=55.0, t = 0.12, 38, p > .05$). Subjects correctly answered independent variable integrity check questions, with the exception of Bryan. After Conditions 2 and 4 (RC and DRO, respectively), he incorrectly reported that instructions for the previous condition were not to try to stop tics. However, he had answered this question correctly in the precondition independent variable integrity checks for these same conditions and answered all other questions correctly for these conditions. No subject left his seat during any of the conditions or engaged in other noncompliant behaviors during the experimental tasks.

DISCUSSION

Both DRO and RC contingencies decreased tic frequency to subbaseline levels, but no

systematic differences between the effects of DRO and RC contingencies emerged for any of the dependent measures examined. This suggests that both mild punishment and positive reinforcement contingencies can produce similar reductions in tic frequency.

The lack of systematic differences in urge and stress ratings during DRO and RC conditions suggests that a mild RC punishment contingency for tics does not necessarily increase either of these two aversive private events. One might expect that repeated exposure to tic-contingent punishment would establish the somatosensory experiences which comprise the MO (urge) as more aversive relative to those produced by a DRO contingency, thus increasing the relative reinforcing value of tics. However, no such pattern was found, nor were ratings generally higher for RC conditions than for DRO

Figure 3. Stress ratings across conditions for each subject. BL = baseline; BL:RE = baseline rebound evaluation; DRO = differential reinforcement of other behavior; RC = response cost.

conditions. Further, stress ratings did not reliably increase from baseline during DRO or RC conditions. Although one could make a general conclusion that RC contingencies do not have a negative impact on MOs (urges) or other aversive private events, it would be important to examine the effects of RC magnitude on these experiences before making such claims. In this study, the gain or loss of a single token was likely of modest reinforcing or punishing magnitude, and thus may have created little stress, or the valence of the consequence may have been too slight to have an impact on the experience of the MO (urge).

It is also possible that the children were too young to experience and report the premonitory urge reliably. This notion has been discussed in the tic disorders literature (e.g., Leckman et al., 1993; Woods et al., 2005), and there is modest

empirical evidence that the modal age of onset of reliable urge reporting is 11 years (Woods et al., 2005). Given that two of the four children in the present study were 11 years old or younger, age also may have been an important factor that influenced the inconsistency of this dependent measure.

This study also showed that exposure to RC contingencies did not generate an increase in tics beyond baseline levels following removal of the contingency. This provides further evidence against the existence of a robust tic-rebound process; nevertheless, the present data do not render the tic-rebound hypothesis fully falsified. Proponents of the tic-rebound phenomenon might reasonably argue that increases in stress or MO (urge) strength during periods of suppression are necessary to produce subsequent rebound. The present data do not refute such a conceptualization, because these allegedly necessary conditions

for tic rebound were not established in the present study. Still, the present data do outline an additional set of conditions under which tic rebound does not occur.

As mentioned above, the present study has several limitations. First, DRO intervals were determined *a priori* instead of being based on individual subjects' rates of target behavior during baseline observations. A more individualized approach would have yielded very different DRO schedules for Alex and Carl than for Bryan and David, which may have affected the results of the study. This limits the extent to which the DRO conditions in the present study can be said to mimic a realistic DRO intervention, but this is not a major concern, because the aim of the study was to provide comparison of RC conditions to the DRO procedures used in previous research rather than to simulate interventions. In fact, traditional DRO procedures are rarely used to treat tics in typically developing youth (Cook & Blacher, 2007). Similarly, it is important to understand that regardless of the tic-reducing effects of RC contingencies, neither applied behavior analysts nor other mental health professionals who treat TS recommend that punishment procedures be used to manage tics, because punishment in general has been reported to increase negative affect (Emurian, Emurian, & Brady, 1985), promote avoidance of people and situations that have been associated with punishment, and increase the odds that the child him- or herself would use similar punitive approaches in interactions with others (Gelfand *et al.*, 1974).

Another concern is that although coders were not told what contingencies were operating for each condition, they may have been cued by subjects' behavior in response to the experimental contingencies. For example, a child exclaiming "Oh no, I lost one!" after a tic could signal to the coder that he or she was reviewing an RC condition. Therefore, it is possible that the coders were not fully naive to each condition.

Future research also is needed to clarify questions raised by our results. For example, the design of the present study does not permit analysis of the relative contributions of the programmed contingencies *per se* and their verbal descriptions, which were provided immediately before each condition. Although observed tic frequencies were lower during DRO and RC conditions than during baseline and BL:RE conditions in the present study, DRO and RC conditions were always preceded by instructions and rules that described the programmed contingencies. It is quite possible that the tic-reducing effects of the programmed RC and DRO contingencies would have been weakened had rules not been provided or that tic rates would have taken longer to decrease. Future research is needed to explore these possibilities and other questions surrounding the interaction of verbal and nonverbal behavioral processes as they relate to tic suppression.

In addition, the present study demonstrated no systematic changes in urge or stress ratings across repeated exposure to RC contingencies. However, systematic replications of the present study using longer periods of exposure to RC contingencies or continuous exposure to RC contingencies (as opposed to periods of RC alternating with periods of exposure to other programmed contingencies, as was the case in the present study) could reveal conditions under which urge ratings do increase or decrease with repeated exposure to RC contingencies for tics.

The most important limitation of the present study involves the parameters of the punisher used. The relatively small magnitude of the punisher and its nonsocial nature limit the ecological validity of the RC procedure. Here, RC conditions actually produced a net gain of tokens for all subjects, thus differentiating them from a real-world punitive arrangement, which one may argue rarely confers a net gain of rewards. Also, the magnitude of punishment in the present study was rather small, in contrast to aversive events such as teasing or embarrassment

that some may experience when tics are emitted in the natural environment. These two factors combined to create a situation in which tics produced consequences arguably much less aversive than those experienced for tics in natural environments. Future research should move toward a more generalizable paradigm by manipulating these parameters to capture the occurrence of naturalistic tic-contingent punishment. As an additional consideration, future studies might evaluate levels of stress by using physiological measures such as skin conductance in addition to verbal reports. Despite these limitations and the many questions remaining for further investigation, the present study expands the generality of previous research on tic suppression, provides valuable preliminary information on the effects of providing aversive consequences for tics, and contributes to the behavioral literature on TS in general.

This is also the first study to demonstrate reinforced suppression using computer-based token delivery and non-DRO schedules. This procedural variation is notable in that it increases confidence in the generality of previous findings using DRO and noncomputerized methods. In terms of contribution to a behavioral understanding of chronic tic disorders such as TS, the present study suggests that the provision of a mild tic-contingent punishment per se does not appear to be necessarily detrimental. In fact, the current study supports a behavioral model of tics by demonstrating that punitive consequences can reliably alter the frequency of tics. In addition, it has been noted that even purely reinforcement-based behavioral interventions often contain punishment-like features (Vollmer, 2002). A careful examination of some commonly used components of behavioral interventions for tics is consistent with this possibility. For instance, behavioral interventions often include self-monitoring and parental prompting of tic-management skill implementation. Although these procedures are not similar to those referenced by everyday

use of the word *punishment* or commonly used punishment procedures, they do involve tic-contingent events (here, either adding a tally on a self-monitoring sheet or receiving a parental prompt) that can have a tic-decreasing effect, thus technically constituting a punishment contingency (Miltenberger, Fuqua, & Woods, 1998). The present study suggests that, in cases in which these components of behavioral interventions do function as mild punishers, their use is not likely to have negative effects such as interfering with tic-suppressing abilities, increasing aversive private experiences such as MO (urge) severity or stress, or creating postsuppression rebound of tics.

The present data show clear similarities between the effects of DRO and RC contingencies for tics, but many questions remain regarding the effects of other parameters of punishment contingencies that may produce effects different from those seen with DRO. This study sets the stage for more focused future research on the conditions under which tic-contingent punishment may produce harmful results. Given that the mere presence of a punishment contingency does not produce such effects, interest should shift to the specific parameters of punishment that may (or may not) do so.

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