Investigating the effects of tic suppression on premonitory urge ratings in children and adolescents with Tourette’s syndrome

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Abstract

Tics represent a complex class of behaviors that have a neurobiological origin and are influenced by factors both internal and external to the individual. One factor that has gained recent attention is the premonitory urge. Contemporary behavioral models suggest that some tics are preceded by aversive somatic urges that increase in severity when tics are suppressed and are attenuated by performance of the tic. It has been proposed that the removal of premonitory urges may strengthen or maintain tics via negative reinforcement. This investigation is the first to empirically evaluate the effect of tic suppression on the premonitory urge phenomenon. Five children and adolescents, ages 8–17 years, participated in the study. Using an ABAB reversal design, tic frequency and subjective premonitory urge ratings were recorded under conditions of free-to-tic baseline (BL) and reinforced tic suppression (differential reinforcement of zero-rate behavior). Results show that four of the five children demonstrated reliable suppression. Of the four children who achieved suppression, three demonstrated a pattern in which subjective urge ratings were higher during suppression than during BL. Results provide preliminary support for the negative reinforcement view of tic function for some children.

Keywords: Tourette; Tic; Behavior; Therapy; Suppression

Introduction

Chronic tic disorders (CTDs), including Tourette’s syndrome (TS), are characterized by involuntary motor and/or vocal tics. Although there is substantial evidence that tics arise from neurobiological dysfunction, there is a growing body of research showing that tic expression can be influenced (both exacerbated and attenuated) by environmental contingencies involving both internal and external stimuli (Himle & Woods, 2005; O’Connor, Brisebois, Brault, Robillard, & Loiselle, 2003; Piacentini et al., 2006; Silva, Munoz, Barickman, & Friedhoff, 1995; Woods & Himle, 2004). Such findings have led to an increased recognition that existing models of TS will need to account for behavioral processes to more fully understand the development,

One internal stimulus that may exert functional influence over tics is the premonitory urge. Although observable tics are the defining features of TS, many individuals report experiencing “urges,” which are described as unpleasant somatic phenomena that “build up” prior to the tic (or upon attempts to resist ticcing) and are temporarily alleviated by performance of the tic (Leckman, Walker, & Cohen, 1993). In some instances, premonitory urges are more bothersome than the tics themselves (Kane, 1994).

Existing research on premonitory phenomena has stemmed primarily from phenomenological reports provided by individuals with TS. Bliss (1980) described sensory signals that preceded his tics along with “a very rapidly escalating desire to satisfy the sensations with movements intended to free oneself from the insistent feeling” (p. 37). Kane (1994) echoed this description and added, “these sensations are not mere precursors to tics; they precipitate tics more than providing a signal of imminence, the pre-tic sensation acts as the aversive stimulus toward which tics are directed” (p. 806).

In one of the first formal investigations of the premonitory urge, Leckman et al. (1993) conducted a cross-sectional study in which they asked 135 individuals with TS (ages 8–71 years) to identify and localize their premonitory urges and found that 93% of respondents reported having an urge to tic. In a more recent study, Kwak, Vuong, and Jankovic (2003) administered a questionnaire to 50 individuals (mean age 23.6 ± 16.7 years) with TS and found that 92% reported the presence of a premonitory urge. Children with tics also report premonitory urges. Banaschewski, Woerner, and Rothenberger (2003) administered a questionnaire to 254 children with TS and found that 24% of those aged 8–10 years, 34% of those aged 11–14, and 57% of those aged 15–19 reported a premonitory urge. Woods et al. (2005) evaluated premonitory urge phenomena in 42 children and adolescents with TS or CTD (age 8–16 years) and found that 41 of 42 children (98%) reported the presence of urges.

Although the exact relationship between tics and premonitory urges is not yet known, there is indirect evidence to suggest that premonitory urges develop over time and become functionally related to the performance of tics. For example, Leckman et al. (1993) found that the respondents in their study reported having first become aware of the premonitory urge an average of 3.1 years after tic onset, suggesting that premonitory urges are absent during early stages of the disorder and emerge over time. Woods et al. (2005) found that although both younger (<10 yrs) and older children (>10 yrs) reported the presence of premonitory urges, urge ratings and tic severity were correlated only for the older children. This further supports the notion that premonitory urges become functionally related to tics over time.

The exact nature of the premonitory urge is unclear, but it appears to play a significant role in tic expression. In fact, most of the participants in both Leckman et al.’s (1993) and Kwak et al.’s (2003) studies (92% and 68%, respectively) reported that their tics eliminated premonitory urges. If this is the case, then it is possible that tics begin as non-functional responses which, with the development of premonitory urges, become strengthened and maintained by automatic negative reinforcement (Evers & van de Wetering, 1994; Woods et al., 2005). This may begin to explain the tendency for some tics to change in topography, location, and complexity over time.

Unfortunately, the functional relationship between premonitory phenomena and tics has not been experimentally verified. One barrier to testing the relationship is that there is no known method for reliably inducing an urge in order to observe its impact on tic expression. Such inductions would be necessary to determine the functional control of the urge over tics. Nevertheless, it may be possible to circumvent this methodological problem by inducing tic suppression and observing the impact of suppression on premonitory urge ratings. If the urge is indeed aversive and the removal of the urge negatively reinforces tics, then blocking the tics should temporarily increase the salience of the urge, thereby increasing the likelihood that an individual will tic to remove the urge (i.e., increases the reinforcing value of urge removal; Michael, 1993). Conversely, if a child with TS is allowed to tic freely, then the urge should be relatively low in salience and strength, as the tics will occur more frequently in the service of urge reduction. An analogous process might be seen in eating behavior. When prevented from eating (i.e., food deprivation), both the positive reinforcer (i.e., food) and negative reinforcer (i.e., removal of hunger) will momentarily become more salient and more effective reinforcers (i.e., increase the likelihood that an individual will eat). Conversely, relative to such
periods, food and hunger will become less effective reinforcers in the moment, as the individual is allowed to eat freely.

Understanding the relationship between the premonitory urge and tic suppression has implications for current behavioral models of TS as well as for treatment. Increased urge ratings during suppression would provide preliminary support for the negative reinforcement view of tic expression. From a treatment standpoint, an increase in premonitory urge “severity” during suppression might suggest that behavioral treatments (e.g., habit reversal training), which teach children to use a competing (incompatible) response to suppress tics, will need to consider that even when children are motivated to use such suppression strategies, performance of the tic may itself have reinforcing consequences (i.e., removal of aversive urges). In essence, this sets up a competition between the two behaviors: ticcing and utilizing the competing response. If this is the case, then some children may benefit from the use of additional reward programs to motivate them to utilize suppression techniques.

Understanding the relationship between suppression and premonitory urge severity may also lead to new insights regarding the mechanism by which behavioral treatments are effective in reducing tics. For example, it has been proposed that competing responses taught in habit reversal, which typically involve the contraction of muscles antagonistic to the tic, may be serve the same function as the tic itself (Miltenberger, Fuqua, & Woods, 1998). One possibility is that the competing response functions to alleviate the urge and, over time, the competing response is strengthened until its performance becomes habitual. While this explanation seems plausible, research on HRT suggests that the most important aspect of a competing response is that it is employed preemptively (i.e., prior to the undesirable behavior, thereby interrupting its occurrence; Miltenberger & Fuqua, 1985) and that the competing response does not necessarily need to be directly incompatible (Woods et al., 1999). If premonitory urges are functionally related to tics, then perhaps it is the case that the competing response does not alleviate the urge, but rather provides the person with a strategy to use to suppress the tic, thereby allowing the urge to habituate.

The current study was designed to evaluate the effects of tic suppression on premonitory urge ratings by obtaining subjective ratings of the premonitory urges during conditions of baseline (BL; i.e., free to tic) and reinforced tic suppression. Experimental preparations utilizing reinforcement for tic-free intervals (differential reinforcement of zero-rate behavior (DRO)) have been shown in several studies to produce significant, reliable, short-term tic suppression in most children (Himle & Woods, 2005; Woods & Himle, 2004). Consistent with the negative reinforcement view, it was predicted that urge ratings would be relatively high during periods of successful tic suppression (because tics are not performed to reduce the urge) when compared with BL conditions in which participants were asked to tic freely.

Methods

Participants

Children were recruited through the Tic Disorders Specialty Clinic at the University of Wisconsin-Milwaukee. Children were eligible to participate if they (a) met the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition-Text Revision (DSM-IV-TR; APA, 2000) criteria for Tourette disorder or chronic tic disorder (either chronic motor tic disorder or chronic vocal tic disorder), (b) were generally healthy, (c) exhibited tics at the rate of at least 1/min while being observed from behind a one-way mirror, (d) had intellectual functioning in the low-average range or above as indicated by a score of greater than 75 on the Wechsler Abbreviated Scale of Intelligence (WASI, The Psychological Corporation, 1999), and (e) endorsed the presence of premonitory sensation as indicated by a score of at least 12 on the Premonitory Urge for Tics Scale (PUTS; Woods, Piacentini, Himle, & Chang, 2005). Children were deemed ineligible if they met the criteria for a clinical diagnosis of attention-deficit hyperactivity disorder as indicated by a severity rating of >5 on the ADHD module of the Anxiety Disorders Interview Schedule-4th Edition (ADIS-IV; Silverman & Albano, 1996) or if they had previously received behavioral treatment for tics that included tic suppression as a primary component of the intervention. Overall, 8 children were recruited to participate. One child was excluded because he/she did not report the presence of a premonitory urge, one child was excluded because he/
she had a severity score > 5 on the ADHD module of the ADIS-IV, and one child was recruited but decided not to participate. Five children who met inclusion/exclusion criteria participated in the study.

Prior to beginning the study, children and parents provided informed consent/assent and underwent an evaluation to determine eligibility. Psychiatric diagnoses were determined according to DSM-IV-TR criteria through a combination of direct observation, structured and unstructured interviews, and paper-and-pencil measures. Each parent and child was administered the ADIS-IV (Silverman & Albano, 1996), the Child Behavior Checklist (CBCL; Achenbach, 2001), and the Conners’ ADHD Parent Rating Scale (CPRS, Conners, 1997). Tic disorder diagnosis and severity was determined using the Yale Global Tic Severity Scale (YGTSS; Leckman et al., 1989). Premonitory urge phenomena were assessed using the PUTS (Woods et al., 2005). This battery of direct-observation, self-report instruments, clinical interviews, and clinician rating scales includes best-available measures and methods for diagnosing chronic tic disorders in children, and each measure has shown good to excellent psychometric properties (see Woods, Piacentini, & Himle, 2007, for a review).

Setup and materials

During all conditions, the child was seated alone in the experimental room facing a table containing a token dispenser and laptop computer. A control room was separated from the experimental room by a one-way observation mirror. During all experimental trials, the child was observed and videotaped from behind the one-way mirror. The token dispenser was a 12” × 12” × 24” rectangular box with an attached, non-functioning internet camera and a clear plastic receptacle attached to its front. The camera provided the deception that the token dispenser was able to monitor the child’s movements. Following the protocol established by Woods and Himle (2004) and Himle and Woods (2005), the child was told that the machine was a “tic detector” capable of monitoring and counting the child’s tics (note: the device did not actually have the ability to detect tics). When activated manually by a researcher, the machine dispensed a colored token into the hopper. Children were told that the tokens could be earned and that they could be used to “buy” prizes upon completion of the study.

The token dispenser sat on a table in the experimental room and was positioned directly in front of the child. The dispenser was manually activated from the adjacent control room by a researcher-operated plunger that was connected to the dispenser via a 5-foot long cable. A laptop computer with a 12-inch display was located next to the token dispenser. The computer used a Microsoft Windows XP operating system to run the Microsoft PowerPoint software. The computer display was blank until activated via a wireless remote control. When activated, an “urge thermometer” appeared on the computer display screen. The urge thermometer was an adapted version of the 9-point “feelings thermometer” rating scale used to rate the severity of anxiety during administration of the ADIS-IV (Silverman & Albano, 1996). The urge thermometer was used to obtain momentary ratings of premonitory urge severity. The scale consisted of nine depictions of thermometers with ascending shading and numbers anchored by qualitative descriptions of “not at all,” “a little bit,” “some,” “a lot,” and “very, very much.” The child was instructed on how to use the scale to rate his/her pre-tic urges using the instructions adapted from those outlined in the ADIS-IV manual. Prior to beginning the experimental trials, the child practiced using the urge thermometer via hypothetical verbal descriptions given by the examiner. The child practiced using hypothetical scenarios until he/she demonstrated understanding of the general premise that more severe feelings/urges corresponded with higher ratings.

Design and procedures

Experimental design

An ABAB withdrawal design was used in which each child was exposed to five consecutive, five-min experimental trials. The 5-min duration was chosen because previous research has suggested that 5-min segments of videotaped tic observation produce samples of behavior that are comparable with longer durations (Himle et al., 2006). The experimental trials involved alternating conditions of BL and reinforced suppression (DRO), which are described in detail below. All trials were conducted consecutively on the same day. Prior to beginning each trial, the child was given standardized instructions describing the trial. A brief manipulation check was conducted after each trial.
Baseline (BL)

During BL trials, the child was instructed to “feel free to tic”, while the “tic detector” monitored and counted his/her tics. The child was told that the urge thermometer would periodically appear on the computer display and that he/she was to verbally rate his/her premonitory urge(s). After delivering the instructions, the experimenter left the room, and the trial began. During the trial, an experimenter monitored the child from behind a one-way mirror and activated the computer display with a wireless remote control. When activated, the urge thermometer appeared on the screen. After the child made his/her rating, the screen went blank. Urge ratings were elicited every 30-s throughout the trial. Upon completion of the trial, the experimenter returned to the experimental room, conducted a brief manipulation check, and provided instructions for the next trial.

Suppression (DRO)

During suppression trials, the child was reinforced for tic-free intervals (i.e., DRO). During DRO trials, the child was instructed to suppress his/her tics and that he/she could earn a token for each tic-free 10-s interval. The children were not provided with instructions on how to suppress their tics, but were told to suppress their tics using any strategy they found useful. Similar to the BL condition, children were asked to make urge ratings when the urge thermometer appeared on the computer screen. The experimenter then left the room and the trial began. During the DRO trials, the researcher monitored the child’s tics from behind the one-way mirror and activated the token dispenser and computer display. Tokens were delivered on a resetting 10-s DRO schedule such that the child received a token for every 10-s interval during which he/she displayed zero tics. If a tic was observed, the interval was reset. Urge ratings were elicited every 30-s. Upon completion of the trial, the experimenter returned to the experimental room, counted the number of tokens that the child earned, conducted a brief manipulation check, and provided instructions for the next trial.

Token exchange and debriefing

Upon completion of the experiment, the child and examiner reviewed the child’s token exchange form. In order to prevent punishing children who were unable to suppress their tics, every child earned his/her most preferred prize regardless of the number of tokens earned. Prior to the study, parents were fully informed on how the tic detector worked and that that their children would be videotaped/observed. The children were fully informed about what they would be asked to do in the study, but they had not been informed of the mild deception involved in the tic detector, nor were they informed that they had been observed by anyone other than the tic detector. However, after the study, each child was informed of the full nature and purpose of the study (including the presence and purpose of deception) and was asked for his/her assent to use his or her data. All children assented to allow the use of their data.

Data collection and analysis

All videotapes were scored for the presence of tics using the procedures outlined by Himle et al. (2006). The dependent variables were tic frequency and mean urge ratings. First, the investigators created operational definitions of each tic displayed by each child. Trained coders then watched the videotapes and recorded the presence of each motor and/or vocal tic using a simple computer program capable of recording and time-stamping computer keystrokes. The computer provided an output listing each keystroke (corresponding to each tic) and the precise time at which the keystroke was made, sensitive to a tenth of a second. A separate key was used to indicate the delivery of each token. Urge ratings were recorded verbatim.

Two raters independently scored each of the videotapes. Interobserver agreement (IOA) was calculated for each session using a frequency-within-interval method (Himle et al., 2006). Each 5-min observation segment was first divided into consecutive 10-s intervals. Agreement within each interval was calculated by obtaining the number of tics recorded by each observer, dividing the higher number of tics observed by the lower number of tics observed, and multiplying by 100%. These scores were then averaged across the entire 5-min segment to yield an overall agreement score. Overall, IOA across all participants was 86% (range 72–94%). In addition to recording the presence of tics, each observer noted the precise time that each token was delivered. Agreement for urge ratings was 100%. Integrity of the independent variable (i.e., delivery of token reinforcers contingent upon suppression) was determined by calculating token–tic intervals (the time between each token delivery and subsequent tic) or token–token intervals (the time between tokens) for each of the DRO conditions. A
successful token delivery was defined as any token delivered within \( 10 \pm 1.5 \) s of either the previous tic or the previous token. According to these criteria, 91\% of tokens were delivered successfully (range 79–98\%).

A brief manipulation check was conducted following each trial. Each child was asked (1) to repeat the instructions for the task, (2) to indicate whether or not they had attempted tic suppression during that trial, and (3) to describe how they earned tokens (i.e., they were required to verbalize understanding of suppression token, i.e. DRO, contingency). None of the children failed any of the manipulation checks.

Data were analyzed through visual inspection. As is typical with ABAB reversal designs, the experimental conditions were considered to have an effect if (a) a change (from BL) in tic frequency and/or mean urge ratings was observed when the experimental condition was introduced, (b) tic frequency and/or mean urge rating returned to BL or near-BL levels when the experimental condition was withdrawn, and (c) the effect was replicated in the same direction when the experimental condition was subsequently re-introduced and withdrawn (Barlow & Hersen, 1984).

**Results**

The results for each of the five participants are presented in Figs. 1–5. Overall, four of the five participants demonstrated a clear and reliable suppression of tics during DRO compared to BL. Of the four that demonstrated this pattern, three demonstrated a pattern in which urge ratings were relatively higher during DRO when compared with BL. Results from each participant are described below.

**Randy**

Randy was a 17-year-old Caucasian male who met the DSM-IV criteria for Tourette disorder and generalized anxiety disorder. Randy obtained a YGTSS total tic severity score of 22/50, placing him in the moderate range of tic severity. His primary tics included exaggerated eye blinking, head jerking, and a complex torso movement that involved tensing of the shoulder and abdominal muscles while pushing on his stomach with his hands. His only vocal tic was throat clearing. He scored 22 on the PUTS and described several premonitory urges, including pressure inside his body, feeling “wound up/tense,” a sense of something

![Fig. 1. Tics per minute (left ordinate) and average premonitory urge ratings (right ordinate) across baseline (BL) and suppression (DRO) for Randy.](image-url)
being “not just right,” and energy needing to escape his body. Data from Randy’s experimental sessions are presented in Fig. 1, in which he demonstrated a clear and reliable tic suppression effect. During the first BL condition, he exhibited tics at a rate of 10.4 tics/min. When DRO was introduced, his tics decreased to 0.8 tics/min. When BL was re-introduced (second BL), his tics increased to a level similar to his first BL condition (10.2 tics/min). His tics again decreased during the second DRO (0.2 tics/min) and increased during the third BL (9.8 tics/min). Overall, his tics were considerably higher during BL compared with DRO. His urge ratings showed the opposite pattern. During the first BL condition, his average urge rating was 2.4 on an 8-point rating scale.
scale. When DRO was introduced, his average urge rating increased to 7.6. His urge rating dropped to 2.0 during the second BL, increased to 6.8 during the second DRO, and returned to BL levels (1.5) when the DRO was removed. In general, Randy’s tics and urge ratings showed an inverse relationship such that his urge ratings were higher during periods of successful suppression and lower during non-suppression (BL) conditions.

Fig. 4. Tics per minute (left ordinate) and average premonitory urge ratings (right ordinate) across baseline (BL) and suppression (DRO) for Cory.

Fig. 5. Tics per minute (left ordinate) and average premonitory urge ratings (right ordinate) across baseline (BL) and suppression (DRO) for Barb.
Lucy

Lucy was a 14-year-old Caucasian female who met the DSM-IV criteria for Tourette disorder. She had no comorbid diagnoses. She received a YGTSS total tic severity score of 23/50, placing her in the moderate range of tic severity. Her motor tics included eye rolling and eye darting. She also had a coughing tic. She scored a 20 on the PUTS. Her urge descriptions included tension in her body, not just the right phenomenon, and a feeling that there was energy in her body that needed to get out. Lucy’s data from the experimental sessions are presented in Fig. 2. Lucy demonstrated a slight tic suppression effect during DRO compared with BL. During the first BL condition, Lucy displayed tics at a rate of 2.6/min. Her tics decreased slightly to 1.8 tics/min during the first DRO. When BL was re-introduced, her tics increased to 3.6/min. During the second DRO, her tics again decreased to 1.8 tics/min and returned to BL levels (2.6 tics/min) during the final BL condition. No data points in the DRO conditions overlapped with BL conditions, suggesting a modest suppression effect. Lucy’s urge ratings were not affected by suppression and remained relatively stable across the experimental conditions.

Jim

Jim was a 13-year-old male who met the DSM-IV criteria for Tourette disorder and a rule-out diagnosis of obsessive–compulsive disorder. He received a YGTSS Total Tic Severity Score of 25/50, placing him in the moderate range. His motor tics included exaggerated eye blinking, brow movements (eyebrow raising), head jerking, and a complex tic in which he scratched his calf muscle until it “felt right”. He also had a coughing tic. He scored 40 on the PUTS and his urge ratings included all items on the measure (itch, pressure, tension, not just right phenomenon, incompleteness, energy). Jim’s data from the experimental sessions are presented in Fig. 3. As is evident from the graph, Jim shows a clear and reliable tic suppression effect. During the first BL condition, Jim exhibited tics at a rate of 3.4 tics/min. When DRO was introduced, his tics decreased to 0.2 tics/min. When BL was re-introduced (second BL), his tics increased to a level similar to his first BL condition (4.4 tics/min). His tics again decreased during the second DRO (0.1 tics/min) and increased during the third BL (5.0 tics/min). Overall, his tics were considerably higher during BL compared with DRO, suggesting a reliable suppression effect. His urge ratings showed the opposite pattern. During the first BL condition, Jim’s average urge rating was 1.8. When DRO was introduced, his average urge rating increased to 3.0. His urge rating dropped to 1.33 during the second BL, increased to 4.38 during the second DRO, and returned to BL levels (2.2) when the DRO was removed. In general, Jim’s tics and urge ratings showed an inverse relationship such that his urge ratings increased during periods of successful suppression and decreased during non-suppression (BL) conditions.

Cory

Cory was a 10-year-old Caucasian male who met the DSM-IV criteria for Tourette disorder, and subclinical generalized anxiety disorder and obsessive–compulsive disorder. He received a YGTSS total tic severity score of 32/50, placing him in the moderate to severe range. His motor tics included head jerking, exaggerated eye blinking, arm jerking, torso/abdominal contractions, and wrist cracking. His vocal tics included grunting and whistling. He scored 36 on the PUTS and endorsed all urge descriptions included on the measure (itch, pressure, tension, not just right phenomenon, incompleteness, energy). Cory’s data from the experimental sessions are presented in Fig. 4. Overall, the DRO had a substantial effect on Cory’s tics. During the first BL condition, Cory exhibited tics at a rate of 35 tics/min. During the first DRO, his tics decreased to 5.8 tics/min. His tics again increased during the second BL condition (59.4 tics/min), again decreased when DRO was reintroduced (4.0 tics/min), and returned to BL levels (54.4 tics/min) during the final BL condition. Overall, his tics were considerably higher during BL compared with DRO. Although his urge ratings were high across all conditions, they generally showed the opposite pattern of his tics. During the initial BL phase, he reported an average urge rating of 5.88. During the first DRO, his urge rating increased to 7.87. His urge rating dropped to 6.9 during the second BL, increased to 8.0 during the second DRO, and dropped again (7.6) when the DRO was removed. In general, Cory’s tics and urge ratings showed an inverse relationship such that his urge ratings
increased during periods of successful suppression and decreased during non-suppression (BL) conditions; however, the magnitude of the effect appears to be small.

**Barb**

Barb was an 8-year-old bi-racial female who met DSM-IV criteria for Tourette disorder. She had no comorbid diagnoses. She obtained a YGTSS total tic severity score of 25/50, placing her in the moderate range of tic severity. Her motor tics included pursing of the lips with tongue protrusions, touching/scratching her groin, and head jerking/shaking. Her vocal tic included a forceful grunt. Barb scored 19 on the PUTS. Her only urge description included an itch that she felt throughout her body. Data from Barb’s experimental sessions are presented in Fig. 5. Barb’s tics remained relatively stable across BL and DRO conditions (with the exception of the second BL, which was slightly higher than the other conditions). This pattern suggests that the DRO had little effect on her tics. Her average urge ratings were also not influenced by the DRO and remained low and relatively stable across both conditions. In fact, despite reporting the presence of premonitory urges on the PUTS, Barb reported little to no urge during any of the experimental conditions.

**Discussion**

In emerging comprehensive models, it has been proposed that some tics are strengthened and maintained by the removal or reduction of aversive premonitory urges (i.e., strengthening though automatic negative reinforcement; Evers & van de Wetering, 1994; Woods et al., 2005). Unfortunately, a functional relationship between premonitory urges and tics has never been experimentally established. In the current study, we directly tested the relationship between tic suppression (or expression) and premonitory urge ratings. It was hypothesized that urge ratings would be higher during periods of successful tic suppression and lower during BL periods in which children were encouraged to tic freely. Of the five children in the study, four demonstrated a clear and reliable suppression effect. Of these four children, three (Randy, Jim, and Cory) reported more intense premonitory urges and tics has never been experimentally established. In the current study, we directly tested the relationship between tic suppression (or expression) and premonitory urge ratings. It was hypothesized that urge ratings would be higher during periods of successful tic suppression and lower during BL periods in which children were encouraged to tic freely. Of the five children in the study, four demonstrated a clear and reliable suppression effect. Of these four children, three (Randy, Jim, and Cory) reported more intense premonitory urges during suppression compared with BL, although the changes in Cory’s premonitory urge ratings during the experimental condition were less pronounced than the changes observed for Randy and Jim. In addition, Cory’s ratings were generally high across all conditions and the ability to observe changes in urge ratings may have been limited by a ceiling effect. The fourth child who achieved suppression (Lucy) demonstrated a suppression effect, but no difference was observed in premonitory urge ratings between BL and DRO conditions. Overall, these results suggest that some, but not all, children experience more severe premonitory urges during periods of successful tic suppression compared with BL.

The finding that some children reported higher urge ratings during suppression provides preliminary support for the automatic negative reinforcement hypothesis. Two children, however, did not yield the same pattern, and this failure to replicate a functional association between the urge and tic expression requires further discussion. One child (Barb) was unable to suppress her tics despite the DRO contingency, thus her data did not provide an adequate test of the hypothesis. The second child (Lucy) was able to suppress her tics to some degree during the DRO, but her urge ratings did not show the predicted pattern (i.e., worsening during suppression). There are several possible explanations for Lucy’s results, each of which suggest avenues for future research. First, it is possible that Lucy had premonitory urges, but that they had not become functionally related to the tic. It has been suggested that tics begin as involuntary responses accompanied by non-functional sensory signals that acquire aversive properties through learning history, possibly through direct stimulus pairings (i.e., respondent conditioning; Woods et al., 2005). As such, Lucy simply may not have had the learning experiences necessary for a functional relationship to be established. Alternatively, it is possible that Lucy’s urges were functionally related to her tics but the DRO contingency was not sufficiently reinforcing to compete with the urges. Stated differently, she may have distributed her responses such that she obtained some of the token reinforcers available during the DRO suppression task while still ticcing enough to remove the urge (hence the modest suppression effect). Future research should examine whether there is a direct relationship between the degree of tic suppression and the degree of change in premonitory urges during suppression. Finally, it is possible that some, but not all, of Lucy’s tics were preceded by premonitory urges and she suppressed those tics that were not preceded by premonitory urges but failed to suppress those tics that
were associated with urges. This would also explain the only modest suppression effect observed. Again, additional research is needed to understand the development of premonitory urges and to elucidate the processes involved in tic suppression.

There are also several limitations and future directions that warrant mention. First, the experimental conditions were relatively brief (5 min). It is unclear whether longer suppression sessions would have had a more pronounced effect on premonitory urge ratings, especially for those children who reported higher urge ratings during the suppression task. If contemporary behavioral models are correct, and tics are negatively reinforced by the removal of the urge, then longer periods of suppression might result in habituation to the urge (which would result in lower premonitory urge ratings over time). If this is the case, then perhaps habituation is the mechanism by which behavioral treatments, such as habit reversal or exposure and response prevention, are able to achieve long-term tic reduction in some children (Verdellen, Keijsers, Cath, & Hoogduin, 2004; Wetterneck & Woods, 2006).

Second, although the urge thermometer was designed to measure premonitory urge severity, it is unclear exactly what dimension of “severity” was being measured (i.e., intensity, valence, etc.) Future studies should attempt to determine the aspects of premonitory urges that contribute to their aversiveness.

A third limitation is that premonitory urge ratings were only obtained every 30 s. More frequent or “online” ratings might uncover more fine-grained relationships between tic suppression and premonitory urge severity. Examination of individual 30 s urge ratings shows that for one of the participants in this study (Jim), suppression and urge ratings showed less variation during the second DRO condition when compared with the first DRO condition. Research utilizing a “real-time” measure of premonitory urge severity along with microanalytic coding would be well suited to study moment-by-moment fluctuations in urge severity and their relationship to tic suppression/expression.

A fourth limitation is that the dependent measures utilized in this study were overall tic frequency and average urge ratings. No attempts were made to measure the relationship between specific tics and specific urges. It is possible that not all tics are suppressible and not all tics are preceded by premonitory urges. In fact, some research has suggested that individuals are able to use premonitory urges as “warning signs”, thereby allowing them to better suppress their tics (Kwak et al., 2003). As such, tics that lack associated urges might be more difficult to suppress. Leckman et al. (1993) provided preliminary evidence to suggest that tics involving specific regions of the body are more likely to be preceded by premonitory urges. They found that head, neck, and shoulder movements were most frequently preceded by urges, whereas simple facial tics such as eyeblinking and mouth movements were least likely to be preceded by urges. This may explain why Lucy, who displayed primarily facial tics, was less able to suppress her tics than some of the other children. Future research should examine (a) whether specific tics are associated with specific urges, (b) whether tics that are accompanied by urges can be more effectively suppressed, and (c) whether suppressing specific tics results in differential ratings of premonitory urge severity. Furthermore, research has also shown that various dimensions of tic severity are differentially related to premonitory urge severity. Woods et al. (2005) found that the number, complexity, and interference domains on the YGTSS correlated with premonitory urge severity but frequency and intensity domains did not. Future research should continue to evaluate how various tic dimensions might be related to the development and course of premonitory urges. Perhaps tics that are complex and/or relatively intense (e.g., head and arm jerking) are associated with more severe premonitory urges compared with tics that are simple and relatively benign (e.g., blinking). If this is the case, then perhaps some, but not all, tics are captured under the negative reinforcement model. Clearly, more research is needed to understand both tics and associated premonitory urges.

It is also possible that aspects specific to the setting and the experimental preparation could have influenced the relationship between premonitory urge ratings and suppression. One factor worthy of consideration is the reinforcement schedule (DRO) that was used to enhance suppression. The DRO was employed because previous studies have shown that children are better able to suppress their tics when reinforcement is delivered for tic-free periods than when they are simply instructed to suppress (Woods & Himle, 2004). However, it is possible that the reinforcement schedule inadvertently influenced the salience or valence of the premonitory urge. For example, if children were distressed about the possibility of losing reinforcers by performing poorly on the suppression task, they may have perceived premonitory urges as being especially aversive.
Finally, although not necessarily a limitation, this study used an ABAB withdrawal design with a small number of subjects. Such designs emphasize internal, rather than external validity. The use of such a design limits the degree to which the results can be generalized to the greater population of children with tics. However, to our knowledge, this is the first study to experimentally investigate changes in premonitory urge ratings during tic suppression. As such, the use of an ABAB design seemed appropriate in order to protect internal validity. Future studies should evaluate the degree to which these findings generalize to the majority of children with tic disorders, as well as to suppression in “real-life” settings such as school, home, or the clinician’s office. Understanding the factors that contribute to the relationship between tic suppression and premonitory urge severity will likely lead to exciting advancements in the understanding and treatment of tics in children.

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