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Variables Associated With Tic Exacerbation in Children With Chronic Tic Disorders

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Abstract

Research has shown that motor and vocal tics fluctuate in frequency, intensity, and form in response to environmental and contextual cues. Behavioral models have proposed that some of the variation in tics may reflect context-dependent interactive learning processes such that once tics are performed, they are influenced by environmental contingencies. The current study describes the results of a function-based assessment of tics (FBAT) from a recently completed study comparing Comprehensive Behavioral Intervention for Tics (CBIT) with supportive psychotherapy. The current study describes the frequency with which antecedent and consequence variables were reported to exacerbate tics and the relationships between these functional variables and sample baseline characteristics, comorbidities, and measures of tic severity. Results showed that tic-exacerbating antecedents and consequences were nearly ubiquitous in a sample of children with chronic tic disorder. In addition, functional variables were related to baseline measures of comorbid internalizing symptoms and specific measures of tic severity.

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Keywords

Tourette disorder; chronic tic disorder; Comprehensive Behavioral Intervention for Tics; function-based assessment

Chronic tic disorders (CTD), including Tourette Syndrome (TS), are a class of childhood-onset neuropsychiatric disorders characterized by involuntary motor and vocal tics (American Psychiatric Association [APA], 2013). In addition to the tics, many individuals also report unpleasant somatic sensations that precede tics (i.e., premonitory urges) and are alleviated when the tic is performed (e.g., Leckman, Walker, & Cohen, 1993). Although the cause of CTD is unknown, there is evidence that tics result from dysfunction of cortico-striatal-thalamo-cortical circuitry (Mink, 2003). One of the more interesting phenomena observed in CTD is that tics are highly variable, leading some to describe them as "ostensibly unpredictable" (Peterson & Leckman, 1998). One of the hallmark features of tics is that they naturally wax and wane in type, form, frequency, and intensity over the course of the disorder (Peterson & Leckman, 1998). In addition, research has shown that they fluctuate in response to specific environmental and contextual cues (Conelea & Woods, 2008; O'Connor, Brisebois, Brault, Robillard, & Loiselle, 2003; Piacentini et al., 2006; Silva, Munoz, Barickman, & Friedhoff, 1995; Woods, Walther, Bauer, Kemp, & Conelea, 2009). A recently proposed behavioral model referred to as the comprehensive integrated (CI) model (Woods, Piacentini, & Walkup, 2007) posits that some of the complex and idiosyncratic variation in symptoms experienced by patients with CTD may reflect context-dependent interactive learning processes such that once tics are performed, they are influenced (i.e., shaped) by environmental contingencies.

When referring to "environment," the CI model considers two types of variables that influence tic expression, either of which can be internal or external to the individual. The first class of variables considered by the CI model includes *antecedents*. Antecedents are stimuli that immediately precede tics. Examples of internal antecedents include mood states (e.g., anxiety, excitement), thoughts (e.g., "If I don't tic, it will bother me more than when I do tic"), and premonitory urges. Examples of external antecedents include specific settings (e.g., classroom, home, public places), activities (e.g., exercise, sedentary activities), and the presence of specific people. The second class of variables considered by the CI model includes *consequences*. Consequence variables are outcomes that occur after tics (i.e., contingent on tics) that may make tics more or less likely to occur, within a particular antecedent context. The most often cited internal consequence that occurs contingent on tic expression is temporary removal of an aversive premonitory urge (Kwak, Vuong, & Jankovic, 2003). External consequences typically involve social reactions, such as being teased, stared at, shushed, comforted, or asked about the tics. Other examples include being asked to leave (or removing oneself from) an area or activity, avoiding/delaying particular tasks, or gaining access to more preferred activities when bouts of tics occur. Antecedents and consequences are often, but not always, associated with each other such that antecedents (e.g., a quiet movie theater) predict the likely consequence(s) that will follow performance of a tic (e.g., shushing from the crowd). The functional relationship between antecedents and consequences allows either variable to momentarily alter the likelihood, frequency,

intensity, and form of tics, either by reinforcing (i.e., through attention, escape, or access to preferred activities or items) or punishing tic performance. It is important to note that consequences can directly impact tics without inferring that (a) tics are caused by the consequence, (b) the child is ticcing purposely, or (c) the child is even aware that tic-contingent consequences exist.

Evidence for the CI model comes from several lines of research. To examine common antecedent variables associated with tic exacerbation, Silva et al. (1995) administered surveys to 14 children and families to determine the impact of 29 different antecedent factors on tics. Of the 29 factors studied, the most commonly endorsed tic-exacerbating antecedents were being upset/anxious, watching television, social gatherings, fatigue, being alone, doctor's office visits, quiet places, and socializing with friends. As would be expected by the CI model, the effect of the various antecedent variables was idiosyncratic. In fact, some of the common exacerbating factors (e.g., doctor's office visits, social gatherings) were associated with a *decrease* in tics for some individuals. In addition, for a small subset of these individuals ($n = 8$), there were strong correlations between the number of tic-exacerbating factors endorsed and the number ($r = .66$) and intensity (i.e., forcefulness, $r = .77$) of motor and vocal tics as rated on the Yale Global Tic Severity Scale (YGTSS; Leckman et al., 1989). In another study, O'Connor et al. (2003) examined environmental factors associated with tic fluctuation in 39 adults diagnosed with CTD. In this study, participants maintained a diary for 10 days and recorded frequency of tics, intensity of urge to tic, and situation where the tics were most likely to occur. The most frequently reported tic-exacerbating activities were socialization, transitions (e.g., moving between appointments), waiting (e.g., waiting in line, anticipating test results), passive attendance (e.g., watching TV), and intellectual work (e.g., writing reports). A few small studies have also experimentally demonstrated that the occurrence of tics can be affected by tic-contingent consequences in natural environments. For example, Watson and Sterling (1998) demonstrated that a child's vocal tic occurred more frequently at the dinner table, particularly when a parent provided attention following the tic.

Finally, laboratory research has also demonstrated that antecedents and consequences can affect the occurrence of tics. Woods and Himle (2004) observed children when they were asked to suppress their tics with and without token reinforcers for tic-free periods. Reinforced suppression resulted in a 76% reduction in tics from baseline levels compared with a 10% reduction during voluntary suppression, showing that tic frequency can be altered when reinforcing consequences are applied. Several subsequent studies have replicated the finding that differential reinforcement procedures can reduce tics in the short term (Capriotti, Brandt, Ricketts, Espil, & Woods, 2012; Himle & Woods, 2005; Himle, Woods, & Bunaciu, 2008; Himle, Woods, Conelea, Bauer, & Rice, 2007). Using the same reinforced suppression procedure, Woods et al. (2009) demonstrated that contextual antecedents (i.e., discriminative stimuli) can come to exert control over tic suppression when repeatedly associated with specific consequences, even when the consequence is removed. In this study, 10 children were exposed to four training sessions. During each session, children were exposed to repeated presentation of three counterbalanced conditions. In the first condition, signaled by a purple stimulus light (*SD*+), participants were instructed to

suppress their tics and received reinforcement for tic-free periods. In the second condition, signaled by an orange stimulus light (*SD*−), participants were instructed again to suppress their tics. However, the reinforcement contingency for suppression was no longer in place. A third baseline condition (no stimulus lights) served as the experimental control. After several training sessions, an experimental test was conducted to assess tic frequency when the participants were exposed to the same three conditions but without any instructions regarding tic suppression and in the absence of the reinforcement contingency. Researchers found that tics were lower for the purple light condition (*SD*+) compared with the orange light condition (*SD*−) even though subjects were not instructed to suppress their tics and reinforcement was no longer delivered. These results tentatively suggest that antecedent stimuli can, through their association with tic-contingent consequences, come to exert control over tics even when the consequence is no longer delivered.

Although a growing body of evidence now suggests that environmental variables can worsen tics, with the exception of a few small studies, little is known about common antecedents and consequences that affect tics in children. This is an important area of study because identifying and understanding antecedents and consequences that exacerbate tics has important implications for treatment. If tic-exacerbating factors can be systematically identified, specific treatment techniques can be used to manipulate or reduce antecedent variables that exacerbate tics (e.g., settings, specific activities) and to modify social and other contingencies that may be worsening tics.

Based on the CI model, researchers from the Tourette Syndrome Association's Behavioral Sciences Consortium have developed a multifaceted treatment approach referred to as Comprehensive Behavioral Intervention for Tics (CBIT; Woods et al., 2008) and tested this treatment in parallel child/adolescent (Piacentini et al., 2010) and adult (Wilhelm et al., 2012) randomized controlled trials. The CBIT treatment package supplements the empirically supported treatment habit reversal training (HRT; see Himle, Woods, Piacentini, & Walkup, 2006, for a review) with a function-based assessment and treatment approach designed to identify antecedents and consequences believed to be exacerbating tics. The current study had two primary purposes: (a) to describe the function-based assessment of tics (FBAT) and (b) to analyze FBAT data collected from the child CBIT trial (Piacentini et al., 2010) to describe the frequency with which various antecedent and consequence variables were reported to exacerbate tics in children participating in the CBIT arm of the randomized controlled trial. As a secondary goal, the current study explored the relationships between the number of tic-exacerbating functional variables (antecedents and consequences) endorsed and sample baseline characteristics, comorbidity, and measures of tic severity. Regarding the latter, we hypothesized that, consistent with previous research (e.g., Silva et al., 1995), the number of tic-exacerbating antecedents and consequences endorsed would correlate with measures of tic severity, particularly tic frequency and intensity.

Method

Participants

Participants were youth ages 9 to 17 diagnosed with CTD who participated in a recently conducted multisite randomized controlled trial comparing CBIT and a psychoeducation and supportive therapy (PST) intervention (Piacentini et al., 2010). Participants were recruited from tic disorders specialty clinics located in three metropolitan areas in different regions of the United States. A total of 126 children were enrolled in the trial, and a full description of the entire study sample can be found in Piacentini et al. (2010) and Specht et al. (2011). Of the children who participated in the study, 63 children were randomly assigned to the PST condition and 61 were randomized to CBIT. For the current study, only participants from the CBIT arm were analyzed, as the FBAT was not part of the PST intervention. Of the 61 children who were assigned to the CBIT arm of the study, FBAT data were available for 51 participants. Data were missing for 6 participants for unknown reasons. Data from 4 participants were missing due to incorrectly completed or illegible FBAT forms. Missing data were approximately equally distributed across the 3 sites.

Baseline demographic characteristics for the current sample are presented in Table 1. The average age of the sample was 11.5 years (*SD* = 2.7). The sample was predominantly Caucasian (82%) and male (70%). Forty-six children in the sample were diagnosed with Tourette disorder (90%), 4 were diagnosed with chronic motor tic disorder (8%), and 1 was diagnosed with chronic vocal tic disorder (2%). Sixty-five percent of children presented with one or more comorbid psychiatric conditions beyond their primary tic disorder diagnosis (see Table 1).

Materials and Procedures

FBAT—The FBAT (Woods et al., 2008) is a semistructured clinical interview designed to help identify antecedent and consequence variables associated with tic exacerbations. To complete the FBAT, the clinician first interviews the patient and his or her family using the FBAT record form as a guide. The FBAT record form contains separate lists of common antecedent and consequence variables shown in previous research to be associated with tic exacerbation. The clinician first asks the child and parent whether the child's tics are worse (i.e., more frequent or more intense) in each of 11 antecedent situations (see Table 2). After reviewing the antecedents listed on the FBAT record form, the family is asked whether there are any additional situations in which the child's tics seem to be worse, and these are added to the form accordingly. Next, after completing the antecedent section, the clinician interviews the family about possible consequences that may follow tics in each of the antecedent situations endorsed. For example, if the family endorses that tics are worse during homework, they are asked who is present at that time and how these individuals respond to the tic exacerbation (e.g., ask the child to try to stop ticcing, provide comfort, give the child breaks from homework, encourage them to complete the assignment, or allow them to stop the assignment, etc.). The FBAT record form lists seven common consequences comprising two primary behavioral functions: social positive reinforcement via attention (e.g., told to stop tics, provided comfort/reassurance, laughed at, etc.) and negative reinforcement via escape from aversive contexts (e.g., the child is asked/allowed to leave a

nonpreferred setting, child is not required to complete a task such as homework, etc.). To the extent possible, the clinician attempts to ascertain both antecedents and consequences (and the specific connection between the two) that may be exacerbating tics. In addition to the FBAT interview, families are asked to monitor tic exacerbations on a daily basis and record antecedents (setting, activity, people present) and consequences (reactions to the tics) associated with the increase in tics. These daily observations are reviewed and incorporated into the FBAT at the beginning of each weekly therapy session.

YGTSS—The YGTSS (Leckman et al., 1989) is a clinician-completed measure that provides 0 to 5 point ratings on five different dimensions: tic number, frequency, complexity, intensity, and interference. Each of these dimensions is scored separately for motor and vocal tics to produce total motor tic and total vocal tic severity scores ranging from 0 to 25. The motor and vocal tic severity scores are combined to produce a total tic severity score ranging from 0 to 50, with higher numbers indicating more severe tics. The YGTSS has demonstrated acceptable internal consistency and acceptable convergent and divergent validity (Leckman et al., 1989). Psychometric analyses have shown high correlations between the motor and vocal tic subscales and the global score and high interrater reliability (IOR). Factor analyses have revealed a two-factor structure (motor tics and vocal tics; Leckman et al.; Storch et al., 2005). The YGTSS was administered to each participant and their parent(s) at baseline.

Anxiety Disorders Interview Schedule for Children–Version IV (ADIS-IV)—The ADIS-IV (Silverman & Albano, 1996) is a semistructured diagnostic interview that assesses the major *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; APA, 1994) anxiety, mood, and externalizing disorders experienced by school-aged children and adolescents. The ADIS-IV has been shown to possess favorable psychometric properties (Silverman, Saavedra, & Pina, 2001; Wood, Piacentini, Bergman, McCracken, & Barrios, 2002).

The Screen for Child Anxiety Related Emotional Disorders (SCARED; Birmaher et al., 1997) is a 41-item parent-report used to screen for child anxiety disorders including generalized anxiety disorder, separation anxiety disorder, panic disorder, social phobia, and school phobia. The measure has both parent and child reports, however, only the child report was used in the current study. The measure has good test–retest reliability and internal consistency (Birmaher et al., 1999; Birmaher et al., 1997). The scale also has excellent discriminant validity, and subscales differentiate between children with various anxiety disorders (Birmaher et al., 1999).

Data Collection

A full description of recruitment, consent, screening, and randomization procedures for the CBIT trial can be found in Piacentini et al. (2010). All participants completed a baseline evaluation that included a structured diagnostic interview (ADIS-IV) as well as several parent and child self-report measures, including the SCARED. All clinician-rated measures (e.g., ADIS, YGTSS) were administered by trained, master's-level clinicians who were naïve to study condition. Children who met all inclusion criteria for the trial were randomly

assigned to 8 sessions of CBIT or PST. Children assigned to the CBIT condition received 8 sessions of CBIT over the course of 10 weeks. The first CBIT session involved psychoeducation as well as a rationale for treatment. Beginning in Session 2, a new tic was targeted for intervention each week. Treatment involved HRT, function-based assessment and intervention, and a variety of ancillary treatment techniques. Therapeutic interventions were delivered simultaneously as a treatment package. A detailed session-by-session review of the CBIT protocol and the therapeutic techniques used in the CBIT trial can be found in Woods et al. (2008). At the second treatment session, patients and their families completed the initial FBAT interview with their clinician as described above. Parents completed the FBAT self-monitoring forms between each session and reviewed the results with their therapist at each study visit. The study clinician maintained an FBAT "master list" of each antecedent and consequence associated with tic exacerbation.

Data Analysis

Data from the FBAT for each participant at all trial sites were entered into an SPSS database and checked by two trained research assistants. Responses to each of the antecedent and consequence items on the FBAT master list were coded as present or absent. IOR was calculated by dividing agreements by total cases and multiplying by 100. The overall IOR was 94%. Though rare, any inconsistent entries between raters were coded by a third rater and discussed until consensus was reached. All statistical analyses were conducted using SPSS/PASW v18.0 statistical software.

Results

Descriptive Results of the FBAT

The percentage of participants endorsing various antecedent and consequence variables on the FBAT is presented in Table 2. All participants endorsed at least two tic-exacerbating antecedents, and all but two participants endorsed at least one tic-contingent consequence associated with tic exacerbation. On average, participants endorsed more antecedents (M = 8.59, SD = 3.05) than consequences (M = 3.20, SD = 2.28), with a mean number of 11.78 (SD = 4.41) tic-exacerbating variables identified. Each of the antecedent variables measured on the FBAT was endorsed with relatively high frequency. The most commonly endorsed tic-exacerbating antecedent was watching television or playing video games (92%), followed closely by home after school (88%), homework (80%), the school classroom (78%), and public places (78%). The most commonly endorsed consequences associated with tic exacerbation were the child being told to stop ticcing (72%) followed by receiving comfort (59%) and being laughed at or teased (35%). To more thoroughly describe the association between specific antecedents and consequences, the various consequences endorsed on the FBAT were categorized as either attention-based (told to stop tics, provided comfort, laughed at/looked at/asked about tics) or escape-based (asked to/allowed to leave the area, does not complete/avoids/delays task or activity). The frequencies with which attention-based and escape-based consequences were associated with each antecedent queried on the FBAT are provided in Table 3. Attention-based consequences were endorsed more often across all antecedents (range = 35%–82%) relative to escape-based consequences (range = 8%–29%).

Associations Between Functional Variables and Sample Characteristics

The number of antecedents and consequences endorsed did not differ by gender, $t(49) = 0.491$, $p = .62$, or whether the child was taking tic medication, $t(49) = 0.241$, $p = .81$. Age was positively correlated with the total number of consequences endorsed ($r = .354$, $p = .011$) but not total antecedents ($r = .154$, $p = .285$).

Associations Between Functional Variables and Comorbidity

To examine whether the number of tic-exacerbating antecedents and/or consequences differed by comorbidity status, the sample was analyzed based on the presence or absence of internalizing and externalizing comorbidity. The internalizing group was not significantly different from the no-internalizing group on tic severity or gender. The internalizing group was significantly older (*M* difference = 1.88 years) than the no-internalizing group, $t(39.470) = 2.821$, $p < .01$. The externalizing group did not differ significantly from the no-externalizing group on gender or tic severity, but the externalizing group was significantly younger (*M* difference = 1.36 years) than the no-externalizing group, $t(38.727) = 2.207$, $p < .01$. Because the groups differed significantly on age in both cases, analyses related to comorbidity included age as a covariate in a one-way ANCOVA. Results show that children diagnosed with an internalizing disorder reported more tic-exacerbating antecedents than did children without an internalizing condition when controlling for age, $F(1, 47) = 5.969$, $p < .05$; $M = 9.71$, $SD = 2.44$ versus $M = 7.59$, $SD = 3.23$, respectively. Though children diagnosed with a comorbid internalizing condition also reported more tic-exacerbating consequences than did those without an internalizing condition, $F(2, 47) = 4.659$, $p < .05$; $M = 3.88$, $SD = 2.38$ and $M = 2.60$, $SD = 2.04$, respectively, was better accounted for by age, $F(1, 47) = 4.921$, $p < .05$, than internalizing status, $F(14, 47) = 1.167$, $p > .05$. Children diagnosed with an externalizing condition endorsed significantly more consequences than those without an externalizing condition, $F(2, 47) = 5.457$, $p < .01$, though this too was better accounted for by age, $F(1, 47) = 10.249$, $p < .01$, than externalizing status, $F(1, 47) = 2.532$, $p > .05$. There was no difference in the number of antecedents endorsed based on externalizing status, $F(2, 47) = 2.309$, $p > .05$.

To further explore the association between comorbid internalizing symptoms and functional variables, we examined the association between the number of tic-exacerbating antecedents and consequences and SCARED total scores and subscale scores. Results show that the SCARED total score did not correlate with the number of antecedents ($r = .157$, $p = .28$) or consequences ($r = .135$, $p = .35$). However, the number of antecedents endorsed did correlate with scores on the panic/somatic anxiety subscale of the SCARED ($r = .316$, $p < .05$) and for children with internalizing problems, the number of consequences endorsed correlated with the SCARED school anxiety/avoidance subscale ($r = .438$, $p < .01$). All other associations between SCARED subscales and the number of functional variables endorsed were nonsignificant ($p > .05$ for all analyses).

Associations Between Functional Variables and Tic Severity

Bivariate correlations of composite function variables (total antecedents and consequences, respectively) were conducted with baseline YGTSS scores. Contrary to our hypotheses, the number of antecedents endorsed did not correlate with YGTSS total tic severity scores ($r = .$

006, $p = .96$). In addition, the number of antecedents endorsed also did not correlate with any of the YGTSS tic severity subscale scores (tic number, frequency, intensity, complexity, or interference; all *p*s = *n*s). Likewise, and contrary to our predictions, the total number of consequences endorsed did not correlate with overall tic severity as measured by the YGTSS ($r = .076$, $p = .59$). However, the number of consequences endorsed was related to the motor tic frequency ($r = .300$, $p < .05$) and motor tic interference ($r = .318$, $p < .05$) subscales of the YGTSS, such that a greater number of tic-exacerbating consequences was associated with greater motor tic frequency and interference.

Discussion

Although there is strong evidence to suggest that tics are caused by neurobiological dysfunction, there is emerging evidence that they fluctuate in form, frequency, and intensity in response to environmental and contextual cues (O'Connor et al., 2003; Silva et al., 1995). The primary purpose of the current study was to describe the results of a systematic evaluation of environmental variables (both antecedents and consequences) associated with parent- and child-reported tic exacerbations in children with CTD. Results show that, when interviewed with a semistructured function-based assessment protocol (i.e., the FBAT), all families reported that their child's tics were noticeably exacerbated across multiple settings and/or activities. In addition, almost all respondents were able to identify one or more specific consequence(s) associated with tic exacerbations within these antecedent contexts. These findings are consistent with previous findings in small samples of children with CTD (e.g., Silva et al., 1995) and provide additional support for contemporary behavioral models (Woods et al., 2007), suggesting that tic variation may in some cases reflect context-dependent interactive learning processes such that once tics are performed, they are shaped and influenced by environmental contingencies.

The secondary aim of the current study was to begin to explore associations between the number of tic-exacerbating variables endorsed and sample baseline characteristics, comorbid symptoms, and tic severity. Several interesting findings emerged. First, we found that the child's age was significantly related to the number of consequence variables endorsed, with older children reporting more tic-exacerbating consequences. One possible explanation for this finding is that older children are likely to have lived with tics longer, and they also live in an increasingly complex social environment, which may increase the opportunity to encounter social consequences for their tics. In addition, research has shown that most individuals with CTD report a pattern of tic worsening (in terms of tic number, frequency, complexity, and variation) through the late childhood years and into adolescence (Bloch & Leckman, 2009; Leckman et al., 1998). It is possible that as tics become more frequent and complex, they also become more noticeable and thus are more likely to garner attention and other social consequences. However, it is also possible (and consistent with the CI model) that the relationship between tic severity, especially in terms of variability, and tic-contingent consequences may be reciprocal. For example, it is possible that as the child ages and tics worsen (perhaps for biological reasons; Peterson & Leckman, 1998), the tics may become more socially noticeable to others and thus be more likely to garner social consequences. This may in turn lead to further tic exacerbation. Future research is needed to examine whether some of the variability and clinical complexity, including the well-

documented waxing-and-waning of symptoms, might be explained by environmental factors.

Contrary to expectations, we failed to find a relationship between total tic severity, as measured by the YGTSS, and the number of functional variables endorsed, although the number of consequences endorsed was significantly related to motor tic frequency and interference. This latter finding is partially consistent with the much smaller survey study by Silva et al. (1995), who found a significant relationship between the total number of antecedents and consequences and the total number of tics and their overall forcefulness. One possible explanation for the differences between Silva et al. and the present study, may be that the FBAT contains fewer items relative to those assessed by Silva et al., and the items that are included in the FBAT predominantly assess external antecedents and consequences. Notably, “being upset or anxious,” the most commonly endorsed tic-exacerbating factor in Silva et al., is not specifically listed as an antecedent on the FBAT. Other research has similarly suggested that internal variables such as specific thoughts, stress, excitement, and other emotional and mood states can exacerbate tics in some individuals (e.g., O’Connor et al., 2003). Although the FBAT allows respondents to endorse “other” functional variables (and indeed some respondents did endorse factors not directly assessed, including positively and negatively valanced emotional states), identification of these variables during the FBAT required families to recognize and recall relevant variables that were not directly cued during the interview. Some children (especially young children) in the current study may have had difficulty recognizing and reporting certain variables associated with tic exacerbation, such as internal variables (e.g., anxiety) that might not be readily observed by the parent. In spite of these limitations, FBAT items were endorsed with relatively high frequency, and were reported by study participants to be associated with tic worsening.

The current study also found that children diagnosed with an internalizing disorder reported more tic-exacerbating contextual factors (i.e., antecedents). In addition, the number of antecedents endorsed was positively correlated with scores on the panic/somatic anxiety subscale of the SCARED, and the number of consequences endorsed was positively correlated with scores on the SCARED school anxiety/avoidance subscale for children with internalizing disorders. Although causality cannot be determined or assumed from our analyses, it is possible that internal factors, such as anxiety, may mediate or otherwise explain the relationship between specific contextual factors and tic-exacerbation. For example, it is possible that certain variables may trigger or exacerbate anxiety in children with CTD (especially those who are already anxious) thereby resulting in tic exacerbations. Alternatively, children who are anxious may more readily recognize when others react to their tics, which may result in increased tics and/or anxiety. For example, the current study found that most children (78%) reported that their tics were worse in the classroom, and more than half (56%) reported attention-based consequences (e.g., being told to stop, teasing) within this context. Several possibilities may explain why these factors exacerbate tics. First, it is possible that attention-based consequences are directly acting on the tics to make them worse. Alternatively, it is possible that for a child who is anxious in the classroom (whether tic-related or not), it is the anxiety, and not the tic-contingent consequences per se, that is responsible for the tic exacerbation. Yet another possibility is

that there is a complex, individualized relationship in which the social consequences of ticcing (or even the perceived likely consequences) lead to anxiety, which in turn might further exacerbate tics (and anxiety) within that context. These are just a few possible examples of the way that complex relationships between antecedents (including internal states) and consequences might impact an individual child. These relationships are likely to be unique to each child depending on his or her situation, disposition, and learning experiences. Additional research is needed to confirm the current findings and to further explore the relationships between tic-exacerbating factors and comorbid symptomatology in children with CTD.

A better understanding of how environmental variables affect tics may provide critical information about how best to intervene to maximize positive clinical outcomes. For example, in the previous scenario in which attention-based consequences and anxiety are believed to be exacerbating tics in the classroom, a skilled therapist might introduce a classroom-based intervention to decrease attention to the tics while also teaching the child anxiety-reduction strategies (along with HRT) to minimize tic exacerbation. Consistent with this idea, the behavioral treatment package tested in the child CBIT trial (Piacentini et al., 2010) included strategies to address factors identified on the FBAT that were believed to be exacerbating tics (for examples of function-based intervention techniques and how they were used clinically in the CBIT trial, see Woods et al., 2008). Unfortunately, because the intervention was delivered as a package of therapeutic techniques, it is not possible to isolate the extent to which the function-based intervention techniques contributed to overall clinical outcomes. However, some controlled case studies (e.g., Watson & Sterling, 1998) have demonstrated that function-based interventions can yield robust decreases in tic frequency. Future research, including component analyses in which the various treatment techniques are isolated, is needed.

In addition to the limitations already noted, other limitations of the current study warrant mention. First, the FBAT was specifically designed for the child and adult CBIT trials and have yet to be tested by other research groups. Although the culmination of several existing lines of research support the face validity of the measure, it has not yet been validated and the psychometric properties are unknown. In particular, the FBAT is designed as a functional assessment measure used to generate hypotheses about variables that may be exacerbating tics. However, real-world contingences are complex and idiosyncratic, and it is not possible within the context of the current study to determine with certainty the extent to which various functional variables were affecting tics.

It is also important to note that it is likely that specific variables may function differently within specific contexts. For example, if a child is sent out of the classroom contingent on a loud or inappropriate vocal tic, this may serve to worsen the tic through negative reinforcement (e.g., escape from an aversive task, such as schoolwork). However, if the same child is asked to leave a movie theater contingent on the same tic, this may serve to reduce the tic through punishment or reinforcement of tic suppression strategies. Although families in the current study were asked to report specifically on whether the various antecedents and consequences measured by the FBAT *exacerbated* tics, experimental studies (e.g., functional analyses) are needed to empirically determine whether parent- and

child-reported factors are indeed causally associated with tic exacerbation and whether tics increase or decrease when these factors are manipulated.

Experimental functional analysis procedures have been used to systematically identify and isolate antecedent and consequence variables maintaining a variety of behaviors (see Hanley, Iwata, & McCord, 2003, for a review). In addition, it was not uncommon in the current study for families to report that multiple consequences were associated with tic exacerbation within a particular antecedent context (e.g., both attention and escape were frequently associated with tic exacerbation in the classroom). Functional analysis procedures present a potentially useful way to systematically isolate specific consequences to determine the relative contribution that each variable has on tic fluctuation.

A final limitation of the current study is that we were unable to examine specific functional variables associated with specific tics. It is possible that some tics may be more or less influenced by functional variables depending on a variety of factors, including the nature of the tic and the individual's unique environment. For example, it is possible that some tics (e.g., loud vocal tics or complex motor tics that are difficult to camouflage) are more or less likely to garner social consequences. This is another important area of future research.

With these limitations in mind, the current study makes several important contributions to the literature. First, it is to date the largest study to use a function-based assessment measure to systematically evaluate environmental variables reported to exacerbate tics in children with CTD. In addition, to our knowledge, it is the first study to examine tic-exacerbating consequence variables, as previous research (e.g., Silva et al., 1995) has focused primarily on antecedent (contextual) factors. The fact that respondents in the current study identified numerous functional variables associated with tic exacerbation, including specific antecedent-consequence associations, lends support to the notion that particular contexts may come to exert influence over tics due to the association between setting cues and tic-contingent consequences. Finally, this study demonstrates that the FBAT is a potentially useful tool for systematically identifying tic-exacerbating variables that could be targeted for intervention.

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Table 1

Participant Characteristics.

Characteristic	***n* (%)**
Gender	
Male	37 (70%)
Female	14 (30%)
Age (*M*, *SD*)	11.5 (2.7)
Tic disorder diagnosis	
Tourette disorder	46 (90%)
Chronic motor tic disorder	4 (8%)
Chronic vocal tic disorder	1 (2%)
Comorbid diagnoses (%)	
Attention deficit hyperactivity disorder	14 (27%)
Obsessive compulsive disorder	6 (12%)
Generalized anxiety disorder	8 (16%)
Separation anxiety disorder	4 (8%)
Social anxiety	9 (18%)
Other diagnoses	4 (8%)
Tic medication	
Yes	16 (31%)
No	35 (69%)
Other psychotropic medication	17 (33%)
Tic severity (*M*, *SD*)	
YGTSS total tic severity score	24.53 (6.13)
YGTSS total motor tic severity score	14.57 (3.82)
YGTSS total vocal tic severity score	9.96 (4.52)

Note. YGTSS = Yale Global Tic Severity Scale.

Table 2

Percent of Sample Reporting Antecedent and Consequence Variables Associated With Tic Exacerbation.

	% endorsed (*N* = 51)
Antecedent variables	
Antecedents measured on the FBAT	
TV/video games	92.2
Home after school	88.2
Homework	80.4
Classroom	78.4
Public place—Social	78.4
Physical activities—Sports	72.5
In car	72.5
Anticipation/waiting	68.6
Meals	56.9
Bedtime routine	56.9
Presence of a specific person	13.7
Other[a]	
Disruption to routine/transition	19.6
Negative emotion (anger, frustration, upset)	15.7
Positive emotion (excited, relaxed)	9.8
Other specific activities (e.g., reading, taking tests, performing, talking about tics)	29.4
Consequence variables	
Attention-based consequences	
Told to stop tic	72.5
Received comfort	58.8
Laughed at/looked at/asked about tics	35.3
Escape-based consequences	
Asked to leave the area/provided break	17.6
Does not complete required chore or task	25.5

Note. FBAT = function-based assessment of tics

[a]Item not included in semistructured interview. Parent or child must endorse without prompting from examiner.

Table 3

Frequency of Attention-Based and Escape-Based Consequences Associated With Commonly Endorsed Tic-Exacerbating Antecedents.

Antecedent (number endorsing)	Consequence	Frequency (%)
Classroom (*n* = 47)	Attention consequences	27 (57%)
	Escape consequences	13 (28%)
	No consequence(s) identified	7 (15%)
Home after school (*n* = 45)	Attention consequences	37 (82%)
	Escape consequences	13 (29%)
	No consequence(s) identified	6 (13%)
Public places (*n* = 40)	Attention consequences	24 (60%)
	Escape consequences	8 (20%)
	No consequence(s) identified	14 (35%)
Watching TV/video games (*n* = 47)	Attention consequences	23 (49%)
	Escape consequences	8 (17%)
	No consequence(s) identified	20 (43%)
Homework (*n* = 41)	Attention consequences	19 (46%)
	Escape consequences	7 (17%)
	No consequence(s) identified	20 (49%)
During meals (*n* = 30)	Attention consequences	13 (43%)
	Escape consequences	8 (27%)
	No consequence(s) identified	16 (53%)
Morning/evening routine (*n* = 30)	Attention consequences	18 (60%)
	Escape consequences	7 (23%)
	No consequence(s) identified	12 (40%)
Sports/physical activity (*n* = 37)	Attention consequences	13 (35%)
	Escape consequences	3 (8%)
	No consequence(s) identified	21 (57%)
Anticipation/waiting (*n* = 35)	Attention consequences	15 (43%)
	Escape consequences	5 (14%)
	No consequence(s) identified	18 (51%)
When riding in car (*n* = 37)	Attention consequences	17 (46%)
	Escape consequences	4 (11%)
	No consequence(s) identified	17 (46%)