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Behavioral Therapy for Tourette Disorder: An Update

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Abstract
Purpose of Review The past decade has realized substantial progress in understanding and treating Tourette disorder (TD). The goal of this review is to highlight recent research on behavioral approaches for treating TD and to identify limitations to this treatment approach and directions for future research.
Recent Findings Two large randomized controlled trials provide the most compelling evidence to date of the efficacy of behavior therapy for reducing tic severity in both children and adults with TD. Historical concerns regarding adverse treatment side effects have been examined and are not supported. However, treatment response remains incomplete and studies have shown that access to trained providers and the burden associated with treatment are significant barriers to utilization. Abbreviated treatment protocols and remote delivery have been investigated and have shown promise for addressing these issues.
Summary Behavior therapy is an efficacious treatment for TD, a better understanding of the behavioral and biological mechanism(s) by which behavior therapy operates will likely lead to improved outcomes. Additionally, it is critical to continue to identify barriers to implementation and improve dissemination of this efficacious treatment option.

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Introduction

Persistent tic disorders (PTD), including Tourette Disorder (TD), are a class of childhood-onset neurodevelopmental movement disorders characterized by involuntary motor and/or vocal tics [1]. Prevalence estimates suggest that PTDs affect 0.5–1 % of school-aged children, disproportionately affect boys, and take a fluctuating course [2]. Although many individuals report some remission of tic symptoms in adolescence and early adulthood, tics persist into adulthood in many individuals. The mechanisms underlying improvement or persistence are unclear [3, 4]. In moderate to severe cases, PTDs are associated with considerable functional impairment and a decreased quality of life [5, 6]. The cause of PTDs remains unknown; however, family, twin, and segregation studies provide strong evidence of polygenic inheritance, although the specific genes involved are yet to be identified [7]. From a neurocognitive perspective, converging lines of research implicate failed inhibition within cortico-striato-thalamo-cortical (CSTC) pathways in the pathogenesis of tics [8].

Based on the biological conceptualization of TD, pharmacotherapy, and, in particular, anti-dopaminergic agents, have historically been considered the first-line of treatment [9]. For less severe tics, alpha agonist preparations can be utilized. While pharmacotherapy is beneficial for many patients, it rarely results in complete or sustained symptom remission and is limited by concerns of unwanted side effects [10], emphasizing the need for ancillary and/or alternative approaches to treatment. Recently, behavior therapy has garnered strong empirical support as an efficacious treatment for TD and is now recommended as a first-line intervention by several

international groups [11–13]. Rather than offering an explanation for the underlying cause of tics, behavioral approaches target environmental (i.e., behavioral) processes believed to maintain and exacerbate tics. A primary assumption of the behavioral model is that the frequency, complexity, and forcefulness of tics can be reduced by eliminating (or altering) environmental/social reinforcers that exacerbate tics and reinforcing the use of specific tic suppression strategies [14].

Overview of Behavioral Approaches to Treating TD and Their Rationale

Although behavior therapy for the treatment of tics has received increased attention over the past decade, the idea that tics can be managed with behavioral techniques is not new. Early research reports demonstrating the successful application of behavior therapy for reducing tics date back to the early 1970s when Nathan Azrin and colleagues described the use of habit reversal training (HRT) to successfully treat tics and other repetitive behaviors [15]. Similarly, early investigations by researchers in the UK demonstrated the efficacy of a behavioral tic suppression procedure known as exposure and response prevention (ERP), which shares some similarity (and differences) with HRT [16, 17]. The central idea behind both HRT and ERP is that tics are strengthened through negative reinforcement [16–18]. The negative reinforcement conceptualization of tics stems from studies showing that most adults and children report that their tics are preceded by aversive premonitory urges that are reduced, at least temporarily, when tics are performed [19, 20]. Based on this conceptualization, both HRT and ERP employ specific therapeutic techniques to teach individuals to become more aware of their tics and associated urges and suppress their tics, for example, by engaging in a physically incompatible behavioral response prior to tic onset [14, 16]. The intent is to facilitate habituation to premonitory urges and break the negative reinforcement cycle [21], much in the same way that repeated and prolonged exposure to a feared stimulus reduces physiological arousal and avoidance behavior characteristic of an anxiety response [22].

More recently, an expanded version of HRT, known as comprehensive behavioral intervention for tics (CBIT), was developed [14]. Although HRT is a primary therapeutic component of this intervention package, CBIT extends beyond the negative reinforcement (i.e., urge-reduction) conceptualization of tics by emphasizing the role of contextual factors (e.g., particular settings, activities, or social reactions that worsen tics) in determining TD severity and impairment. For example, the CBIT model posits that when tics are performed, they often elicit reactions from others. When such reactions are delivered contingent upon tics, they can exacerbate the intensity and frequency of tics and premonitory urges through the same operant reinforcement processes that influence voluntary behavior [23••]. In addition, although the specific mechanism remains unclear, there is substantial evidence that tics are exacerbated by psychological factors such as stress, anticipation, anxiety, boredom, and other affective and mood states [24]. To address these tic-exacerbating factors, along with HRT, CBIT includes a set of function-based therapeutic strategies to systematically identify and reduce contextual tic exacerbations [14].

Emerging Evidence for the Negative Reinforcement Hypothesis in TD

Although the negative reinforcement hypothesis has been difficult to test directly, several recent laboratory investigations have examined the effect of tic suppression (and execution) on premonitory urges using variations of a reinforced tic suppression paradigm [25, 26]. Within this paradigm, token rewards are provided when individuals suppress their tics for brief periods of time, essentially setting up a competition between suppressing tics and tolerating aversive premonitory urges while earning rewards versus allowing tics to occur in order to reduce urges and forgoing rewards. In one early pilot study, children with TD were asked to provide periodic urge ratings during alternating periods of tic suppression and a free-to-tic control condition. This study found that urge ratings were higher during periods of tic suppression relative to the free-to-tic condition [27]. This is consistent with the idea that tic performance decreases urges, as tic rates were lower during suppression than under free-to-tic conditions.

A more recent study replicated this finding in 15 children with TD/PTD [28•]. In addition to reinforced suppression and free-to-tic conditions, this study included a third "escape" condition in which children were allowed to initiate 10-s breaks from the reinforced suppression protocol (i.e., were allowed brief periods to tic) without losing the rewards they earned by suppressing their tics. Results were consistent with earlier findings [27] and showed that urge ratings were higher during periods of suppression and escape relative to the free-to-tic condition. Furthermore, during the escape condition, urge ratings increased during suppression (i.e., just before breaks) and decreased when ticcing resumed (i.e., just after breaks). In another recent investigation urge ratings were collected continuously during conditions of free-to-tic and tic suppression in 17 patients with TD [29•]. In both conditions, urge intensity was found to increase prior to, and decrease shortly after, tics were performed.

While the above studies provide support for the negative reinforcement hypothesis, it is noteworthy that at least two recent studies have failed to show a significant relationship between premonitory urge severity and tic suppressability [30, 31] and yet another study found considerable individual

variability in urge-tic relationships with some individuals showing increased urge ratings during suppression (consistent with the negative reinforcement hypothesis) and others showing *decreases* in urge ratings during suppression [32]. Studies are also mixed regarding whether premonitory urges decrease during and after periods of tic suppression and/or behavior therapy. While some treatment studies have shown decreases in premonitory urges both during and after behavior therapy [17, 33], at least one laboratory-based study failed to find decreases in urge ratings during a 40 min of tic suppression [34]. These findings emphasize the need for more research to understand the role and course of premonitory urges in TD.

Functional (Contextual) Factors Associated with Tic Severity

As noted above, the CBIT model posits that although tics are involuntary, they can nonetheless be influenced by the same reinforcement processes that influence voluntary behavior. For many years, evidence for this view was largely inferred from early operant research on other "involuntary" behaviors [35] and from a heterogeneous group of small studies suggesting relations between environmental influences and tics [36]. However, several more recent studies have investigated tic-environment relations more systematically. Results from these studies strongly support the idea that reactions from others can function to increase tic severity within a particular context.

In one recent study, parents and children with TD were interviewed using a structured protocol and were asked to keep daily records of situational tic exacerbations [23••]. Consistent with findings from previous research [37], all participants reported that their child's tics reliably increased in specific settings and/or during specific activities (e.g., at home after school, in public places, when in the classroom, and/or when engaged in activities such as playing videogames or completing homework). Importantly, almost all respondents were also able to identify one or more tic-contingent consequences (i.e., reactions) associated with these tic exacerbations, with most reporting that their child received some form of attention for tics (e.g., provided comfort or told to stop) or was allowed to escape a non-preferred task (e.g., homework) or continue a preferred task (e.g., videogame) when tics worsened. The number of consequences endorsed also correlated with motor tic frequency and interference [23••].

Consistent with these findings, two additional independent studies of children with TD and their caregivers found that higher scores on the Tic Accommodation and Reactions Scale (TARS), an assessment instrument designed to assess the number and frequency of consequences experienced for ticcing, were positively correlated with tic severity as well as measures of tic-related impairment [38, 39]. In addition, one of these studies [39] reported that children with internalizing problems (e.g., anxiety) experienced more tic-related consequences than those without comorbid internalizing problems, perhaps partially explaining the association between anxiety and increased tic severity [24]. The second author and colleagues are currently collecting longitudinal data to more definitely evaluate whether naturally occurring consequences for ticcing prospectively affect future tic severity.

Efficacy of Behavior Therapy for TD

Over the past 30 years, numerous investigations have demonstrated the efficacy of HRT and ERP for reducing tics [40]. However, most of these studies were limited by small sample sizes and methodological shortcomings. To address this, investigators in the USA recently reported the results of two large, multi-site, randomized controlled trials comparing the efficacy of CBIT to a supportive psychotherapy control condition [41••, 42••]. In both trials, patients with TD or PTD were randomized to eight sessions (10 weeks) of CBIT or supportive therapy followed by three monthly booster sessions. Assessments were conducted by condition-blind independent evaluators at baseline, post-treatment, and at 3- and 6-month follow-up. The primary outcome measure was the gold-standard Yale-Global Tic Severity Scale (YGTSS) [43]. Responder status was determined using the Clinician Global Impressions-Improvement (CGI-I) Scale, with ratings of "very much improved" and "much improved" indicating responder status. In the child trial, 126 children (ages 9–17) were randomized. Results showed that CBIT was associated with a significantly greater decrease on the YGTSS at post-treatment (effect size = 0.68). Further, 53 % of children receiving CBIT were rated as treatment responders versus 19 % in the control group, and 87 % of responders maintained treatment gains at 6-month follow-up. In the adult trial, 122 adults (ages 16–69 years) were randomized to the same conditions (CBIT versus supportive therapy). Results showed that CBIT led to a significantly greater decrease on the YGTSS (effect size = 0.57) and 38 % of patients receiving CBIT were rated as treatment responders versus 6 % in the control group. Similar to the child trial, 80 % of participants receiving CBIT maintained treatment gains at 6 months post-treatment. In addition, two recent meta-analytic studies of behavior therapy for TD reported medium to large effect sizes for behavior therapy relative to comparison conditions [44•, 45].

Neural Correlates of Behavior Therapy for TD

To date, few studies have directly investigated the neural changes associated with response to behavior therapy for TD. In one small investigation, eight participants (from the aforementioned adult CBIT trial) completed a measure of

response inhibition (the visuospatial priming task, VSP) during fMRI [46•]. Results were compared to eight healthy control participants matched for age, gender, education, and IQ, before and after a 10-week waiting period. Relative to controls, TD subjects showed greater putamen activation during the VSP task prior to treatment, less activation at post-treatment, and a significant decrease in putamen activation was observed pre- to post-CBIT in TD patients. Though preliminary, these results suggest that CBIT might alter aberrant brain activation within CSTC circuitry. Interestingly, the study also found that greater tic reduction during CBIT (as measured by the YGTSS) was associated with less change in VSP task-related activation in the inferior frontal gyrus (Broadman's area 47) pre- to post-treatment. Given that studies with healthy controls have found increased engagement in this (and other) cortical regions while performing the VSP task in adults [47], the authors interpreted these later findings to suggest that adequate inferior frontal gyral activation might be a necessary prerequisite for CBIT to be efficacious. Another study used EEG to examine motor- and event-related electrocortical response while completing a stimulus-response compatibility task administered pre- and post-treatment to 20 TD patients receiving a cognitive-behavior therapy for TD [48]. Results were compared to 20 healthy controls matched on age, gender and IQ. Results showed that TD patients, relative to controls, demonstrated delayed stimulus-locked LRP onset latency and larger response-locked LRP peak amplitude during inhibition processing, both of which corrected after treatment. Evidence for frontal overactivation during the NoGo (inhibition) portion of the task was also observed, but remained unchanged pre- to post-treatment.

Disseminating and Implementing Behavior Therapy for TD

Although CBIT has shown to be efficacious for reducing tics, large survey studies have shown that it is not widely available. A pair of recent online surveys involving adults ($N = 672$) and parents of youth ($N = 740$) with a self-reported diagnosis of TD or PTD, conducted in the USA, found that only 17 % of treatment-seeking adults had received behavior therapy for tics, with only 4 % reporting that treatment included habit reversal training [49]. Among parents, only 24 % of treatment-seeking families reported having received behavior therapy, with only 7 % reporting that treatment included habit reversal training. Among the most commonly cited reasons for having not received behavior therapy were lack of access to knowledgeable and trained treatment providers and concerns that behavior therapy would cause new tics to emerge (i.e., tic substitution), tic worsening, or exacerbation of co-occurring psychiatric symptoms, which are known to commonly co-occur in TD [50]. Dissemination and implementation efforts have begun to examine the safety and tolerability of CBIT as well as novel approaches to dissemination and implementation, including modifying the CBIT protocol to increase feasibility of implementation and delivering CBIT remotely through telehealth.

Addressing Common Misperceptions Regarding Behavior Therapy for Tics

One of the primary barriers to widespread adoption of behavior therapy as a first-line intervention for TD has been lingering concerns that treating tics using behavioral methods will lead to the emergence of new symptoms and/or a paradoxical increase in tics [51, 52]. To address these concerns, the CBIT clinical trials investigators conducted an empirical examination of symptom substitution in 228 participants from the CBIT randomized controlled trials using four indices: (1) the onset of new tic symptoms during treatment, (2) the occurrence of adverse events, (3) changes in tic medications during the study, and (4) worsening of co-occurring psychiatric symptoms [53•]. Results of this analysis showed several interesting and encouraging findings. First, across both treatment conditions, participants in the CBIT trials exhibited an average of 1.25 new bothersome tics over the 10-week trial period; a finding that is not particularly surprising given that tics are known to take a fluctuating and changing course [3]. Importantly, behavior therapy did not differ from supportive psychotherapy on the likelihood of new tic onset or the number of newly emerged tics, and treatment response following CBIT was not uniquely associated with new tic onset. Second, tic worsening during the 10-week study period was rare across both treatment conditions. Among those receiving behavior therapy, only one child participant (2 %) and four adult participants (6 %) reported tic worsening during the study, rates that were comparable to, if not slightly lower than, what was reported in the supportive therapy condition in which four children (6 %) and four adults (7 %) reported tic worsening. Third, there were no differences between the two treatment conditions in the number of children or adults who reported changes or initiation of tic medication during the study. Finally, there were no statistically significant differences between the two treatment conditions on any measure of co-occurring psychiatric and behavioral symptoms following treatment or at 6-month follow-up, and measures of ADHD, OCD, ODD, depression, and anxiety were all modestly improved at post-treatment in both treatment arms [54]. Collectively, the results of this investigation suggest that behavior therapy does not result in tic worsening nor does it confer increased risk for the onset or development of new tics and demonstrates the safety and tolerability of behavior therapy for TD.

Implementation Research

To address accessibility problems, research has begun to examine novel methods for implementing CBIT via new settings and new modalities. These efforts have examined two primary avenues: increasing the number and breadth of providers trained in administering behavior therapy for TD, and using technology to deliver CBIT remotely. Given that neurology and pediatric clinics are typically the first point of therapeutic contact for most patients with TD, training medical professionals who practice in these clinics to deliver behavior therapy is a potentially fruitful way to increase accessibility. However, time constraints and limitations on reimbursement are likely to prohibit a full course of treatment as described in published manuals [14] and commonly delivered in behavioral health clinics. A recently published case series demonstrated that an abbreviated CBIT protocol (referred to as CBIT-NP) could be effectively and feasibly delivered by nurse practitioners and physicians practicing in neurology and developmental pediatric clinics [55•]. In this study, 14 youth (ages 9–17) with TD received 4–6 sessions of CBIT delivered over 6–8 weeks, with each session lasting 20–25 min. Of the nine participants who completed at least four treatment sessions, five were rated as treatment responders by independent evaluators, using ratings of "very much improved" or "much improved" on the Clinician's Global Impressions Improvement Scale as the criterion for responder status. Patient and parent satisfaction ratings with CBIT-NP were high. However, even with the abbreviated protocol, time constraints remained a burden to implementation. Poor patient adherence to treatment was also reported to be a problem in some cases. Another study evaluated the efficacy of CBIT delivered by occupational therapists trained in CBIT [56]. In this study, 30 children (ages 7–19) with TD received eight sessions of standard CBIT. A significant reduction in the number of tics, overall tic severity, and subjective discomfort from tics was observed. In addition, significant improvements were noted across various occupational domains, such as the ability to complete schoolwork, socialize, and complete basic activities of daily living. These findings are encouraging, but more work is needed to determine how to best modify the CBIT protocol to enhance feasibility and improve adoption across various practice settings while also maintaining the integrity of the treatment.

A second emerging area of implementation research is the use of technology to deliver CBIT to those who do not have access to a trained CBIT therapist in their area. A recent randomized controlled pilot trial with 20 youth with TD compared CBIT delivered face-to-face (F2F) to CBIT delivered via high-speed videoconference [57, 58]. In this study, videoconference patients traveled to a local clinic and interfaced with a clinician in a remote location via specialized telehealth equipment. That study found that both delivery modalities were equally efficacious, with both groups showing reductions in tic severity similar to what was observed in the child CBIT trial and treatment gains were maintained at 1-month follow-up. In addition, patient and parent acceptability ratings for both delivery modalities were high and comparable across groups. Another study tested another telehealth model that even further reduced travel burden for patients, by having them attend sessions from their homes via their personal computers. This randomized waitlist-controlled trial with 20 youth with TD examined the efficacy and acceptability of CBIT delivered remotely into the patients' homes using voice over internet protocol (VoIP) [59]. Significantly greater reductions in clinician- and parent-rated tic severity were observed in the CBIT VoIP condition relative to waitlist. However, only one third of those receiving CBIT-VoIP were rated as treatment responders, which is lower than the response rate reported in the large CBIT child trial [41••]. Patient and parent satisfaction with VoIP delivery were high; however, the authors noted that the study therapists experienced audio-visual difficulties and challenges with respect to patient distraction that might have impacted the effectiveness of treatment. Finally, the first author and his colleagues are currently testing the efficacy of an interactive, self-guided, online CBIT program, called Tichelper.com, in a randomized controlled trial. Results are forthcoming.

Conclusion

The past decade has seen an exciting, exponential growth in the evidence supporting the utility of behavior therapy for TD. Recent research has firmly established the efficacy of behavioral interventions, allayed concerns about untoward side effects, and provided insights into contextual and neural variables that influence symptom expression. So, where to now in the next decade? Much work remains to be done. Basic science research efforts are needed to more fully elucidate the processes that underlie TD. Applied research is needed to go beyond showing that behavior therapy for TD works, but also showing how it can be brought to scale and have maximum public health impact. Moreover, bidirectional translation between basic behavioral and neuroscientific findings and applied research will likely lead to novel and more effective treatments going forward.

Compliance with Ethical Standards

Conflict of Interest Dr. Himle has received grants from the National Institutes of Health and the Tourette Association of America. Dr. Capriotti reports grants from the American Academy of Neurology, outside of the submitted work.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 5th ed. Washington, DC: American Psychiatric Association; 2013.
2. Robertson MM, Eapen V, Cavanna AE. The international prevalence, epidemiology, and clinical phenomenology of Tourette syndrome: a cross-cultural perspective. J Psychosom Res. 2009;67:475–83.
3. Shprecher DR, Rubenstien LA, Gannon K, Frank S, Kurlan R. Temporal course of the Tourette syndrome clinical triad. Tremor Other Hyperkinet Mov. 2014;4:243.
4. Shprecher DR, Gannon K, Agarwal N, Shi S, Anderson JS. Elucidating the nature and mechanism of tic improvement in Tourette syndrome: a pilot study. Tremor Other Hyperkinet Mov. 2014;4:217.
5. Conelea CA, Woods DW, Zinner SH, et al. Exploring the impact of chronic tic disorders on youth: results from the Tourette Syndrome Impact Survey. Child Psychiatry Hum Dev. 2011;42:219–42.
6. Storch EA, Merlo LJ, Lack C, et al. Quality of life in youth with Tourette's syndrome and chronic tic disorder. J Clin Child Adolesc Psychol. 2007;36:217–27.
7. State MW. The genetics of Tourette disorder. Curr Opin Genet Dev. 2011;21:302–9.
8. Ganos C, Roessner V, Munchau A. The functional anatomy of Gilles de la Tourette syndrome. Neurosci Beiobehav Rev. 2013;37:1050–62.
9. Shprecher DR, Kious BM, Himle MB. Advances in mechanistic understanding and treatment approaches to Tourette syndrome. Discov Med. 2015;20:295–301.
10. Shprecher DR, Schrock L, Himle MB. Neurobehavioral aspects, pathophysiology, and management of Tourette syndrome. Curr Opin Neurol. 2014;27:484–92.
11. Verdellen C, van de Griendt J, Hartmann A, Murphy T. European clinical guidelines for Tourette syndrome and other tic disorders. Part III: behavioural and psychosocial interventions. Eur Child Adolesc Psychiatry. 2011;20:197–207.
12. Steeves T, McKinlay BD, Gorman D, et al. Canadian guidelines for the evidence-based treatment of tic disorders: behavioural therapy, deep brain stimulation, and transcranial magnetic stimulation. Can J Psychiatry. 2012;57:144–51.
13. Murphy TK, Lewin AB, Storch EA, Stock S. Practice paramers for the assessment and treatment of children and adolescents with tic disorder. J Am Acad Child Adolesc Psychiatry. 2013;52:1341–59.
14. Woods DW, Piacentini J, Chang S, et al. Managing Tourette Syndrome: A Behavioral Intervention for Children and Adults. New York: Oxford University Press; 2008.
15. Azrin NH, Nunn RG. Habit reversal: a method of eliminating nervous habits and tics. Behav Res Ther. 1973;4:619–28.
16. Bullen JG, Hemsley DR. Sensory experiences as a trigger in Gilles de la Tourette's syndrome. J Behav Ther Exp Psychiatry. 1983;14:197–201.
17. Verdellen CW, Keijsers GP, Cath DC, Hoogduin CA. Exposure with response prevention versus habit reversal in Tourette's syndrome: a controlled study. Behav Res Ther. 2004;42:501–11.
18. Evers RAF, va de Wetering BJM. A treatment model for motor tics based on a specific tension reduction technique. J Behav Ther Exp Psychiatry. 1994;25:255–60.
19. Crossley E, Seri S, Stern JS, Robertson MM, Cavanna AE. Premonitory urges for tics in adult patients with Tourette syndrome. Brain Dev. 2014;36:45–60.
20. Woods DW, Piacentini JP, Himle MB, Chang S. Premonitory urge for tics scale (PUTS): initial psychometric results and examination of the premonitory urge phenomenon in youths with tic disorders. J Dev Behav Pediatr. 2005;26:397–403.
21. Van de Griendt JMTM, Verdellen CWJ, van Dijk MK, Verbraak MJPM. Behavioural treatment of tics: habit reversal and exposure with response prevention. Neurosci Biobehav Rev. 2013;37:1172–7.
22. Kaczkurkin AN, Foa EB. Cognitive-behavioral therapy for anxiety disorders: an updated on the empirical evidence. Dialogues Clin Neurosci. 2015;17:337–46.
23. •• Himle MB, Capriotti MR, Hayes LP, et al. Variables associated with tic exacerbation in children with chronic tic disorders. Behav Modif. 2014;38:163–83. **Study examining contextual antecedents and consequences shown to exacerbate tics in treatment-seeking children with TD. Such factors are important targets for intervention within the CBIT model**.
24. Hoekstra PJ, Dietrich A, Edwards MJ, Elamin I, Martino D. Environmental factors in Tourette syndrome. Neurosci Biobehav Rev. 2013;37:1040–9.
25. Woods DW, Himle MB. Creating tic suppression: comparing the effects of verbal instruction to differential reinforcement. J Appl Behav Anal. 2004;37:417–20.
26. Green DJ, Koller JM, Robichaux-Viehoever A, Bihun EC, Schlaggar BL, Black KJ. Reward enhances tic suppression in children within months of tic disorder onset. Dev Cog Neurosci. 2015;11:65–74.
27. Himle MB, Woods DW, Conelea CA, Bauer CC, Rice KA. Investigating the effects of tic suppression on premonitory urge ratings in children and adolescents with Tourette's syndrome. Behav Res Ther. 2007;45:2964–76.
28. • Capriotti MR, Brandt BC, Turkel JE, Lee HJ, Woods DW. Negative reinforcement and premonitory urges in youth with Tourette syndrome: an experimental evaluation. Behav Modif. 2014;38:276–96. **An experimental study showing that premonitory urge ratings increase prior to tics and decrease when tics are performed. Provides preliminary direct evidence for the negative reinforcement model of tics**.
29. • Brandt VC, Beck C, Sajin V, et al. Temporal relationship between premonitory urges and tics in Gilles de la Tourette syndrome. Cortex. 2016;77:24–37. **Experimental study demonstrating the temporal connection between tics and urges, supporting the negative reinforcement model. One of the first studies to examine the temporal relationship between tics and urges using continuous recording**.
30. Ganos C, Kahl U, Schunke O, et al. Are premonitory urges a prerequisite of tic inhibition in Gilles de la Tourette syndrome? J Neurol Neurosurg Psychiatry. 2012;83:975–8.
31. Specht MW, Nicotra CM, Kelly LM, et al. A comparison of urge intensity and the probability of tic completion during tic freely and tic suppression conditions. Behav Modif. 2014;38:297–318.
32. Brabson LA, Brown JL, Capriotti MR, et al. Patterned changes in urge ratings with tic suppression in youth with chronic tic disorder. J Behav Ther Exp Psychiatry. 2016;50:162–70.
33. McGuire JF, Piacentini J, Scahill L, et al. Bothersome tics in patients with chronic tic disorders: characteristics and individualized treatment response to behavior therapy. Behav Res Ther. 2015;70:56–63.
34. Specht MW, Wood DW, Nicotra CM, et al. Effects of tic suppression: ability to suppress, rebound, negative reinforcement, and habituation to the premonitory urge. Behav Res Ther. 2013;51:24–30.
35. Hefferline RF, Keenan B, Harford RA. Escape and avoidance conditioning in human subjects without their observation of the response. Science. 1959;130:1338–9.

36. Conelea CA, Woods DW. The influence of contextual factors on tic expression in Tourette's syndrome: a review. J Psychosom Res. 2008;65:487–96.
37. Silva RR, Munoz DM, Barickman J, Friedhoff AJ. Environmental factors and related fluctuation of symptoms in children and adolescents with Tourette's disorder. J Child Psychol Psychiatry. 1995;36:305–12.
38. Capriotti MR, Piacentini JC, Himle MB, et al. Assessing environmental consequences of ticcing in youth with chronic tic disorders: The Tic Accommodation and Reactions Scale. Child Health Care. 2015;44:205–20.
39. Eaton CK, Jones AM, Gutierrez-Colina AM, et al. The influence of environmental consequences and internalizing symptoms on children's tic severity. Child Psychiat Hum Dev. 2016; epub ahead of print
40. Himle MB, Woods DW, Piacentini JC, Walkup JT. Brief review of habit reversal training for Tourette syndrome. J Child Neurol. 2006;21:719–25.
41.•• Piacentini J, Woods DW, Scahill L, et al. Behavior therapy for children with Tourette disorder. JAMA. 2010;303:1929–37. **A multi-site randomized controlled trial comparing CBIT to supportive therapy for children with TD. This study demonstrated the efficacy and safety of CBIT for reducing tics in children with TD as well as strong maintenance of treatment gains at 1-year follow-up**.
42.•• Wilhelm S, Peterson AL, Piacentini J, et al. Randomized trial of behavior therapy for adults with Tourette syndrome. Arch Gen Psychiatry. 2012;20:197–207. **A multi-site randomized controlled trial comparing CBIT to supportive therapy in a large sample of adults with TD. This study demonstrated the efficacy and safety of CBIT for reducing tics in adults with TD well as strong maintenance of treatment gains at 1-year follow-up**.
43. Jeon S, Walkup JT, Woods DW, et al. Detecting a clinically meaningful change in tic severity in Tourette syndrome: a comparison of three methods. Contemp Clin Trials. 2013;36:414–20.
44.• McGuire JF, Piacentini JP, Brennan EA, et al. A meta-analysis of behavior therapy for Tourette syndrome. J Psychiatr Res. 2014;50:106–12. **A recent meta-analysis of treatment outcome studies with a total of 438 participants with TD showing behavior therapy to be associated with a moderate to large effect size**.
45. Bate KS, Malouff JM, Thorsteinsson ET, Bhullar N. The efficacy of habit reversal therapy for tics, habit disorders, and stuttering: a meta-analytic review. Clin Psychol Rev. 2011;31:865–71.
46.• Deckersbach T, Chou T, Britton JC, et al. Neural correlates of behavior therapy for Tourette's disorder. Psychiatry Res. 2014;224:269–74. **One of the only studies to date to use fMRI to examine brain changes associated with behavior therapy for TD**.
47. Wright CI, Keuthen NJ, Savage CR, et al. Brain correlates of negative and positive visuospatial priming in adults. Neuroimage. 2005;30:983–91.
48. Morand-Beaulieu S, O'Connor KP, Sauve G, Blanchet PJ, Lavoie ME. Cognitive-behavioral therapy induces sensorimotor and specific electrocortical changes in chronic tic and Tourette's disorder. Neuropsychologia. 2015;79:310–21.
49. Woods DW, Conelea CA, Himle MB. Behavior therapy for Tourette's disorder: utilization in a community sample and an emerging area of practice for psychologists. Prof Psychol Res Pr. 2010;41:518–25.
50. Freeman RD, Fast DK, Burd L, Kerbeshian J, Robertson MM, Sandor P. An international perspective on Tourette syndrome: selected findings from 3500 individuals in 22 countries. Dev Med Child Neurol. 2000;42:436–47.
51. Burd L, Kerbeshian J. Treatment-generated problems associated with behavior modification in Tourette disorder. Dev Med Child Neurol. 1987;29:831–3.
52. Scahill L, Woods DW, Himle MB, et al. Current controversies on the role of behavior therapy in Tourette syndrome. Mov Disord. 2013;28:1179–83.
53.• Peterson AL, McGuire JF, Wilhelm S, et al. An empirical examination of symptom substitution associated with behavior therapy for Tourette's disorder. Behav Ther. 2016;47:29–41. **Secondary analysis of data from the adults and child CBIT studies showing that behavior therapy was not associated with adverse side effects in children and adults with TD**.
54. Woods DW, Piacentini JC, Scahill L, et al. Behavior therapy for tics in children: Acute and long-term effects on psychiatric and psychosocial functioning. J Child Neurol. 2011;26:858–65.
55.• Ricketts EJ, Gilbert DL, Zinner SH, et al. Pilot testing behavior therapy for chronic tic disorders in neurology and developmental pediatric clinics. J Child Neurol. 2015;31:444–50. **A pilot study examining an abbreviated CBIT protocol administered in neurology and pediatric clinics showing the abbreviated protocol to be effective for reducing tics and generally acceptable to patients and physicians**.
56. Rowe J, Yuen HK, Dure LS. Comprehensive behavioral intervention to improve occupational performance in children with Tourette disorder. Am J Occup Ther. 2013;67:194–200.
57. Himle MB, Olufs E, Himle J, Tucker BTP, Woods DW. Behavior therapy for tics via videoconference delivery: an initial pilot test in children. Cog Behav Prac. 2010;17:329–37.
58. Himle MB, Freitag M, Walther M, Franklin SA, Ely L, Woods DW. A randomized pilot trial comparing videoconference versus face-to-face delivery of behavior therapy for childhood tic disorders. Behav Res Ther. 2012;50:565–70.
59. Ricketts EJ, Goetz AR, Capriotti MR. A randomized waitlist-controlled pilot trial of voice over internet protocol-delivered behavior therapy for youth with chronic tic disorders. J Telemed Telecare. 2015;22:153–62.