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Clinical Features of Tourette Syndrome and Tic Disorders

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Abstract

Background: Tourette syndrome (TS) is a neurodevelopmental disorder characterized by motor and vocal tics--rapid, repetitive, stereotyped movements or vocalizations lasting at least one year in duration. The goal of this article was to review the long-term clinical course of tics and frequently co-occurring conditions in children with TS.

Methods: We conducted a traditional literature search to locate relevant articles regarding long-term outcome and prognosis in TS and tic disorders.

Results: Tics typically have an onset between the ages of 4 and 6 years and reach their worst-ever severity between the ages of 10 and 12 years. By age 10 years, most children are aware of nearly irresistible somatosensory urges that precede the tics. A momentary sense of relief typically follows the completion of a tic. Over the course of hours, tics occur in bouts, with a regular inter-tic interval. Tics increase during periods of psychosocial stress, emotional excitement and fatigue. Tics can become “complex” in nature and appear to be purposeful. Tics can be willfully suppressed for brief intervals and can be evoked by the mere mention of them. Tics typically diminish during periods of goal-directed behavior. Over the course of months, tics wax and wane. By early adulthood, roughly three-quarters of children with TS will have greatly diminished tic symptoms and more than one-third will be virtually tic free.

Conclusion: Although tics are the defining aspect of TS, they are often not the most enduring or impairing symptoms in children with TS. Indeed in TS tics rarely occur in isolation, and other coexisting conditions--such as behavioral disinhibition, hypersensitivity to a broad range of

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sensory stimuli, problems with visual motor integration, procedural learning difficulties, attention-deficit hyperactivity disorder, obsessive-compulsive disorder, depression, anxiety, and emotional instability--are often a greater source of impairment than the tics themselves. Measures used to enhance self-esteem, such as encouraging independence, strong friendships and the exploration of interests, are crucial to ensuring positive adulthood outcome.

I finally apprehend the magnitude of the background noise that I have been experiencing for decades... the people around me do not share my tics because they do not hear the drumbeat. They do not feel the sensations without sources, do not have irresistible urges to pause in midsentence, do not receive strict internal commands to trace with their eyes in midair the shape of each of Aristotle's regular solids, and so on in endless, bewildering variety... Finally and most important, I feel convinced that this complex challenging enigmatic internal world is the obvious core of Tourette's [1].

Tic disorders have been the subject of speculation for at least 300 years. In the past 25 years, Tourette syndrome (TS) has come to be recognized as a model developmental disorder occupying the nexus of neurology and psychiatry [2]. TS is a childhood-onset neuropsychiatric disorder characterized by multiple motor and vocal tics that last at least a year in duration [3]. Once thought to be a rare condition, TS is known to affect four to six in every 1000 children [5–8]. Transient tic disorder, characterized by tics that are present for less than a year in duration, and chronic tic disorders, which are characterized by either motor or vocal tics, but not both, have a prevalence of approximately 20% and 5%, respectively, in children [5–8]. Individuals with TS commonly experience comorbid psychiatric disorders such as attention-deficit hyperactivity disorder (ADHD) and obsessive-compulsive disorder (OCD) [4–12]. These comorbid conditions often cause more impairment in individuals with TS than the tics themselves.

The purpose of this article is to review the clinical course of individuals with TS. We begin by focusing on the nature and course of tic symptoms in TS, then focus on the clinical course of common comorbid conditions and finish by discussing the adulthood global functioning and psychosocial outcome of children with TS [13]. The conclusion will summarize, for clinicians, the prognostic information we use to explain the expected clinical course of TS to families seeking evaluation in our clinic.

Tic symptoms

A tic is a sudden, repetitive, non-rhythmic, stereotyped motor movement or vocalization involving discrete muscle groups [10]. Tics can be described based on their anatomical location, number, frequency, and duration [14]. Another useful descriptor is the intensity or "forcefulness" of the tic, as some tics call attention to themselves simply by virtue of their exaggerated, forceful character [14]. Tics can also be described in terms of their "complexity" [14]. Complexity refers to how simple or involved a movement or sound is, ranging from brief, meaningless, abrupt fragments (simple tics) to ones that are longer, more involved, and seemingly more purposive in character (complex tics). Simple tics are sudden, brief (usually less than 1 second in duration), meaningless movements or sounds. Complex tics are sudden, more purposive appearing, stereotyped movements of longer duration that

can include “orchestrated” combinations of motor or vocal or motor and vocal tics. The observed range of tics is extraordinary, so that virtually any voluntary motor movement or vocalization can emerge as a tic.

Tics usually have their onset in the first decade of life around the age of 4–6 years with simple motor movements such as eye blinking, nose twitching, or facial grimaces [10]. Motor tics usually progress in a rostrocaudal direction with time [15]. Vocal tics, when they appear, typically first manifest themselves a year or two after the onset of motor tics [15]. Vocal tics begin as simple vocalizations such as throat clearing, sniffing, or fractions of words [15].

Many TS patients experience premonitory urges [16, 17]. A premonitory urge is a sensory phenomenon that occurs immediately prior to a tic, similar to the need to sneeze or scratch an itch [16, 17]. Individuals often describe the need to tic as the buildup of tension, usually in the body location where the tic is about to occur, but in some individuals the tension occurs throughout the body [16, 17]. Depending on the intensity of the urge the individual may consciously decide to tic or not to tic. However, if the urge is very strong, it can be impossible to resist. The actual tic may be felt as relieving this tension or sensation, similar to scratching an itch. After a tic is done, there is often a fleeting and incomplete sense of relief. Awareness of premonitory urges increases with age and is present in as many as 90% of adolescents with TS [16, 17]. Gaining an awareness of these difficult to describe premonitory urges lies at the heart of habit reversal training which has proven to be one of the most efficacious treatments for TS [18, 19].

During the course of a day tic symptoms of TS generally occur in bouts and over weeks to months they wax and wane in severity [9, 20]. Factors such as psychosocial stress, excitement, anxiety, social events and fatigue are known to exacerbate tics in the moment and psychosocial stress has been shown to be predictive of future tic severity [21–24]. However, for many individuals, focused concentration, especially involving fine-motor control such as playing a musical instrument, dancing, or playing sports, can lead to a marked reduction of tics [10]. Many TS patients are able to temporarily suppress tics, but often at the expense of concentration and exhaustion [10]. As children get older they typically develop a greater ability to suppress tics [10]. Interestingly, recent studies suggest that environments conducive to tic suppression result in reduced tic frequency without adverse consequences or a rebound in tic frequency or severity [25].

When Georges Gilles de la Tourette originally described the clinical syndrome that now bears his name, tics were hypothesized to be persistent and lifelong; our current knowledge suggests this is generally not the case [13, 15, 26, 27]. Tics typically emerge around the age of 4–6 years, reach their worst ever point early in the second decade of life, and then, on average, improve during adolescence [13, 15, 26]. Fig. 1 demonstrates the clinical course of tic severity in two cohorts of 42 and 46 children, respectively, with TS followed until early adulthood [15, 26].

Fig. 2 describes the early adulthood tic outcome of more than 80 children followed from initial evaluation (average age 11 years) to follow-up in young adulthood [15, 26]. Over one-

third of children with TS were completely tic free at follow-up, slightly less than half had minimal to mild tics, and less than a quarter had moderate or greater tics at follow-up. These results contrast to their worst ever period when all individuals experienced at least a moderate level of tic severity. Less than 5% of individuals reported experiencing worse tics in early adulthood than during their childhood. Similar results of tic improvement have been reported in a large cohort of children with tics and co-occurring ADHD [28].

Based on the results of a longitudinal follow-up study of 65 individuals with TS and 65 matched community controls without tic or OCD symptoms, higher levels of tic severity in late adolescence are associated with lower levels of global functioning [29]. Tic severity was also associated with higher internalizing, externalizing, and total problems scores on the Child Behavior Checklist [29, 30]. Individuals with more severe tic severity at age 18 years were also more likely to have co-occurring OCD [29].

Demographic and clinical data, the results of neuropsychological testing, and findings from structural neuroimaging studies obtained in childhood have been assessed to determine whether any of these variables are predictive of tic severity as assessed early in adulthood. In general, childhood clinical characteristics are rather poor determinants of future adulthood tic severity, with only current tic severity in early adolescence being weakly associated with tic severity in early adulthood [26]. Worst ever tic severity and the presence of comorbid illnesses in childhood were not associated with tic severity in adulthood [26]. Poor fine-motor skills in childhood, as measured by the Purdue Pegboard test, were associated with increased adulthood tic severity [31]. Smaller caudate volume on childhood MRI scans was also associated with increased adulthood tic severity [32]. Childhood structural neuroimaging and neuropsychological testing data, although not robust enough to be a useful clinical prognosticator of outcome, does suggest that there may be specific neuropathological processes associated with persistent TS into adulthood. Attention has focused on abnormalities within cortico-striatal-thalamo cortical circuits, possibly involving inhibitory interneurons within the basal ganglia [33, 34]. A full review of the neuropathology and pathophysiology of TS is beyond the scope of this article but has been reviewed in depth elsewhere [35–38].

The usual improvement of tic symptoms over the course of adolescence has significant implications for the use of behavioral, pharmacological, and neurosurgical treatments in children with TS. For example, although modestly effective pharmacological treatments for TS (i.e., alpha-2 agonists and antipsychotics) are typically used to reduce impairing tic symptoms, there is no evidence that suggests that these pharmacological treatments alter the long-term course of TS. In the absence of ideal anti-tic medications that could eliminate tics and given the significant potential side effects of the pharmacological agents typically prescribed (such as weight gain on the atypical neuroleptics), these agents should only be administered when a child presents with persistent and significantly impairing tics. In contrast, behavioral interventions such as Comprehensive Behavioral Intervention for Tics (CBIT) should be offered to all patients with impairing tics [39]. It is also important to encourage families to keep their child's development on track. This often involves psychoeducational interventions with the child, their families, peers and school personnel as well as encouraging the child to participate in developmentally appropriate activities (sports

activities, school plays, etc) despite the presence of overt tic symptoms [40]. Finally, more invasive interventions for TS such as deep brain stimulation and neurosurgery are strongly discouraged until well into adulthood, even for patients with impairing tics. This recommendation is made because many children's tics will improve with time regardless of treatment. A full review of the available treatments for TS is beyond the scope of this review but has been described well elsewhere [39–41].

Comorbid conditions

Attention-deficit hyperactivity disorder.

In epidemiologic samples, greater than half of individuals with TS experience comorbid ADHD [7]. The rates are much lower among children with chronic motor or vocal tic disorder [7]. The prevalence of ADHD in patients with TS who reach clinical attention may be even higher [11, 29]. Based on the results of a longitudinal follow-up study of 65 individuals with TS and 65 matched community controls without tic or OCD symptoms, higher levels of ADHD severity in late adolescence are associated with a significantly lower level of global functioning [29]. ADHD severity was also associated with higher internalizing, externalizing, and total problems scores on the Child Behavior Checklist [29, 30] as well as the Socialization domain of the Vineland [42]. Individuals with more severe ADHD severity at age 18 years were also more likely to have co-occurring learning disorders [29].

Neuropsychological studies of children and adolescents with both TS and ADHD showed a similar increase in errors of omission and in the variability of their reaction times on the Conner's Continuous Performance Task [43] compared to children with TS-only and unaffected controls [44]. On other neuropsychological tests including the Stroop Color-Word Interference Test [45], the Beery Visual-Motor Integration Test [46], and the Purdue Pegboard Test [47], the ADHD alone group showed significant deficits relative to the normal controls. The TS alone and the TS plus ADHD groups were intermediate in their performance but these differences were not significant. When ADHD is present in individuals with TS, the ADHD symptoms typically precede the onset of tic symptoms and are often associated with greater problems with self-esteem, peer acceptance, and academic achievement than the tics themselves [48]. Not surprisingly, comorbid ADHD symptoms in childhood have been associated with a decreased quality of life and global functioning in early adulthood for individuals with TS [5, 9, 49–53]. Unfortunately, studies examining the long-term clinical course of ADHD, specifically in individuals with comorbid tics, are quite limited [28]. In the general ADHD population, however, it has been shown that the hyperactivity symptoms of ADHD generally improve during adolescence, whereas the inattention symptoms of ADHD often persist into adulthood [54].

Pharmacological treatment of ADHD in children with TS is recommended [9, 54–56]. For example, a study conducted by the Tourette Syndrome Study Group demonstrated that both clonidine, an alpha-2 adrenergic agonist, and methylphenidate, a psychostimulant, are effective treatments for ADHD in individuals with comorbid tics [55–57]. Case reports and clinical observations have suggested that stimulants may exacerbate tic symptoms in some individuals with TS [58]. For this reason, the pharmaceutical companies and FDA-approved

package inserts currently list tic symptoms as a contraindication to the use of most psychostimulant medications. However, evidence from randomized clinical trials in children with comorbid tics suggests that methylphenidate typically does not cause an increase in tic severity [55–57]. However, clinical experience and limited experimental evidence suggest that the use of amphetamine derivatives to treat ADHD may exacerbate tics, particularly when used at higher doses [59]. It is also of interest that alpha-2 agonists are most effective in treating tics when ADHD is present as a co-morbid condition [57].

Obsessive-compulsive disorder.

Roughly one-third to one-half of children with TS will experience comorbid OCD throughout their lifetime [9, 12]. Symptoms of OCD that are subclinical in severity are even more common. OCD symptoms in patients with TS often begin around the time that the tics reach their worst ever point, but symptoms can also appear *de novo* in later adolescence or adulthood. OCD patients with comorbid tics tend to have greater rates of symmetry obsessions, and counting, repeating, ordering, and arranging compulsions than pediatric-onset OCD patients without comorbid tic symptoms [60–62]. Based on the results of a longitudinal follow-up study of 65 individuals with TS and 65 matched community controls without tic or OCD symptoms, higher levels of OCD severity in late adolescence are associated with a significantly lower level of global functioning [29]. OCD severity was also associated with higher internalizing, externalizing, and total problems scores on the Child Behavior Checklist [29, 30] as well as the Socialization domain of the Vineland [41]. Individuals with greater OCD severity at age 18 years were also more likely to have co-occurring anxiety disorders and Conduct disorder [29].

Tic-related OCD has many distinctive features when compared to non-tic related OCD [60]. For example, children with OCD and comorbid tics are likely to have a worse response to selective-serotonin reuptake inhibitors (SSRIs) than children without comorbid tics [62]. In contrast, children with OCD, with or without comorbid tics, appear to have a similar response to cognitive behavioral therapy [62]. Another treatment option for OCD patients with comorbid tics is antipsychotic medication. A meta-analysis of antipsychotic augmentation trials for treatment refractory OCD suggests that OCD patients with comorbid tics on an SSRI may have an improved response to this intervention [63]. Long-term outcome studies of children with TS suggest that increased IQ and smaller caudate nucleus volumes on structural MRI scans obtained in childhood may be associated with increased OC symptoms in early adulthood [64]. Adulthood outcome studies suggest that childhood OCD patients with comorbid tics may have an increased likelihood of remission of OCD symptoms by adulthood [64]. These data suggest that OC symptoms in children with OCD and comorbid tics may follow a similar developmental trajectory to the tics themselves [65]. However, it is also important to note that among adults with persistent TS, comorbid OCD has been associated with higher levels of other comorbidity (ADHD, body dysmorphic disorder, trichotillomania, social phobia, substance use disorder) but not more severe tic symptoms [66].

Other comorbid conditions.

Children with TS have higher rates of comorbid developmental disorders including Autism Spectrum Disorders (ASD), learning disorders, disruptive behavior disorders, and major depression than the general population [8, 9, 24, 67]. In children with both ASD and TS it is not uncommon to observe motor stereotypies as well as motor and vocal tics. The symptoms of these comorbid conditions typically appear prior to the time that tics reach clinical attention. When present, aggressive treatment of these conditions is warranted. Higher rates of restless legs syndrome and migraines have also been reported although the etiological links across these disorders remains in doubt [68–70]. Currently, there is no evidence to suggest that the recommended treatment of these conditions should differ between individuals with and without comorbid tic disorders. Explosive rage attacks can be particularly challenging in individuals with TS, but therapies such as parent management training and anger control training, which are effective in the general population, are also effective in TS [71–73]. Children with TS experience comorbid depressive and anxiety disorders during the course of adolescence and early adulthood more frequently than unaffected controls [26, 29, 48–53]. Roughly 60% of children with TS will experience one or more episodes of major depression and 40% will meet criteria for a non-OCD anxiety disorder [29]. Children with TS and their parents should be educated to recognize the signs and symptoms of these conditions. These conditions are even more sensitive to increases in psychosocial stress than is TS [21]. Finally, a variety of post infectious autoimmune conditions including Sydenham's chorea [74], and pediatric neuropsychiatric disorders associated with streptococcal infections (PANDAS) [75], can present as new onset tic disorders. Although GABHS infections have been postulated as the main initial autoimmune response inciting event contributing to the sudden onset of tics and other neuropsychiatric symptoms in a subgroup of patients, it is well documented that sudden tic symptom onset or worsening can be triggered by other infectious agents (e.g., herpes simplex virus, varicella zoster virus, human immunodeficiency virus, *Borrelia burgdorferi*, *Mycoplasma pneumoniae*, sinusitis, and the common cold) [76]. This remains a controversial field, but the onset of tics in these cases is typically very sudden (overnight) and the tics are accompanied by the sudden onset of three or more other neuropsychiatric symptoms (including: a markedly increased level of anxiety, emotional lability, irritability, aggressive behavior, sudden difficulties with concentration or learning, developmental regression [loss of abilities], sleep difficulties, and urinary frequency and/or an increased urge to urinate) [77].

What parents need to know

Table 1 presents some of the key psychoeducational points that we typically convey to families when evaluating and treating children with TS [40]. In addition, educating peers and teachers about TS can also help a child become a 'self-advocate' and not feel ashamed of having a limited ability to control their tics. In our view, the sensory component of tics, the premonitory urges, is an essential ingredient in understanding TS. It is also a key element of Habit Reversal Training [18, 19]. Likewise, reviewing the natural history of TS (Fig. 1 & 2) and noting that the tics typically diminish considerably by the end of the second decade of life is another important point to emphasize. Indeed, more than three-quarters of children with significant childhood tic symptoms will experience fewer and/or less severe tics in early

adulthood and over one-third will be completely tic free in adulthood. It is also worth noting that tics often disappear during the performance of familiar tasks that require focused attention and motor control such as playing a musical instrument, playing sports, or dancing. Such activities can be beneficial in general and can help children persevere through particularly challenging bouts of tics. Inquiring about and supporting a child's strengths, interests, and independence is a key task of clinicians that will potentially ensure the best long term outcomes. Another key issue is that a greater proportion of children with TS experience developmental disorders, ADHD, learning disorders, and disruptive behavioral disorders than among the general population. Symptoms of these conditions generally precede the onset of tics. Given this high rate of co-occurrence, families need to know that the social, emotional, and academic outcomes in adulthood are not synonymous with tic outcomes. Although tics usually diminish by early adulthood, this is not always the case. As a result patients and families need to know that many adults with TS live happy, accomplished lives despite having persistent tic symptoms. It is also important to recognize that persistent severe tic symptoms, even after controlling for comorbid ADHD, are associated with lower levels of global functioning and higher levels of internalizing and externalizing problems [29]

Unanswered questions, an agenda for future research

Although the phenomenology and natural history of TS and tic disorders is reasonably well established, more work needs to be done. In terms of measurement the Yale Global Tic Severity Scale (YGTSS) has emerged as the gold standard with excellent psychometric properties [14, 78–80]. However, it has its limitations. Originally designed to apply to all individuals with any tic disorder, it is most widely used in clinical trials and in cross-sectional studies of children and adults with TS as opposed to population-based studies. As a result, the distribution of YGTSS scores in most of the clinical trials are skewed. This is most apparent in the 'Number' and 'Frequency' domains of the YGTSS [14]. Although the motor and vocal tics form separate factors [10,79], a single tic severity rating on the YGTSS may make more sense [81]. In addition, it is probable that monitoring the moment-to-moment patterns of intertic intervals may advance our understanding of the waxing and waning pattern of tics [20]. Other useful scales include the PUTS [17] and the TS Diagnostic Confidence Index [82]. It is likely that the intensity of premonitory urges as measured by the subjective ratings on the PUTS may be positively associated with the levels of activation in the insula, anterior cingulate, supplementary motor area, and the primary somatosensory cortex. Activations in these areas are known to precede and accompany tic onset [83, 84]

Other enduring questions concern 'why.' Why do tics emerge when they do? Why do motor tics typically precede vocal tics? Why is there a rostral→caudal progression of tic symptoms? Why are the vast majority of tic disorders transient or limited to a chronic motor tic disorder [5–7]? Why does psychosocial stress, emotional excitement, and fatigue impact tic severity [21–24]? Why do tics remit, or at least improve dramatically, in most individuals by the end of the second decade of life [13, 15 26]? Why do ADHD and tic-related OCD occur as commonly as they do [4, 11, 12, 29]? Why are these disorders so much more common in individuals with TS versus a chronic motor tic disorder [7]? What about restless legs syndrome and migraines [69–71]? Here genetic [36, 84–87], neuropathological [33, 34,

88–91], neurophysiological [92], and neuroimaging studies [35, 83, 84, 92] combined with emerging animal models [93–98] and the study of TS patient-specific induced pluripotent stem cells [99] may finally yield definitive answers.

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A.

B.

Figure 1. Course of Tic Severity over the First Two Decades.

A. Data on the relative severity of tics are presented for 42 individuals with Tourette syndrome (A-D) [9]. The relative tic severity scale goes from 0 (no tics) to 5 (severe tics). Estimates from the patient and a respective parent were obtained independently.

B. Box plot representing age when tic disorder symptoms were at their worst (N=46) [16].

Figure 2. Tic Outcomes in Early Adulthood.

Tic severity in early adulthood (N=82). Adulthood tic severity class is defined by Yale Global Tic Severity Scale [Total Tic Score] (YGTSS): no tics (YGTSS: 0), minimal tics (YGTSS: 1–9), mild tics (YGTSS: 10–19), moderate or greater tics (YGTSS: 20). By contrast, all individuals had moderate or greater severity tics in childhood. Less than 5% of individuals reported having worse adulthood tics than in childhood. Adapted from Fig 2. in Bloch & Leckman [7].

Table 1:**Key Points**

- Tourette syndrome (TS) is best understood as both a sensory as well as a motor disorder characterized by a reduction in the normal “automatic” ability to suppress or “gate” irrelevant information in sensory and motor domains. One common manifestation is the presence of ‘premonitory urges’ that commonly precede the onset of tics.
- Tics wax and wane in severity over weeks to months. It is important not to chase every increase in tic severity with medication and search for a psychological or medical explanation for each exacerbation.
- Psychosocial and physical illness can make tics temporarily worse as does fatigue and emotional excitement. A predictable environment with appropriate sleep and hygiene is often beneficial to individuals with TS.
- Tics often disappear during the performance of familiar tasks that require focused attention and motor control such as playing a musical instrument, playing sports, or dancing. Such activities can be beneficial in general and can help children persevere through particularly challenging bouts of tics.
- Educating parents, siblings, peers, and teachers about TS can help a child become a ‘self-advocate’ and not feel ashamed of being unable to control their tics. Inquiring about and supporting a child’s strengths, interests, and independence is a key task of clinicians as that will ensure the best long term outcomes.
- As children get older they typically develop a greater ability to suppress tics. Environments conducive to tic suppression result in reduced tic frequency without adverse consequences or a rebound in tic frequency or severity.
- The worst ever tic symptoms usually occur between 8 and 12 years.
- At present, cognitive behavioral interventions should be considered the first-line treatment for persons with tic disorders
- Pharmacological treatments for tics should focus on minimizing impairment, not eliminating tics. There is, as yet, no evidence that pharmacological treatments alter the long-term clinical course of TS.
- Although tics, in some form, persist in the majority of cases well into adulthood, by the end of the second decade of life more than half of the individuals with TS will have minimal or no tics. Unfortunately those individuals whose tic severity remains elevated typically have a diminished level of global functioning.
- Given the high rate of co-occurring conditions such as Attention Deficit Hyperactivity Disorder and Obsessive-Compulsive Disorder, the social, emotional, and academic outcomes in adulthood are not synonymous with tic outcomes. Inquiring about and providing appropriate interventions for these disorders and other comorbid conditions is another key to achieving the best long term outcomes.
- Many adults with TS live happy, accomplished lives despite having persistent tic symptoms. This is typically achieved by building on skills and interests throughout development and by not letting the tic symptoms interfere with the emergence of an independent life trajectory.