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Homework Adherence Predicts Therapeutic Improvement from Behavior Therapy in Tourette's Disorder

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Abstract

Behavior therapy is a first-line intervention for Tourette's Disorder (TD), and a key component is the practice of therapeutic skills between treatment visits (i.e., homework). This study examined the relationship between homework adherence during behavior therapy for TD and therapeutic outcomes, and explored baseline predictors of homework adherence during treatment.

Participants included 119 individuals with TD (70 youth, 49 adults) who received behavior therapy in a clinical trial. After a baseline assessment of tic severity and clinical characteristics, participants received 8 sessions of behavior therapy. Therapists recorded homework adherence at each therapy session. After treatment, tic severity was re-assessed by independent evaluators masked to treatment condition.

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Greater overall homework adherence predicted tic severity reductions and treatment response across participants. Early homework adherence predicted therapeutic improvement in youth, whereas late adherence predicted improvement in adults. Baseline predictors of greater homework adherence in youth included lower hyperactivity/impulsivity and caregiver strain. Meanwhile in adults, baseline predictors of increased homework adherence included younger age, lower hyperactivity/impulsivity, obsessive-compulsive severity, anger, and greater work-related disability.

Homework adherence is an integral component of behavior therapy and linked to therapeutic improvement. Strategies that improve homework adherence may optimize the efficacy of behavioral treatments and improve treatment outcomes.

Keywords

Tics; Homework Adherence; Behavior Therapy; Comprehensive Behavioral Intervention for Tics

Introduction

Tourette's Disorder and persistent tic disorders (collectively referred to as TD) are neurodevelopmental conditions that affect almost 1% of the population (Scahill et al., 2014). For many individuals with TD, tics cause school/work difficulties, and social problems, emotional distress, and at times, physical pain (Conelea et al., 2011, 2013). Youth and adults with TD often experience co-occurring psychiatric conditions such as attention deficit/hyperactive disorder (ADHD), obsessive compulsive disorder (OCD), and anxiety disorders (Freeman et al., 2000). The combination of tics and associated psychiatric conditions can result in problems across multiple domains of functioning (e.g., school, work, social life, family functioning, negative self-view) and poor overall quality of life (Cloes et al., 2017; Conelea et al., 2011, 2013; Hanks et al., 2016; Storch et al., 2007). Thus, interventions to effectively manage TD bear considerable importance across the lifespan.

While TD has been historically managed with pharmacological treatments (Essoe et al., 2019), behavior therapy is an efficacious intervention for TD that yields large treatment effects across clinical trials (McGuire et al., 2014; Piacentini et al., 2010; Wilhelm et al., 2012), and has shown some secondary benefit on co-occurring psychiatric conditions and psychosocial functioning (McGuire et al., 2020; Woods et al., 2011). Given its efficacy and tolerability (Peterson et al., 2016), behavior therapy is currently recommended as a first-line intervention for TD by multiple professional organizations (Murphy et al., 2013; Pringsheim et al., 2019; Steeves et al., 2012; Verdellen et al., 2011). Nevertheless, only approximately 50% of youth (Piacentini et al., 2010) and 38% of adults (Wilhelm et al., 2012) with TD exhibit a positive treatment response to behavior therapy. Moreover, even amongst those who exhibit a positive treatment response, bothersome tics often persist and cause impairment (Piacentini et al., 2010; Wilhelm et al., 2012). Therefore, it is important to determine factors that contribute to treatment response and improve therapeutic outcomes for this evidence-based intervention (Essoe et al., 2019; Scahill et al., 2013).

Homework adherence, sometimes referred to as homework compliance (Chakrabarti, 2014), is one factor that may influence behavior therapy outcomes, but its effect on TD treatment remains unexamined. “Homework” broadly refers to the utilization (or practice) of therapeutic skills between therapy sessions. When patients practice skills between therapy sessions (i.e., exhibit “good” homework adherence), the learning that begins within therapy sessions is strengthened through repetition and becomes more readily accessible. Beyond facilitating the generalization of learning from the clinic to a patient’s natural environment (e.g., home, school, work place), the practice of therapeutic skills between therapy sessions also makes learning more resilient to contextual changes and the passage of time (Kazantzis & Lampropoulos, 2002). Although homework adherence remains unexamined in behavior therapy for TD, it has been well-studied in the psychosocial treatments (e.g., cognitive behavioral therapy) of OCD and anxiety—conditions related to TD, and often co-occur with TD.

In OCD, empirical investigations have generally identified that greater homework adherence predicts greater therapeutic improvement (Abramowitz et al., 2002; Anand et al., 2011; Maher et al., 2012; Olatunji et al., 2015; Park et al., 2014; Wheaton et al., 2016). Homework adherence itself may be differentially impacted by various factors. For example, in pediatric OCD, greater baseline OCD severity was associated with increased homework adherence, and greater levels of externalizing symptoms were associated with decreased homework adherence (Park et al., 2014). Please see Wheaton & Chen (2020) and Leeuwerik et al. (2019) for a discussion on the importance of homework adherence in OCD.

In contrast, the relationship between homework adherence and treatment outcomes in anxiety disorders is less clear (Cammin-Nowak et al., 2013; Hughes & Kendall, 2007; Schmidt & Woolaway-Bickel, 2000; Westra et al., 2007; Westra & Dozois, 2006; Wetherell et al., 2005; Woods et al., 2002; Woody & Adessky, 2002; Wu et al., 2020). Some reports suggest that the timing of homework adherence (early versus late adherence in treatment) may influence therapeutic improvement, and timing patterns differ between samples of youth and adults (Park et al., 2014; Simpson et al., 2011; Westra & Dozois, 2006). As meta-analyses demonstrate that homework adherence is broadly associated with therapeutic improvement across psychosocial treatments (Kazantzis et al., 2016; Mausbach et al., 2010), understanding the relationship between homework adherence and therapeutic improvement from behavior therapy for TD may offer new insights for enhancing tic severity reductions achieved during this evidence-based treatment. Please see Kazantzis et al. (2017) for further discussion on homework adherence for anxiety and depression.

For behavior therapies such as habit reversal training (HRT; Azrin & Peterson, 1990) and its successor, Comprehensive Behavioral Interventions for Tics (CBIT; Woods et al., 2008), two therapeutic skills—awareness training and competing response training—are emphasized. Awareness training builds awareness to the occurrence of tics and eventually incorporates detection of early tic movements or premonitory urges that precede the tic. Meanwhile, competing response training focuses on developing and implementing a competing response contingent upon the early detection of the tic. A competing response is a behavior that is physically incompatible with the tic, is socially discrete, and could be maintained for up to one minute (or until the urge is dissipated/tolerated). In practice, once a tic or an urge is

detected, the patient performs the competing response to inhibit the expression of the targeted tic. After these skills are learned within therapy sessions, between-session practice (homework) is applied to reinforce and strengthen the learned behavioral responses. A social support person (usually a caregiver or partner) is trained to assist the patient in the repeated implementation of these skills outside of therapy sessions.

Practicing therapeutic skills outside of therapy sessions is important for skill development, and also enables skill recall and implementation in ecologically valid situations outside of the therapist's office (Cummings et al., 2014). For instance, patients with TD who have "good" homework adherence would regularly practice therapeutic skills and acquire greater experience implementing these skills during daily activities. This would strengthen behavior therapy skill learning, facilitate the generalization of learning across real-life situations, and likely produce greater reduction in tic severity. However, patients with "intermediate" or even "poor" homework adherence would likely experience less skill learning, exhibit less generalization of learning in ecologically valid settings (e.g., home, work, school), and experience less reduction in tic severity.

This study examined homework adherence in 119 individuals with TD who received behavior therapy as part of two randomized clinical trials. First, we characterized behavior therapy homework adherence and compared differences between "good" and "intermediate or poor" homework adherence. Second, we examined whether homework adherence changed across treatment sessions. Third, we examined the predictive relationship between homework adherence and reductions in tic severity and treatment response. Fourth, we evaluated whether outcomes differed between early and late homework adherence. Finally, we investigated baseline factors that predicted homework adherence based on the extant literature in related disorders.

Methods

Participants

Participants received behavior therapy for TD as part of two randomized multisite clinical trials ([NCT00218777](#), [NCT00231985](#); Piacentini et al., 2010; Wilhelm et al., 2012) These studies employed similar inclusion criteria, with exception of age. All participants had: (1) a diagnosis of TD of moderate or greater severity; (2) English fluency; (3) an estimated IQ > 80; and (4) a stable dose of psychiatric medication for at least six weeks with no planned changes (or were medication free). Exclusion criteria included: (1) an unstable medical condition; (2) a current diagnosis of substance abuse/dependence; (3) a lifetime diagnosis of pervasive developmental disorder, mania, or psychosis; or (4) four or more previous sessions of behavior therapy for tics.

Participants were 119 individuals with TD (70 youth and 49 adults) who were 21 years of age on average ($M = 21.76$, $SD = 14.08$, range: 9 – 67 years) and predominantly male ($n = 80$, 67.2%). While there were no baseline differences between youth and adults on clinical characteristics, there was a small demographic difference regarding the preponderance of males between groups ($V = .18$, see Table 1).

Measures

Diagnostic Interviews.—Participants completed a diagnostic interview to determine TD and co-occurring diagnoses. While most youth ($n = 59$, 49.58%) were administered the Anxiety Disorders Interview Schedule (ADIS) for DSM-IV-TR: Child Version (Silverman & Albano, 1996), older adolescents and adults ($n = 60$, 50.42%) completed the Structured Clinical Interview for DSM-IV (SCID; First & Spitzer, 1996). Both of these clinical interviews have good reliability and validity (First & Spitzer, 1996; Silverman et al., 2001; Wood et al., 2002).

Tic Severity.—Participants were administered the Yale Global Tic Severity Scale (YGTSS) at baseline and post-treatment (Leckman et al., 1989). The YGTSS is a clinician-rated scale used to measure tic severity and produces a total tic score (range: 0 – 50). The YGTSS total tic score has shown good reliability, validity, and treatment sensitivity (Jeon et al., 2013; Leckman et al., 1989; McGuire et al., 2018; Storch et al., 2005, 2011), with good internal consistency observed across assessments ($\alpha = .75 - .85$).

Treatment Response.—The Clinical Global Impressions of Improvement scale (CGI-I) was used to determine treatment response (Guy, 1976). The CGI-I is a clinician rating of global improvement in TD-related functioning relative to baseline on a 7-point scale (Cohen et al., 1988; Leckman et al., 1988), in which lower scores indicate symptom improvement and higher scores indicate worsening. Ratings of (1) very much improved or (2) much improved correspond with positive treatment response (Jeon et al., 2013; Storch et al., 2011).

Attention Deficit Hyperactivity Disorder (ADHD).—The severity of ADHD symptoms was assessed using the Attention Deficit Hyperactivity Disorder-Rating Scale (ADHD-RS; DuPaul et al., 1998). The ADHD-RS contains 18 items rated on a 4-point scale, and contains an inattention subscale (9-items) and a hyperactivity/impulsivity subscale (9-items). The ADHD-RS has good reliability and validity in youth and adults (McGuire, 2019; Scahill et al., 2001). The Inattention subscale ($\alpha = .93$) and Hyperactivity/Impulsivity subscale ($\alpha = .87 - .89$) both exhibited good internal consistency across assessments.

Obsessive-Compulsive Disorder (OCD).—The severity of OCD symptoms was captured using the Yale-Brown Obsessive-Compulsive Scale (Y-BOCS; Goodman et al., 1989). The Y-BOCS is a clinician-administered scale that assesses OCD symptom type and severity and has a parallel version for youth (Scahill et al., 1997). The Y-BOCS total score consists of 10 items rated on a 5-point scale, with higher scores corresponding to greater OCD severity (range: 0 – 40). The Y-BOCS and its parallel child version have good reliability and validity (Goodman et al., 1989; Scahill et al., 1997), with excellent internal consistency observed across assessments ($\alpha = .93$).

Externalizing Symptoms.—Externalizing symptoms were measured differently in youth and adults due to study design differences. The Child Behavior Checklist (CBCL) for ages 6 to 18 is a measure of general youth behavior that was completed by parents of youth in the child clinical trial (Achenbach & Edelbrock, 1991). The CBCL produces two overall scores

of Internalizing symptoms and Externalizing symptoms. The CBCL has excellent psychometric properties (Achenbach & Edelbrock, 1979; Edelbrock & Achenbach, 1984). Meanwhile in the adult clinical trial, adults completed the State-Trait Anger Expression Inventory-2nd edition (STAXI-2; Spielberger, 1988). The STAXI-2 is a reliable and valid self-report measure that consists of four scales: state anger, trait anger, anger expressions (with two subscales, inward and outward expression of anger), and anger control (with two subscales, inward and outward anger control). Higher scores reflect greater anger, anger expression, and reduced anger control (Lievaart et al., 2016; Spielberger, 1988). Good internal consistency was observed for all STAXI-2 subscales within the current sample ($\alpha = .75 - .93$).

Family Functioning.—The Caregiver Strain Questionnaire (Brannan et al., 1997) was administered to caregivers of youth participants to assess the degree to which TD has negatively affected family functioning. The Caregiver Strain Questionnaire consists of 21 items rated on a 5-point scale, summing to a total score (Woods et al., 2011), with higher scores corresponding to greater strains on family functioning. Acceptable psychometric properties have been reported for this scale (Brannan et al., 1997), with good internal consistency found across assessments ($\alpha = .89 - .92$).

Disability.—The Sheehan Disability Scale (SDS; Leon et al., 1992) was administered to adults and older adolescents to assess work-, social-, and family-related disability. The SDS consists of three self-report items on a 10-point scale. It is reliable and valid, and has been used in treatment studies (Deckersbach et al., 2006; Leon et al., 1992).

Homework Adherence.—At each therapy session, therapists reviewed the homework assigned from the prior visit and rated adherence on a 7-point Likert scale using the following anchors: 1–2 (Poor Compliance, 1 = noncompliant), 3–5 (Intermediate Compliance, 4 = compliant about ½ the time), and 6–7 (Good Compliance, 7 = completely compliant). For example, Session 3 homework adherence rating would characterize a participant's adherence with homework assigned at Session 2. Homework adherence ratings were extracted from sessions in which core behavior therapy skills were assigned (i.e., awareness training and competing response training) and averaged across relevant sessions. Overall homework adherence refers to the average across all therapy sessions (Session 2 through Session 8). Meanwhile, early homework adherence refers to the average homework adherence rating for early sessions (Session 2 through Session 5) and late homework adherence refers to the average rating for late therapy sessions (Session 6 through Session 8).

Procedures

Child recruitment occurred at Johns Hopkins School of Medicine, the University of California Los Angeles, and the University of Wisconsin-Milwaukee, with adults recruited from Massachusetts General Hospital/Harvard Medical School, the University of Texas Health Science Center at San Antonio, and Yale's Child Study Center. Study procedures were approved by each local Institutional Review Board. Adult participants provided written consent, and youth participants provided assent while their parents provided written consent.

Participants completed a baseline assessment to characterize psychiatric diagnoses, tic severity, psychiatric comorbidity, and psychosocial functioning. Assessments were conducted by independent evaluators (IEs) who were masked to treatment, trained to reliability, and supervised using a structured protocol (Piacentini et al., 2010; Wilhelm et al., 2012). Afterward, participants received eight sessions of CBIT over 10 weeks from therapists who had masters-level or higher education. Prior to delivering treatment, therapists were systematically trained to deliver CBIT using treatment manuals (Woods et al., 2008) closely supervised over two training cases. After demonstrating adherence to the treatment protocol, therapists provided CBIT in the study and received weekly site-level and cross-site supervision. Training included completion of session summary sheets, which detailed therapeutic skills and homework adherence items. Therapy sessions were recorded and randomly selected to evaluate fidelity to the treatment protocol. There was good fidelity to the treatment protocol in both clinical trials (Piacentini et al., 2010; Wilhelm et al., 2012).

At each therapy session, therapists assigned homework according to the manualized treatment protocol (Woods et al., 2008), and documented homework assignments. Homework assignments typically involved 3 – 4 formal practice sessions of therapeutic skills that lasted about 30 minutes in duration, with informal practice of skill-use throughout daily life. At the following session, therapists reviewed with participants previously assigned homework, and discuss potential adjustment to improve skill implementation. Based on this information, therapists completed a session summary sheet in which participant's homework adherence over the past week was rated. At the end of treatment, participants completed a post-treatment assessment where tic severity (YGTSS) and treatment response (CGI-I) were assessed by IEs. Please see Piacentini et al. (2010) and Wilhelm et al., (2012) for further information on assessment and treatment protocols.

Analytic plan

Eight participants (3 youth and 5 adults, 7.5%) discontinued behavior therapy, and were excluded from analyses. Additionally, four other participants (1 youth and 3 adults, 1.6%) had one or more missing late homework adherence ratings, but were included in early adherence analyses. First, descriptive statistics characterized the sample and homework adherence ratings. Chi-square tests and t-tests compared differences between age groups (youth and adults) in baseline demographic and clinical characteristics (e.g., sex, baseline YGTSS scores, co-occurring conditions; Table 1). Second, a repeated measures analysis of variance examined whether homework adherence differed across treatment visits. Third, linear regression models evaluated whether homework adherence ratings predicted tic severity reductions from baseline to post-treatment on YGTSS total tic scores. Additionally, logistic regression models examined whether homework adherence ratings predicted treatment response on the CGI-I. We explored whether dichotomized homework adherence (“good” adherence: score > 6; “intermediate/poor” adherence: ≤ 6) was associated with treatment response (Figure 1), as a simplified analysis of “Good” vs “Less Than Good” adherence may be preferable for practitioners to discuss with patients during psychoeducation. Lastly, forward selection linear regression models investigated whether baseline clinical characteristics predicted homework adherence ratings.

Results

Homework Adherence Across Behavior Therapy Sessions

Homework adherence changed across treatment visits and exhibited a different pattern for youth and adults ($F_{4.5, 376.7} = 2.65, p\eta^2 = .03, p = .028$). For youth with TD, homework adherence exhibited a quadratic trend with a dip in adherence midway through treatment ($F_{1,57} = 5.89, p\eta^2 = .094, p = .018$). Meanwhile, adults with TD exhibited a linear decline in homework adherence ($F_{1,27} = 7.34, p\eta^2 = .214, p = .012$; see Figure 2).

Homework Adherence and Tic Severity Reductions

Overall homework adherence ($\beta = .20, p = .037$) predicted tic severity reductions on the YGTSS at the post-treatment assessment ($R^2 = .04, F_{1, 109} = 4.44, p = .037$). When examining adherence between youth and adults, a different pattern emerged. Early homework adherence ($\beta = .38, p = .058$) showed a trend to predict tic severity reductions for youth with TD, whereas late homework adherence did not ($p = .99; R^2 = .14, F_{2,61} = 4.97, p = .01$). Meanwhile for adults with TD, late homework adherence predicted tic severity reductions ($\beta = .42, p = .036$) but early homework adherence did not ($p = .33; R^2 = .11, F_{2,40} = 2.50, p = .10$).

Homework Adherence and Treatment Response

Overall homework adherence ($B = .71, OR = 2.04, 95\% CI: 1.31 - 3.19$) predicted treatment response on the CGI-I ($X^2(111) = 12.21, p < .001$). Given that a simplified analysis between “Good” versus “Less than Good” is clinically relevant, we explored whether dichotomized homework adherence was associated with treatment response. There was a significant association between treatment response and homework adherence (see Figure 1, $\chi^2(1, N = 111) = 13.91, V = .35, p < .001$). Participants with good homework adherence were more likely to exhibit a positive treatment response (70%) compared to those with intermediate/poor homework adherence (i.e., “Less than Good”, 34.4%).

Further logistic regressions that treats the adherence scale as a continuous variable revealed early and late homework adherence differentially predicted treatment response in youth and adults. For youth with TD, early homework adherence ($B = 1.05, p = .045, OR = 2.86, 95\% CI: 1.03 - 7.97$) predicted treatment response, but late homework adherence did not ($p = .96; X^2(64) = 10.67, p = .005$). Meanwhile for adults with TD, late homework adherence ($B = 1.11, p = .023, OR = 3.02, 95\% CI: 1.17 - 7.81$) predicted treatment response but early homework adherence did not ($p = .31; X^2(43) = 9.16, p = .01$).

Baseline Predictors of Early and Late Homework Adherence

In youth with TD, lower hyperactivity/impulsivity scores ($\beta = -.394, p = .002$) predicted greater early homework adherence ($R^2 = .140, F_{1,56} = 10.28, p = .002$). Additionally, reduced tic—related family strain ($\beta = -.383, p = .004$) predicted greater late homework adherence ($R^2 = .147, F_{1,52} = 8.93, p = .004$). No other baseline characteristics predicted early or late homework adherence over and above the aforementioned predictors (e.g., baseline OCD severity, inattention score on the ADHD-RS, CBCL externalizing score, baseline YGTSS total tic and impairment scores; $p = .19-.74$).

In adults with TD, lower trait anger scores ($\beta = -.463, p = .003$), less social disability ($\beta = -.452, p = .009$), and greater work disability ($\beta = .543, p = .003$) predicted greater early homework adherence in behavior therapy ($R^2 = .326, F_{3,37} = 5.97, p = .002$). Meanwhile, baseline predictors of greater late homework adherence ($R^2 = .618, F_{6,32} = 11.26, p < .001$) included younger age ($\beta = -.312, p = .004$), greater work disability ($\beta = .62, p < .001$), lower social disability ($\beta = -.606, p < .001$), lower OCD severity ($\beta = -.432, p < .001$), lower ADHD hyperactivity/impulsivity scores ($\beta = -.543, p = .001$), and lower outward anger expression score ($\beta = -.611, p < .001$). No other baseline characteristics predicted early or late homework adherence over and above the aforementioned predictors (e.g., all other STAXI-2 scales and subscales, inattention score on the ADHD-RS, YGTSS total tic score, and YGTSS Impairment score; $p = .16-.99$).

Discussion

This study examined the relationship between homework adherence and therapeutic improvement from behavior therapy and investigated baseline predictors of homework adherence among individuals with TD. Increased adherence to behavior therapy homework predicted greater reductions in tic severity and positive treatment response. Participants with good homework adherence were more likely to display a positive treatment response compared to those with intermediate (or less) homework adherence. These findings highlight the importance of homework adherence in behavior therapy and suggest that treatment outcomes may be improved if homework adherence were optimized. However, strategies to enhance homework adherence during behavior therapy may likely differ between youth and adults. In youth with TD, homework adherence may be strengthened by the use of behavioral reward systems to reinforce the practice of behavior therapy skills. This can help maintain good homework adherence throughout behavior therapy, and particularly midway through treatment when adherence appears to diminish among youth. Meanwhile for adults with TD, greater homework adherence may be achieved by framing skill practice in relation to the individual's treatment goals and values. This may help adults with TD to persist in practicing behavioral skills throughout treatment course, despite any setbacks, tic exacerbations, and/or other related challenges that may emerge. This may explain in part the predictive relationship between late homework adherence and improved therapeutic outcomes among adults with TD. While these two strategies may contribute to enhanced utilization of behavior therapy skills, the inclusion of a social support person (e.g., parent or partner) is important to provide corrective feedback on accurate tic detection (awareness training) and inhibition (competing response training) during homework activities.

When examining baseline predictors of homework adherence, greater hyperactivity/impulsivity scores (but not inattention scores) predicted lower homework adherence across youth and adults. This is consistent with previous research in anxiety and OCD, and may explain prior findings linking the presence of co-occurring ADHD with attenuated benefit from behavior therapy (McGuire et al., 2014). During practice sessions, patients are often stationary and seated across from the social support person in order to facilitate tic observation and correct competing response implementation. Patients with greater hyperactivity/impulsivity may find it more challenging to be sedentary while practicing therapeutic skills and/or difficult to implement competing responses that temporarily

immobilize parts of the body (e.g., crossing arms to inhibit an arm tic also prevents fidgeting). Therefore, therapists may develop between-session homework practice activities specifically for non-sedentary settings (e.g., while taking walks or doing chores) and/or assign homework practice during periods of reduced hyperactivity/impulsivity (e.g., after physical exercises, when ADHD medication is at peak effectiveness). Although further research is needed to clarify the precise mechanism by which hyperactivity/impulsivity impedes homework adherence, the aforementioned strategies may prove useful to improve homework adherence in the interim.

Beyond hyperactivity/impulsivity, family and social functioning emerged as possible common negative predictors of homework adherence between youth and adults. In youth with TD, greater strain on family functioning was associated with reduced homework adherence in later therapy sessions. While parents may initially be involved and motivated early in treatment, families with more dysfunction and/or burden appear to have greater difficulty maintaining adherence over time (e.g., parents may no longer have the capacity to practice with youth, behavioral reward system adherence may decline among parents). Meanwhile in adults with TD, greater social disability and anger was associated with lower homework adherence. Although seemingly different from youth, the central cause for lower homework adherence may be the same. Adults with greater social disability and anger would likely have greater difficulty interacting with a social support person (e.g., partner, friend) to practice behavior therapy skills or may even lack a social support person altogether. These homework exercises could be further complicated when the social support person provides corrective feedback on tic detection and/or implementation of competing responses—eliciting anger and frustration from the patient who is trying to appropriately implement skills. Given that baseline predictors of homework adherence appear to relate to social support, innovative solutions are needed to overcome this challenge. For instance, therapists may seek to address these baseline homework adherence barriers with social support persons at the outset of treatment.

Lastly for adults with TD, greater work disability predicted greater homework adherence throughout treatment. This suggests that adults whose tics cause greater occupational interference may be more motivated to practice behavior therapy skills between sessions or may have more time available to complete homework assignments. As behavior therapy for TD can improve functional outcomes (e.g., work disability, social disability; McGuire, 2019) these adults may experience practical benefits from homework adherence that serve to reinforce regular skill use. For instance, an adult with TD who regularly practices behavior therapy skills at work and/or in social settings may experience fewer problems at work and/or in social situations due to tics. These positive experiences (i.e. fewer problems) would serve to reinforce skill practice and use in the patient's natural environment.

Despite several methodological strengths of this study, a few limitations remain. First, we did not capture all possible demographic and clinical characteristics for baseline predictors of homework adherence. Therefore, there may be unexamined characteristics that influence homework adherence that warrant further examination. On balance, measures of common co-occurring psychiatric conditions and key aspects of psychosocial functioning were included that would connect findings to standard clinical care. Second, while the YGTSS

and CGI-I are gold-standard measures of tic severity and treatment response in clinical trials, reliance on a single measure may unintentionally inflate response rates (Loerinc et al., 2015). Although this is an unlikely concern due to the many precautions taken in these multisite clinical trials (e.g., IE training and on-going monitoring), future trials should consider additional parameters to classify treatment response (e.g., multiple outcome measures, reliable change indices). Third, ratings of homework adherence were entirely reliant on therapists' report. While therapists had considerable contact with patients and social support persons, there was no objective measure of behavior therapy homework adherence between sessions. Future research should incorporate objective measures of homework adherence (e.g., time stamped video recording homework practices).

In summary, homework adherence predicts tic severity reductions and treatment response to behavior therapy in youth and adults with TD. Findings support the importance of between-session practice of behavior therapy skills for patients to exhibit therapeutic benefit. Therapists should emphasize the importance of homework adherence between therapy sessions during psycho-education, and implement strategies to optimize homework adherence early on in treatment (e.g., implementation of a behavioral reward system, connecting skill practice to goals and values). When baseline predictors of reduced homework adherence are present (e.g., greater hyperactivity/impulsivity, impediments to participation of the social support person), therapists should implement strategies to compensate for these challenges and revise treatment plans accordingly (e.g., discussions with social support person regarding homework implementation). While these suggestions are based on clinical experience, future research should investigate empirical approaches to optimize homework adherence for individuals with TD. Strategies that optimize homework adherence may enhance the efficacy of behavioral therapy, lead to greater tic severity reductions, and higher treatment response rates. Indeed, this may be most relevant for patients with TD who experience greater inattention/hyperactivity and/or have a clinical presentation that may impede the involvement of a social support person in treatment.

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Highlights

- Behavior therapy is a first-line evidence-based treatment for Tourette's Disorder
- Behavior therapy homework adherence predicted tic severity reductions
- Hyperactivity/impulsivity and social support predicted homework adherence
- Behavior therapy homework adherence differed slightly between youth and adults
- Strategies to improve homework adherence could optimize behavior therapy outcomes

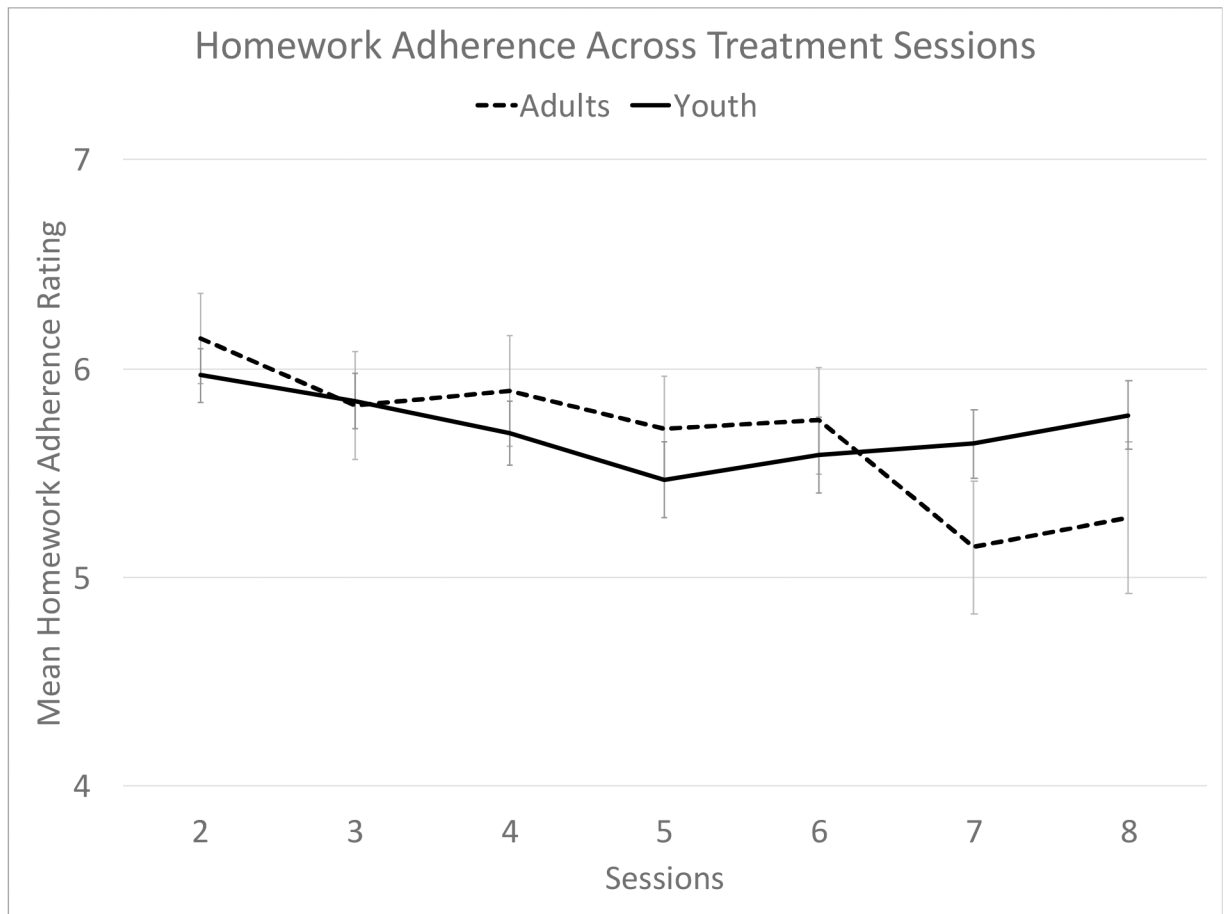


Figure 1. Averaged Homework Compliance Ratings Across Treatment Sessions. Homework adherence was rated on a 7-point Likert scale using the following anchors 1 = Poor, 4 = Intermediate, and 7 = Very Good.

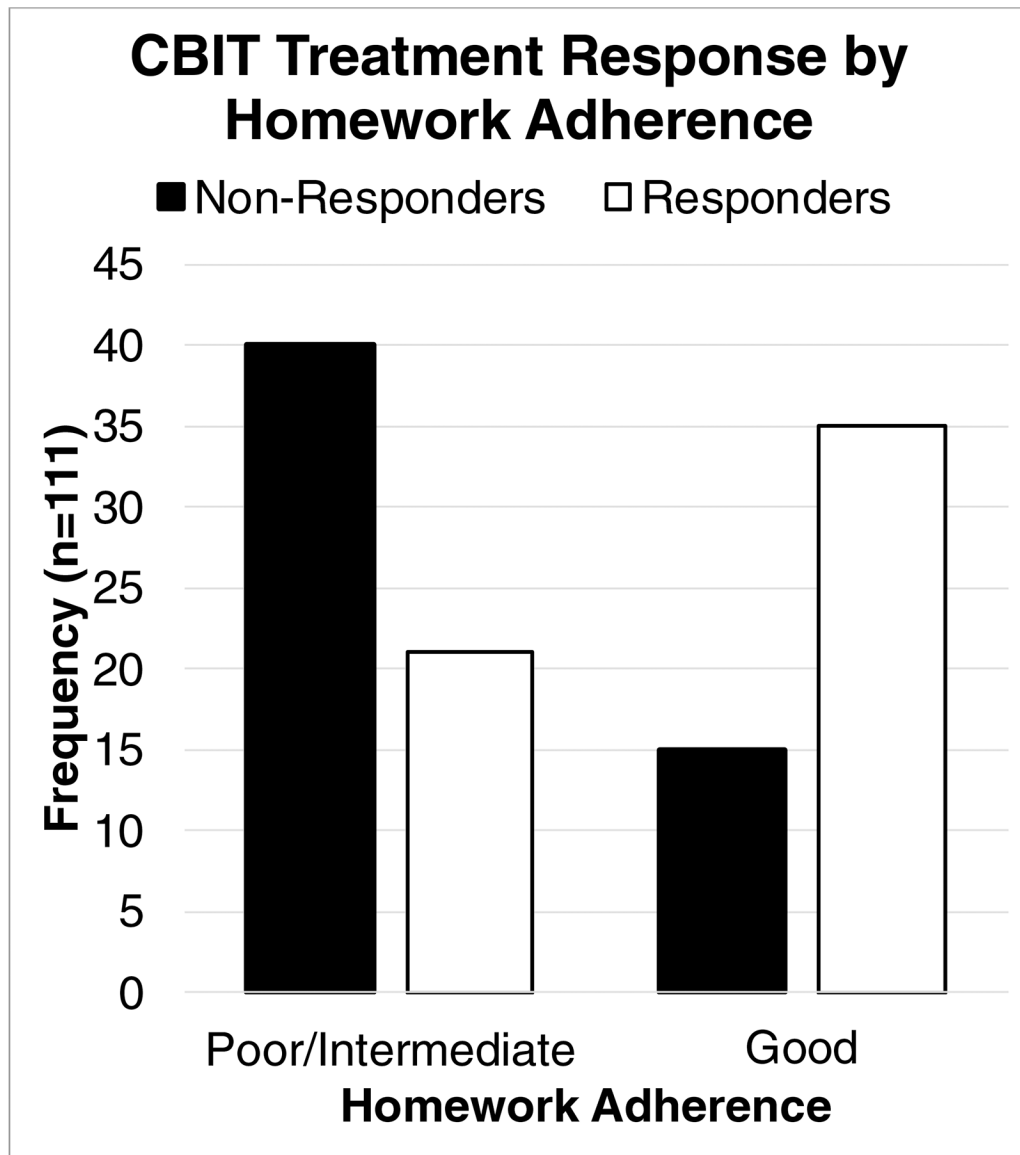


Figure 2. Homework Adherence and Treatment Response.
 Frequency of treatment response as organized by homework adherence categories.

Table 1.

Demographic and clinical characteristics of participants by age group (N = 119).

Characteristics	Overall	Adult	Child	Age-Group Comparison
	<i>mean (SD)</i>	<i>mean (SD)</i>	<i>mean (SD)</i>	<i>p (t-test)</i>
Age in years	21.76 (14.08)	35.14 (12.85)	12.39 (2.82)	
YGTSS Total Tic Score	24.45 (6.43)	23.82 (0.97)	24.90 (0.74)	.516
	<i>n (%)</i>	<i>n (%)</i>	<i>n (%)</i>	<i>p (X²)</i>
Sex				
Female	39 (32.8%)	21 (42.9%)	18 (25.7%)	.050
Male	80 (67.2%)	28 (57.1%)	52 (74.3%)	
Race				
Caucasian	96 (80.7%)	39 (79.6%)	57 (81.4%)	.701
Non-Caucasian	23 (19.3%)	10 (20.4%)	13 (18.6%)	
Medication Status				
On Tic Medications	39 (37.9%)	12 (29.3%)	27 (43.5%)	.144
No Medications	64 (62.1%)	29 (70.7%)	35 (56.5%)	
Diagnoses				
Chronic Vocal Tic Disorder	2 (1.7%)	1 (2%)	1 (1.4%)	--
Chronic Motor Tic Disorder	11 (9.2%)	7 (14.3%)	4 (5.7%)	
Tourette's Disorder	106 (89.1%)	41 (83.7%)	65 (92.9%)	
Co-occurring Conditions				
Any ^a	65 (54.6%)	23 (46.9%)	42 (60%)	.159
OCD	20 (16.8%)	10 (20.4%)	10 (14.3%)	.379
Anxiety Disorders ^b	30 (25.2%)	8 (16.3%)	22 (31.4%)	.062
ADHD	35 (29.4%)	14 (28.6%)	21 (30%)	.866

Abbreviations: ADHD = Attention Deficit/Hyperactive Disorder; OCD = Obsessive Compulsive Disorder; YGTSS = Yale Global Tic Severity Scale.

^aParticipants who met diagnostic criteria for any psychiatric conditions, including OCD, ADHD, anxiety and depressive disorders.

^bGeneralized anxiety, social anxiety, separation anxiety, specific phobia, panic disorder, and post-traumatic stress disorder.