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Behaviour Research and Therapy 42 (2004) 501–511

BEHAVIOUR RESEARCH AND THERAPY

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Exposure with response prevention versus habit reversal in Tourettes's syndrome: a controlled study

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Received 15 October 2002; received in revised form 2 April 2003; accepted 12 May 2003

Abstract

The intentional nature of tics provides the opportunity to apply behavioural interventions aimed at tic reduction through interruption of stimulus-response sequences. The aim of this study has been to evaluate the effect of exposure and response prevention (ER) versus habit reversal (HR) in 43 Tourette's syndrome (TS) patients. The three outcome measures were: the Yale Global Tic Severity Scale (YGTSS), 15-min tic frequency registrations monitored at the institute and 15-min home tic frequency registrations. Both treatment conditions resulted in statistically significant improvements on all outcome measures ($p < 0.0001$). No significant differences were found between the treatment conditions on any of the outcome measures, although there was a tendency in favour of ER on the YGTSS ($p = 0.05$). These results suggest that, at least in the short term, TS tic symptoms can be treated effectively with both types of treatment.

Keywords: Tourette's syndrome; Tics; Exposure; Habit reversal; Behaviour therapy; Treatment outcome

1. Introduction

Tourette's syndrome (TS) is a neuropsychiatric disorder characterized by multiple motor and vocal tics. Tics are sudden, rapid, recurrent, nonrhythmic, stereotyped movements or vocalizations that are experienced as irresistible but can be suppressed for varying lengths of time (American

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0005-7967/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0005-7967(03)00154-2

Psychiatric Association, 1994). Tics and TS related impulsive behaviours can be provoked by both external and internal events (Eapen, Moriarty, & Robertson, 1994; Leckman, King, & Cohen, 1999). Bliss (1980) had described unpleasant sensory experiences that precede tics, and that can be relieved by performing the tic. This description has challenged the commonly held belief that tics are involuntary. Several studies addressing the phenomenon of premonitory sensations and the intentional nature of tics have been performed thereafter (see Scahill, Leckman, & Marek, 1995, for a review). In tic-disordered patients, over 90% of tics seem to be preceded by unpleasant sensations and urges in contrast to 7% of patients with other movement disorders (Lang, 1991; Leckman, Walker, & Cohen, 1993). In general, performance of tics relieves these sensations. In addition, there seems to be a strong relationship between the experience of premonitory sensations and the ability to suppress tics (Kurlan, Lichter, & Hewitt, 1989).

Whereas a biological basis for TS and its associated phenomena is generally assumed, insight into the functional maintenance of tics may be provided by learning theory (Turpin, 1983). Through a process of operant conditioning, i.e. negative reinforcement, the sequence of unpleasant premonitory sensations followed by tics that relieve these sensations may account for the maintenance of tics. Due to their potential to eliminate unpleasant sensory stimuli, tics can be considered as conditioned responses that will be performed whenever a new sensation appears. In addition, through classical conditioning, different kinds of stimuli (i.e. cognitive, emotional, and external) may become associated with the sensory stimuli and ticcing responses.

Derived from learning theory principles, interventions have been developed aimed at interrupting the stimulus-response sequences. To date, the hallmark of behavioural interventions for tics is habit reversal (HR). HR is based on the premise that tics are maintained by response chaining, lack of awareness of their occurrence, excessive practice, social reinforcement and tolerance of the tics (Azrin & Nunn, 1973). The primary ingredients of HR are an awareness training on the occurrence of a specific tic, and subsequently the application of a response incompatible with the tic, to interrupt or inhibit the tic (Miltenberger, Fuqua, & McKinley, 1985; Peterson & Azrin, 1992). In addition, HR may comprise relaxation and reinforcement techniques (Azrin & Nunn, 1973; Peterson & Azrin, 1992). By applying HR, tic reductions between 55% and 95% have been reported (Peterson & Azrin, 1993).

Derived from the well-known repertoire of behavioural techniques, a new strategy for tics has been developed as an extension to HR, i.e. exposure and response prevention (ER; Hoogduin, Verdellen, & Cath, 1997). ER entails exposure to the sensations and urges that precede tics, and response prevention of the tics. Theoretically, the patient habituates to the premonitory experiences, thus resulting in tic reduction (Hoogduin et al., 1997). ER has proven to be effective in the treatment of obsessive–compulsive disorder (OCD; Abramowitz, 1996; Riggs & Foa, 1993). Tics in TS bear similarities with compulsions seen in OCD with regard to their intentional character (Cath et al., 2001; Lang, 1991; Turpin, 1983). In OCD, prolonged exposure to feared stimuli by means of ER results in decrements of both subjective anxiety and heart rate (Grayson, Foa, & Steketee, 1982; Marks, 1987). In one report of a TS patient to whom ER has been applied, improvement of voluntary tic control and relief from the premonitory itching sensation has been demonstrated (Bullen & Hemsley, 1983). Hoogduin et al. (1997) have tested the habituation hypothesis in TS patients during ten 2-h sessions, in which the patients were exposed to the sensory experiences while suppressing every tic or impulse. Within-session habituation was found in three of the four patients. Improvements in ticcing behaviour varied from 68% to 83% (Hoogduin et al., 1997).

Studies on HR are in most cases uncontrolled, containing small sample sizes and poorly defined diagnostic criteria. The aim of the present study was to perform a controlled study, extending the preliminary data on ER in TS, using larger sample sizes, and in comparison with HR. The first hypothesis was that both ER and HR are effective in reducing TS tic symptoms, although the effect is possibly accomplished by different pathways of stimulus-response interruption in both techniques (Azrin & Peterson, 1990; Hoogduin et al., 1997). The second hypothesis was that ER results in larger tic symptom reductions than HR, since ER is directed towards disrupting the response sequence for all tics at once, whereas HR intervention focuses at one tic at a time. In addition, ER is applied to intervene in the response sequence as early as possible, i.e. immediately following the premonitory sensation. Early sequence interruption is associated with larger (and less effortful) behaviour change than disrupting the response sequence in the middle (Baumeister, Heatherton, & Tice, 1994).

2. Method

2.1. Patients

Patients were referred for this study by the National TS Foundation and by psychiatrists and neurologists from various outpatient services. For inclusion in the study, the patients had to meet DSM-IV criteria (APA, 1994) for Tourette's disorder. Exclusion criteria were major depression, psychotic disorder, autism, mental retardation and the presence of a neurological disorder other than TS. The use of medication during treatment was not considered an exclusion criterion, provided it was adhered to a fixed daily dose throughout the study. Two experienced clinicians (first and fourth authors) independently screened the patients on in- and exclusion criteria. Forty-five referred patients met the in- and exclusion criteria. Written informed consent was obtained from the patients as well as from their parents when children were involved. Two patients withdrew from the study after completing the intake procedure and before randomization, one due to travel expenses, the other due to a substantial reduction of tics by the time of referral. Of the remaining 43 patients, 34 were males and nine were females. The mean age of the sample was 20.6 years (SD = 12.1; range 7–55). Mean age at onset was 6.8 years (SD = 3.6; range 3–18), and mean duration of TS symptoms was 13.8 years (SD = 10.7; range 1–45). Forty patients (93%) reported premonitory experiences (i.e. focal or global sensory sensations and urges) associated with at least some of their tics. Seventeen patients (40%) were taking medication to reduce tics. These included antipsychotics (n = 13) and clonidine (n = 5); one patient used both pipamperon and clonidine. Twelve patients (28%) had used TS medication in the past. One patient used antidepressants (amitriptyline) at the time of referral. Of the 43 patients, six (14%) had an additional DSM-IV diagnosis of OCD and 13 (30%) of attention deficit hyperactivity disorder (ADHD).

2.2. Design

Patients were treated either at the Nijmegen University outpatient clinic or at a multicentre outpatient institute for work related and somatoform disorders. After the intake procedure, randomization was conducted separately for patients with and without medication to either ER (n

= 21) or HR (n = 22). Next, pre-treatment assessment was administered to both the groups. Subsequently, patients in the ER condition received 12 weekly treatment sessions, including two training sessions, in which patients learned to suppress tics. Patients in the HR condition received 10 weekly treatment sessions. A post-treatment assessment was completed 1 week after the last session for both conditions. All assessments and treatment sessions were videotaped.

Follow-up (FU) data were obtained 3 months after the last treatment session. For 12 (57%) patients from the ER group and 13 (59%) patients from HR, FU was obtained 3 months after having received additional treatment according to a cross-over design. Assignment to the alternative treatment had taken place in accordance with routine clinical practice.

2.3. Therapists and assessors

Therapists were graduate students in clinical psychology fulfiling their practical training at one of the participating institutes. Therapists were carefully trained in applying the treatment protocols for ER and HR. During the study, they received supervision every 2 weeks, in which each patient was extensively followed and problems were discussed. Videotaped sessions were viewed during supervision to enhance treatment integrity.

Assessors were research assistants who had received an extensive training in administering the YGTSS and in the rating of videotaped tic frequency. Following the method recommended by Shapiro, Shapiro, Young, and Feinberg (1988), before rating each videotape, assessors viewed a segment of the videotape to establish consensus concerning the tic symptoms.

2.4. Treatments

Both treatment conditions were conducted according to treatment manuals for ER (described in Hoogduin et al., 1997; Verdellen, Hoogduin, & Plandsoen, 1994), and HR (Azrin & Nunn, 1973; Azrin & Peterson, 1990). Sessions in the ER condition lasted for 120 min each, corresponding to the recommended time to attain habituation in the treatment of OCD (Marks, 1987). The HR condition consisted of 60-min treatment sessions, in accordance with its application in clinical practice and case studies (Azrin & Peterson, 1990).

In the two ER training sessions, patients systematically learned to suppress tics for even longer lasting times. Whenever a tic occurred, the therapist spurred the patient to improve his performance. In the following 10 sessions, patients were to apply the response prevention procedure for two consecutive hours. Contrary to the training sessions, in these sessions, the occurrence of tics was registered, instead of the duration of tic suppression. To optimize exposure, patients were asked to concentrate on the sensory experiences and the corresponding locations in their bodies. In addition, patients were asked to take tic-eliciting objects into the sessions and to try to provoke premonitory urges. Meanwhile, they had to resist every urge or desire to perform tics. Therapists acted like coaches in helping the patients to accomplish this task. Patients were told they would benefit most from the treatment if they practiced the exercises at home.

HR consisted of an awareness training of each tic followed by a competing response training to inhibit the tic. In the awareness training, patients learned to detect and describe each tic, using self-monitoring and self-registration procedures. In the competing response training, patients learned to apply an incompatible response for 1 min after the first signal when a tic was about

to occur, thus interrupting the tic. Patients also had to perform this response when the tic had occurred. In 10 sessions, as many isolated tics as possible were treated. Patients were told they would benefit most from the treatment if they practiced the exercises at home.

2.5. Measurements

The outcome measures were: (1) The Dutch version of the Yale Global Tic Severity Scale (YGTSS; Leckman et al., 1989; Wetering & Cath, unpublished manuscript) (2) tic frequency observed at the institute (TF-institute) and (3) tic frequency monitored at home (TF-home).

The YGTSS is a well-established semi-structured clinical rating scale with satisfactory convergent and discriminant validity and interrater reliability (Leckman et al., 1989; Walkup, Rosenberg, Brown, & Singer, 1991). Information on tic severity is acquired for motor and vocal tics separately in five dimensions: number, frequency, intensity, complexity and interference. These dimensions are summated and the subscale scores are obtained. A rating of impairment is added to provide a final global TS severity rating varying from 0 (no tics) to 55 (severe tics).

TF-institute was obtained using a mechanical counter by observing the first 15 min of the videotaped YGTSS administrations. Standardized videotape tic counts of at least 5-min duration have been found to provide reliable and stable measures of tic frequency and are sufficiently correlated with YGTSS ratings (Chapell et al., 1994).

TF-home was obtained by family members of the patients through direct observation of the patient for 15 min each day at fixed times (between 7 and 8 PM) and during fixed activities. For this purpose, the patient's parent or partner used a mechanical counter.

At pre- and post-treatment assessment, assessors completed the YGTSS and asked the patients for TF-home registrations. Two trained assessors scored the videotaped YGTSS administrations. In addition, two assessors observed the videotaped YGTSS administrations and rated tic frequency. The assessors were blind for treatment condition and assessment (pre- or post-treatment). With regard to the TF-home registrations, averaged week scores corresponding to the weeks of administering the assessments were used for the analyses.

Additional YGTSS administrations were performed a week after finishing the alternative treatment and at 3 months FU.

2.6. Statistical analysis

To analyse the interrater agreements, Pearson correlation coefficients were calculated. Patient characteristics and pre-treatment TS severity scores were compared between the groups using univariate χ^2 tests for discrete variables and *t*-tests for continuous variables. To investigate treatment effects, gain scores (pre-treatment scores minus post-treatment scores) were calculated on the outcome measures in both conditions. Subsequently, whilst taking into account the number of sessions per condition (i.e. 12 for ER and 10 for HR), weighted gain scores were obtained. Data were checked with respect to the assumptions of normality and homogeneity of variances. A logarithmic transformation for tic frequency scores was applied to meet the assumption of normality. These transformations were used in all analyses, except for the descriptive statistics. Weighted gain scores were entered in a two-way multivariate analysis of variance (MANOVA) for both conditions together to test the improvement at post-treatment assessment, with treatment

condition as between-subject factor. In addition to completer analysis, intent-to-treat analysis was performed in which data of the noncompleters were also included according to the last measure carried forward procedure. In all the analyses, two-tailed $p < 0.05$ was considered significant.

3. Results

High levels of interrater reliability were obtained for the YGTSS ($r = 0.98$) and for TF-institute scores ($r = 0.99$).

No significant differences were found between the groups on any of the patient characteristics or pre-treatment TS severity scores (Table 1).

Two patients from the ER condition (10%) and four patients from the HR condition (18%) did not complete the study. One patient dropped out after the first ER training session for unknown reasons. Five other patients dropped out after having received four or more sessions, due to time expenses or travelling costs (HR, $n = 3$), or because the parents felt their children were too young for the treatment (HR, $n = 1$; ER, $n = 1$). Mean scores between completers and noncompleters on any of the patient characteristics or pre-treatment outcome measurements were comparable.

Mean scores of the outcome measures for the completers on ER and HR at pre-and post-treatment assessment are presented in Table 2.

Multivariate analysis showed that Wilks' lambda (intercept) was significant ($F(3,31) = 18.21$, $p < 0.0001$), indicating that there was a significant time effect for the three outcome measures

Table 1
Study sample: patient characteristics and pre-treatment assessment scores of TS severity measures for the ER and HR conditions, test values and significance

Variables		ER ($n = 21$)	HR ($n = 22$)	Test statistic	p
Sex	n (M/F)	17/4	17/5	0.09[b]	n.s.
Age (year)	M (SD)	22.0 (13.0)	19.2 (11.4)	0.76[c]	n.s.
Age of appearance of TS symptoms (year)	M (SD)	7.5 (3.9)	6.1 (3.3)	1.35[c]	n.s.
Duration of TS (year)	M (SD)	14.5 (11.6)	13.1 (10.1)	0.41[c]	n.s.
Comorbidity					
ADHD	n	6 (29%)	7 (32%)	0.05[b]	n.s.
OCD	n	4 (19%)	2 (9%)	0.89[b]	n.s.
TS medication	n	8 (38%)	9 (41%)	0.04[b]	n.s.
YGTSS	M (SD)	2.1 (7.7)	23.1 (7.1)	1.31[c]	n.s.
TF-institute	M (SD)	151.8 (139.3)[a]	142.8 (147.5)	0.25[c]	n.s.
TF-home	M (SD)	86.9 (85.8)	107.2 (120.8)	−0.61[c]	n.s.

Notes: ER = exposure and response prevention; HR = habit reversal; ADHD = attention deficit hyperactivity disorder; OCD = obsessive–compulsive disorder; YGTSS = Yale Global Tic Severity Scale; TF - institute = YGTSS tic frequency ratings; TF - home = tic frequency ratings at home; n.s. = not significant.

[a] $n = 20$.

[b] χ^2 statistic.

[c] Student t-test for independent samples.

Table 2
Completer sample: means (pre- and post-treatment scores), effect sizes and percentages of patients who improved >30% on ER (n = 19) and HR (n = 18). All scores are unweighted for the number of treatment sessions

Measures	Pre	Post	ES	PPI >30%
	M (SD)	*M* (SD)		
YGTSS				
ER	26.2 (7.6)	17.6 (7.6)	1.42	58
HR	24.1 (7.2)	19.7 (9.3)	1.06	28
TF-institute				
ER	139.7 (133.3)	79.5 (114.9)	0.90	74
HR	151.1 (158.4)	102.7[a] (98.7[a])	0.47	53
TF-home				
ER	88.4 (90.3)	28.4 (33.7)	0.88	89
HR	116.9 (131.6)	36.9 (55.1)	0.73	72

Notes: ER = exposure and response prevention; HR = habit reversal; YGTSS = Yale Global Tic Severity Scale; TF - institute = YGTSS tic frequency ratings; TF - home = home tic frequency ratings; Pre = pre - treatment assessment; Post = post - treatment assessment; ES = effect sizes; PPI = percentage of patients who improved.
[a] n = 15.

taken simultaneously. There was no overall main effect for condition ($F(3,30) = 1.81$, $p = 0.17$), but there was a trend favouring ER ($F(1,32) = 3.96$, $p = 0.05$) on the YGTSS. Post-hoc analyses on the difference scores for the separate outcome measures revealed comparable results.

To gain further insight into the clinical significance of the improvements achieved in the two conditions, effect sizes for the ER and HR completer samples (after 12 and 10 sessions, respectively) were calculated for the three outcome measures following Cohen's d for one sample repeated measures (Cohen, 1988). Effect sizes are presented in Table 2. On the YGTSS, effect sizes were satisfactory for both conditions. On the tic frequency outcome measures, effect sizes were moderate for the ER condition, and moderate (TF-home) to low (TF-institute) for the HR group. In addition, for each of the outcome measures, the percentage of patients demonstrating clinically significant improvements (i.e. greater than 30%) was calculated (see Table 2). The percentage of patients with improvements greater than 30% on at least one of the outcome measures was 95% for the ER condition and 83% for the HR condition. The percentage of patients showing clinically significant improvements at each of the three outcome measures was 42% for ER and 17% for HR.

Intent-to-treat analysis including end-point scores for the noncompleters revealed comparable post-hoc and main results. There was a significant time effect ($F(3,39) = 17.65$, $p < 0.0001$), but no main effect for condition ($F(3,39) = 1.68$, $p = 0.19$). A trend favouring ER was found on both the YGTSS ($F(1,41) = 3.70$, $p = 0.06$) and on TF-institute ($F(1,41) = 3.34$, $p = 0.07$).

In Table 3, mean scores on the YGTSS outcome measure for all included patients are presented at pre-and post-treatment assessment, after completion of the alternative treatment and at FU.

Effect sizes for the second phase of the study showed relevant improvements for ER following HR (0.95), but no improvements for HR following ER (0.04). Effect sizes on the YGTSS at FU were high compared to pre-treatment assessment (see Table 3).

Table 3
Mean YGTSS scores for all included patients at pre-treatment assessment (Pre), at post-treatment assessment (Post 1), after completing the alternative condition (Post 2) and at follow-up (FU), corresponding number of patients (*n*) and effect sizes (ES). All scores are unweighted for the number of treatment sessions

Condition	Pre		Post 1		Condition	Post 2		FU		ES	ES	ES
	n	*M* (SD)	*n*	*M* (SD)		*n*	*M* (SD)	*n*	*M* (SD)	Pre–Post 1	Post 1–Post 2	Pre–FU
ER	21	26.1 (7.7)	19	17.6 (7.6)	HR	12	17.4 (7.4)	17	14.0 (9.3)	1.41	0.04	1.49
HR	22	23.1 (7.1)	18	19.7 (9.3)	ER	13	15.5 (10.0)	14	13.5 (8.4)	0.84	0.95	1.95

Notes: ER = exposure and response prevention; HR = habit reversal; YGTSS = Yale Global Tic Severity Scale.

4. Discussion

The main conclusion from this study is that both ER and HR are effective interventions in the treatment of tics in TS. These results support our hypothesis and are in line with the literature (Azrin & Peterson, 1990; Hoogduin et al., 1997). Patients in both conditions showed significant reductions at the YGTSS and tic frequency outcome measures analysed simultaneously ($p < 0.0001$). The results were comparable for the intent-to-treat sample.

To our knowledge, this is the first controlled study to date that has evaluated the effectiveness of ER on tics, in comparison to HR, taking into account tic measures in both the clinical and the home setting. The tic frequency outcome measures appeared to be weakly related ($r = 0.25$), which may reflect environmental influences on tic symptom severity (Kurlan & McDermott, 1993).

Our expectation that the patients in the ER condition would benefit more from the treatment than those with HR was only marginally confirmed. No statistically significant differences between the two conditions were found. However, a differential trend was discerned favouring ER on the YGTSS ($p = 0.05$). In addition, effect sizes on each of the outcome measures and percentages of patients showing clinically significant improvements (i.e. >30%) were larger for the ER condition than for HR. On face value, the YGTSS subscale scores (not presented in this article) showed an advantage for ER on the dimension ‘number of tics’. These findings may be the result of ER intervening with all tics at once, thus providing more opportunity to treat more different tics, whereas HR reduces one tic at a time. It can be speculated that the trend in favour of ER would have reached significance when study groups would have been larger, resulting in larger statistical power. On the other hand, ER contained longer lasting treatment sessions than HR, which also could explain the tendency of ER to be more effective than HR. At this point, it is not possible to draw conclusions at this aspect.

At 3 months FU, the improvements over time on the YGTSS outcome measure were maintained, although it should be noted that 14% of the patients did not complete FU (ER: $n = 4$; HR: $n = 8$). FU did not entail a ‘pure’ comparison between ER and HR, since 68% of the completer sample (ER: $n = 12$; HR: $n = 13$) had received additional treatment according to a cross-

over design. Therefore, no conclusions can be drawn about the longer-term effects of ER or HR separately.

According to learning theory, the effectiveness of both ER and HR seems to be the result of interruption of stimulus-response sequences. In HR, tic reduction is obtained through the application of a competing response after the first signal that a tic is about to occur (Azrin & Peterson, 1990). Evers and van de Wetering (1990) have argued that the response to a premonitory sensation does not necessarily need to be incompatible with the tic, provided that premonitory tension is being reduced in a way similar to that of the tics. Hoogduin et al. (1997) have hypothesized that prolonged exposure to premonitory stimuli through tic suppression (i.e. ER) results in habituation to the sensations and urges and subsequently tic reduction. Habituation to premonitory sensations as a possible underlying mechanism of change was examined for the ER study sample using subjective sensation severity ratings. The results demonstrate significant reductions in sensory experiences both within and between sessions (Verdellen et al., manuscript in preparation). Theoretically, habituation may also be responsible for the effect of HR, since competing response training is aimed at interruption and subsequently prevention of the tic, thus resulting in exposure to premonitory stimuli (Turpin, 1983).

Mechanisms other than habituation also might have been responsible for the observed improvements, e.g. increased ability to suppress tics or enhanced self-control. Moreover, the interventions may have resulted in heightened awareness of the sensory experiences preceding tics, thus enhancing the ability to suppress various tics that previously had escaped awareness (Kurlan et al., 1989).

Finally, the TS waxing and waning course may have played a role in the improvement. However, the mean duration of TS symptoms was 14 years in the sample under study, which makes the possibility of spontaneous recovery less likely.

At this point, some drawbacks concerning this study need to be addressed. First, there was no waiting-list/no-treatment condition to control for TS natural influences (Turpin, 1983).

Second, there was a difference between the treatment conditions, with ER including two training sessions, whereas HR did not contain a training period. Training sessions were considered necessary for the ER condition to teach patients to suppress tics for a sustained period of time. Sustained tic suppression was considered a prerequisite to attain habituation and subsequently for ER therapy to be effective. In the analyses, this difference between conditions was accounted for by calculating weighted gain scores on the outcome measures. Furthermore, ER sessions lasted 120 min each to reach habituation, whereas HR sessions were of 60-min duration. Future research should address the necessity of 2-h sessions to attain ER effect.

The third issue concerns the application of videotaped recordings to measure tic symptom severity. The use of videotape ratings is described as cumbersome and labour intensive, requiring suitable technical equipment (Kurlan & McDermott, 1993; Leckman, Towbin, Ort, & Cohen, 1988). In our study, 4% of the video material could not be used because of technical problems, resulting in missing data. In addition, tics may be more difficult to discern on videotape than by direct observations. However, reliability between the assessors was found to be very satisfactory and comparable to reliability levels found in other studies (Chapell et al., 1994; Goetz, Tanner, Wilson, & Shannon, 1987).

The results of this study support the application of behaviour therapy as an alternative to pharmacotherapy with antidopaminergic agents, which is currently the treatment of first choice for TS. Several controlled studies regarding the use of medication have revealed tic reductions ranging

from 34% to 91% (see Carpenter, Leckman, Scahill, & McDougle, 1999, for a review). In a recently performed 12-week controlled trial comparing pimozide with risperidone, significant improvements of tics were found on the Tourette's Symptom Severity Scale (Bruggeman et al., 2001). Eighteen percent of the patients dropped out, mainly because of unbearable side effects. The dropout rate found in our study was 14%, with fewer dropouts in the ER group ($n = 2$) than in HR ($n = 4$).

In conclusion, in the present study, both ER and HR were shown to be effective in reducing tic symptoms. The results advocate the application of ER as an extension to HR. The challenge for the future is to compare these behavioural interventions with pharmacotherapy and the combination of both treatments, including longer-term FU data. Furthermore, future research should attempt to gain more insight into the active ingredients of the interventions and the underlying mechanisms of change, taking into account principles of learning theory and habituation paradigms.

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