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Reappraisal is an effective emotion regulation strategy in children with Tourette syndrome and ADHD

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ABSTRACT

Background and objectives: Difficulties in emotion regulation (ER) have been associated with several psychiatric disorders, emphasizing a need for a greater understanding of the concept and its associations with disruptive behavior. We aimed to study the ER strategy of cognitive reappraisal with an experimental test to increase our knowledge of emotional processes in child psychopathology.

Methods: In the present study, we examined emotional reactivity and cognitive reappraisal with a computer task in 160 medication-naïve children aged 8–12 comprising four groups: Fifty-eight children with Tourette syndrome (TS), 26 children with attention-deficit/hyperactivity disorder (ADHD), 19 children with TS and ADHD, and 57 typically developing controls.

Results: The use of cognitive reappraisal reduced negative affect across all participants and the ability to reappraise was positively correlated with age, whereas reactivity was not. Overall, groups did not differ in reactivity or regulation success. Looking at specific differences within groups, however, only the ADHD group did not significantly decrease negative affect when reappraising. Finally, the use of strategies considered to be efficacious was correlated with regulation success, whereas the use of a less adaptive strategy related to suppression was associated with reactivity, but not regulation of emotions.

Limitations: The study was limited by small, clinical contrast groups and a lack of blinding to diagnostic status in the coding of verbal strategies employed during the task.

Conclusions: Cognitive reappraisal appears to be a beneficial ER strategy for children regardless of diagnostic status. Our findings indicate that children can learn and employ an adaptive ER strategy when instructed in the technique, even in the presence of attention problems, which is highly relevant to therapeutic approaches to dysregulated behavior.

1. Introduction

The capacity of adaptive emotion regulation (ER) in childhood and adolescence is crucial for engaging in social environments and this capacity has obtained a key role in models of psychopathology (Aldao, Nolen-Hoeksema, & Schweizer, 2010). In children with Tourette syndrome (TS), explosive outbursts have been described as more disruptive than tics (Leclerc, O'Connor, Forget, & Lavoie, 2011), and in attention-deficit/hyperactivity disorder (ADHD), dysregulated emotions are a central part of the clinical presentation (Graziano & Garcia, 2016). Further examination of the role of ER ability in these neuropsychiatric disorders is crucial to understanding the processes that underlie disruptive behavior.

ER is a complex concept comprising multiple processes. One widely used conceptualization is the process model of emotion regulation which identifies five regulation strategies: situation selection, situation modification, attentional deployment, cognitive change, and response modulation (Gross, 2014). Strategies for regulating emotions can be directly related to this model, such as reappraisal related to cognitive change (McRae, 2016). Cognitive reappraisal is recognized as a useful strategy for regulating emotions (Aldao et al., 2010; Dennis & Hajcak, 2009; Hendricks & Buchanan, 2016; Ochsner, Bunge, Gross, & Gabrieli,

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Table 1
Participant characteristics.

Characteristic	TS (n = 58)	ADHD (n = 26)	TS + ADHD (n = 19)	Controls (n = 57)	*p*
Mean age (*SD*)	9.9 (1.3)	9.6 (1.1)	9.6 (1.3)	9.9 (1.3)	.570[a]
Male, n (%)	48 (82.8)	19 (73)	14 (73)	47 (82.5)	.627[b]
Mean IQ (*SD*)	102.2 (9.7)	94.7 (8.6)	99.6 (10.8)	103.7 (11.4)	.003[a]
Mean SES (*SD*)	5.7 (1.4)	4.4 (1.8)	4.9 (1.8)	6.0 (1.4)	.001[c]
Mean ADHD-RS T-score, inattention (SD)		84.0 (17.1)	77.5 (15.0)		.188[d]
Mean ADHD-RS T-score, hyperactivity/impulsivity (SD)		80.1 (19.3)	75.1 (17.0)		.374[d]
Comorbidity					
ODD, n (%)	4 (6.9)	5 (19)	4 (21)	0 (0)	.103[e]
Conduct disorder, n (%)	0 (0)	1 (3)	1 (5)	0 (0)	.188[e]
OCD, n (%)	3 (5.2)	0 (0)	2 (10)	0 (0)	.293[e]
GAD, n (%)	2 (3.4)	0 (0)	0 (0)	0 (0)	1.000[e]
SAD, n (%)	2 (3.4)	1 (3)	0 (0)	0 (0)	1.000[e]
Specific phobia, n (%)	4 (6.9)	0 (0)	0 (0)	0 (0)	.380[e]
Tics NOS, n (%)	0 (0)	1 (3)	0 (0)	0 (0)	.437[e]
ADHD subtype					
Combined, n (%)	NA	20 (76)	11 (57)	NA	.173[b]
Inattentive, n (%)	NA	6 (23)	6 (31)	NA	.524[e]
Hyperactive/impulsive, n (%)	NA	0 (0)	2 (10)	NA	.173[e]

TS = Tourette syndrome. ADHD = Attention-deficit/hyperactivity disorder. SES = Parental socioeconomic status. ADHD-RS = ADHD Rating Scale. ODD = Oppositional defiant disorder. OCD = Obsessive compulsive disorder. GAD = Generalized anxiety disorder. SAD = Separation anxiety disorder. NOS = Not otherwise specified. NA = Not applicable.

[a] One-way ANOVA.
[b] Chi-square test of homogeneity.
[c] Fisher-Freeman-Halton exact test of independence.
[d] Independent samples *t*-test. [e]Fisher's exact test.

2002) and can be defined as "rethinking the meaning of affectively charged stimuli or events in terms that alter their emotional impact" (Ochsner & Gross, 2008). Unlike the automatically occurring regulation, reappraisal is a top-down process related to cognitive control. Children as young as the age of three are capable of reappraising (Hua, Han, & Zhou, 2015; Mischel & Baker, 1975) and this ability increases with age (McRae, Gross, et al., 2012; Silvers et al., 2012). Reappraisal modifies the physiological and emotional response, whereas the less effective strategy of suppression reduces the outward response but leaves physiological and self-report measures of negative affect unaffected (Aldao et al., 2010; Hendricks & Buchanan, 2016). This distinction is evident on a neural level as well. Whereas the frontal engagement in reappraisal happens relatively early in the emotion-generative process, reducing activity in amygdala and insula, the frontal engagement in suppression occurs later and leads to an increased activity in these regions (Ochsner & Gross, 2008). While suppression traditionally refers to the physical suppression of expressed emotions, we conceptualize suppression as the negation of negative stimuli. In the framework of the process model of emotion regulation, expressive suppression and suppression as the negation of negative stimuli can be argued to be types of response modulation, with expressive suppression targeting the emotion and negation targeting the stimulus causing the emotion. Although emotion negation has the potential to downregulate emotions with greater effect than suppression (Herbert, Deutsch, Platte, & Pauli, 2013), negation of negative stimuli resembles suppression with regard to the more superficial quality of the inhibition.

The generation of emotions is a complex process, largely dependent on emotional reactivity. Reactivity carries a two-fold meaning reflecting both the threshold at which a stimulus elicits a response and the nature of that response (Carthy, Horesh, Apter, Edge, & Gross, 2010; Silvers et al., 2012). Theories on child temperament highlight the interplay between reactivity and regulation with individual ER style interacting with the natural response to a stimulus (Dennis & Hajcak, 2009). A vast body of literature has studied reactivity in children with ADHD whereas very few studies have examined reactivity in TS. Reactivity styles in ADHD are associated with an increased intensity of emotions and higher reactivity behaviorally and physiologically (Fogleman, Leaberry, Rosen, Walerius, & Slaughter, 2018). In a study of adults with TS, interpersonal reactivity styles differed compared to a control group (Eddy, Macerollo, Martino, & Cavanna, 2015); however, this study was limited by varying comorbid disorders and mixed medication status. Regarding ER, TS and ADHD have been associated with explosive behavior (Graziano & Garcia, 2016) with recent studies pointing to ADHD as pivotal to this dysregulation of emotions (Budman & Olson, 2000; Chen et al., 2013).

The aim of the present study was to investigate reappraisal and reactivity in medication-naïve groups of children with TS, ADHD, TS + ADHD, and typically developing children with an experimental task that has previously been used in typically developing populations. We hypothesized that we would discover a main effect of employing the strategy of reappraisal across all participants and that the groups would show a staircase effect with the control group achieving the highest regulation success scores followed closely by the TS group and ultimately the groups including children with ADHD. For reactivity, we expected the ADHD groups to score higher than the remaining groups. Finally, we were interested in examining in an explorative manner the effectiveness of different verbal reappraisal strategies.

2. Methods

This study was part of a project approved by the Regional Committee on Health Research Ethics (journal number H-2-2013-085) and the Danish Data Protection Agency (journal number 2017-58-0015). We obtained written informed consent from caregivers of all participants in accordance with the Declaration of Helsinki.

2.1. Participants

We included a total of 160 medication-naïve participants aged 8–12 in the study: Fifty-eight children with TS, 26 children with ADHD, 19 children with TS and ADHD, and 57 typically developing children (Table 1). As no previous studies could guide the selection of an appropriate sample size, we aimed to be able to detect at least medium sized possible deficits in the primary clinical group (children with TS) when compared to the control group (typically developing children). With an a priori alpha value of .05 and assumed power of .80, this required a sample size of at least 51 in each of these two groups.

Unfortunately, exclusion criteria targeted primarily the ADHD groups with 33 potential participants being found non-eligible prior to screening (mainly due to prior or present use of psychotropic medication) and 29 participants being excluded post assessment due to comorbid psychosis or autism, IQ < 80, neurological conditions, or the presence of tics not fulfilling criteria for TS. We allocated participants to one of the four groups following multi-informant assessment with the semi-structured diagnostic interview Kiddie-Schedule for Affective Disorders and Schizophrenia, Present and Lifetime Version (K-SADS-PL; Kaufman et al., 1997), the Yale Global Tic Severity Scale (YGTSS; Leckman et al., 1989), and the ADHD Rating Scale (ADHD-RS; DuPaul, Power, Anastopoulos, & Reid, 1998). The YGTSS is a clinician-rated instrument that evaluates number, frequency, intensity, complexity, and interference of tics, and the ADHD-RS is a parent- and teacher-rated questionnaire addressing ADHD symptoms (inattention and hyperactivity/impulsivity). Psychologists or a medical doctor performed the interviews with the parent(s) and the child separately and reached a diagnosis in consultation with a specialist in child and adolescent psychiatry. Children were eligible for inclusion in one of the clinical groups if they met DSM-IV (American Psychiatric Association, 2000) criteria for either TS or ADHD. Exclusion criteria were severe comorbidity (autism spectrum disorder and psychotic disorders), birth at gestational age < 37 weeks, presence of any neurological condition, or IQ below 80 (assessed with the Wechsler Intelligence Scale for Children – fourth edition (WISC-IV; Wechsler, 2004)). We recruited participants for the clinical groups from the local child and adolescent outpatient clinic and from a pediatric department in the Capital Region of Denmark in the period from 2013 to 2016. Children in the control group did not meet criteria for any lifetime psychiatric disorder and were randomly selected via the Danish Civil Registration System (Pedersen, 2011) and matched on age and sex with the TS group. We characterized the socioeconomic status of the parents of each participant using the International Standard Classification of Education (Unesco, 2012).

2.2. Picture Reappraisal Task

Variations of the Picture Reappraisal Task (PRT) have been used in several previous studies (McRae, Gross, et al., 2012; Ochsner et al., 2004, 2002; Silvers et al., 2012) as an experimental measure of reappraisal. In our study, participants were shown 15 neutral images and 30 negative images on a computer using E-prime software (Psychology Software Tools, Pittsburgh, PA) and were asked to either look at the pictures and react naturally to them or to actively decrease negative emotions. The cue for neutral images was always “Look” (responding naturally), whereas the cue for negative images alternated between “Look” (reactivity) and “Decrease” (reappraisal) creating a total of three conditions: 1) “Look neutral”, 2) “Look negative”, and 3) “Decrease negative”. The cue screen was displayed for three seconds followed by the picture for 10 seconds. Finally, a rating screen appeared for six seconds asking the participants to rate their level of negative affect on a scale from one to five, with one representing complete absence of negative affect and five representing strong negative affect. Contrary to former versions of the task, we displayed the images in blocks of 10 pictures with the cue “Look” and five with the cue “Decrease” to avoid accidentally measuring trial-by-trial switching instead of reappraisal. Aversive pictures were counterbalanced between the negative conditions with similar normative ratings of valence for each condition (3.34 and 3.37, respectively). This created four versions of the experiment (A, B, C, and D) as a result of combining two distributions of negative images with two sequences (starting with “Look” or “Decrease”, respectively). Six participants were tested on a different version of the task regarding order of images and cue time. These children saw the same pictures, and their measures of reactivity and regulation success were not different from the remaining participants. There were no differences in distribution of versions across participants or within the groups. Pictures were selected from the International Affective Picture System (IAPS pictures 1050, 1120, 1201, 1300, 1321, 1930, 2120, 2130, 2688, 2780, 2810, 2900, 3022, 3230, 3280, 5470, 5820, 5970, 6190, 6300, 7000, 7002, 7004, 7009, 7010, 7041, 7090, 7100, 7140, 7150, 7224, 7380, 7595, 7950, 9050, 9250, 9404, 9421, 9470, 9480, 9490, 9582, 9594, 9600, 9611; Lang, Bradley, & Cuthbert, 2008) and had all previously been used in similar studies with corresponding age groups.

All participants underwent a practice session with instructions on how to react naturally and how to reappraise. For all trials in the “Decrease negative” condition the test administrator would give one or two prompts to ensure the child answered timely and to act as a reminder for the children with attention problems: “How can you make this picture better” or “How can you make this picture less unpleasant”. The task was filmed to allow for subsequent coding of reappraisal strategies. The first author conducted the coding of the videos according to the previously published Reappraisal Tactic Coding Guide (McRae, Ciesielski, & Gross, 2012) with the following modifications: In addition to the ten categories from the Coding Guide (‘Explicitly positive’, ‘Change current circumstances’, ‘Reality challenge’, ‘Change future consequences’, ‘Agency’, ‘Distancing’, ‘Technical-analytic-problem solving’, ‘Acceptance’, ‘Non-specific reappraisal’, and ‘Failure to reappraise’) we added two extra categories (‘Negating the negative’ and ‘No negative affect’). The former category can be associated with suppression strategies as the tactic involves simply saying the picture would be better if the elements causing discomfort weren't there or were replaced with something better. The latter category was included for whenever children explicitly stated that they did not feel any discomfort. Whereas the original coding guide used a system of estimating the degree to which each category is used, we coded the specific strategy for each reappraisal.

2.3. Data analyses

Statistical analyses were performed using SPSS version 22.0. The raw data employed in the analyses is available upon request, without reservations, to all researchers.

We excluded participants with less than two thirds of ratings per condition available (number of missing ratings per condition > 5), leading to five participants in total being excluded (two from the TS group, two from the TS + ADHD group, and one from the control group). One participant from the control group was excluded due to a markedly deviant response profile suggesting reversed ratings. We assessed differences in number of missing ratings across conditions with the Friedman test with a Bonferroni correction for multiple comparisons and differences in number of missing ratings between groups with the Kruskal-Wallis H test, as data was not normally distributed. We assessed group differences in age, sex, IQ, SES, symptom severity, and comorbidity with relevant statistical tests (Table 1) while controlling for multiple comparisons, although statistical analyses of group differences should be interpreted with caution due to the small sample size of the ADHD groups.

We examined regulation and reactivity across all participants following the procedure of Silvers et al. (2012) with regulation representing the percent decrease in negative affect from “Look negative” to “Decrease negative” and reactivity representing the percent increase in negative affect comparing “Look neutral” to “Look negative”. Due to a non-normal distribution of reactivity, but not regulation, we performed a Friedman test with Bonferroni corrected pairwise comparisons to investigate differences between ratings of negative affect on conditions one (“Look neutral”), two (“Look negative”), and three (“Decrease negative”). We expected to find a higher rating of negative affect in the “Look negative” condition compared to the “Look neutral” as a representation of emotional reactivity, and we expected lower ratings on the “Decrease negative” condition compared to the “Look negative” as a representation of ER. We examined correlations between age and reappraisal using Pearson's product-moment correlation and age and reactivity using Spearman's rank-order correlation. We expected to find a medium correlation between age and reappraisal ability and no relationship between age and reactivity. Finally, although the PRT is not a speeded task, we examined differences in reaction times (RT; the time from the picture disappears from the screen until the participant presses a button to rate negative affect) with a one-way repeated measures ANOVA and Bonferroni corrected post hoc analyses. We expected an increasing staircase effect of RT with conditions, indicating that the negative affect associated with looking at aversive images would prolong reaction times.

We examined the effect of condition on rating of negative affect within groups using a Wilcoxon signed-rank test with effect size estimates ($r = z$/N(sqrt), where N represents the total number of observations and not cases). We furthermore conducted an ANCOVA controlling for age for the analysis of group differences in regulation success, as previous studies have suggested that ER improves with age up to late adolescence (Silvers et al., 2012). Finally, we ran a Kruskal-Wallis H test for the analysis of reactivity across groups.

We examined group differences in the use of strategies for each category separately and for categories one to nine combined representing the total use of a potentially advantageous strategy. We conducted Spearman's rank-order correlations including all participants in the analyses to assess the relationship between regulation success, reactivity, and age and the use of effective (categories one to nine) and ineffective ('Negating the negative') strategies. Fourteen participants were not included in this specific analysis due to missing videos (five with TS and three from each of the remaining groups).

3. Results

3.1. Participant characteristics

There was no significant difference in missing ratings across conditions (respectively 5.2%, 4.6%, and 8.6%) or between groups (1.8%, 1.6%, 1.3%, and 1.6%, respectively). Groups did not differ significantly on age, sex, comorbidity (other than ADHD), ADHD subtype, or symptom severity, but did differ on parental SES and IQ (Table 1).

3.2. Main effects of condition and associations with age and reaction times

Ratings of negative affect were significantly different across conditions, χ^2 (2) = 245.116, $p < .001$. Post hoc analysis revealed significantly different median ratings following a natural response to neutral images (*Mdn* = 1.00) compared to negative images (*Mdn* = 2.50; $p < .001$). As expected, ratings following reappraisal (*Mdn* = 2.13) were lower than ratings following a natural response to negative images ($p < .001$). We found a small, but significant correlation between age and reappraisal ability ($r(158) = 0.227$, $p = .004$) and no correlation between age and reactivity ($r_s(158) = 0.061$, $p = .443$). RT's were significantly different for the three conditions (F (1.769, 281.341) = 212.721, $p < .001$, partial $\eta^2 = 0.572$), with RT increasing significantly from looking at neutral pictures ($M = 1712.91$, $SD = 33.73$), to negative pictures ($M = 2001.02$, $SD = 37.21$), to finally reappraising negative pictures ($M = 2446.53$, $SD = 42.99$), and this was also the case for all groups (Table 2).

3.3. Group differences in regulation and reactivity

Ratings of negative affect differed between conditions for all groups, mirroring the results for the total sample. As the only exception, children in the ADHD group did not significantly decrease their ratings of negative affect when asked to reappraise compared to reacting naturally (Fig. 1; Table 3).

For the analysis of group differences in regulation, we did not find a statistically significant difference after adjusting for age, F(3, 155) = 1.063, $p = .367$, partial $\eta^2 = 0.020$. The control group showed a mean increase in negative affect (reactivity) of 134% followed by the TS + ADHD group with 109%, the TS group with 107%, and finally the ADHD group with a 98% increase (Table 4), but there was no statistically significant difference between groups on reactivity, $\chi^2(3) = 6.031$, $p = .110$. Including IQ and SES as covariates did not change the present statistically insignificant result for regulation success.

3.4. Reappraisal strategies

We found a significant, positive medium sized correlation across all participants between total number of theoretically effective strategies employed and regulation success (Table 5). This correlation was driven primarily by the specific strategy 'Change current circumstances'. We did not find a correlation between the theoretically ineffective suppression-like strategy 'Negating the negative' and regulation success, nor did we find a correlation between number of effective strategies employed and reactivity. Higher reactivity scores were associated with more frequent use of the strategy reflecting suppression. In accordance with the previously described correlation between age and regulation success, we also found a significant correlation between age and number of effective strategies employed, which was once again driven by the specific strategy 'Change current circumstances' (Table 5).

4. Discussion

In the present study we examined profiles of emotion regulation and reactivity in four groups of clinically well-described and medication-naïve children with TS, ADHD, TS + ADHD, and controls. The results for all participants corroborate reappraisal as an effective ER strategy and support earlier findings by demonstrating an association between age and regulation success, but not between age and reactivity. As expected, we did not find any statistically significant group differences in regulation ability between the TS group and the control group; nor did we find an overall difference between the groups with ADHD and the control group, which was unexpected. For the second outcome of reactivity, we did not find elevated scores in the ADHD groups as hypothesized.

From the unadjusted descriptives we do see the expected pattern of regulation success with the control group achieving the highest score, the ADHD group the lowest score, and the TS groups positioned along this spectrum, but groups did not differ significantly in regulation ability when controlling for age. However, when we examined reappraisal within groups, the ADHD group was the only group to not decrease negative affect significantly following reappraisal, although the limited power afforded by the small sample size and the lack of

Table 2
Mean Reaction Times Across Conditions. TS = Tourette syndrome. ADHD = Attention-deficit/hyperactivity disorder. RT = Reaction time.

	TS	ADHD	TS + ADHD	Controls
Mean RT (ms), "Look neutral" (SD)	1680.1 (426.7)	1969.6 (436.5)	1765.0 (480.4)	1609.3 (356.3)
Mean RT (ms), "Look negative" (SD)	2012.6 (488.6)	2121.0 (486.2)	2036.4 (457.0)	1919.5 (445.2)
Mean RT (ms), "Decrease negative" (SD)	2454.9 (561.4)	2451.7 (624.3)	2443.9 (424.8)	2435.8 (534.7)

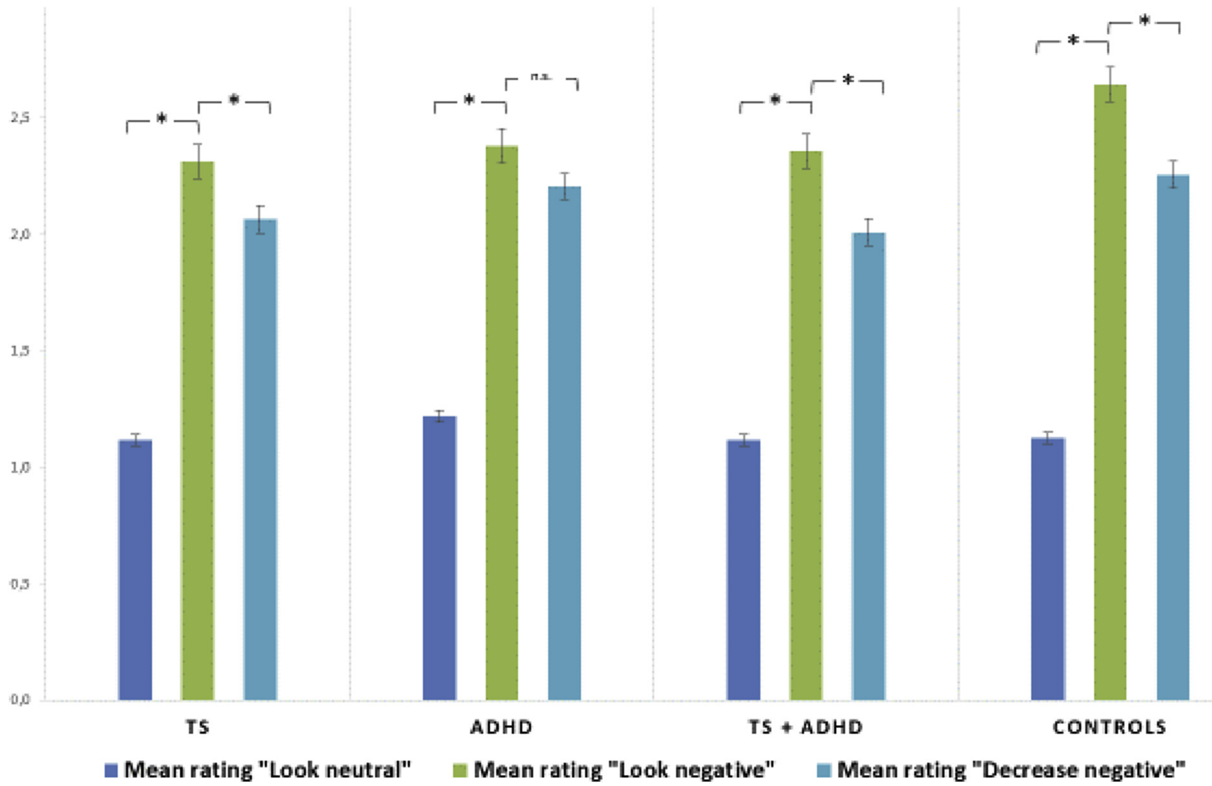

Fig. 1. Mean ratings across groups. TS = Tourette syndrome. ADHD = Attention-deficit/hyperactivity disorder. n.s. = Not significant. Error bars represent the standard error.

Table 3
Reactivity and regulation within groups.

Group	Reactivity			Regulation		
	Increase in negative affect on "Look neutral" vs. "Look negative"	p[a]	r[b]	Decrease in negative affect on "Look negative vs. "Decrease negative"	p[a]	r[b]
TS, *Mdn*	1.1	< **.001**	.61	0.2	< **.001**	.35
ADHD, *Mdn*	1.3	< **.001**	.61	0.1	.140	.20
TS + ADHD, *Mdn*	0.9	< **.001**	.60	0.3	**.002**	.51
Controls, *Mdn*	1.5	< **.001**	.61	0.3	< **.001**	.47

Mdn = Median. TS = Tourette syndrome. ADHD = Attention-deficit/hyperactivity disorder.
[a] Wilcoxon signed-rank test.
[b] Effect size ($r = z$/N(sqrt)).

Table 4
Mean scores of reactivity and regulation.

Group		Reactivity		Regulation			
				Unadjusted		Age-adjusted	
	N	M	SD	M	SD	M	SE
TS	58	107.80	69.19	9.33	19.13	9.09	2.31
ADHD	26	98.68	71.34	4.57	18.26	6.19	3.57
TS + ADHD	19	109.34	84.37	13.81	15.27	14.20	4.05
Controls	57	134.53	73.67	13.91	16.00	12.22	2.36

TS = Tourette syndrome. ADHD = Attention-deficit/hyperactivity disorder.

controlling for multiple comparisons point to the importance of replicating this finding in a larger group of children with ADHD. Although, in the present study, our analyses relate to an investigation of differences and not sameness between groups, we found moderate evidence in favor of the null hypothesis using Bayesian testing, reflecting no difference in regulation ability between children with TS and controls. One explanation for the overall lack of difference between groups on regulation success might be that the images were not sufficiently unpleasant to differentiate the groups, as the age span made it challenging to select images that would create negative affect in a

Table 5
Correlations between regulation success, reactivity, and age and reappraisal strategies.

	Total reappraisal		'Change current circumstances'		'Negating the negative'	
	r_s (df)	p	r_s (df)	p	r_s (df)	p
Regulation success	.322 (144)	< **.001**	.317 (103)	**.001**	-.103 (102)	.300
Reactivity	.016 (144)	.844	.186 (103)	.058	.260 (102)	**.008**
Age	.261 (144)	**.001**	.297 (103)	**.002**	-.120 (102)	.225

Total reappraisal = Strategies from category one to nine combined. df = Degrees of freedom.

twelve-year-old without traumatizing an eight-year-old. Another explanation might stem from the nature of reappraisal. Unlike spontaneously occurring regulation in everyday life, the PRT addresses reappraisal as the sole potential strategy. It may be that children regardless of group are able to learn to apply this strategy when explicitly instructed how to do so. This finding is in line with an earlier study of similarly guided reappraisal in children with anxiety where the authors did not find any difference in reappraisal ability compared to a control group (Carthy et al., 2010). A study of self-reported ER strategies in adults with TS additionally demonstrated that individuals with TS did not differ from healthy controls in their use of reappraisal, but that they were more likely to use suppression (Drury, Wilkinson, Robertson, & Channon, 2016).

Previous studies have demonstrated maladaptive ER in children with ADHD (Lugo-Candelas, Flegenheimer, Harvey, & McDermott, 2017; Shushakova, Ohrmann, & Pedersen, 2018). Our results, however, indicate that children with ADHD can regulate their emotions successfully when guided, which may prove relevant in treatment or in demanding settings such as school. Interestingly, the TS + ADHD group presented with the highest adjusted score for regulation success, although this result was not significant. One explanation for this may relate to the representativeness of the sample. As the majority of the TS + ADHD group was recruited from a pediatric clinic with nationwide responsibility for the care and management of children with TS, these children would have been referred with TS as their primary diagnosis, thus presumably presenting with milder ADHD symptoms than children referred directly to a child psychiatric clinic. However, ADHD-RS scores for the ADHD group and the TS + ADHD group were not significantly different from each other (Table 1), and both groups presented with scores two standard deviations above the norm. As a final consideration, the exclusion criterium of IQ below 80 may have led to an atypical representation of ADHD with regard to intellectual abilities.

Contrary to our hypothesis, the ADHD groups did not display heightened reactivity; conversely, the control group presented with the highest mean level, although this finding was not significant. One possible explanation for the low reactivity scores in the ADHD groups may be that emotional stimuli need to be more powerful to create a response in these children. Children with ADHD are generally more exposed to negative interactions with parents, teachers (Johnston & Jassy, 2007), and peers (Landau, Milich, & Diener, 1998) which may create a higher threshold for negative input due to habituation. This is supported by the reactivity scores (Table 4). Only the control group presented with scores resembling previous studies of reactivity in healthy controls (134% compared to 137% in Silvers et al., 2012), whereas the remaining groups showed increases ranging from 98 to 109%. Thus, it does not appear to be a case of increased reactivity in the control group, but rather decreased reactivity in the clinical groups. Further, emotional reactivity, and as a result also reappraisal, is dependent on emotion recognition ability and potentially concurrent alexithymia, which may have influenced results. A recent review demonstrated that emotional faces and particularly fearful ones were abnormally recognized by individuals with ADHD (Borhani & Nejati, 2018) and in the present study, eight out of a total of 45 images depicted faces. Future studies should thus control for emotion recognition ability and alexithymia in connection with the assessment of reappraisal ability.

The finding that seemingly effective strategy use was associated with regulation success supports reappraisal as an adaptive strategy. We found an interesting dissociation, where the most highly used advantageous reappraisal strategy was associated with reappraisal success, but not emotional reactivity, while the use of a suppression-associated strategy was related to emotional reactivity, but not reappraisal success. We saw a small association between reactivity and the efficacious reappraisal strategy, which approached the threshold for statistical significance (Table 5), although there was no association between the summated effective strategies and reactivity. The association between a suppression-like strategy and reactivity is interesting and could be indicative of a tendency to employ quick and seemingly downregulating strategies in children with psychopathology high in reactivity, such as a reliance on suppression in depression, social anxiety, and panic disorder (Aldao et al., 2010), as well as in TS, in which this reliance was associated with depressive symptomatology (Drury et al., 2016). The present findings, however, do not indicate increased reactivity in children with psychopathology, warranting further investigation. Disentangling the relationship between reactivity and (mal)adaptive regulation strategies would require studies comparing guided and spontaneous regulation directly, while employing outcome measures relying on self-report and physiological measures. Although the present groups did not differ in their use of strategies, an interesting meta-analysis on emotion regulation strategies across different psychopathologies found that the frequency of use of maladaptive strategies (rumination, avoidance, and suppression) was positively correlated with level of psychopathology, and conversely that adaptive strategies (acceptance, reappraisal, and problem solving) were associated with less psychopathology (Aldao et al., 2010). It is possible that these differences in spontaneous regulation are attenuated under guidance, pointing to a potential gain from practicing adaptive strategies in children with dysregulated behavior.

A number of limitations, centering around sample size, lack of blinding, and stimulus material, were evident in the present study. While the inclusion of the combined TS + ADHD group could provide important insights into the shared and specific contributions to regulation ability in a comorbid group compared to single diagnosis groups (Aldao, 2016), the small sample size severely limits the power of analyses and insufficient statistical power may have limited the significance of the statistical comparisons. Specifically, sensitivity analyses demonstrated that with the included number of participants, differences between the TS ($n = 58$) and TS + ADHD ($n = 19$) groups would have to reach effect sizes of at least 0.75 in order for us to detect these. Similarly, a direct comparison between the TS group and the ADHD group (n = 26) would require effect sizes of at least 0.67 to reach significance. One major limitation was the lack of blinding. Test administrators were not blinded to diagnostic status, and the coder was not blinded when assessing strategy use. Ratings of negative affect, which were the primary outcome, were not affected by the lack of blinding as this measure was self-evaluated by the participants. Self-report is fundamental to understanding the child's emotions and earlier studies have found self-reported negative affect following reappraisal to be associated with corresponding physiological and neural changes (Silvers et al., 2012). However, this method also created some bias as self-report is known to be susceptible to mood and requires metacognitive abilities, and the experience of the emotion can be mixed with the experience of the regulation. Moreover, one study with adults found that test participants often relied on another strategy than the one they were instructed to use (Demaree, Robinson, Pu, & Allen, 2006). Future studies would benefit from a multi-method approach incorporating physiological measures as a more objective basis for comparison. An additional limitation related to the task was the attempt to create an appropriate amount of negative affect in all age groups which led to some pictures simply not producing the desired negative affect in all children. Ideally, aversive images should be tailored to the child's individual arousal threshold to ensure all children experience the same level of negative affect. Finally, although previous studies applying the PRT have consisted of 15 images to be reappraised, the relatively small number of reappraisals in addition to the fact that children were not able to reappraise on all images, may potentially be part of the explanation of the lack of differences found across groups.

In conclusion, although research has suggested that the symptomatology of ADHD and to a lesser extent TS is frequently accompanied by emotional dysregulation, we did not in the present study find any group differences in reappraisal ability when children were trained in the procedure. The lack of group differences in guided ER ability is of special relevance to therapeutic approaches to children with these disorders who experience difficulties with spontaneous, unguided emotion regulation, although from the present study we are unable to comment on the long-term effects of this training or how it might translate to everyday problems with disruptive behavior.

CRediT authorship contribution statement

Julie Hagstrøm: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - original draft, Visualization. **Katrine Maigaard:** Conceptualization, Investigation, Writing - review & editing. **Anne Katrine Pagsberg:** Writing - review & editing, Supervision. **Liselotte Skov:** Resources, Writing - review & editing. **Kerstin Jessica Plessen:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Signe Vangkilde:** Conceptualization, Methodology, Software, Validation, Formal analysis, Writing - review & editing, Supervision.

Declaration of competing interest

The authors have no conflicts of interest to disclose.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbtep.2019.101541.

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