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Accepted for publication in 'Journal of Behavior Therapy and Experimental Psychiatry'

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INTERNAL SHIFTING IMPAIRMENTS IN RESPONSE TO EMOTIONAL INFORMATION IN DYSPHORIC ADOLESCENTS

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Abstract

Background and Objectives: Previous studies have suggested that internal cognitive control impairments may play an important role in the development of depression. Despite a growing body of research in adults, the ability to shift internal attention between mental representations in working memory has received little attention in younger populations. This study investigated internal shifting capacity between emotional and non-emotional information in dysphoric and non-dysphoric adolescents.

Methods: Twenty dysphoric and 34 non-dysphoric adolescents (10-17 years) completed an Internal Shifting Task, with pictures of angry and neutral faces, to measure the ability to shift attention between information held in working memory.

Results: Dysphoric adolescents showed specific shifting impairments when processing emotional material relative to non-dysphoric adolescents. Valence-specific analyses revealed that shifting was particularly impaired when shifting from negative to neutral information. By comparison, relative to non-dysphoric adolescents, dysphoric adolescents did not show shifting impairments when non-emotional features of the pictures had to be processed.

Limitations: The study is limited by the absence of a structured clinical interview as dysphoria was determined dimensionally. Furthermore, a comparison of the effects of different negative stimuli on shifting could not be made since sad stimuli were not included in the stimulus set.

Conclusions: The results confirm the link between depressive symptoms and emotion-specific shifting impairments in adolescents and indicate that targeting shifting ability in response to emotional stimuli may be a promising avenue for prevention programs. Longitudinal research is needed to replicate results and to explore the role of internal shifting impairments in the etiology and maintenance of depression.

Keywords: Dysphoria; Shifting; Working memory; Emotion; Adolescents

1. Introduction

Depressive symptoms in adolescents are common (Balazs, 2013) and have a variety of negative consequences, such as impaired social relationships and an increased risk for suicide (Birmaher et al., 1996; Horowitz & Garber, 2006). Moreover, adolescent depressive symptoms are highly predictive for chronic and severe depressive episodes in adulthood (Lewinsohn, Rohde, Seeley, Klein, & Gotlib, 2000), which indicates the need to study underlying cognitive processes in dysphoric adolescents before a chronic course emerges.

Cognitive theories have mainly focused on the *content* of depressive cognition and assigned a crucial role to negative schemas of the self, world, and future in the development and persistence of depression (Beck, 1976). The proposition that cognitive schemas have a major influence on the processing of information stimulated research on the relationship between cognitive *processes* and depressive symptoms. Results of these studies provided evidence for depression-related information processing biases (Neshat-Doost, Taghavi, Moradi, Yule, & Dalgleish, 1998; Timbremont, Braet, Bosmans, & Van Vlierberghe, 2008) and indicated a better memory for negative information and an attentional bias towards negative information among adolescents who are currently depressed or at risk for depression (Gibb, Benas, Grassia, & McGeary, 2009; Hankin, Gibb, Abela, & Flory, 2010). It is assumed that these negative processing biases lead to repetitive negative thoughts (i.e. rumination) and sustained negative affect, which in turn contribute to and intensify depressive symptoms (Clark & Beck, 2010). Despite the interesting findings regarding depressogenic information processing, so far it is still unclear to what extent adolescent depressive symptoms are associated with impairments on the level of fundamental cognitive control processes, which refer to executive functions such as working memory. Yet, the investigation of such processes is of particular interest since it has been shown that the capacity to cognitively control incoming

information positively impacts one's ability to deal with stressful events and to manage emotional responses (Ochsner & Gross, 2005).

1.1. Depressive Symptoms and Cognitive Control Impairments

Cognitive control refers to the ability to selectively attend to relevant stimuli, select and maintain relevant goals, and inhibit the processing or response to irrelevant or previously relevant stimuli (Brydges, Anderson, Reid, & Fox, 2013; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuiss, 2004). This ability is related to three important executive functions: shifting between tasks or mental sets (*shifting*), inhibiting dominant responses or irrelevant information (*inhibition*), and monitoring and updating the contents of working memory (*updating*) (Miyake et al., 2000). Recently, it has been proposed that impaired cognitive control may be an important component for understanding prolonged negative affect and recurrent negative thoughts in depression (Joormann & D'Avanzato, 2010; Koster, De Lissnyder, Derakshan, & De Raedt, 2011). The majority of the past studies on cognitive control in depressed or dysphoric adolescents have used cognitive control tasks including non-emotional information and provided mixed results with only a few studies indicating a clear group difference (for a review see Vilgis, Silk, & Vance, 2015). The little research that demonstrated group differences regarding cognitive control ability showed that depressed adolescents were less accurate (i.e., higher error rates) and responded more slowly (i.e., higher response times) compared to healthy adolescents (Bloch et al., 2013; Gunther, Konrad, De Brito, Herpertz-Dahlmann, & Vloet, 2011; Hardin, Schroth, Pine, & Ernst, 2007). However, multiple studies on cognitive control functions yielded mixed or no results (Han et al., 2012; Kyte, Goodyer, & Sahakian, 2005; Wilkinson & Goodyer, 2006). For instance, previous studies investigating general shifting, determined by tests such as the Wisconsin Card Sorting Test (WCST; Grant & Berg, 1948), were inconclusive showing either no difference between depressed adolescents and healthy controls (Favre et al., 2009) or a lower score on shifting in the depressed group (Gunther et al.,

2011; Holler, Kavanaugh, & Cook, 2014). By contrast, studies examining inhibition, with an antisaccadic eye movement task (Hardin et al., 2007) or a go/no-go task (Gunther et al., 2011) provided some support for impaired inhibition in depressed or dysphoric adolescents, yet, empirical evidence is far from being consistent (Vilgis et al., 2015).

Given prior inconclusive results regarding general cognitive control impairments, one possibility is that cognitive control in dysphoric or depressed adolescents might be particularly disturbed when processing emotional information (Joormann, Yoon, & Zetsche, 2007; Koster et al., 2011; Vilgis et al., 2015). Although research using cognitive control tasks including emotional stimuli in pediatric mood disorders and dysphoric adolescents is rather scarce (for a review see Mueller, 2011), a few studies have provided such evidence. Ladouceur et al. (2005) and Tavitian et al. (2014) administered an Emotion *N*-back task and found evidence for working memory impairments in the presence of emotional and neutral information in depressed youngsters compared to healthy controls. Furthermore, results from the Affective go/no go task also support impaired processing of negative stimuli in adolescents suffering from depression (Kyte et al., 2005; Ladouceur et al., 2006; Maalouf et al., 2012). Finally, a study using the Negative Affective Priming task showed a higher interference and inhibition of negative stimuli in dysphoric adolescents compared to healthy controls (Wante, Mueller, Demeyer, De Raedt, & Braet, 2015). Although the aforementioned studies provide initial evidence for dysfunctional cognitive control over emotional stimuli, it has recently been proposed that depressed people might experience specific difficulties with *internal* cognitive control rather than with *external* cognitive control processes (Koster, De Lissnyder, & De Raedt, 2013).

1.2. Depressive Symptoms and Internal Shifting Ability

Whereas *external* cognitive control refers to the selection and modulation of external information, such as perceptual attributes of cues or targets, *internal* cognitive control can be described as the ability to process and modulate internally generated information, such as

mental sets in working memory (Chun, Golomb, & Turk-Browne, 2011; Wager, Jonides, & Smith, 2006). Impaired internal control over negative thoughts may result in difficulties regulating negative affect and thus might be of particular relevance in the development of depressive symptoms (Koster et al., 2013). An interesting paradigm to explore shifting between mental representations in working memory is the Internal Shifting Task (IST; Chambers, Lo, & Allen, 2008; De Lissnyder, Koster, & De Raedt, 2012), which is an affective variant of the shifting task of Garavan (1998) and Gehring, Bryck, Jonides, Albin, and Badre (2003). The IST used in this study includes pictures of faces and consists of an emotional and a non-emotional condition. In the emotional condition, participants are asked to perform a silent mental count of the number of negative and neutral faces. In the non-emotional condition, participants are instructed to mentally count the amount of male and female faces. The IST design allows to measure efficiency of general shifting (across emotional and non-emotional condition), condition-specific shifting (emotional condition vs. non-emotional condition), and valence-specific shifting (shifting from negative to neutral or vice versa). Results of a study in depressed adolescents and young adults using an IST with neutral and affective words revealed greater shifting difficulties in the emotional condition compared to healthy controls (Lo & Allen, 2011). Moreover results of prospective studies in adults using a pictorial IST indicated that emotion-specific shifting impairments are associated with increased rumination in response to stress (De Lissnyder, Koster, Goubert, et al., 2012) and play an important role in the prediction of depressive symptoms at one year follow up (Demeyer, De Lissnyder, Koster, & De Raedt, 2012).

1.3. The Current Study

Despite the increased risk for an adult depressive episode in adolescents with depressive symptoms (Pine, Cohen, Cohen, & Brook, 1999), research on the role of internal cognitive control in response to emotional stimuli in dysphoric adolescents remains scarce. The present

study aimed to examine internal shifting ability in dysphoric adolescents with the use of the IST including pictures of angry and neutral faces (De Lissnyder, Koster, & De Raedt, 2012). In line with prior shifting studies in adults (De Lissnyder, Koster, Derakshan, & De Raedt, 2010; De Lissnyder, Koster, Everaert, et al., 2012; De Lissnyder, Koster, Goubert, et al., 2012; Demeyer et al., 2012; Koster et al., 2013), we included angry faces as negative target stimuli in that these kind of emotional stimuli are thought of bearing direct personal relevance to adolescents suffering from depressive symptoms and can be associated with depression-related interpersonal difficulties and schemas of social rejection (Gotlib, Krasnoperova, Yue, & Joormann, 2004; Hames, Hagan, & Joine, 2013; Mueller, De Rubeis, Lange, Pawelzik, & Sutterlin, 2016). According to interpersonal theories of depression, depressed individuals engage in inappropriate social behaviors that are likely to elicit social rejection, which in turn confirms negative schemas and increases depressive symptoms (Coyne, 1976; Joiner, Alfano, & Metalsky, 1992). Since angry faces might activate depression-related schemas of social rejection and therewith increase negative affect, these stimuli may strongly attract attention in dysphoric adolescents (Gilboa-Schechtman, Ben-Artzi, Jeczemien, Marom, & Hermesh, 2004).

The study had three specific goals. First, we investigated whether dysphoric adolescents relative to unaffected adolescents showed *general* shifting impairments. Based on prior research in depressed or dysphoric adolescents which failed to find general cognitive control deficits (Vilgis et al., 2015), and shifting deficits in particular (Favre et al., 2009), we expected no differences between the groups with regard to general shifting impairments. Second, we aimed to investigate to what extent dysphoric adolescents showed *specific* shifting impairments when processing the emotional features of the target stimuli. Drawing on a few studies investigating cognitive control of emotional stimuli in adolescents with elevated depressive symptoms (Maalouf et al., 2012; Tavitian et al., 2014; Wante et al., 2015) and prior internal shifting studies among currently depressed and at-risk individuals (De Lissnyder, Koster, Goubert, et al., 2012;

Demeyer et al., 2012; Koster et al., 2013; Lo & Allen, 2011), we hypothesized a greater shift cost in the emotional condition compared to the non-emotional condition only in the dysphoric group. Finally, we explored whether dysphoric adolescents showed *valence-specific* shifting impairments. On the basis of recent cognitive models of depression (Joormann & D'Avanzato, 2010; Koster et al., 2011), we predicted higher shift costs related to shifting from angry to neutral information compared to shifting from neutral to angry information in dysphoric adolescents but not in non-dysphoric adolescents.

Because of the continuous development of cognitive control processes, such as shifting between mental sets, during adolescence (Diamond, 2002) and gender differences in the neural processes of cognitive control (Koch et al., 2007; Li et al., 2009), age and gender were included as standard covariates throughout all analyses. Moreover, to filter out the confounding effects of other relevant variables that may impact differences shifting ability between the dysphoric and the non-dysphoric group, we explored the impact of several covariates of no interest in a second round of analyses. Based on previous adult studies indicating an association between rumination and shifting (De Lissnyder et al., 2010; De Lissnyder, Koster, Goubert, et al., 2012; Demeyer et al., 2012; Koster et al., 2013), we added rumination as a control variable to exclude its potential contribution to the results. Furthermore, since dysphoria and anxiety are frequently associated with one another (AACAP, 2007) and to rule out a potential contributing factor, we added anxiety symptoms as a control variable. Next, we controlled for other co-occurring symptoms besides anxiety that could influence shifting ability in the dysphoric group by including the overall level of psychopathology symptoms. Finally, given that working memory and intelligence appear to be highly correlated (Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014), we also controlled for intelligence.

2. Materials and Methods

2.1. Participants

Eighty-two adolescents between 10 and 17 years of age (54% female, M_{age} = 12.30, *SD* = 1.65) volunteered for this study. In order to obtain a youth sample with a broad range of depressive symptoms, non-referred (*N*= 41 or 50%), at-risk (*N*= 24 or 29%), and referred adolescents (*N*= 17 or 21%) were included in the sample. Non-referred adolescents were recruited through advertising in schools. At-risk youngsters were selected from a screening sample of youngsters who were participating in a larger, school-based study. Youngsters from the screening sample were invited to the study if their scores were above or equal to a cut-off score of 11 on the Children's Depression Inventory (CDI; Kovacs, 1992; Mattison, Handford, Kales, & Goodman, 1990). A cut-off score of 11 on the CDI has been shown to have relatively good psychometric properties in predicting depression in youth and is considered to represent mild levels of depression (Kaslow, Rehm, & Siegel, 1984; Shemesh et al., 2005; Worchel et al., 1990). The referred adolescents were recruited from two clinical centers and were invited if they were referred for treatment of internalizing problems. Twenty-eight participants were excluded from the analyses due to accuracy rates below 60% on the IST. These participants did not significantly differ from the final sample on the basis of gender, age, intelligence, or depressive symptoms (all *p*s > .085). This resulted in a final sample of 54 adolescents (57% female, M_{age} = 12.30, *SD* = 1.19; see Table 1). Based on their CDI scores at the moment of testing, participants were classified as dysphoric (CDI ≥ 11; *n* = 20) or non-dysphoric (CDI < 11; *n* = 34). In the *dysphoric* group (range CDI scores = 11-25), 25% were from the referred sample, 45% from the at-risk sample, and 30% from the non-referred sample, whereas in the *non-dysphoric* group (range CDI scores = 0-10), 67% were from the non-referred sample, 15% from the at-risk sample, and 18% from the referred sample. Age and gender of the participants were included as standard covariates in all analyses. The research protocol was approved by the Ethics Committee of Ghent University Hospital. Youngsters signed informed assent while legal

guardians signed informed consent. After completing the questionnaires and the task, participants were compensated with two cinema tickets.

Table 1

Characteristics of the Study Sample

	Dysphoric	Non-dysphoric
N	20	34
Depression***	15.80 (4.50)	6.82 (2.81)
Rumination	18.92 (4.71)	16.78 (4.83)
Anxiety***	40.85 (5.45)	33.60 (6.64)
Total problem score*	41.00 (26.20)	26.52 (20.41)
Age**	13.10 (1.92)	11.82 (1.55)
Intelligence	43.15 (6.78)	41.64 (6.33)
Sex (female/male)	14/6	17/17

Note. Standard deviations are shown in parentheses. *$p < .05$; **$p \leq .01$; *** $p < .001$

2.2. Measures

2.2.1. Depressive symptoms.

The CDI (Kovacs, 1992; Dutch version by Timbremont & Braet, 2002) is a 27-item self-report questionnaire designed to assess depressive symptoms in youth. Each item has three response options, which vary in severity (e.g., “I do most things wrong”, “I do many things wrong”, “I do everything wrong”). The CDI showed good psychometric qualities in terms of internal consistency and test-retest reliability in non-clinical samples (Craighead, Smucker, Craighead, & Ilardi, 1998; Timbremont & Braet, 2002). Cronbach’s alpha on the CDI in this sample was $\alpha = .80$.

2.2.2. Rumination.

The FEEL-KJ is a 90-item self-report measure and is designed to assess adaptive and maladaptive emotion regulation (ER) strategies in response to anxiety, sadness, and anger (Cracco, Van Durme, & Braet, 2015). The items are rated on a five-point scale, ranging from never to almost always. The FEEL-KJ has been shown to have good psychometric qualities, in terms of reliability and validity (Cracco et al., 2015; Grob & Smolenski, 2005). In the current study, only the subscale "Rumination" was used and Cronbach's alpha was .69.

2.2.3. Trait Anxiety.

The trait version of the State-Trait Anxiety Inventory for Children (STAI-TC; Bakker, Wieringen, Ploeg, & Spielberger, 2004; Spielberger, 1973) is a 20-item self-report questionnaire that assesses the frequency and intensity of anxiety symptoms. Items are rated on a 3-point Likert scale with 1 = 'almost never' and '3' = often. The STAI-TC is considered as a reliable and valid measure for assessing anxiety symptoms in youngsters. Internal consistency in this study was good with a Cronbach's alpha of .86

2.2.4. General Psychopathology

The Child Behavior Checklist is a parent-report questionnaire measuring emotional and behavioral problems in youngsters (CBCL; Achenbach & Rescorla, 2001; Dutch version by Verhulst, Ende, & Koot, 1996). It consists of 113 items, which are scored on a three-point scale. In this study, only the CBCL Total Problem scale was used and Cronbach's alpha was good with $\alpha = .95$.

2.2.5. Intelligence

Raven's Standard Progressive Matrices (SPM) is a non-verbal IQ measure that consists of 60 incomplete matrices (Raven, Court, & Raven, 1977). For each matrix, the participant is presented with 6 pieces and is instructed to choose the one that best fits the missing part. Results of psychometric studies indicate that SPM is a good predictor of fluid intelligence and correlates

strongly with general intelligence (Spearman's g; e.g., Carroll, 1993; Flanagan & McGrew, 1998; Rushton, 1998).

2.2.6. Internal Shifting Task

The IST (De Lissnyder, Koster, & De Raedt, 2012) was programmed using the E-prime 2.0 software package and was run on a laptop with a 72-Hz, 17-inch color monitor. The pictorial stimuli were selected from two validated databases: a recently developed database of child face images (Verfaillie, Theuwis, & Wante, 2012) and the child faces of the Radboud Faces Database (Langner et al., 2010). The pictures were set at 360 x 360 pixels and were adjusted to reduce interference of background stimuli (hair). The final stimulus set included 24 neutral faces and 24 angry faces. Participants were told that pictures of faces would appear in the center of the screen one at a time. They were asked to silently count the amount of pictures in a certain category observed over the block of trials. There were two task conditions: an emotional condition and a non-emotional condition. In the emotional condition (or *emotion condition),* participants had to focus on the emotion of the pictures and were asked to perform a silent mental count of the number of angry and neutral faces. In the non-emotional condition (or *gender* condition) participants had to focus on the gender of the pictures and were asked to mentally count of the number of male and female faces. When a stimulus was presented, the subjects had to press the spacebar as quickly as possible to indicate that they had internally updated the counters of the categories and this allowed to measure *reaction time*. The next picture was shown 200 ms after pressing the spacebar. At the end of each block, participants were instructed to report the number of pictures in each category and this was used to measure *accuracy*. The emotional and non-emotional condition were performed sequentially and the order in which the conditions were completed was counterbalanced across participants. Both conditions consisted of 12 blocks of trials with at random 10 to 14 presented pictures within each block. Each block of trials consisted of shift and repeat trials. A *shift trial* refers to a trial

in which the target picture has to be updated on a different category as the preceding picture (*n*-1). A *repeat trial* refers to a trial in which the target stimulus has to be updated on the same category as the preceding picture (*n*-1). An example of a block of items, including shift and repeat trials, and a stimulus display is shown in Figure 1.

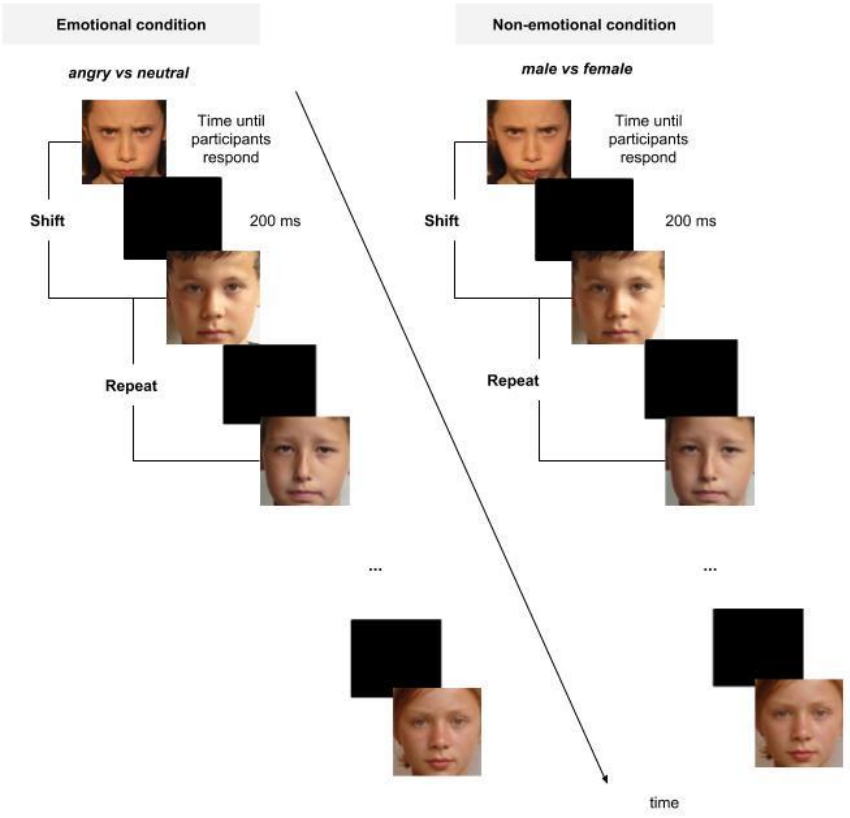


Fig. 1 Example of a block of items and a stimulus display. In the emotional condition (shown in the left half of the figure*)*, participants have to focus on the *emotion* of the pictures and are asked to perform a mental count of the number of angry and neutral faces. In the non-emotional condition (shown in the right half of the figure*)*, participants have to focus on the *gender* of the pictures and were asked to keep a silent mental count of the number of male and female faces. In shift trials, the target picture has to be updated on a different category as the preceding

picture. In repeat trials, the target stimulus has to be updated on the same category as the preceding picture.

2.3. Procedure

All participants were invited to the lab at the Faculty of Psychology and Educational Sciences. After signing assent/consent, participants were seated in front of a computer and received task instructions both orally and in writing. Before starting with the experiment proper, participants completed the practice phase including three blocks of items. Next, the adolescents were instructed to complete the experiment phase consisting of 12 blocks of items in both the emotional and the non-emotional condition. After finishing the IST, all participants completed Raven's SPM and filled out the self-report questionnaires. This order of testing prevents priming effects caused by self-report questionnaires and ensures that the intelligence test or questionnaires do not tire or overwhelm participants before starting the IST. One of the parents completed the CBCL while waiting for their child to finish the task.

2.4. Data Analyses

In order to analyze shifting impairments in the two groups, a 2 x 2 x 2 (Condition [emotion, gender] x Shift Type [shift, repeat] x Group [dysphoric, non-dysphoric]) repeated-measures (rm)ANCOVA was conducted on response time (RT) data. To further investigate significant interactions, shift costs were calculated by subtracting RTs in repeat trials from RTs on shift trials. Several types of shift costs are examined: (1) to explore general impairments in shifting ability, shift costs across the emotional and the non-emotional condition are examined (*general shift cost*); (2) to explore shifting impairments related to the task relevance of emotional information, shift costs within the emotional condition [*emotion shift cost:* RT shift trials (angry-neutral, neutral-angry) minus RT repeat trials (angry-angry, neutral-neutral)] and the non-emotional condition [*gender shift cost:* RT shift trials (male-female, female-male) minus RT repeat trials (male-male, female-female)] are assessed; and (3) to explore shift and repeat

trials within the emotional condition, shift and repeat sequences within the emotional condition are compared, referred to as valence face *N*-1 followed by valence face *N* (*angry-neutral, neutral-angry; angry-angry, neutral-neutral*). The effort required to engage attention towards angry faces, is calculated by subtracting reaction times in neutral-neutral trials from reaction times in neutral-angry trials (*engagement cost*). The effort required to disengage attention from angry faces towards neutral faces, is calculated by subtracting reaction times in angry-angry trials from reaction times in angry-neutral trials (*disengagement cost*).

To ensure that no other relevant variables were related to the differences in shifting ability between the dysphoric and non-dysphoric group, we reran all analyses and added rumination, anxiety symptoms, overall level of psychopathology symptoms (CBCL Total Problems), and intelligence (total score on Raven's SPM) as covariates of no interest. Since all effects remained significant after adding all abovementioned covariates simultaneously to the model, the results of this additional analysis are not further discussed. Effects sizes are provided as eta squared (η^2) and Cohen's *d*, as appropriate. Alpha was set at $p = 0.05$, two-tailed. Analogous to previous IST studies (e.g., De Lissnyder, Koster, Everaert, et al., 2012; Demeyer et al., 2012), median RT were used in the RT analyses to reduce the influence of outliers on the data. Overall means and SDs as a function of group are shown in Table 2. The average accuracy rate was 75%, with a significant difference between conditions, $F(1, 52) = 58.41$, $p < .001$, $\eta^2 = .52$. Consistent with earlier research in adults (Koster et al., 2013), accuracy rates were higher in the emotional condition ($M = 86\%$, $SD = 11\%$) compared to the non-emotional condition ($M = 64\%$, $SD = 17\%$). There was no significant difference in accuracy rate between both groups, $F(1, 52) = 1.42$, $p = .24$, $\eta^2 = .01$.

Table 2

Mean response times and standard deviations (in ms) for the different trial types as a function of group

		Dysphoric		Non-dysphoric	
		M	SD	M	SD
Emotion condition					
	Switch	2076	550	2043	531
	No-switch	1324	285	1518	541
	Angry-neutral	2059	502	1976	487
	Neutral-angry	2116	649	2185	662
	Angry-angry	1300	307	1612	644
	Neutral-neutral	1416	348	1432	456
Gender condition					
	Switch	1816	290	1939	445
	No-switch	1318	277	1293	356

3. Results

3.1. Group Characteristics

As expected, groups differed on depressive symptoms, $F(1, 52) = 81.66$, $p < .001$, $\eta^2 = .61$, with a significantly higher score in the dysphoric group compared to the non-dysphoric group. The mean score on rumination did not significantly differ between both groups, $F(1, 51) = 2.31$, $p = .135$, $\eta^2 = .04$. One-way ANOVAs indicated significant group differences on anxiety symptoms, $F(1, 51) = 16.92$, $p < .001$, $\eta^2 = .25$, total problem scores, $F(1, 47) = 4.72$, $p = .035$, $\eta^2 = .09$, and age, $F(1, 52) = 7.17$, $p = .01$, $\eta^2 = .12$. No significant differences between the two groups were found for intelligence $F(1, 51) = .67$, $p = .41$, $\eta^2 = .01$, or gender distribution , $\chi 2\ (1, 54) = 2.06$, $p = .151$ (Table 1).

3.2. Shifting Impairments in Emotional and Non-emotional Condition

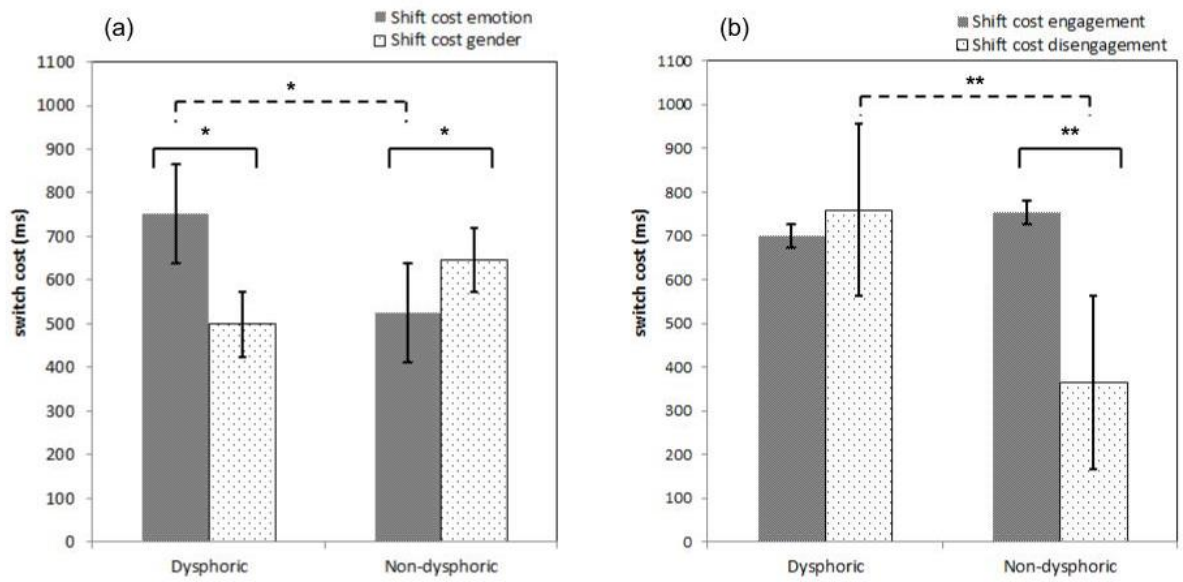
The results of the rmANCOVA with Condition (emotion, gender) and Shift Type (shift, repeat) as within-subject factors and Group (dysphoric, non-dysphoric) as between-subject factor indicated a significant main effect of Condition, $F(1, 49) = 5.26$, $p = .026$, $\eta^2 = .05$, with slower response times to the emotion condition (M = 1793 ms, SD = 488 ms) than to the gender condition (M = 1620 ms, SD = 340 ms). Analyses also revealed a significant main effect of Shift Type, $F(1, 49) = 14.22$, $p < .001$, $\eta^2 = .07$, with slower response times to shift trials (M = 1963 ms, SD = 403 ms) than to repeat trials (M = 1366 ms, SD = 346 ms). Most importantly, analyses showed a significant three-way interaction among Condition, Shift Type, and Group, $F(1, 49) = 10.66$, $p = .002$, $\eta^2 = .03$[1]. To further explore these results, we examined general and condition-specific shift costs. There were no significant differences between the groups with regard to general shift cost, $t(52) = .07$, $p = .946$, Cohen's $d = .02$. Results of between-group analyses showed that the shift cost in the emotion condition was significantly higher in the dysphoric group compared to the non-dysphoric group, $t(52) = -2.46$, $p = .017$, Cohen's $d = .65$, while there was a trend significant group difference on shift costs in the gender condition, $t(51) = 1.95$, $p = .056$, Cohen's $d = .50$. Moreover, results of within-group comparisons revealed that, for the dysphoric group, the shift cost in the emotion condition was significantly higher than in the gender condition, $t(19) = 2.55$, $p = .02$, Cohen's $d = .78$. For the non-dysphoric group, however, the shift cost in the gender condition was significantly higher than the shift cost in the emotion condition, $t(33) = -2.13$, $p = .04$, Cohen's $d = .38$ (Figure 2a).

3.3. Valence-specific Shifting Impairments

The results of the rmANCOVA with Valence Face *N*-1 (neutral, angry) and Valence Face *N* (neutral, angry) as within-subject factors and Group (dysphoric, non-dysphoric) revealed a significant interaction between Valence Face *N* and Group, $F(1, 49) = 6.28$, $p = .016$, $\eta^2 = .04$,

[1] The three-way interaction is also significant when excluding *referred* adolescents with low CDI scores from the non-dysphoric group, $F(1, 43) = 9.88$, $p = .003$, $\eta^2 = .03$.

and between Valence Face *N*-1 and Valence Face *N*, $F(1, 49) = 6.89$, $p = .012$, $\eta^2 = .06$. Most importantly, a significant three-way interaction was obtained between Valence Face *N*-1, Valence Face *N*, and Group, $F(1, 49) = 4.64$, $p = .036$, $\eta^2 = .04$[2]. Results of between-group analyses showed no significant differences between groups with regard to the engagement cost, $t(52) = .39$, $p = .70$, Cohen's $d = .11$, while the disengagement cost was significantly higher in the dysphoric group compared to the non-dysphoric group, $t(52) = -3.22$, $p = .002$, Cohen's $d = .88$. By comparison, results of within-group comparisons revealed that, for the non-dysphoric group, the engagement (neutral to angry) cost was significantly higher than the disengagement cost (angry to neutral), $t(33) = 3.47$, $p = .001$, Cohen's $d = .91$. No significant differences between engagement and disengagement cost emerged in the dysphoric group, $t(19) = -.55$, $p = .59$, Cohen's $d = .12$ (Figure 2b).



[2] The three-way interaction is trend significant when excluding *referred* adolescents with low CDI scores from the non-dysphoric group, $F(1, 43) = 3.37$, $p = .073$, $\eta^2 = .03$.

Fig. 2 (a) Mean shift cost (RT *shift* trials minus *RT repeat* trials) and standard error of the mean in the emotion versus the gender condition for non-dysphorics and dysphorics. (b) Mean shift cost and standard error of the mean in the engagement (RT *neutral-angry* trials minus RT *neutral-neutral* trials) versus the disengagement (RT angry-neutral trials minus RT *angry-angry* trials) condition for non-dysphorics and dysphorics. *Note.* *$p < .05$; **$p \leq .01$; *** $p < .001$.

4. Discussion

The main goal of this study was to assess internal shifting impairments related to emotional and non-emotional information in dysphoric adolescents by adopting the IST (De Lissnyder, Koster, & De Raedt, 2012). Pertinent to the study hypotheses we found that: (1) dysphoric adolescents did not show general shifting impairments relative to unaffected adolescents; (2) the dysphoric group did experience specific shifting difficulties in the emotional condition of the task compared to the non-dysphoric group; and (3) while there were no significant group differences when shifting from neutral to negative information (i.e. engagement), dysphoric adolescents showed greater impairments when shifting from negative to neutral information (i.e. disengagement) compared to non-dysphoric adolescents.

In general, the results provide evidence for emotion-specific shifting impairments in dysphoric adolescents. Specifically, dysphoric adolescents only showed greater shifting impairments compared to non-dysphoric adolescents when emotional features of the presented pictures had to be processed, but not when non-emotional features were task-relevant. This corresponds to the results of previous cognitive control studies in dysphoric or depressed adolescents (e.g., Kyte et al., 2005; Ladouceur et al., 2006; Wante et al., 2015) and is in line with the idea that cognitive control processes are particularly hampered when processing emotional information (Joormann, Yoon, et al., 2007). The current results are also consistent with a study of Lo and Allen (2011) indicating an affective bias in internal shifting in depressed

youth and multiple internal shifting studies among adults at risk for developing depression (De Lissnyder, Koster, Goubert, et al., 2012; Demeyer et al., 2012; Koster et al., 2013). The results further showed that non-dysphoric adolescents showed a trend significantly higher shift cost in the non-emotional condition (i.e. male vs. female faces) compared to dysphoric adolescents. This indicates that non-dysphoric adolescents do not perform better, and even perform slightly worse, in the non-emotional condition compared to dysphoric adolescents. This result clearly points to the absence of shifting impairments in response to non-emotional information in dysphoric adolescents and is consistent with a number of previous studies that failed to find general cognitive control deficits in depressed and dysphoric adolescents (Vilgis et al., 2015).

Noteworthy, however, the present findings contrast with earlier research using the IST in clinically depressed adults which provided evidence for general but no emotion-specific shifting impairments (De Lissnyder, Koster, Everaert, et al., 2012). Importantly, our study included dysphoric adolescents, while adult studies often include depressed participants with a history of chronicity or multiple depressive episodes. Thus, a potential explanation for the discrepancy is that general cognitive control impairments are a feature of severe and chronic depression, while dysfunctional cognitive processing of emotional stimuli is already observed in mildly depressed individuals at risk for the development of more severe depressive episodes (Joormann & Gotlib, 2007). This idea is also supported by a study of Holler et al. (2014), which indicated lowered general set shifting in severely, but not in mildly, depressed adolescents.

Within-group analyses further revealed that while dysphoric adolescents showed a *higher* shift cost in the emotional condition (i.e., angry vs. neutral faces) compared to the non-emotional condition (i.e., male vs. female faces), the non-dysphoric group experienced a *lower* shift cost in the emotional condition versus the non-emotional condition. The latter finding, which points to a faster shifting response when processing emotional features in healthy adolescents, corresponds to the results of a prior IST study in adults (De Lissnyder, Koster, &

De Raedt, 2012) and can be explained by the fact that the ability to quickly categorize and to flexibly shift attention towards and away from emotional expressions is important for adaptive social functioning and may have evolutionary significance by facilitating a prompt response to emotionally salient and threatening stimuli (De Lissnyder, Koster, & De Raedt, 2012; Lang, Bradley, & Cuthbert, 1990). This generally faster response to distinguish and shift between emotional information compared to neutral information was not observed in the dysphoric group and in fact, the opposite tendency was found. This clearly indicates that emotional processing is perturbed in dysphoric adolescents.

Further analyses of valence-specific effects in the emotional condition revealed no significant differences between both groups with regard to engagement or shifting from neutral to angry faces. Importantly, however, a higher disengagement cost was found in the dysphoric group relative to unaffected adolescents. In other words, dysphoric adolescents experienced greater difficulties in shifting away from angry faces compared to non-dysphoric adolescents. These results correspond to earlier studies in adults (e.g., Koster et al., 2011; Levens & Gotlib, 2010) and provide evidence for impaired attentional disengagement from negative faces in dysphoric adolescents. This finding also suggests that the dysphoric group experienced specific difficulties to direct attention away from emotional information (*top-down, higher-order* cognitive processing), instead of having an early attentional bias towards emotional information (i.e. *early automatic* processing). By contrast, unaffected adolescents not only disengaged quicker from negative faces relative to dysphoric youths but also relative to their own engagement toward angry faces. Such an effect can be explained by the fact that disengaging from a negative stimulus is a natural emotion regulating response to change the emotional impact (Ochsner & Gross, 2005) and can thus be considered as a more automatic and adaptive process than engaging attention toward negative stimuli in healthy adolescents. The lack of such a differential effect in dysphoric youth could explain their tendency to negatively elaborate

on negative information and their inability to redirect attention to neutral or more positive information (Jones, Siegle, & Thase, 2008) .

These results of the present investigation may have important clinical implications since the inability to shift or to disengage attention from negative information may intensify negative emotional responses and hinder the use of adaptive ER strategies, such as cognitive reappraisal or positive refocusing (Joormann & D'Avanzato, 2010; Kovacs, Joormann, & Gotlib, 2008). In this context, targeting internal cognitive control over emotional stimuli may be a promising avenue for future depression prevention programs. Specifically, the ability to disengage attention from negative information during stressful events will also make it more easy to cognitively reappraise the situation and thereby decrease negative affect (Troy & Mauss, 2011). On this topic, research in depressed adults has already provided promising evidence for a significant effect of cognitive control training on ER and stress reactivity (Hoorelbeke, Koster, Vanderhasselt, Callewaert, & Demeyer, 2015).

The present study has several strengths. First, in contrast to the majority of previous cognitive control studies in depressed or dysphoric adolescents (Vilgis et al., 2015), our study included emotional stimuli, which enabled us to investigate both general and emotion-specific shifting impairments. Moreover, the IST adopted in this study included pictures of faces instead of verbal stimuli order to provide higher ecological validity (Bradley et al., 1997). Second, while the focus of previous work has mainly been on the cognitive control in relation to externally presented stimuli, the IST paradigm allows us to investigate internal cognitive control by assessing the ability to shift attention between mental presentations held in working memory. This may be a particularly relevant process to investigate in dysphoric individuals given the negative internal or self-focused attention that characterizes depression (Pyszczynski & Greenberg, 1987). Finally, studying underlying mechanisms in dysphoric youngsters is important, in part, because adolescence proves a critical period of vulnerability to depression

and because of the elevated risk of a depressive disorder in adulthood following first-onset depression in adolescence (Fombonne, Wostear, Cooper, Harrington, & Rutter, 2001). Moreover, while previous studies in depressed adults are limited by depression severity, recurrent episodes, and often prior pharmacological interventions, studying dysphoric adolescents enables us to have a clearer look at the baseline cognitive processes.

However, in interpreting the results of this study, several limitations should be acknowledged. First, we assessed depressive symptoms through a self-report questionnaire. Although the CDI is a reliable screening instrument (Kovacs, 1992), the use of a structured clinical interview is required to check the presence of a depressive disorder (Hien et al., 1998). Second, in contrast to multiple studies investigating the processing of sad information in depression or dysphoria (e.g., Hankin et al., 2010; Joormann, Talbot, & Gotlib, 2007; Kyte et al., 2005), the current study examined shifting impairments in relation to angry faces. Since sad faces were not included in our stimulus set, it was not possible to compare the effects of different types of negative stimuli or to determine whether the observed effects are stimulus-specific or relate to negative emotional stimuli in general. Third, a large number of participants were excluded due to accuracy rates near chance level (i.e., < 60%). Notably, the accuracy rates obtained in the present study, especially in the gender condition, are *clearly lower* compared to multiple previous studies in which an IST including adult faces was employed in adults and average accuracy rates ranged between 83 and 88% (e.g., De Lissnyder, Koster, & De Raedt, 2012; De Lissnyder, Koster, Everaert, et al., 2012; Demeyer et al., 2012). This incongruence may be explained by the different age groups studied (Zelazo & Carlson, 2012). Specifically, previous studies using an IST with emotional faces were conducted in adult samples (e.g., De Lissnyder, Koster, & De Raedt, 2012; De Lissnyder, Koster, Everaert, et al., 2012; Demeyer et al., 2012), while the current study tested internal shifting in a sample of young adolescents with a mean age of 12 years old. Interestingly, however, the accuracy rates in the current study are

comparable with the studies of Lo and Allen (2011) and Beckwe, Deroost, Koster, De Lissnyder, and De Raedt (2014) in which an IST with verbal stimuli was used in youth and young adults. Therefore, an alternative explanation for the relatively low accuracy rates in the current study may be found in the type of stimuli included in the IST. In contrast to the first-mentioned studies using pictures of adult faces as target stimuli (e.g., De Lissnyder, Koster, & De Raedt, 2012; De Lissnyder, Koster, Everaert, et al., 2012; Demeyer et al., 2012), the present study used child faces and the study of Lo and Allen (2011) and Beckwe et al. (2014) used verbal stimuli, which may both be more ambiguous compared to adult faces (Bradley et al., 1997; Wild et al., 2000). In line with this argument, a face recognition study of Wild et al. (2000) showed that both children and adults performed significantly less accurate in classifying children's faces by gender compared to classifying adult faces. Based on these considerations, it can be concluded that future studies using the IST in children or adolescents are warranted to replicate the current findings. Moreover, these studies should consider the use of other stimuli (e.g., adult faces) or should provide more time for practice with feedback to explore whether these adjustments improve accuracy rates on the IST in general and in the non-emotional condition in particular.

Finally, it will be interesting to replicate this study on adolescents who are vulnerable to depression and previously depressed adolescents to explore if cognitive control plays a role in the development or recurrence of depression and not merely represents a symptom of depressed mood. In fact, if future longitudinal research continues to demonstrate the underlying role of maladaptive cognitive control processes, directly targeting these processes with computerized training tasks may improve the efficacy of standard prevention programs (Siegle, Ghinassi, & Thase, 2007).

5. Conclusions

In sum, dysphoric adolescents experienced specific shifting impairments when emotional features of the pictures had to be processed. Moreover, valence-specific analyses revealed greater difficulties shifting from angry to neutral faces relative to non-dysphoric adolescents, while there were no significant group differences when shifting from neutral to negative information. It will be important for future studies to investigate the association between internal shifting and adaptive ER. Moreover, longitudinal studies are needed to investigate shifting impairments in at risk-youngsters and adolescents previously diagnosed with depression to explore the role of internal cognitive control processes in the development and maintenance of depression.

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