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BRIEF ARTICLE

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Processes of change in a school-based mindfulness programme: cognitive reactivity and self-coldness as mediators

Katleen Van der Gucht, Keisuke Takano, Filip Raes and Peter Kuppens

Faculty of Psychology and Educational Sciences, University of Leuven, Leuven, Belgium

ABSTRACT

The underlying mechanisms of the effectiveness of mindfulness-based interventions for emotional well-being remain poorly understood. Here, we examined the potential mediating effects of cognitive reactivity and self-compassion on symptoms of depression, anxiety and stress using data from an earlier randomised controlled school trial. A moderated time-lagged mediation model based on multilevel modelling was used to analyse the data. The findings showed that post-treatment changes in cognitive reactivity and self-coldness, an aspect of self-compassion, mediated subsequent changes in symptoms of depression, anxiety and stress. These results suggest that cognitive reactivity and self-coldness may be considered as transdiagnostic mechanisms of change of a mindfulness-based intervention programme for youth.

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Mindfulness; cognitive reactivity; self-compassion; depression; anxiety

The utility of various universal intervention programmes to improve emotional well-being in a school context is supported in different studies and meta-analyses (e.g. Werner-Seidler, Perry, Calear, Newby, & Christensen, 2017). These approaches are in general effective, albeit with small or medium effect sizes (Bellon et al., 2015; Werner-Seidler et al., 2017). During the last decade, mindfulness-based interventions (MBIs) have gained increased empirical support (Zenner, Herrnleben-Kurz, & Walach, 2014). In MBIs students are taught to become aware of, and relate in a non-judgmentally and compassionate way to the change and flux of thoughts, feelings and bodily sensations. They become able to observe thoughts and emotions as temporary and automatic events in the mind (Kabat-Zinn, 1994).

One possible way to optimize the effectiveness of psychological interventions is to investigate processes of change, in other words, uncovering the echanisms through which interventions are effective. This does not only help to understand the phenomena and intervention itself, but also to demarcate specific interventions from others in term of what are the active ingredients.

Two key components and possible mediators in MBIs are cognitive reactivity and self-compassion (Gu, Strauss, Bond, & Cavanagh, 2015). Cognitive reactivity refers to the ease with which negative (often ruminative) thinking patterns are (re-)activated when in a mild dysphoric state (Scher, Ingram, & Segal, 2005). Cognitive reactivity is increased in vulnerable people, for example, formerly depressed individuals (Van der Does, 2005), and it predicts who is more likely to become depressed (again) in the future (Kruijt et al., 2013). Cognitive reactivity, thus, is regarded as a vulnerability factor for depression and for depressive relapse in particular. MBIs central focus is to "tackle" the process of cognitive reactivity (e.g. see Segal, Williams, & Teasdale, 2002). And previous studies have indeed found that MBIs can positively affect cognitive reactivity (Van der Gucht, Takano, Van Broeck, & Raes, 2015).

Self-compassion, is defined as the tendency (or vice versa, the lack thereof) to be caring, warm and understanding towards oneself when faced with personal shortcomings, problems or failures (Neff, 2003). Recent studies point to the importance of making a distinction between a negative aspect that reflects

CONTACT Katleen Van der Gucht katleen.vandergucht@kuleuven.be
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toxic mechanisms ("self-coldness") and positive aspects that reflect the "true protective nature" of self-compassion (for a more thorough discussion on this topic we refer to (López et al., 2015; Muris, Otgaar, & Petrocchi, 2016; Strauss et al., 2016). Previous research on MBIs has found that self-compassion is likely an important mechanism of change in symptoms of depression and relapse (Kuyken et al., 2010). In turn, increases in self-compassion predict reductions in perceived stress, rumination, and depressive symptoms in adolescents (Galla, 2016).

To increase knowledge regarding change processes in MBIs such as the ones outlined above, there is a need for studies using appropriate longitudinal designs and data analytic models. We examined cognitive reactivity and self-compassion (and its two sub-constructs self-coldness and self-kindness) as potential mediators of students' improvement in emotional well-being in a school-based mindfulness intervention. Research on therapeutic mechanisms of change in this age group is still in its infancy and more research is needed to find out whether mechanisms of change might be different compared to adults. Our data derives from an earlier randomised controlled school trial on the efficacy of MBI as a universal prevention programme for depressive symptoms (Raes, Griffith, Van der Gucht, & Williams, 2014). Results showed that the school-based mindfulness programme was successful at significantly reducing symptoms of depression compared to usual-curriculum control with an overall medium effect size.

First we aimed at extending the findings reported in Raes et al. (2014) by additionally testing the efficacy of MBI for symptoms of anxiety and stress and for both process variables cognitive reactivity and self-compassion. Second we examined the unique indirect effects of both process variables in changing symptoms of depression, anxiety and stress in MBI as compared to the control condition. We therefore used a moderated mediation analysis addressing temporality of changes in processes and outcomes. Specifically, we examined if changes in cognitive reactivity and self-compassion predicted subsequent changes in symptoms of depression, anxiety and stress. We hypothesised that cognitive reactivity and self-compassion would mediate changes in symptoms of depression, anxiety and stress. Because of the limited number of studies analysing the mediating roles of self-coldness and self-kindness as two different constructs, there were no specific hypotheses regarding these variables.

Method

Participants and procedure

Between September 2009 and June 2011, 408 students (131 females and 63 males; mean age = 15.4 years; *SD* = 1.2) from five different schools participated in a randomised controlled trial examining the efficacy of a school-based mindfulness programme aimed at reducing and preventing depression in an adolescent population (Raes et al., 2014). A detailed description of the study procedure is given in Raes et al. (2014). In short, each school offered one or two pairs of parallel classes. One class was randomised to the mindfulness condition and the other to the control (no intervention) condition. The MBI consisted of eight 100 min. weekly sessions delivered during school hours. Data (pre-, post- and follow-up assessments) were collected during class at the same times for the mindfulness and control groups: one week before, one week after delivery of the programme and again six months after the programme was completed. All participants provided written informed consent. The ethical committee of the University of Leuven approved the study.

Measures

Main outcomes were symptoms of depression, anxiety and stress. Cognitive reactivity and self-compassion were considered process variables and included in the analyses as potential mediators.

Symptoms of depression, anxiety and stress

The 21-item Depression Anxiety Stress Scales (DASS-21) was used (Lovibond & Lovibond, 1995). DASS-21 consists of three 7-item scales designed to assess depression, anxiety and stress symptoms. Items are scored on a 4-point scale. Each subscale measures the extent to which each state has been experienced over the past week. Good psychometric properties are reported for the original as well as the Dutch version that was used in the present study (Beurs, Van Dyck, Marquenie, Lange, & Blonk, 2001). In the present study, internal consistency coefficients (Cronbach's alphas) range between 0.71 and 0.88 for all scales and across all time points.

Cognitive reactivity

A short form of the revised Leiden Index of Depression Sensitivity (LEIDS-R) was used to assess to what extent participants display negative forms of thinking in

response to low mood (Van der Does, 2002). The short form contains 17 items (e.g. *When I feel down: I more often feel hopeless about everything, I lose my temper more easily, I spend more time thinking about the possible causes of my mood*) scored on a 5-point scale. The total score was used with higher scores reflecting higher levels of cognitive reactivity. In the present study Cronbach's alphas range between 0.87 and 0.91 across all three time points. Research shows that the LEIDS is a valid and convenient measure to assess cognitive reactivity, both in clinical and non-clinical populations (Solis, Antypa, Conijn, Kelderman, & Van der Does, 2016).

Self-compassion

A short form of the self-compassion scale was used in this study (SCS-SF) (Raes, Pommier, Neff, & Van Gucht, 2011). The SCS-SF consists of 12 items. Items are rated on a seven-point response scale ranging from 1 (*almost never*) to 7 (*almost always*). Six items measure negative aspects (self-coldness) and are reverse coded, the other six items measure positive aspects. Good psychometric properties are reported (Raes et al., 2011). In this study we used the total self-compassion score, the self-coldness score calculated as the sum of all negative items and the self-kindness score calculated as the sum of all positive items. In the present study Cronbach's alphas for the total score range between 0.73 and 0.83, for self-coldness between 0.83 and 0.85, and for self-kindness between 0.75 and 0.79, across all three time points.

We included other measures in this trial that are not reported in this manuscript. For example a questionnaire to measure mindfulness (15-item five-factor mindfulness questionnaire; Baer, Carmody, & Hunsinger, 2012). However, the internal consistency for the mindfulness questionnaire was too low to be trusted (Cronbach's alpha 0.47).

Intervention

The mindfulness group programme consisted of eight weekly 100 min sessions and integrated elements of Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1990) and Mindfulness-Based Cognitive Therapy (MBCT; Segal et al., 2002). A detailed description of the programme is given in Raes et al. (2014). Students develop specific skills in their capacity to become non-judgmentally aware of thoughts, feelings and sensations, and increase their capacity to replace automatic, habitual and often judgmental reactions with more conscious and skilful responses. The programme was delivered by certified mindfulness trainers with more than three years' experience. Two of them were clinical psychologists and one was a medical doctor.

Statistical analysis

To test the intervention effect on (a) outcomes (depression, anxiety and stress), and (b) putative mediators (cognitive reactivity and self-compassion), we used a piecewise multilevel model with three levels: time points (Level-1) were nested within persons, and persons (Level-2) were nested within school (Level-3). In this model, (a) the dummy coded assessment time (as a level-1 variable), (b) the treatment condition (as a level-2 variable) and (c) their cross-level interactions were included in predicting the outcome. Time points were coded by two dummy variables, T2 and T3, with T2 indicating the post-treatment and T3 indicating the follow-up assessment. Condition was a dummy variable to represent the intervention (1) and control (0) conditions. In the final model intercepts and slopes were allowed to vary randomly across persons and schools. Gender was added to all models as a control variable.

A corrected significance level was calculated for multiple comparisons according to the method described by Benjamini and Hochberg (1995).

To test the mediation effect we first estimated a lower level time-lagged mediation model on the treatment group. Central to the analyses was that the proposed mediators served as lagged time-varying predictors (i.e. change in *M* from T1 to T2) of subsequent changes in the outcome. This model was specified as:

$$M_{ij} = d_{Mjk} + a_{jk} * \text{Tslope2}_{ijk} + r_{Mijk},$$

$$Y_{ij} = d_{Yjk} + b_{jk} M(i-1)jk + c'_{jk} * \text{Time}_{ijk} + r_{Yijk}.$$

In the above equations, M_{ijk} represents a putative mediator and Y_{ijk} is the outcome of the *j*th participant of the *k*th school at the *i*th assessment occasion. The coefficient a_{jk} refers to the a-path, that is, the linear change in the mediator over time (i.e. from T1 to T2; Tslope2 coded as 0 1 1 for pre-, post- and follow-up assessments). The coefficient b_{jk} refers to the b-path, the time-varying lagged association between the mediator and the outcome, with control for the effect of time (coded as 0 1 2) on the outcome (c′). This model was based on the procedure outlined by Bauer, Preacher, and Gil (2006). Time (*T*), mediator (*M*) and

outcome (Y) are measured at level 1. Random effects for both intercepts (d_{Mjk} and d_{yjk}) and coefficients (a_{jk} and c_{jk}) were retained (Bauer et al., 2006). The mediation effect comprised the cross-product of the a_{jk} and b_{jk} coefficients and statistical significance of the product was determined by the indirect mediation effect confidence interval (MacKinnon & Luecken, 2008).

Finally, we re-estimated a model on the whole sample (including treatment and control group, dummy coded) for moderated mediation by including condition as a level-2 predictor in the model. Thus, we tested moderated mediation by examining if each potential mediator mediated the effect of time on outcome, and if the mediation effect was moderated by condition.

The "lme4" package (Bates, Maechler, Bolker, & Walker, 2015) in R (R Development Core Team, 2007) was used for the multilevel analysis.

Results

Preliminary analyses

Correlations among variables at baseline are given in Table 1. Cognitive reactivity was positively associated with symptoms of stress, anxiety and depression. Self-compassion, self-kindness and self-coldness, are negatively associated with symptoms of stress, anxiety and depression, and cognitive reactivity. We used independent t-tests to examine gender differences on symptoms and potential mediators, showing no gender differences in depression and cognitive reactivity. However, self-compassion (SC), self-kindness (SC-K) and self-coldness (SC-K) was significantly lower (SC: $t(389) = -4.62$, $p < .001$; SC-K: $t(391) = -3.11$, $p = .002$; SC-C: $t(395) = -4.40$, $p < .001$) in girls (SC: $M = 45.74$, SD = 10.84; SC-W: $M = 23.27$, SD = 5.61; SC-C: $M = 22.55$, SD = 7.14) compared to boys (SC: $M = 51.04$, SD = 11.05; SC-W: $M = 25.18$, SD = 6.28; SC-C: $M = 25.95$, SD = 7.30). Also symptoms of anxiety and stress were significantly higher (anxiety: $t(386) = 2.90$, $p = .003$; stress: $t(387) = 2.49$, $p = .013$) in girls (anxiety: $M = 5.08$, SD = 3.63; stress: $M = 7.69$, SD = 3.99) compared to boys (anxiety: $M = 4.01$, SD = 3.29; stress: $M = 6.66$, SD = 3.76).

Intervention effects on outcomes and potential mediators

The condition × time interaction was significant at T2 and T3 for symptoms of depression, anxiety and stress (see Table 2). The effect at both time points was negative, which suggests that participants in the MFS group, unlike those from the control group, experienced a clear symptom reduction one week after the training (T2) and during follow-up (T3). A significant effect of time was found in the MBI condition on outcomes (depression: $B = -0.68$, $p < .001$; anxiety: $B = -0.66$, $p = .04$; stress: $B = -0.98$, $p = .018$). There was no significant effect of time in the control condition (depression: $B = 0.003$, $p = .991$; anxiety: $B = 0.08$, $p = .720$; stress: $B = -0.08$, $p = .838$).

Considering potential mediators we found a significant condition × time effect for cognitive reactivity at T2 and for self-coldness at T3. No significant condition × time effects were found for the total scores of the self-compassion scale or the scores of the subscale self-kindness. There was no significant interaction between condition, time and gender for any of the outcomes.

Was the effect of time on depression, anxiety and stress in the MBI condition mediated by the changes observed in cognitive reactivity and self-coldness?

Table 3 presents the coefficients of the mediated pathway of cognitive reactivity and self-coldness on outcomes, and the confidence interval test for the indirect effect. The indirect effect was significant for cognitive reactivity meaning that the decrease in cognitive reactivity post-intervention mediated the reduction of symptoms of depression, anxiety and stress. The indirect effect was also significant for self-coldness, meaning that a decrease in self-critical thinking mediated the effect on depression, anxiety and stress.

Was this mediation effect moderated by condition?

For the model with cognitive reactivity as the mediator, the interaction term in the model that tested for difference in a-paths (i.e. effect of time on the mediator at T2) as a function of condition (MBI versus control) was, −3.94 (SE = 1.81), $p = .080$. The coefficient indicates that MBI had a stronger effect on cognitive reactivity than the control condition, however, this differences was not significant.

For depression and anxiety there was a statistically significant difference on the b-paths (i.e. the mediator to outcome relation) as a function of condition, that is,

Table 1. Correlations among variables at baseline.

	Mean (SD)	1	2	3	4	5	6	7
1. Depression	4.19 (3.76)	1.000						
2. Anxiety	4.68 (3.57)	0.562*	1.000					
3. Stress	7.29 (4.00)	0.638*	0.623*	1.000				
4. Cognitive reactivity	25.68 (11.47)	0.493*	0.460*	0.574*	1.000			
5. Self-compassion	47.62 (11.28)	−0.487*	0.411*	0.507*	0.522*	1.000		
6. Self-coldness	3.93 (1.24)	0.473*	0.405*	0.529*	0.534*	0.878*	1.000	
7. Self-kindness	4.01 (0.99)	−0.332*	−0.272*	−0.299*	−0.319*	0.797*	0.412*	1.000

*$p < .001$.

−0.06 (0.03), $p = .022$ and −0.061 (SE = 0.03), $p = .016$, respectively, meaning that the mediator was more strongly related to depression and anxiety in the MBI condition compared to the control condition. There was no statistically significant difference on the b-paths as a function of condition for the outcome stress, that is, −0.016 (SE= 0.03), $p = .584$.

For the model with self-coldness as the mediator, the cross-level interaction term in the model that tested for difference in a-paths (i.e. effect of time on the mediator at T2) as a function of condition (MBI versus control) was marginally significant, 1.63 (SE = 0.73), $p = .059$, indicating that MBI had a stronger effect on self-coldness than the control condition.

There was no statistically significant difference on the b-paths as a function of condition for the outcomes depression, anxiety and stress, that is, 0.06 (SE= 0.04), $p = .136$; 0.01 (SE = 0.04), $p = .865$ and −0.01 (SE= 0.04), $p = .906$, respectively.

Table 2. Results of multilevel model estimating intervention effect piecewise at T2 and T3 on outcomes and potential mediators.

	Intercept	*B* (SE) T2:Condition	*B* (SE) T3:Condition
Main outcomes[a]			
Depression	4.35 (0.32)	−1.29 (0.40)** $p = .001$	−1.40 (0.48)** $p = .004$
Anxiety	4.53 (0.32)	−1.21 (0.38)** $p = .005$	−1.46 (0.46)* $p = .0137$
Stress	7.12 (0.29)	−1.49 (0.41)*** $p < .001$	−1.78 (0.62)* $p = .0282$
Potential mediators			
Cognitive reactivity	25.14 (0.88)	−3.81 (1.54)* $p = .044$	−4.02 (2.04) $p = .108$
Self-compassion	4.01 (0.06)	0.12 (0.11) $p = .290$	0.17 (0.09) $p = .059$
Self-coldness	24.04 (0.56)	1.22 (0.81) $p = .159$	2.14 (0.78)** $p = .006$
Self-kindness	24.10 (0.44)	0.04 (0.91) $p = .969$	−0.30 (0.83) $p = .727$

[a]A Benjamini and Hochberg (1995) corrected significance level $p < .03$ was used for the main outcomes.
*$p < .05$.
**$p < .01$.
***$p < .001$.

Discussion

In this study, we evaluated the potentially mediating roles of cognitive reactivity, self-compassion and its subcomponents self-kindness and self-coldness in relation to symptoms of depression, anxiety and stress. We used a multilevel moderated time-lagged mediation model based on pre-, post- and follow-up assessments from a randomised controlled trial comparing a school-based mindfulness intervention versus a no treatment control condition (Raes et al., 2014).

We found that cognitive reactivity mediates the intervention effect on symptoms of depression, anxiety and stress. This mediating effect was stronger in the MBI condition than the control condition. This was illustrated in the model-testing efficacy by the significant condition time interaction effect for cognitive reactivity post-intervention. Also the moderated mediation model testing for differences in a-paths showed a stronger effect of time on cognitive reactivity in the MBI condition, however, the difference in condition was not significant ($p = .08$) in this model. There was also a stronger relationship with symptoms of depression and anxiety compared to symptoms of stress. This shows the relevance of cognitive reactivity as a central therapeutic mechanism in MBIs. Participants learn to recognise when the process of cognitive reactivity is activated at an early enough stage, before it transforms what might be just a transient state of low mood into a more persistent and intense state of depression. These results also extend our previous findings of two uncontrolled trials in a population of adolescent and young adult cancer survivors (Van der Gucht et al., 2016) and economically disadvantaged people (Van der Guchtet al., 2015). In these studies we found a significant reduction in cognitive reactivity post-MBI which was associated with a reduction in symptoms of depression, anxiety and stress.

Table 3. Mean estimates of multilevel coefficients (SE) and confidence intervals for cross-lagged mediation of cognitive reactivity and self-coldness on the associations between time and symptoms of depression anxiety and stress.

	a	b	ab [95% CI]	c′
Depression				
Cognitive reactivity	−3.99 (1.60) $p = .065$	0.06 (0.02)*** $p < .001$	−0.24 (0.13) [−0.531; −0.033]	−0.02 (0.34) $p = .950$
Self-coldness	3.76 (0.71)** $p = .005$	−0.12 (0.02)*** $p < .001$	−0.45 (0.11) [−0.695; −0.247]	0.18 (0.35) $p = .609$
Anxiety				
Cognitive reactivity	−3.99 (1.60) $p = .065$	0.05 (0.02) $p = .003$	−0.199 (0.12) [−0.469; −0.017]	−0.13 (0.36) $p = .720$
Self-coldness	3.76 (0.71)** $p = .005$	−0.13 (0.02) $p < .001$	−0.488 (0.12) [−0.743; −0.274]	0.21 (0.37) $p = .580$
Stress				
Cognitive reactivity	−3.99 (1.60) $p = .065$	0.11 (0.02) $p < .001$	−0.44 (0.20) [−0.856; −0.088]	−0.12 (0.36) $p = .744$
Self-coldness	3.76 (0.71)** $p = .005$	−0.21 (0.03) $p < .001$	−0.789 (0.19) [−1.186; −0.451]	0.35 (0.39) $p = .375$

Note: a: change in M (cognitive reactivity, self-coldness) from T1 to T2; b: effect of M on the dependent variable (depression, anxiety and stress); ab: indirect effect; c′: direct effect.
*$p < .05$.
**$p < .01$.
***$p < .001$.

Examining the construct of self-compassion, the picture is slightly more complex. Our results suggest that only self-coldness (corresponding to self-critical thinking including self-judgment, isolation, and over-identification) was a significant mediator of the intervention effect on symptoms of depression, anxiety and stress. This means that in our study the MBI intervention was effective in reducing self-coldness. This reduction in levels of self-judgment, isolation, and over-identification mediates the intervention effect. We could not found a significant intervention effect on self-kindness, corresponding to the positive components of a self-compassionate mind-state (self-kindness, common humanity and mindfulness). This finding is somewhat surprising as MBIs explicitly target to become more self-compassionate. Therefore, we would not only expect a reduction in levels of self-coldness but also an increase in self-kindness. Possible explanations for our finding might be that adopting a true compassionate frame of mind involves (1) a more sequential process with as a first step a reduction in self-coldness, and (2) needs more training via boost sessions or more specific interventions such as Compassion Focused Therapy (Gilbert, 2009) to increase these positive components. As far as we know there was only one previous study with a longitudinal design including pre, mid-programme and post-data, examining potential mediating effects and temporal ordering of mindfulness, self-compassion (based on SCS total score) and anxiety (Bergen-Cico & Cheon, 2014). The authors only found a mediating effect of mindfulness but not of self-compassion, although there was a significant increase in self-compassion over time in the mindfulness condition. The authors suggest that the internalisation of self-compassion may require a more sustained period of meditation practice. Future research is needed to explore the role and concept of self-compassion and especially the interplay between both self-coldness and self-kindness. Frequent monitoring of both processes can enhance our understanding of changes during the course of the interventions and at follow-up.

Our results are consistent with the theoretical reports and empirical scientific literature on MBIs (Chiesa, Anselmi, & Serretti, 2014; Gu et al., 2015). Both processes that we studied, cognitive reactivity and self-coldness, can be considered as transdiagnostic mechanisms of change to improve mental well-being, as they both mediated the reduction in symptoms of anxiety and depression. This is in line with previous research (e.g. Drost, van der Does, van Hemert, Penninx, & Spinhoven, 2014). Based on a prospective cohort study ($n = 2981$) Drost et al. (2014) concluded that repetitive negative thinking is an important transdiagnostic factor responsible for the co-occurrence of emotional disorders. Also self-criticism is a vulnerable risk factor for a number of psychological disorders (e.g. depression, social anxiety, eating disorders and self-injurious behaviours) and predicts poor responses to brief psychological and pharmacological treatments for depression (Shahar et al., 2015, and references in there). This is particularly relevant for the adolescent target group in our study because this is an age group marked by increases in emotionality and heightened vulnerability for mental problems. It is a transitional stage and might be seen as a critical time window to deliver effective mental health promoting programmes. We hope that our study can provide

further refinement of the theoretical and clinical frameworks underlying psychological interventions for prevention research with adolescents.

A number of limitations should be considered when interpreting the results. Analyses were based on self-reported data. Future studies should broaden beyond self-report outcome measures to look at biological parameters as process variables. We used a no-intervention control which did not allow us to conclude that the effect was not due to nonspecific factors. Treatment protocol adherence and therapist competence were not formally evaluated. Strengths of this study include a large dataset based on a randomised controlled trial conducted in a real life context, examining effects over two post-intervention time points.

Overall, this study was the first to assess mediators of change in a school-based mindfulness programme for symptoms of depression, anxiety and stress. The findings demonstrate that MBI is successful in reducing cognitive reactivity and self-coldness and that these changes mediate the effects on symptoms of depression, anxiety and stress. This is especially important and useful when looking at adolescence as a transition period in which training can lead to a state of mind which offers protection against the vulnerabilities associated with self-criticism, over-identification, isolation, aggression, hopelessness and rumination.

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