Prospective Associations Between Sleep Disturbance and Repetitive Negative Thinking: The Mediating Roles of Focusing and Shifting Attentional Control

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Although considerable evidence has linked sleep disturbance to symptoms of psychopathology, including repetitive negative thinking, few studies have examined how sleep disturbance may predict repetitive negative thinking over time. Further, no study to date has examined specific mechanisms that may account for this relationship. The present study sought to address these gaps in the literature by testing focusing and shifting attentional control as two potential mediators of the relationship between sleep disturbance and repetitive negative thinking over a 6-month period. A final sample of 445 unselected community participants completed measures of sleep disturbance and repetitive negative thinking at Time 1, measures of focusing and shifting attentional control 3 months later, and measures of repetitive negative thinking again 6 months later. Results revealed that focusing, but not shifting, attentional control mediated the relationship between sleep disturbance and repetitive negative thinking, specifically, worry, rumination, and obsessions. These findings provide preliminary evidence for focusing attentional control as a candidate mechanism that may explain the causal role of sleep disturbance in the development of repetitive negative thinking observed in various disorders.

Keywords: sleep; repetitive thinking; attentional control; anxiety

Sleep disturbance has recently been proposed as a transdiagnostic process that may contribute to multiple forms of psychopathology (Harvey, Murray, Chandler, & Soehner, 2011). Recent research has linked sleep disturbance to specific disorders, including mood (Pillai, Kalmbach, & Ciesla, 2011) and anxiety-related disorders (Cox & Olatunji, 2016), and there is strong evidence suggesting that sleep disturbance is linked to increased risk for suicidal ideation and suicide attempts (Pigeon, Pinquart, & Conner, 2012). The presence of sleep disturbance across diverse disorders is consistent with a transdiagnostic view, and understanding how sleep disturbance relates to other transdiagnostic processes may offer important insights into multiple forms of psychopathology. One such process is repetitive negative thinking, or thoughts that are recurrent and excessive, include negative content, and are perceived as difficult to control (Ehring & Watkins, 2008). For example, extant research indicates associations between sleep disturbance and rumination, or negative thought related to perceived threats to the self and/or negative past experiences (Trapnell & Campbell, 1999), in both unselected (Cox, Ebesutani, & Olatunji, 2016) and sleep-disordered samples (Carney, Harris, Moss, & Edinger, 2010) even when controlling for negative affect (Thomsen, Mehlsen, Christensen, & Zachariae, 2003). Further, rumination following a stressor is linked to poor sleep that night in unselected college student samples (Guastella & Moulds, 2007; Zoccola, Dickerson, & Lam, 2009), and daily rumination is linked to subsequent poor
sleep over 1 week in college students with elevated depression symptoms (Pillai, Steenbur, Ciesla, Roth, & Drake, 2014).

Research with sleep-disordered (O’Kearney & Pech, 2014) and healthy samples (Norell-Clarke, Jansson-Frojmark, Tillfors, Harvey, & Linton, 2014; Weise, Ong, Tesler, Kim, & Roth, 2013) has also linked sleep disturbance and worry, or repetitive thought about negative future events (Borkovec, Ray, & Stober, 1998). Although prospective research suggests that sleep disturbance predicts worry over 1 year among unselected adolescents (Danielsson, Harvey, MacDonald, Jansson-Frojmark, & Linton, 2013) and that poor sleep predicts increased worry the next day in those with generalized anxiety disorder (GAD; Thielsch et al., 2015), one study of daily sleep and worry in a high-worry sample found no evidence for an effect of sleep disturbance on subsequent worry (McGowan, Behar, & Luhmann, 2016). Unlike worry, obsessions have not traditionally been considered a variant of repetitive negative thought (Ehring & Watkins, 2008). However, the intrusive, repetitive, and distressing nature of obsessions (Julien, O’Connor, & Aardema, 2007) may share similar functions with other forms of repetitive negative thinking (Ehring & Watkins, 2008). Recent evidence suggests that sleep disturbance is uniquely associated with unacceptable thoughts, but not contamination, washing, or symmetry symptoms of obsessive-compulsive disorder (OCD) in unselected community participants (Raines et al., 2015). Similarly, insomnia is linked to obsessions, but not compulsions, even when controlling for symptoms of depression in unselected college students (Timpano, Carbonella, Bernert, & Schmidt, 2014).

Despite evidence linking sleep disturbance and repetitive negative thinking, a notable limitation of the extant research is the relative lack of studies assessing the relationship between sleep disturbance and repetitive negative thinking over time. Although a small body of work has examined the prospective link between sleep disturbance and worry (Danielsson et al., 2013; McGowan et al., 2016; Thielsch et al., 2015), these studies have yielded mixed results. Further, no study to date has examined the links between sleep disturbance and rumination or obsessions over time. Another important limitation of the available literature is the question of mechanism—that is, if sleep disturbance contributes to repetitive negative thinking over time, by what intermediate processes does sleep disturbance have this effect? One candidate mechanism is attentional control. Attentional control involves the ability to flexibly direct attention and consists of two factors: focusing attention in the face of distractors and shifting attention between tasks or competing demands (Olafsson et al., 2011). Considerable research has delineated the negative effects of sleep loss on attention (Van Dongen, Maislin, Mullington, & Dinges, 2003), and this effect is found for both total sleep deprivation (Drummond, Gillin, & Brown, 2001) and partial sleep restriction (Sadik, Dan, & Bar-Haim, 2011). A recent study also found that subjective sleep disturbance is correlated with decreased attentional control (Cox et al., 2016).

Deficits in attentional control are also linked to repetitive negative thinking. In healthy samples, decreased cognitive control is linked to anxiety-related processes, including worry and anxious arousal (Vasey, Chriki, & Toh, 2017), and decreased attentional control is associated with increased rumination (Cox et al., 2016; Macatee et al., 2016), worry (Cox et al., 2016), and obsessions (Macatee et al., 2016). Similar relationships are found in clinical populations characterized by repetitive negative thinking (Armstrong, Zald, & Olatunji, 2011; Bardeen, Fergus, & Orcutt, 2015; Hsu et al., 2015). However, limited research has examined the differential links between focusing and shifting attentional control and repetitive negative thinking, and the extant findings are mixed. A recent study found that focusing attentional control, but not shifting attentional control, accounted for the prospective effect of repetitive negative thinking on symptoms of psychopathology (Mills et al., 2016). Another study found that decreased focusing attentional control was associated with rumination, but not worry or obsessions, and there were no differential links between focusing and shifting attentional control and repetitive negative thinking among those with GAD or OCD (Armstrong et al., 2011). Thus, additional research is necessary to clarify the relationships between focusing and shifting attentional control and repetitive negative thinking.

The present study sought to examine the prospective effects of sleep disturbance on attentional control and repetitive negative thinking over a 6-month period. The present investigation also examined the unique roles of focusing and shifting attentional control as potential mechanisms in the relationship between sleep disturbance and repetitive negative thinking. It was hypothesized that focusing and shifting attentional control at 3 months would together mediate the respective relationships between sleep disturbance at baseline and rumination, worry, and obsessions assessed 6 months later. Given the mixed findings on the unique roles of focusing and shifting attention, exploratory analyses were conducted to assess whether one form of attentional control would
mediate this relationship over and above the effect of the other.

Method

Participants

A total of 777 participants enrolled in the study. Seven hundred and fifty participants had complete data at Time 1, 581 participants had complete data at Time 2, and 510 participants had complete data at Time 3. A total of 445 participants (79.3% female) had complete data at all three time points. The mean age of the participants was 40.09 years (SD = 13.42), ranging from 18 to 65 years. The ethnicity composition was as follows: Caucasian (n = 375; 84.5%), African American (n = 30; 6.7%), Asian (n = 20; 4.5%), Hispanic/Latino (n = 9; 2%), other (n = 10; 2.3%). Participants who did not complete the study did not differ from those who did complete the study on gender or race. However, there was a significant difference in age between those who completed the study (M = 39.86) and those who did not (M = 37.62), t(549.53) = –2.65, p < .01. Similarly, there was a significant difference in baseline insomnia symptoms between those who completed the study (M = 8.45) and those who did not (M = 9.47), t(756) = 2.21, p < .05.

Procedure

Participants were recruited through ResearchMatch, a national health volunteer registry that was created by several academic institutions and supported by the U.S. National Institutes of Health as part of the Clinical Translational Science Award (CTSA) program. ResearchMatch has a large population of volunteers who have consented to be contacted by researchers about health studies for which they may be eligible. Healthy (no reported conditions) ResearchMatch volunteers were recruited. Participants received a link to complete an online battery of questionnaires and were informed that they would have the opportunity to enter their name into a drawing for a $50 gift card after the completion of each survey. Participants received a total of three identical survey batteries over a 6-month period. Participants who completed the first survey (Time 1) received the second and third surveys 3 (Time 2) and 6 months (Time 3), respectively, after completion of the first survey. Study data were collected and managed using REDCap (Research Electronic Data Capture) hosted at Vanderbilt University (Harris et al., 2009). REDCap is a secure, web-based application designed to support data capture for research studies and is supported by UL1 TR000445 from NCATS/NIH. Review and approval for this study and all procedures was obtained from the Vanderbilt University Institutional Review Board, and informed consent was obtained from all individual participants included in the study.

Measures

Attentional Control Scale (ACS)

The ACS (Derryberry & Reed, 2002) is a 20-item self-report measure of the general ability to flexibly control and direct attention and consists of two factors: focusing and shifting (Olafsson et al., 2011). The shifting factor consists of 10 items, and the focusing factor consists of 9 items. Items on the ACS are rated on a Likert scale from 1 (almost never) to 4 (always), and higher scores indicate better attentional control. The ACS has demonstrated good discriminant, convergent, and predictive validity (Judah, Grant, Mills, & Lechner, 2014), and the two-factor model (focusing and shifting) has demonstrated adequate fit (Olafsson et al., 2011). The ACS focusing factor demonstrated adequate internal consistency at Time 2 (α = .86) in the present sample. Likewise, the ACS shifting factor demonstrated adequate internal consistency at Time 2 (α = .82) in the present sample.

Insomnia Severity Index (ISI)

The ISI (Bastien, Vallieres, & Morin, 2001) is a seven-item self-report measure of insomnia symptoms over the past 2 weeks and is used to detect cases of insomnia and assess treatment response. Items on the ISI are rated on a Likert scale from 1 (none) to 4 (very severe), and higher scores indicate a higher severity of insomnia. The ISI has demonstrated good concurrent, convergent, and predictive validity (Bastien et al., 2001; Morin, Belleville, Belanger, & Ivers, 2011). The ISI demonstrated adequate internal consistency at Time 1 (α = .89) in the present sample.

Obsessive-Compulsive Inventory–Revised (OCIR)

The OCIR (Foa et al., 2002) is an 18-item self-report measure of OC symptoms in the past month. The OCIR consists of six subscales measuring specific categories of OC symptoms (washing, checking, ordering, neutralizing, hoarding, and obsessing). Only the three-item obsessing subscale was used in the present analysis. The OCIR has demonstrated good test–retest reliability and convergent and discriminant validity, and the six-factor structure has demonstrated good fit (Foa et al., 2002). The OCIR obsessing subscale demonstrated adequate internal consistency at Times 1 and 3 (α = .84 and α = .85, respectively) in the present sample.

Penn State Worry Questionnaire (PSWQ)

The PSWQ (Meyer, Miller, Metzger, & Borkovec, 1990) is a 16-item self-report measure of the tendency to worry. Items are rated on a Likert
demonstrated good test–retest reliability (Meyer et al., 1990) and good convergent and discriminant validity (Brown, Antony, & Barlow, 1992). The PSWQ demonstrated good internal consistency at Times 1 and 3 (α = .94 and α = .95, respectively) in the present sample.

Rumination-Reflection Questionnaire (RRQ)

The RRQ (Trapnell & Campbell, 1999) is a 24-item self-report measure of self-attentiveness used to distinguish rumination from reflection. Only the 12-item rumination subscale was used in the present study. Items are rated on a Likert scale from 1 (not at all typical of me) to 5 (very typical of me), and higher scores indicate an increased tendency to worry. The RRQ has demonstrated good test–retest reliability (Meyer et al., 1990) and good convergent and discriminant validity (Brown, Antony, & Barlow, 1992). The RRQ demonstrated good internal consistency at Times 1 and 3 (α = .94 at both time points) in the present sample.

Data analysis was employed with SPSS 23. Three multivariate mediation analyses were conducted to assess focusing and shifting attentional control at Time 2 (at 3 months) as parallel mediators of the relationship between sleep disturbance at Time 1 and rumination, worry, and obsessions at Time 3 (at 6 months). In each model, rumination, worry, or obsessions at Time 1 were included as a covariate.

Mediation analyses were conducted with the PROCESS macro, and bias-corrected bootstrap confidence intervals were calculated to test the significance of the indirect effects (Hayes, 2013). Missing data were addressed with two methods. Prior to data analysis, for measures with one item missing, mean imputation was used to replace the missing item. If more than one item was missing on a given measure, that measure was considered missing. The exception to this procedure was the obsessions subscale of the OCIR. Given that this subscale was only three items, mean imputation was not used, and it was considered missing if there were one or more missing items. During data analysis, consistent with the PROCESS macro (Hayes, 2013), listwise deletion was utilized for missing measures.

Results

Associations between study variables

Means and standard deviations for study variables are shown in Table 1. All study variables were significantly correlated, p < .01.

Multivariate mediation: rumination

As shown in Figure 1 and Table 2, results of a mediation analysis using ordinary least squares path analysis revealed that sleep disturbance at Time 1 significantly influenced rumination at Time 3 through its effect on focusing attentional control at Time 2, but not through shifting attentional control at Time 2. Increased sleep disturbance at Time 1 significantly predicted decreased focusing attentional control at Time 2 (a = –.1132), and

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Table 1

Descriptive Statistics and Correlations for Study Measures (n = 445)

<table>
<thead>
<tr>
<th>Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ISI.T1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2. ACS.F.T2</td>
<td>-.28*</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>3. ACS.S.T2</td>
<td>-.22*</td>
<td>.62*</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4. RRQ.T1</td>
<td>.45*</td>
<td>-.38*</td>
<td>-.35*</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5. RRQ.T3</td>
<td>.39*</td>
<td>-.43*</td>
<td>-.37*</td>
<td>.81*</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6. PSWQ.T1</td>
<td>.42*</td>
<td>-.36*</td>
<td>-.40*</td>
<td>.71*</td>
<td>.63*</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>7. PSWQ.T3</td>
<td>.40*</td>
<td>-.42*</td>
<td>-.40*</td>
<td>.62*</td>
<td>.70*</td>
<td>.80*</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>8. OCIR.O.T1</td>
<td>.40*</td>
<td>-.34*</td>
<td>-.28*</td>
<td>.54*</td>
<td>.47*</td>
<td>.49*</td>
<td>.48*</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>9. OCIR.O.T3</td>
<td>.36*</td>
<td>-.37*</td>
<td>-.23*</td>
<td>.44*</td>
<td>.50*</td>
<td>.35*</td>
<td>.46*</td>
<td>.71*</td>
<td>–</td>
</tr>
</tbody>
</table>

Note. ISI.T1 = Insomnia Severity Index, Time 1; ACS.F.T2 = Attentional Control Scale–Focusing factor, Time 2; ACS.S.T2 = Attentional Control Scale–Shifting factor, Time 2; RRQ.T1 = Ruminations and Reflection Questionnaire–Rumination subscale, Time 1; RRQ.T3 = Ruminations and Reflection Questionnaire–Rumination subscale, Time 3; PSWQ.T1 = Penn State Worry Questionnaire, Time 1; PSWQ.T3 = Penn State Worry Questionnaire, Time 3; OCIR.O.T1 = Obsessive-Compulsive Inventory–Revised, Obsessions subscale, Time 1; OCIR.O.T3 = Obsessive-Compulsive Inventory–Revised, Obsessions subscale, Time 3; M = mean; SD = standard deviation.

⁎ p < .01.
decreased focusing attentional control at Time 2 significantly predicted increased rumination at Time 3 ($b = -0.0231$). In contrast, sleep disturbance at Time 1 did not significantly predict shifting attentional control at Time 2, and shifting attentional control at Time 2 did not significantly predict rumination at Time 3.

A 95% bias-corrected bootstrap confidence interval for the total indirect effect of focusing and shifting attentional control ($ab = 0.0029$) based on 10,000 bootstrap samples did not include zero ($0.0006–0.0058$), indicating a significant indirect effect of sleep disturbance at Time 1 on rumination at Time 3 through focusing attentional control at Time 2. Effect-size calculations estimating the ratio of the indirect effect to the total effect (Alwin & Hauser, 1975) indicate that 31% of the effect of sleep disturbance at Time 1 on rumination at Time 3 occurs through the indirect effect of focusing attentional control at Time 2. In contrast, the 95% bias-corrected bootstrap confidence interval for the specific indirect effect of focusing attentional control at Time 2 ($ab = 0.0026$) based on 10,000 bootstrap samples did not include zero ($0.0006–0.0058$), indicating a significant indirect effect of sleep disturbance at Time 1 on rumination at Time 3 through focusing attentional control at Time 2.

Table 2

Unstandardized Model Coefficients for the Hypothesized Model Predicting Rumination ($n = 458$)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>$M_1$ (ACS.F.T2)</th>
<th>$M_2$ (ACS.S.T2)</th>
<th>$Y$ (RRQ.T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X$ (ISI.T1)</td>
<td>$a = -0.11$, $p &lt; .001$</td>
<td>$a = -0.05$, $p &lt; .001$</td>
<td>$c’ = 0.01$, $p &lt; .001$</td>
</tr>
<tr>
<td>$M_1$ (ACS.F.T2)</td>
<td>$-0.15$, $p &lt; .001$</td>
<td>$-0.18$, $p &lt; .001$</td>
<td>$b_1 = 0.02$, $p &lt; .001$</td>
</tr>
<tr>
<td>$M_2$ (ACS.S.T2)</td>
<td>$-0.15$, $p &lt; .001$</td>
<td>$-0.18$, $p &lt; .001$</td>
<td>$b_2 = 0.004$, $p &lt; .001$</td>
</tr>
<tr>
<td>Cov (RRQ.T1)</td>
<td>$32.37$, $p &lt; .001$</td>
<td>$33.84$, $p &lt; .001$</td>
<td>$i_y = 1.37$, $p &lt; .001$</td>
</tr>
<tr>
<td>Constant</td>
<td>$R^2 = 0.16$</td>
<td>$R^2 = 0.13$</td>
<td>$R^2 = 0.67$</td>
</tr>
<tr>
<td>$F(2, 455) = 41.98$, $p &lt; .001$</td>
<td>$F(2, 455) = 33.31$, $p &lt; .001$</td>
<td>$F(4, 453) = 226.16$, $p &lt; .001$</td>
<td></td>
</tr>
</tbody>
</table>

Note. ACS.F.T2 = Attentional Control Scale–Focusing factor, Time 2; ACS.S.T2 = Attentional Control Scale–Shifting factor, Time 2; RRQ.T3 = Rumination and Reflection Questionnaire–Rumination subscale, Time 3; ISI.T1 = Insomnia Severity Index, Time 1; RRQ.T1 = Rumination and Reflection Questionnaire–Rumination subscale, Time 1; SE = standard error.
shifting attentional control at Time 2 included in the
model, there was not a significant direct effect of
sleep disturbance at Time 1 on rumination at Time 3
(c' = .0056, p > .05).

**Multivariate Mediation: Worry**

As shown in Figure 2 and Table 3, results of a
mediation analysis using ordinary least squares
path analysis revealed that sleep disturbance at
Time 1 significantly influenced worry at Time 3
through its effect on focusing attentional control
at Time 2, but not shifting attentional control at
Time 2. Increased sleep disturbance at Time 1 signifi-
cantly predicted decreased focusing attentional
control at Time 2 (a = -.1425), and decreased
focusing attentional control at Time 2 significantly
predicted increased worry at Time 3 (b = -.3581).
In contrast, sleep disturbance at Time 1 did not
significantly predict shifting attentional control at
Time 2, and shifting attentional control at Time 2
did not significantly predict worry at Time 3.

The 95% bias-corrected bootstrap confidence
interval for the total indirect effect of focusing and
shifting attention control (ab = .0545) based on
10,000 bootstrap samples did not include zero
(.0206 – .1063), indicating a significant indirect
effect of sleep disturbance at Time 1 on worry at
Time 3 through the combined effect of focusing
and shifting attentional control at Time 2. However,
when the two proposed mediators were considered
separately, only the indirect effect of focusing
attentional control was significant. Specifically,
the 95% bias-corrected bootstrap confidence
interval for the specific indirect effect of focusing
attentional control at Time 2 (ab = .0510) based on
10,000 bootstrap samples did not include zero

![FIGURE 2](image-url)

**Note.** *p < .05, **p < .001.*

Table 3

<table>
<thead>
<tr>
<th>Outcome</th>
<th>M₁ (ACS.F.T2)</th>
<th>M₂ (ACS.S.T2)</th>
<th>Y (PSWQ.T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictor</td>
<td>Coeff.</td>
<td>SE</td>
<td>p</td>
</tr>
<tr>
<td>X (ISI.T1)</td>
<td>a</td>
<td>-14</td>
<td>.04</td>
</tr>
<tr>
<td>M₁ (ACS.F.T2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₂ (ACS.S.T2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cov (PSWQ.T1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>i_M₁</td>
<td>31.15</td>
<td>.75</td>
</tr>
<tr>
<td>R²</td>
<td>.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F(2, 452)</td>
<td>36.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>&lt;.001</td>
<td></td>
<td></td>
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</tbody>
</table>

**Note.** ACS.F.T2 = Attentional Control Scale–Focusing factor, Time 2; ACS.S.T2 = Attentional Control Scale–Shifting factor, Time 2;
PSWQ.T3 = Penn State Worry Questionnaire, Time 3; ISI.T1 = Insomnia Severity Index, Time 1; PSWQ.T1 = Penn State Worry
Questionnaire, Time 1; SE = standard error.
(.0180–.1034), indicating a significant indirect effect of sleep disturbance at Time 1 on worry at Time 3 through focusing attentional control at Time 2. Effect-size calculations estimating the ratio of the indirect effect to the total effect (Alwin & Hauser, 1975) indicate that 25% of the effect of sleep disturbance at Time 1 on worry at Time 3 occurs through the indirect effect of focusing attentional control at Time 2. In contrast, the 95% bias-corrected bootstrap confidence interval for the specific indirect effect shifting attentional control at Time 2 \((ab = .0035)\) based on 10,000 bootstrap samples did include zero \((-0.0066–0.0273)\), indicating no significant indirect effect of sleep disturbance at Time 1 on worry at Time 3 through shifting attentional control at Time 2. With focusing and shifting attentional control at Time 2 included in the model, there remained a significant direct effect of sleep disturbance at Time 1 on worry at Time 3 \((c' = .1530, p < .05)\).

**Multivariate Mediation: Obsessions**

As shown in Figure 3 and Table 4, results of a mediation analysis using ordinary least squares path analysis revealed that sleep disturbance at Time 1 significantly influenced obsessions at Time 3 through its effect on focusing attentional control at Time 2, but not through shifting attentional control at Time 2. Increased sleep disturbance at Time 1 significantly predicted decreased focusing attentional control at Time 2 \((a = -.1439)\), and decreased focusing attentional control at Time 2 significantly predicted increased obsessions at Time 3 \((b = -.0710)\). In contrast, sleep disturbance at Time 1 significantly

![Diagram](image-url)
predicted shifting attentional control at Time 2 $(a = -0.1095)$, but shifting attentional control at Time 2 did not significantly predict obsessions at Time 3.

The 95% bias-corrected bootstrap confidence interval for the total indirect effect of focusing and shifting attention control $(ab = .0074)$ based on 10,000 bootstrap samples did not include zero (.0003–.0170), indicating a significant indirect effect of sleep disturbance at Time 1 on obsessions at Time 3 through the combined effect of focusing and shifting attentional control at Time 2. However, when the two proposed mediators were considered separately, only the indirect effect of focusing attentional control was significant. Specifically, the 95% bias-corrected bootstrap confidence interval for the specific indirect effect of focusing attentional control at Time 2 $(ab = .0102)$ based on 10,000 bootstrap samples did not include zero (.0028–.0223), indicating a significant indirect effect of sleep disturbance at Time 1 on obsessions at Time 3 through focusing attentional control at Time 2. Effect-size calculations estimating the ratio of the indirect effect to the total effect (Alwin & Hauser, 1975) indicate that 30% of the effect of sleep disturbance at Time 1 on obsessions at Time 3 occurs through the indirect effect of focusing attentional control at Time 2. In contrast, a 95% bias-corrected bootstrap confidence interval for the specific indirect effect shifting attentional control at Time 2 $(ab = -.0028)$ based on 10,000 bootstrap samples did include zero (−.0107–.0012), indicating no significant indirect effect of sleep disturbance at Time 1 on obsessions at Time 3 through shifting attentional control at Time 2. With focusing and shifting attentional control at Time 2 included in the model, there was not a significant direct effect of sleep disturbance at Time 1 on obsessions at Time 3 ($c' = .0266, p > .05$).

**Discussion**

The findings of the present study suggest that sleep disturbance predicts focusing attentional control over 3 months. This finding is consistent with previous research showing that acute sleep loss impairs cognitive function, including attention (Goel, Rao, Durmer, & Dinges, 2009). The prospective nature of the present study suggests that sleep disturbance has both a proximal and a distal effect on aspects on cognitive function. In contrast, sleep disturbance did not predict shifting attentional control. Recent research on focusing and shifting attentional control suggest that these factors may reflect two distinct aspects of cognitive control. Specifically, focusing attentional control may reflect inhibitory control processes (i.e., the ability to inhibit distractors in order to focus attention), and shifting attentional control may reflect switching (i.e., the ability to flexibly switch attention from one task to another; Judah et al., 2014; Wiersma & Roeyers, 2009). Over time, sleep disturbance may have a greater impact on attentional control processes that draw more on inhibitory control. However, this result should be replicated before more definitive inferences can be made, particularly with behavioral measures of attention that can delineate inhibition and switching.

The finding that focusing, but not shifting, attentional control predicts repetitive negative thinking over 3 months is consistent with previous research linking focusing attentional control to anxiety-related processes, such as worry (Judah et al., 2014), rumination (Armstrong et al., 2011), and general anxiety symptoms (Olausson et al., 2011). The findings also lend support to the view that focusing and shifting attentional control may be differentially linked to symptoms of psychopathology (Mills et al., 2016). Deficits in the ability to inhibit distractors in order to focus on a desired stimulus may facilitate repetitive negative thinking that takes the form of worry, rumination, and obsessions. This process may then confer vulnerability for disorders like GAD, depression, and OCD. Interestingly, shifting attentional control did not predict repetitive negative thinking over time. This finding suggests that the ability to switch attention between competing demands or tasks may be less relevant to the experience of intrusive cognition.

An important finding of the present study is that sleep disturbance predicts increased repetitive negative thinking over 6 months through its effect on focusing, but not shifting, attentional control. This effect was found for rumination, worry, and obsessions. This finding is consistent with previous research suggesting that focusing attentional control uniquely accounts for the relationship between repetitive negative thinking and symptoms of psychopathology (Mills et al., 2016). Previous research has shown that acute sleep loss leads to increased amygdala reactivity to negative stimuli and decreased functional connectivity between the medial prefrontal cortex and amygdala (Yoo, Gujar, Hu, Jolesz, & Walker, 2010), areas linked to the regulation of cognitive control (Cooper, 2010) and affective function (Davidson, 2002), respectively. Future research is needed to examine whether similar brain regions are relevant to understanding how deficits in cognitive control processes due to sleep disturbance impairs the ability to regulate or inhibit repetitive negative thinking.

Previous research has highlighted the proximal impact of acute sleep disturbance on cognitive control
processes, such as attention (Drummond et al., 2001) and anxiety-related processes (Babson, Trainor, Feldner, & Blumenthal, 2010). Importantly, the present finding that deficits in focusing attentional control mediate the prospective relationship between sleep disturbance and repetitive negative thinking extends previous research by showing that sleep disturbance also has distal effects on cognitive and affective function. This finding suggests that those with sleep disturbance may have a diminished ability to inhibit repetitive negative thinking when it occurs. Over time, excessive intrusions of repetitive negative thinking may confer vulnerability for the development of psychopathology. This interpretation is consistent with the proposal that sleep disturbance is a transdiagnostic process that contributes to various forms of psychopathology (Harvey et al., 2011). The results of the present study may have important implications for the prevention and treatment of psychopathology. Specifically, these findings highlight the importance of sleep health for both cognitive control and emotional function and suggest the utility of public health initiatives aimed at promoting healthy sleep. Further, these findings suggest that sleep may be an important target for intervention in the treatment of disorders characterized by repetitive negative thinking. Improving disturbed sleep may increase cognitive control and thereby enhance the ability to regulate repetitive negative thinking. Attentional control may similarly be an important treatment target. Indeed, interventions aimed at increasing cognitive control (Cohen, Mor, & Henik, 2015) may buffer the impact of sleep disturbance on repetitive negative thinking.

Although this study is the first to indicate that focusing attentional control is a mediator of the relation between sleep disturbance and repetitive negative thinking over time, it is important to consider these findings within the context of the study limitations. First, the sample consisted of unselected community participants, and no information was collected regarding diagnostic status. Thus, it is unclear whether the findings of the present study generalize to clinical samples characterized by sleep disturbance and repetitive negative thinking. However, it is useful to note that 13% of the sample was above the cutoff for clinically significant insomnia at Time 1 (Bastien et al., 2001), 20% of the sample was above the cutoff for clinically significant obsessions at Time 3 (Foa et al., 2002), and 30% of the sample was above the cutoff for high worry at Time 3 (Korte, Allan, & Schmidt, 2016). Second, the present study relied on self-report data. The perception of sleep and attentional control may be entirely distinct from objective measurements of these variables. Thus, it is possible that those who perceive that their sleep is disturbed also perceive problems with attentional control and repetitive negative thinking. Further, it is also possible that the findings are due to shared method variance (Cole & Maxwell, 2003). Future research should utilize both objective and behavioral measures of the study variables in a multimethod approach to address these concerns. Third, an important concern in mediation modeling is the issue of assessment timing. Although the present study suggests that shifting attentional control does not mediate the relationship between sleep disturbance and repetitive negative thinking, it is possible that 3 months is not the optimal lag at which to detect this effect. Future studies should sample these variables at various time lags to determine whether shifting attentional control has an effect at a different time than focusing attentional control. Fourth, as noted, participants who did not complete the study reported more sleep disturbance compared with study completers. This discrepancy may limit generalizability to those with the most severe sleep disturbance. In addition, it may be the case that the present findings underestimate the observed effects of sleep disturbance. Finally, causal implications are limited in the absence of an experimental manipulation of sleep on repetitive negative thinking. Future research utilizing sleep deprivation or sleep restriction paradigms are necessary to fully examine sleep disturbance as a causal factor in decreased attentional control and increased repetitive negative thinking. Despite these limitations, the present study offers the first evidence that sleep disturbance predicts repetitive negative thinking over time through its effect on focusing attentional control. Considering the high rate of adults who report getting less than the recommended amount of sleep (Centers for Disease Control and Prevention, 2009), it is critical to continue to examine the link between sleep disturbance and psychopathology, as well as the mechanisms that may explain this link.

Conflict of Interest Statement
The authors declare that there are no conflicts of interest.

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Accepted: December 7, 2016
Available online: 17 August 2017