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[10.1080/87565641.2014.983636](https://doi.org/10.1080/87565641.2014.983636)

Document Version

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Citation for published version (APA):

Cecil, C. A. M., Viding, E., McCrory, E. J., & Gregory, A. M. (2015). Distinct mechanisms underlie associations between forms of childhood maltreatment and disruptive nocturnal behaviors. *Developmental Neuropsychology*, 40(3), 181-199. <https://doi.org/10.1080/87565641.2014.983636>

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**Distinct mechanisms underlie associations between forms of childhood maltreatment
and disruptive nocturnal behaviours**

SELF-ARCHIVING VERSION

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Citation: Cecil, C.A.M., Viding, E., McCrory, E.J. & Gregory, A.M. (In Press).

Distinct mechanisms underlie associations between forms of childhood maltreatment and disruptive nocturnal behaviours. *Developmental Neuropsychology*.

DOI: 10.1080/87565641.2014.983636

Acknowledgements: We would like to thank the young people, teachers and key workers who have taken part in this project. We are grateful to Feras Abo Anour, Jo Guiney and Yvonne Whelan for their valuable help with data collection. CAM Cecil was supported by a Kids-Company charity studentship during the writing of the article.

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Abstract

Childhood maltreatment is associated with risk for sleep disturbances, including Disruptive Nocturnal Behaviours (DNBs). Yet, little is known regarding associations between specific forms of maltreatment and DNBs, or factors that mediate and moderate these associations. Data from a community sample of high-risk youth ($n = 193$; $M = 18.87$ years) indicated that self-reported emotional and sexual abuse during childhood made specific contributions to DNBs at the time of assessment. Trauma-related psychopathology mediated the effects of emotional abuse. Furthermore, executive function moderated the effects of sexual abuse. Findings suggest that distinct mechanisms underlie associations between maltreatment types and DNBs.

Introduction

Disruptive Nocturnal Behaviours (DNBs) denote a class of sleep disturbances that include nightmares, sleep terrors, nocturnal panic attacks and dream enactment behaviours such as kicking or punching (Germain, Hall, Krakow, Katherine Shear, & Buysse, 2005). DNBs are thought to reflect intense emotional distress and psychophysiological arousal (Spoomaker, Schredl, & van den Bout, 2006; Zadra & Dondori, 2000). These sleep disturbances are highly comorbid with a range of psychiatric symptoms and are an important marker of poor individual functioning (Roberts & Lennings, 2006). DNBs are strongly associated with prior trauma exposure (Lavie, 2001). Indeed, DNBs feature as one of the most frequently reported symptoms amongst trauma-exposed individuals and can persist for decades following the traumatic event (Germain, Buysse, Shear, Fayyad, & Austin, 2004; Mellman & Hipolito, 2006; Schreuder, Kleijn, & Rooijmans, 2000; Steine et al., 2012).

Childhood maltreatment, including physical, sexual, and emotional abuse and neglect is recognized as a salient form of developmental trauma exposure, with widespread effects on psychobiological, emotional and behavioural functioning extending throughout the lifespan (Cicchetti & Toth, 2005). While the majority of extant research of DNBs has focused on traumatic events occurring during adulthood (see Lavie, 2001, for a review), childhood maltreatment is emerging as an important risk factor for long-term sleep difficulties in general as well as DNBs in particular (Agargun et al., 2003; Greenfield, Lee, Friedman, & Springer, 2011). Individuals who frequently report nightmares are twice as likely to have a history of childhood maltreatment compared to those with lower nightmare frequency (Agargun et al., 2003). Furthermore, frequency of bad dreams and nightmares significantly increases with severity of childhood maltreatment, following a dose-response gradient (Duval, McDuff, & Zadra, 2013). These disturbances can be enduring, with reports of disturbed sleep and dreaming persisting even ten years after disclosure of childhood abuse (e.g. Noll, Trickett, Susman, & Putnam, 2006). It is currently unclear, however, whether risk of DNBs varies depending on the type of maltreatment experienced (Babson & Feldner, 2010; Caldwell & Redeker, 2005).

Specificity of maltreatment type effects

A number of studies have examined the effects of specific maltreatment types on sleep disturbances (including DNBs), with inconsistent findings. Some studies have reported no

difference in the impact of distinct maltreatment types, supporting a more global, non-specific effect of traumatic events on disrupted sleep (e.g. Agargun et al., 2003; Cuddy & Belicki, 1992; Germain et al., 2004). In contrast, other studies have provided evidence for maltreatment type specificity. These have generally converged around sexual abuse as a particularly detrimental form of childhood maltreatment on sleep and dreaming (see Steine et al., 2012, for a review). Sleep disturbances are highly prevalent among sexually abused individuals. For example, Calam and colleagues (1998) reported that sleep disturbances were the most common symptom identified amongst sexually abused children one month after clinical assessment, and that such disturbances appeared to worsen with time. Furthermore, sleep disturbances associated with sexual abuse have been found to differ from those seen following physical abuse (e.g. Glod, Teicher, Hartman, & Harakal, 1997).

Inconsistencies in the literature (i.e. evidence of global vs. specific effects) are likely to reflect a number of methodological differences across studies, including the characteristics of the population examined (e.g. psychiatric vs community samples; age range; gender composition) the specific type of sleep disturbance assessed (e.g. trauma-related nightmares, DNBs, general sleep problems), and the type of analysis used (e.g. categorical vs continuous approaches). Importantly, studies have differed greatly in the number of maltreatment types included, most often limited by an exclusive focus on sexual and physical abuse (Steine et al., 2012). Given that maltreatment types are highly interrelated, this approach may result in the overestimation of effects attributed to specific forms of maltreatment (Fallon et al., 2010; Herrenkohl & Herrenkohl, 2009; Higgins & McCabe, 2001).

Studies have also varied in the type and number of covariates included (e.g. socio-demographic variables, additional variables associated with disrupted sleep). One factor that has been particularly overlooked is exposure to subsequent trauma (Babson & Feldner, 2010). Rates of lifetime victimization are much greater in maltreated versus non-maltreated individuals (Margolin & Gordis, 2000). For example, maltreated youth are at increased risk of community violence exposure (CVE; Cecil, Viding, Barker, Guiney, & McCrory, 2014), which is also associated with increased sleep disturbances (Lepore & Kliever, 2013). Yet, we are not aware of any study including CVE as a potential confound, even though effects attributed to maltreatment may in part be due to more temporally proximal exposure to community violence. In summary, a systematic examination is needed that addresses the above limitations, in order to explore the relationship between all forms of maltreatment and DNBs. Particularly, it is important to clarify whether maltreatment types differentially

associate with DNBs, as this may carry important implications for risk assessment, individualized treatment formulation and the identification of more specific targets for the prevention of DNBs.

Trauma-related psychopathology as a potential mediator of maltreatment effects on DNBs

Beyond clarifying how maltreatment types are associated with DNBs, it is important to investigate putative mechanisms that may underlie the effects of maltreatment on disturbed sleep. One factor that may shed light on the link between maltreatment and DNBs is trauma-related psychopathology. Maltreatment is recognized as a key developmental risk factor for a range of psychopathological symptoms, including post-traumatic stress and depression – both of which are highly comorbid with DNBs (Levin & Fireman, 2002; Zadra & Donderi, 2000). For example, DNBs such as nightmares are regarded as a core feature of post-traumatic stress disorder (PTSD, American Psychiatric Association, 2013). Nightmare frequency is linearly associated with PTSD severity (e.g. Pigeon, Campbell, Possemato, & Ouimette, 2013), and the use of imagery rehearsal therapy to reduce nightmares has been shown to improve global PTSD symptoms (Krakow, Hollifield, Johnston, & et al., 2001). DNBs are also related to severity of depressive symptoms and predict suicidal ideation amongst depressed patients (Sjostrom, Waern, & Hetta, 2007; Tanskanen et al., 2001). It is important to note, however, that this relationship is bidirectional, with severity of psychopathological symptoms also predicting characteristics and duration of sleep disturbances (see Babson & Feldner, 2010, for a review).

The association between maltreatment, psychopathology and disturbed sleep is consistent with the existence of multiple potential pathways to DNBs. For example, it is possible that maltreatment represents a common aetiological factor in both trauma-related psychopathology and DNBs (i.e. direct effect). Furthermore, psychiatric symptoms may, at least in part, mediate the effect of maltreatment on DNBs (i.e. indirect effect). Specifically, childhood maltreatment may increase risk of psychiatric outcomes, which in turn increases vulnerability to DNBs. One preliminary study found that maltreatment predicted sleep disturbances even after accounting for psychiatric symptoms, which supports a more direct link between maltreatment and sleep disturbances (Noll et al., 2006). However, this study only examined the effects of sexual abuse on global sleep difficulties, without accounting for other maltreatment types. Therefore, it remains unclear whether trauma-related

psychopathology mediates the impact of maltreatment on DNBs, and whether this effect may vary depending on the form of maltreatment experienced.

Severity of DNBs following maltreatment may be moderated by executive functions

In addition to a paucity of information concerning possible mediators between maltreatment and DNBs, little is known regarding factors that may moderate these associations (Steine et al., 2012). Literature on early life stress has long documented that an individual's intrinsic characteristics may increase or decrease risk for negative outcomes following trauma exposure (Afifi & Macmillan, 2011). One such characteristic is executive function (EF), which encompasses a range of cognitive processes necessary for purposeful, goal-directed action. These processes include the inhibition of dominant emotional and behavioural responses, cognitive flexibility and monitoring information in the environment (Augusti & Melinder, 2013).

Executive functions may be a candidate moderator for two reasons. First, with regards to maltreatment, EFs are thought to play an important role in coping with traumatic experiences, with risk for negative outcomes following trauma exposure reduced for those individuals with better EFs (Wekerle, Waechter, & Chung, 2012; Yehuda, Flory, Southwick, & Charney, 2006). Second, with regards to DNBs, it is relevant that EFs are subserved by a network of cortical frontal structures (particularly the prefrontal cortex, PFC) that act to down-regulate activity in limbic areas of the brain (esp. amygdala), and are thus centrally involved in the modulation of physiological and emotional arousal (Nielsen & Levin, 2007). In fact, EFs are often used as a neuropsychological marker of PFC function (Alvarez & Emory, 2006).

Compared to the waking state, sleep and dreaming are generally marked by increased activity in both the PFC and amygdala, amongst other regions (Nofzinger et al., 2004). While the amygdala is hypothesized to generate fear expression in dreams, the PFC is thought to act as a negative feedback loop in order to promote fear extinction (Nielsen & Levin, 2007). As such, disruptions in PFC may increase susceptibility to DNBs. Although deficits in EFs have previously been examined in relation to both maltreatment (Majer, Nater, Lin, Capuron, & Reeves, 2010; Navalta, Polcari, Webster, Boghossian, & Teicher, 2006) and sleep disturbances (Fortier-Brochu, Beaulieu-Bonneau, Ivers, & Morin, 2012; Riedel & Lichstein,

2000), no study to our knowledge has investigated whether EFs moderate the association between maltreatment types and DNBs.

The current study

Based on a community sample of high-risk youth and young adults, the present study addressed three main aims: (i) to examine whether distinct forms of maltreatment differentially impact DNBs (i.e. specificity of effects); (ii) to investigate whether trauma-related psychopathology mediates the association between maltreatment types and DNBs; and (iii) to test whether executive functions moderate the severity of DNBs following exposure to different forms of maltreatment. Based on previous studies (e.g. Noll et al., 2006), we expected that sexual abuse would emerge as a particularly strong predictor of DNBs. We also expected that maltreatment effects would be partially mediated by levels of trauma-related psychopathology. Finally, given the role of EFs in moderating the impact of trauma, and the importance of underlying PFC function in the top-down regulation of arousal, we expected that lower EF performance would be associated with increased DNB severity amongst maltreated youth. All analyses stringently controlled for a range of relevant confounds, including socio-demographic characteristics and current exposure to community violence.

Methods

Participants

The current sample was recruited as part of a larger study ($n = 204$, age range = 16-24 years) examining the effects of developmental adversity on individual functioning. These analyses include only participants for whom data on DNBs was available ($n = 193$). A number of recruitment channels were used in order to include individuals with varying levels of maltreatment exposure. Forty-seven percent ($n = 91$) of participants were recruited at Kids Company, a charitable organization that provides services and support to vulnerable inner-city youth (typically via self-referral), many of whom have experienced severe developmental adversity. The other fifty-three percent of participants ($n = 102$) were recruited from a number of London-based secondary schools ($n = 74$) and internet websites ($n = 28$), including Gumtree, Experimatch and the University College London (UCL) subject pool. The majority of participants were below 21 years of age (81.3%) and 54.3% were female ($n = 103$). The

sample was ethnically diverse, with 44.6% of participants self-identifying as White, 39.9% as Black, 9.8% as Mixed and 5.7% as Asian.

Procedure

All procedures were approved by the UCL Research Ethics Committee (*ID No: 2462/001*). Youth from the charity were introduced to the research by a member of staff, and, if interested, were provided further information about the study by one of the research team. As a result, all of the youth who met with the researchers had shown interest in the study and agreed to participate. In schools, youth initially received information during a brief presentation and were given additional details if interested. Out of the participants who initially consented to take part in the study, 89.6% attended the agreed time slots and completed the testing session. Participants recruited via websites were provided information about the study online, and interested individuals were asked to fill in a brief screening form, so that it could be ensured that only participants with similar socio-demographic characteristics to youth recruited in other sites (i.e. charity and schools) were included in the study (i.e. age, sex, ethnicity and level of neighbourhood deprivation). Eligible participants were asked to select a time slot for the testing session. All participants provided informed consent prior to participation. Testing took place in a quiet room within Kids Company, the young person's school or UCL depending on recruitment source. Participants from the charity and from websites were compensated for their time individually; however students recruited from school settings received group compensation for school equipment or a final year party in line with head-teacher preferences. Full details of the recruitment procedures are available elsewhere (Cecil et al., 2014). Information on how recruitment sites compare in relation to the study variables is available as an online supplement.

Measures

Background characteristics

Data on age, sex, ethnicity and IQ were collected from all participants. Cognitive ability was assessed using the two-subtest version of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), with all participants scoring within a range of 70-125 ($M = 101.30$, $SD = 11.85$). Participant post code information was used to obtain a census-derived and area-weighted Index of Multiple Deprivation (IMD, 2011) score. The IMD is an aggregate measure of multiple indicators of neighbourhood deprivation, spanning: (i) income; (ii)

employment; (iii) health and disability; (iv) education skills and training; (v) barriers to housing and services; (vi) crime; and (vii) living environment (Noble, Wright, Smith, & Dibben, 2006). Higher values indicate female gender, non-white ethnicity, older age, higher cognitive ability and greater neighbourhood deprivation.

Community violence exposure over the past year was assessed using items from the validated, self-report Children's Report of Exposure to Violence (CREV; Cooley, Turner, & Beidel, 1995). The CREV records frequency of exposure to different forms of violence from 0 = 'never' to 4 = 'every day', including being beaten up, robbed, chased, shot and killed. Three subscales were used in the present study: hearing about, witnessing, and directly experiencing (i.e. being a victim of) community violence ($\alpha = .79 - .89$). The CREV has been used with both child and adolescent populations (e.g. Cooley-Quille, Boyd, Frantz, & Walsh, 2001). A total score of community violence exposure was derived by averaging the three CREV subscales.

Measures of Psychopathology

Participants completed the Trauma Symptom Checklist for Children (TSCC-A; Briere, 1996), a 44-item, self-report measure that includes 5 clinical scales (anxiety, depression, post-traumatic stress, anger and dissociation) and 2 validity scales (under- and hyper-response). Items are rated on a 4-point Likert scale ranging from 'never' to 'almost all of the time'. One item from the PTSD subscale was removed due to overlap with DNBs ('bad dreams or nightmares'). Construct, convergent and discriminant validity have been well-established using both child and adolescent samples (Briere, 1996; Sadowski & Friedrich, 2000). Cronbach alpha for the scales varied from .84 to .87. A global index of trauma-related psychopathology was derived by summing the five TSCC-A subscales.

Measures of Executive Function (EF)

EF was measured using two tests. First, participants were administered the Trail Making Test – part B (TMT B; Reitan, 1992) by a member of the research team who had been trained by a psychologist with experience in neuropsychological testing. The TMT B is a widely used test that requires participants to connect a series of numbers and letters by alternating between sequential and ascending order (e.g. 1-A-2-B-3-C etc.). The score used is the total time taken to complete the sequence (seconds), whereby higher values indicate worse performance.

Performance on this task has been shown to primarily reflect cognitive flexibility (Kortte, Horner & Whindham, 2010), but is also influenced by a number of other abilities, including set-shifting, response inhibition and attentional switching, as well as involving a visual search and motor speed component (Stuss & Levine, 2002). At a neural level, TMT-B scores have been shown to associate with frontal lobe activation, particularly in the dorsolateral and medial PFC, across both fMRI and functional near-infrared spectroscopy studies (e.g. Hagen et al., 2014; Zakzanis, Mraz & Graham, 2005).

Second, the Digit Span Backwards (Wechsler, 1997) was administered as a measure primarily reflecting working memory, as well as including an attentional, phonological and visuospatial component. In this task, participants are presented verbally with a sequence of numbers (one per second), and are asked to correctly reproduce orally the sequence in reverse order, from last to first. The first trial consists of two digits, and a new digit is added every two trials, with a maximum of eight digits. Participants are asked to stop if they fail two trials consecutively. The score used is the total number of correct trials, whereby higher values represent better performance. Similarly to the TMT B, performance on the Digit Span Backward has been shown to correlate with frontal lobe function, particularly the dorsolateral PFC, as evidenced by neuroimaging studies using PET, near-infrared spectrometry and fMRI (e.g. Hoshi et al., 2000; Gerton et al., 2004).

Measure of Childhood Maltreatment

Childhood maltreatment was assessed using the Childhood Trauma Questionnaire – Short Form (CTQ; Bernstein & Fink, 1998). The CTQ is a 28-item self-report measure screening for experiences of maltreatment “while growing up”. The CTQ comprises of 5 subscales measuring emotional abuse (e.g. “people in my family said hurtful or insulting things to me”), sexual abuse (e.g. “someone tried to make me do sexual things or watch sexual things”), physical abuse (e.g. “I got hit or beaten so hardly that it was noticed by someone like a teacher, neighbour or doctor”), emotional neglect (e.g. “my family was a source of strength and support”, reversed) and physical neglect (“my parents were too drunk or high to take care of the family”). The scales show high internal consistency in our sample ($\alpha = .70 - .97$). By including ‘I currently feel unsafe at home’ as an additional yes/no item we were able to ascertain that none of the participants included in the study were currently vulnerable to

violence in the domestic environment (e.g. by family or partner). As such, the present study investigates the effects of childhood (i.e. past) maltreatment.

Measure of Disruptive Nocturnal Behaviours (DNBs)

DNBs were measured using the Pittsburgh Sleep Quality Index - Addendum for PTSD (PSQI-A; Germain et al., 2005). The PSQI-A assesses the frequency of 7 DNBs within the past month, including hot flashes, idiopathic and trauma-related nightmares, general nervousness, severe anxiety/panic, night terror and dream enactment behaviours (e.g. kicking, punching). Each item is rated on a four point scale ranging from 'not in the past month' to 'three or more times a week' ($\alpha = .81$). A global score is obtained by summing responses from the 7 items (scores can range from 0-21).

Statistical Analysis

The models to be tested in the present study are visually presented in Figure 1. Analyses were performed on SPSS package v. 21 (2012).

The main analysis proceeded in three parts. First, we used a multivariate regression model to test the specificity of maltreatment type effects on DNBs (Figure 1A). All covariates were included as predictors in the first block (age, sex, ethnicity, IQ, neighbourhood deprivation, CVE), followed by the five maltreatment types in the second block. This analysis enabled the examination of whether any maltreatment type is uniquely associated with DNBs, over and above the effect of confounding variables as well as shared variance between maltreatment types. Level of significance was established via 95% confidence intervals of the unstandardized estimates (*B*) and associated *p* values, while standardized estimates (Std. *B*) were used as a measure of effect size.

In the second part of the analysis we examined whether global trauma-related psychopathology mediates the effects of maltreatment types on DNBs, using Preacher and Hayes' (2008) SPSS macro for bootstrapped mediation (INDIRECT). The macro generates unstandardized estimates for all paths in the mediation model (see Figure 1B), and applies bootstrapping (10,000 samples with replacement) to obtain bias-corrected 95% confidence intervals (95% CI) for indirect paths. Indirect effects are considered significant if the CIs do not cross zero. Mediation was only assessed for those maltreatment types that emerged as significant unique predictors of DNBs (Figure 1A). All mediation analyses controlled for covariates as well as shared variance between maltreatment types.

In the third part of the analysis we investigated whether markers of executive function moderate the association between maltreatment types and DNBs (Figure 1C). As in Part 2, these analyses were run for maltreatment types that were uniquely associated with DNBs. Maltreatment types, the moderator, and their product term were entered into a regression model, after controlling for covariates and variance shared with other maltreatment forms. Models were tested separately for the two measures of executive function as they tap into related but dissociable aspects of EF, and thus may potentially play different roles in the associations between maltreatment and DNBs.

***** Figure 1 *****

Results

Descriptives and bivariate correlations across the study variables are presented in Table 1. So as to contextualize the means reported in Table 1, we note that (a) most of the sample (67.4%; $n = 130$) experienced at least one form of childhood maltreatment (i.e. scored at or above the Low maltreatment threshold specified by the CTQ manual); and (b) 32% of youth ($n = 62$) showed clinically significant levels of DNBs (i.e. based on the cut-off score of 4 or above; see Germain et al., 2005). DNBs were positively associated with female sex, older age and higher levels of community violence exposure. As expected, DNBs were moderately-to-strongly associated with all forms of trauma-related psychopathology ($r = .37-.62, p < .001$) and childhood maltreatment ($r = .28-.46, p < .001$). DNBs were not related to either measure of executive function. Maltreatment was significantly associated with worse performance on the TMT B ($r = .21, p < .01$) but not with the Digit Span Backwards.

***** Table 1 *****

Specificity of maltreatment type effects

The multivariate regression model testing for maltreatment specificity is displayed in Table 2. With regards to covariates (Block 1), both sex and current levels of CVE were found to be significant independent predictors of DNB severity. When entering all maltreatment types simultaneously as predictors (Block 2), only emotional abuse ($B = .41, \text{Std. } B = .49, 95\% \text{ CI} = .23-.58, p < .001$) and sexual abuse ($B = .20, \text{Std. } B = .18, 95\% \text{ CI} = .03-.36, p < .05$) emerged as unique contributors DNBs. It is worth noting that the effect size of emotional abuse was over twice as large as that of sexual abuse. Given the interrelatedness of maltreatment types, both levels of tolerance and variance inflation factors (VIFs) were examined, but neither indicated a high level of multicollinearity (tolerance $> .80$; VIF < 2.60).

***** Table 2 *****

Mediation of trauma-related psychopathology

Mediation analyses were conducted exclusively for emotional and sexual abuse, controlling for covariates and other maltreatment types. Emotional abuse was associated with global psychopathology (path a; $B = .68$, $SE = .13$, $t = 5.33$, $p < .001$), which in turn associated with DNBs (path b; $B = .28$, $SE = .05$, $t = 5.90$, $p < .001$). The total effect of emotional abuse on DNBs was significant (path c; $B = .40$, $SE = .09$, $t = 4.61$, $p < .001$), and decreased after accounting for trauma-related psychopathology (path c'; $B = .20$, $SE = .08$, $t = 2.37$, $p < .05$). Trauma-related psychopathology significantly mediated the effects of emotional abuse on DNBs (indirect effect: $B = .19$, 95% CI = .10 – .34). In contrast, sexual abuse did not independently associate with psychopathology (path a; $B = .08$, $SE = .12$, $t = .69$, $p = .49$) and psychopathology did not mediate the association between sexual abuse and DNBs (indirect effect: $B = .02$, 95% CI = -.04 – .11).

As a post-hoc analysis, we examined whether mediation of emotional abuse effects varied across domains of psychopathology. All domains were found to partially mediate associations between emotional abuse and DNBs (in order of effect; PTSD: $B = .22$, 95% CI = .12 – .38; anxiety: $B = .17$, 95% CI = .06 – .33; dissociation: $B = .17$, 95% CI = .08 – .31; depression: $B = .16$, 95% CI = .06 – .27; anger: $B = .06$, 95% CI = .01 – .15).

Measures of executive function as moderators

As with the mediation analyses, moderation analyses were conducted for emotional and sexual abuse. Scores on the TMT B moderated the association between sexual abuse and DNBs ($F(9, 159) = 2.67$, $p = .008$) but not emotional abuse ($p = .42$). As can be seen in the decomposition of the interaction (Figure 2), where sexual abuse was dichotomized for visualization purposes, severity of DNBs linearly increased with poorer TMT B performance for youth who had experienced sexual abuse ($N = 29$, based on scoring at or above the Low CTQ threshold), but not for those who had not experienced this form of maltreatment. Scores on the Digit Span Backwards did not moderate severity of DNBs following either emotional or sexual abuse.

As a post-hoc analysis, we explored whether TMT B scores and sexual abuse also interact to predict trauma-related psychopathology. Such an analysis was conducted to establish whether

poorer performance on this test reflects a general vulnerability factor following sexual abuse or whether it specifically underlies risk for DNBs. No interactions were found in relation to either global psychopathology or individual domains of psychopathology.

***** Figure 2 *****

Discussion

In the current study we used self-report questionnaire data to investigate the nature of the established association between childhood maltreatment and DNBs in a sample of high-risk youth. Specifically, we examined whether: (i) forms of childhood maltreatment were differentially associated with DNBs, (ii) trauma-related psychopathology mediated these associations, and (iii) executive function performance moderated the severity of DNBs following exposure to different types of maltreatment. Three key findings emerged. First, when the contribution of different forms of maltreatment was assessed, only emotional and sexual abuse (but not physical abuse, emotional neglect or physical neglect) emerged as independent predictors of DNBs. This indicates that susceptibility to DNBs varies as a function of maltreatment type. Second, levels of trauma-related psychopathology were found to mediate the effects of emotional abuse on levels of DNBs, but not the effects of sexual abuse. Finally, one measure of executive function, the TMT B (primarily reflecting cognitive flexibility) moderated the association between sexual abuse and DNBs, but no interaction effect was found for emotional abuse. The pattern of findings in our mediation and moderation analyses suggests that distinct mechanisms may underlie the association between DNBs and different forms of maltreatment (i.e. emotional and sexual abuse).

Emotional and sexual abuse as contributors to DNBs

Two forms of childhood maltreatment – emotional and sexual abuse – were uniquely associated with DNBs, supporting trauma specificity within this class of sleep disturbances. The effect of emotional abuse was over twice as large as that found for sexual abuse. The present study is the first, to our knowledge, to identify an independent effect of emotional abuse on DNBs, perhaps due to the fact that past research has typically focussed on other forms of maltreatment, especially sexual abuse. Emotional abuse may have been overlooked in the past due to the fact that it does not necessarily constitute an imminent danger to the child (Chamberland, Fallon, Black, & Trocmé, 2011). However present findings point to the need for future studies to measure this maltreatment type as it is a particularly strong risk factor for DNBs. With regards to sexual abuse, findings are consistent with a number of

previous studies documenting a strong relationship between this form of maltreatment and disturbed sleep (Steine et al., 2012). We also extend previous findings by showing that this association is robust even after controlling for a range of potentially confounding variables, including socio-demographic characteristics, current levels of community violence exposure, and other maltreatment types. Of note, the present study set to examine whether any form of maltreatment is associated with DNBs, over and above *shared variance* between maltreatment types. This does not exclude, however, the possibility that such shared variance may also play an important role in DNBs.

Emotional abuse, trauma-related psychopathology and DNBs

Given the considerable overlap between trauma exposure, trauma-related psychopathology and disturbed sleep, we were interested in examining to what extent levels of psychopathology mediate the association between maltreatment types and DNBs. We found that trauma-related symptoms mediated the effects of emotional abuse (but not sexual abuse) on DNBs. When we examined whether this effect varied according to the specific domain of psychopathology, we found evidence of mediation across all domains assessed. These findings are consistent with maltreatment studies that point to emotional abuse as a particularly important independent predictor of psychiatric symptoms, including anxiety, depression and dissociation (Arata, Langhinrichsen-Rohling, Bowers, & O'Brien, 2007; Edwards, Holden, Felitti, & Anda, 2003; McGee, Wolfe, & Wilson, 1997; Sar, Akyuz, Kundakci, Kiziltan, & Dogan, 2004; Simeon, Guralnik, Schmeidler, Sirof, & Knutelska, 2001), which are in turn associated with DNBs in the sleep literature (Agargun et al., 2003; Germain, Buysse & Nofzinger, 2008; Levin & Fireman, 2002; Nielsen et al., 2000).

Affective disturbances are likely to be a key factor linking emotional abuse, psychopathology and DNBs. Emotional abuse (e.g. being made to feel worthless, inadequate, or unloved) is thought to severely compromise the development of the self-system, leading to negative perceptions of the self, dysphoric emotions and difficulties in affective regulation (Briere & Runtz, 1990; McGee et al., 1997). These disturbances are not only characteristic of certain psychiatric symptoms (e.g. anxiety, depression), but have also been shown to predict nightmare frequency (Spoormaker et al., 2006). Importantly, the present findings suggest that factors mediating the effect of emotional abuse on DNBs are distinct from those mediating the effect of sexual abuse, as the latter appeared to increase risk of DNBs independently of trauma-related psychopathology. The specific pattern of our results suggests that the findings

are unlikely to simply reflect shared method variance. However, given that mediation analyses were based on cross-sectional, self-report information, it will be important in future to make use of multi-rater data in order to examine how maltreatment, psychopathology and DNBs interrelate over time.

Sexual abuse, cognitive flexibility and DNBs

Another key finding was that one measure of executive function, TMT B, moderated the severity of DNBs following sexual abuse. More specifically, amongst youth who had experienced sexual abuse, lower TMT B scores were related to increased DNB severity. In contrast, no moderation effects were observed for emotional abuse. Previous studies have shown that EF abilities assessed by the TMT B, particularly cognitive flexibility, are important for reappraising and contextualizing traumatic experiences, thereby promoting resilient outcomes following trauma exposure (Wekerle et al., 2012). However, this evidence alone is not sufficient in explaining why moderation would be found for sexual abuse and not for emotional abuse.

Although speculative, it is possible that this moderation effect may be specific to sexual abuse because frontal brain regions activated during TMT B performance (esp. PFC) are centrally involved in the down-regulation of physiological arousal and fear expression, which are thought to be key factors linking sexual abuse and DNBs (Noll et al., 2006; Steine et al., 2012). Sleep demarcates a period of increased vulnerability and is therefore inhibited by physical threat (Dahl & Lewin, 2002). Compared to other forms of maltreatment, such as emotional abuse, sexual abuse is likely to represent a major threat to a child's physical integrity, resulting in feelings of danger and heightened arousal, which in turn disrupt sleep (Steine et al., 2012). Furthermore, in contrast to other forms of maltreatment that also constitute an immediate threat (e.g. physical abuse), sexual abuse often takes place at night and/or in the child's bedroom, which may strengthen associations between physical threat, fear and the sleeping environment (Noll et al., 2006). Thus, for youth who have experienced sexual abuse, perceived or actual danger may disturb sleep - and over time learnt associations between fear and the sleeping environment may act as a maintaining factor for sleep disturbances after the termination of abuse (Steine et al., 2012).

If it is the case that sexual abuse impacts DNBs primarily via heightened arousal and fear, decreased activity in regions that down-regulate these processes may act as a

vulnerability factor for DNBs following sexual abuse. Although consistent with our findings, such a hypothesis is clearly speculative, and necessitates replication using more direct measures of brain function. In particular, it will be important to establish key differences between neural correlates and cognitive processes underlying performance on the TMT B vs Digit Span Backward, so as to clarify why only the former was found to moderate the effects of sexual abuse on DNBs.

Implications and considerations for interventions

The current findings indicate that emotional and sexual abuse are two important risk factors for DNBs. When working with trauma-exposed individuals, screening for these forms of childhood maltreatment may be helpful in identifying individuals at particularly high risk of DNBs. Conversely, if a young person presents with DNBs it may be important for the clinician to reflect on whether their assessment should include some consideration of abuse history, even if this is of a preliminary and exploratory nature. The pattern of findings reported here are suggestive of distinct mechanisms underlying the association between maltreatment types and DNBs. If these findings are replicated, it may be important to begin to assess whether individualized treatment strategies are preferable. For example, for individuals presenting with DNBs and an emotional abuse history, addressing current levels of trauma-related psychopathology may be central to any intervention that aims to reduce their sleep difficulties. By contrast, for individuals presenting with DNBs and a sexual abuse history, inclusion of cognitive-behavioural interventions focussed on addressing maladaptive cognitions and avoidance behaviours related to fear and hyperarousal may be important. Future research is, of course, necessary to test these hypotheses explicitly. With regards to sleep research, the results presented here underscore the importance of assessing the full range of maltreatment experiences and to account for interrelations between maltreatment types in analyses. Importantly, increased recognition of emotional abuse in sleep research is warranted.

Limitations and future directions

The current findings should be interpreted in the light of several limitations. First, we assessed maltreatment based on self-reports, which can be particularly susceptible to retrospective biases. However, a recent study found similar effects on individual functioning

between retrospective and prospective maltreatment reports (Scott, McLaughlin, Smith, & Ellis, 2012). An important limitation of the study is the lack of information regarding the timing and duration of maltreatment, both of which may influence associations between maltreatment and DNBs. Future studies may benefit from including these potential moderators as well as examining possible cumulative effects associated with experiencing multiple maltreatment types. Second, the fact that maltreatment, trauma-related psychopathology and DNBs were rated by youth themselves raises the possibility of shared method variance. In future, it would be important to examine whether mediation effects may be replicated using multi-rater data. It would also be interesting to establish to what extent youth reports of DNBs converge with objective sleep assessments (e.g. polysomnography), even though these have provided limited insights so far, primarily because DNBs such as bad dreams may not be identifiable using laboratory instruments (Germain et al., 2008). The use of broader sleep measures (e.g. PSQI; Buysse et al., 1998) would also help to identify maltreatment effects that may be associated with other aspects of sleep in addition to DNBs. Third, it is important to note that while the TMT-B is often used as a measure of cognitive flexibility, performance on this test is also influenced by a number of other abilities. Future studies may benefit from using a more direct measure of frontal lobe activity. This will allow clarification of whether our findings truly reflect the importance of variations in PFC function in moderating the effects of sexual abuse on DNBs. If so, this may reflect the key role of this brain area in modulating arousal and fear extinction. Fourth, because of sample size limitations we only included sex as a free-standing covariate within our analyses. It would be interesting in future to examine whether sex moderates the effect of maltreatment types on DNBs, and whether the mediation and moderation effects observed here vary across sex. It is also important to note that recruitment strategy used in the present study precludes us from determining to what degree the participants were representative of youth from the settings from which they were sampled. Finally, while our data are consistent with the possibility of a causal role of emotional and sexual abuse on DNBs, the cross-sectional nature of the study precludes us from establishing the directionality of our findings. For example, it was not possible to ascertain whether maltreatment exposure preceded DNBs. The use of prospective longitudinal data would be informative in clarifying relationships between the study variables. Future studies addressing these limitations may lend further insights into mechanisms underlying the effects of childhood maltreatment on DNBs.

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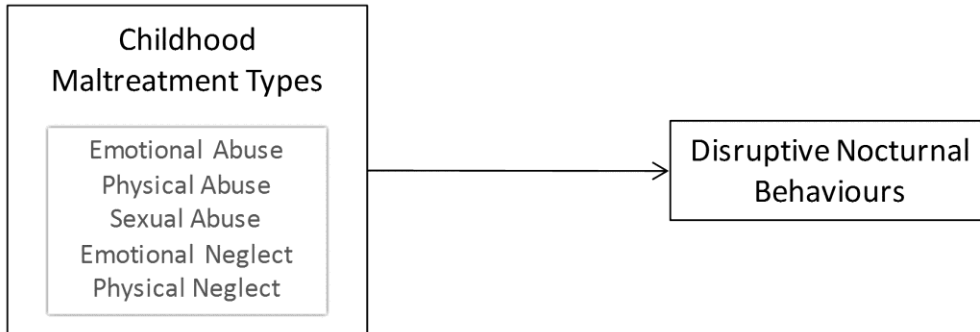
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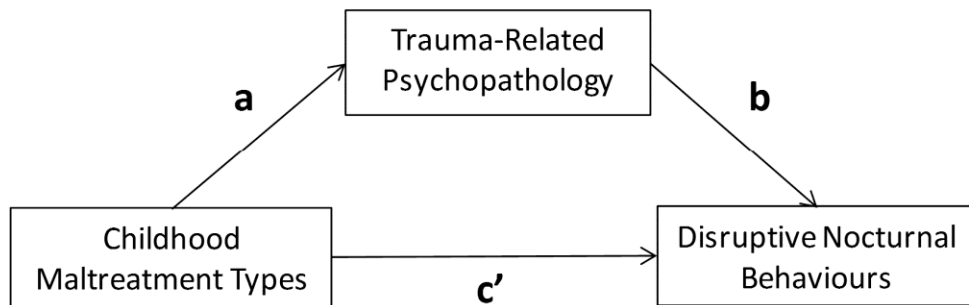
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Figure 1. Models to be tested

A. Specificity of maltreatment type effects



B. Mediation



C. Moderation

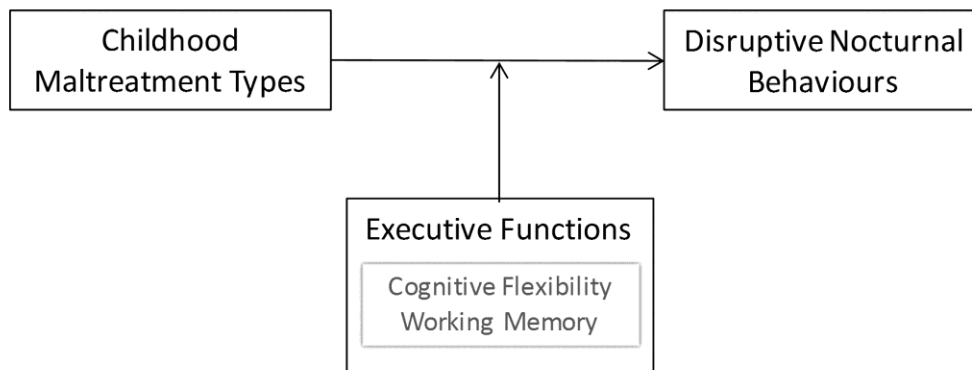


Table 1. Descriptives and correlations between study variables and DNBs

	M (<i>SD</i>) or %	Disruptive Nocturnal Behaviours
Covariates		
Sex (female)	53%	.23***
Age	18.87 (2.27)	.18*
Ethnicity		
White	44.10%	-.04
Black	40.70%	.05
Mixed	9.80%	-.04
Asian	5.40%	.04
IQ	101.30 (11.85)	-.09
Neighbourhood Deprivation	28.51 (11.06)	.12
Community Violence Exposure	17.32 (12.96)	.26***
Childhood maltreatment		
Emotional abuse	9.63 (4.69)	.46***
Physical abuse	7.54 (4.23)	.30***
Sexual abuse	6.01 (3.35)	.32***
Emotional neglect	10.32 (4.68)	.28***
Physical neglect	7.17 (3.09)	.29***
Trauma-related psychopathology		
Anxiety	6.65 (4.91)	.56***
Depression	6.34 (4.67)	.54***
Anger	7.06 (5.70)	.37***
PTSD	8.55 (6.21)	.62***
Dissociation	9.04 (5.97)	.53***
Executive functions		
Trail Making Test B	82.62 (33.36)	.12
Digit Span Backward	5.15 (1.59)	-.06

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$. $N = 148$. *Abbreviations* = PTSD, Post-Traumatic Stress Disorder. $M (SD)$ of Disruptive Nocturnal Behaviours = 3.40 (3.89). Point-biserial correlation is used for testing associations with dichotomous variables.

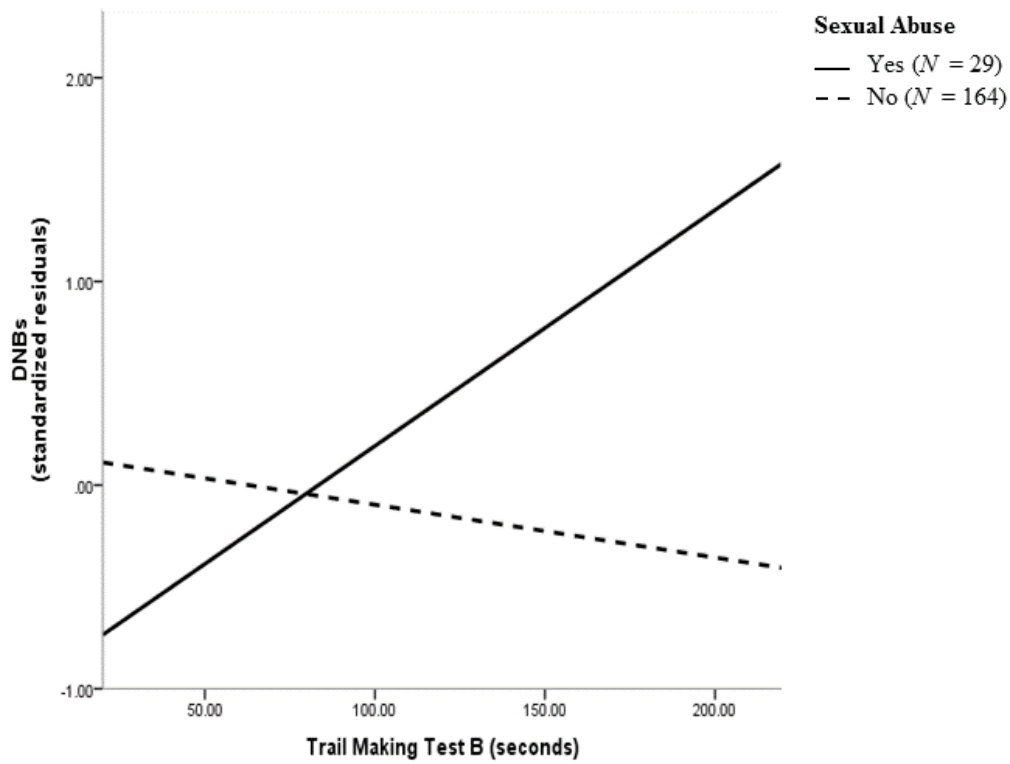
^a Sex coded as 0 = male, 1 = female.

^b Each ethnicity coded as 0 = no, 1 = yes.

Table 2. Specificity of maltreatment type effects on DNBs

Variables	Disruptive Nocturnal Behaviours						
	<i>B</i>	Std. <i>B</i>	95% CI		<i>Adj R</i> ²	<i>R</i> ² change	<i>F</i> change
			UL	LL			
<i>Block 1: Covariates</i>					.11	.14	4.63***
Sex	1.99***	.25	.84	3.13			
Age	.24	.14	-.05	.53			
Ethnicity	-.17	-.03	-.92	.59			
IQ	-.01	-.02	-.06	.04			
Neighbourhood deprivation	-.01	-.02	-.07	.05			
Community violence exposure	.08***	.25	.03	.13			
<i>Block 2: Childhood maltreatment</i>					.26	.17	7.66***
Emotional abuse	.41***	.49	.23	.58			
Sexual abuse	.20*	.18	.03	.36			
Physical abuse	.01	.01	-.16	.17			
Emotional neglect	-.12	-.14	-.30	.06			
Physical neglect	-.15	-.12	-.42	.11			

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$. $N = 148$. Abbreviations = *B*, unstandardized beta; Std. *B*, standardized beta; CI, 95% confidence interval; LL, lower limit of the 95% CI; UL, upper limit of the 95% CI.

Figure 2. Cognitive flexibility as a moderator of sexual abuse effects on DNBs

N.B. The Y-axis displays the standardized residuals of the DNB measure, controlling for covariates.

ONLINE SUPPLEMENT

Descriptive statistics across the study variables by recruitment site

	Recruitment Source ^a		
	Kids Company Mean (SD) or %	Schools Mean (SD) or %	Internet Mean (SD) or %
Covariates			
Sex (female)	54.9%	52.7%	50.0%
Age	19.57 (2.09)	17.04 (.65)	21.39 (1.89)
Ethnicity			
White	20.9%	83.8%	17.9%
Black	68.1%	10.8%	25.0%
Mixed	9.9%	4.1%	25.0%
Asian	1.1%	1.4%	32.1%
IQ	97.79 (12.39)	101.62 (9.45)	112.07 (10.50)
Neighbourhood Deprivation	34.36 (9.87)	21.59 (7.40)	28.99 (12.47)
Community Violence Exposure	24.46 (14.08)	11.16 (7.66)	10.93 (7.88)
Childhood maltreatment			
Emotional abuse	11.21 (5.45)	7.82 (3.35)	9.25 (3.09)
Physical abuse	9.06 (5.15)	6.17 (2.83)	6.21 (1.50)
Sexual abuse	6.79 (4.46)	5.05 (2.36)	6.00 (2.91)
Emotional neglect	12.05 (5.16)	8.44 (3.16)	9.61 (4.45)
Physical neglect	8.47 (3.76)	5.73 (1.51)	6.75 (1.78)
% Any maltreatment ^b	82.4%	48.6%	67.9%
Trauma-related psychopathology			
Anxiety	8.23 (5.52)	5.19 (4.11)	5.42 (2.85)
Depression	7.82 (5.29)	4.88 (3.67)	5.36 (3.29)
Anger	9.29 (6.13)	5.52 (4.84)	3.89 (2.97)
PTSD	12.52 (6.89)	6.73 (5.04)	7.60 (4.68)
Dissociation	11.29 (6.57)	7.14 (4.61)	6.71 (4.43)
Executive functions			
Trail Making Test B	99.82 (37.43)	71.29 (18.09)	61.42 (25.73)
Digit Span Backward	8.45 (3.13)	9.22 (2.55)	11.21 (2.98)
Sleep measure			
Disruptive Nocturnal Behaviours	4.34 (4.58)	2.42 (2.72)	2.96 (3.42)
% Above cut-off ^c	41.8%	24.3%	21.4%

Abbreviations: PTSD, Post-Traumatic Stress Disorder.

^a Kids Company charity $N = 91$; Schools $N = 74$; Internet websites $N = 28$

^b Maltreated youth are defined as youth who had experienced at least one form of maltreatment at or above the Low maltreatment severity threshold specified by the CTQ manual

^c Percentage of youth scoring at or above the clinically meaningful cut-off score of 4 on the PSQI-A (Germain et al, 2005).