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BRIEF REPORT

Symptom-Specific Effects of Cognitive Therapy and Behavior Therapy for Insomnia: A Network Intervention Analysis

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Objective: Cognitive therapy (CT) and behavior therapy (BT) are both effective for insomnia but are expected to work via different pathways. Empirically, little is known about their symptom-specific effects. ***Method:*** This was a secondary analysis of a randomized controlled trial of online treatment for insomnia disorder ($N = 219$, 72.9% female, mean age = 52.5 years, $SD = 13.9$). Participants were randomized to CT ($n = 72$), BT ($n = 73$), or wait-list ($n = 74$). Network Intervention Analysis was used to investigate the symptom-specific treatment effects of CT and BT throughout treatment (wait-list was excluded from the current study). The networks included the Insomnia Severity Index items and the sleep diary-based sleep efficiency and were estimated biweekly from Week 0 until Week 10. ***Results:*** Participants in the BT condition showed symptom-specific effects compared to CT on "sleep efficiency" (Week 4–8, post-test), "difficulty maintaining sleep" (Week 4), and "dissatisfaction with sleep" (post-test). Participants in the CT showed symptom-specific effects compared to BT on "interference with daily functioning" (Week 8, post-test), "difficulty initiating sleep", "early morning awakenings," and "worry about sleep" (all post-test). ***Conclusions:*** This is the first study that observed specific differential treatment effects for BT and CT throughout the course of their treatment. These effects were more pronounced for BT than for CT and were in line with the theoretical background of these treatments. We think the embedment of the theoretical background of CT and BT in empirical data is of major importance to guide further treatment development.

What is the Public Health Significance of this Article?
Cognitive therapy and behavior therapy are both effective for insomnia in a stand-alone format. In this study, we showed that over the course of treatment, cognitive therapy and behavior therapy have different symptom-specific effects. These differences are in line with the theoretical backgrounds of the treatments. Knowledge on these different points of engagement may guide further treatment development.

Keywords: insomnia, network analysis, cognitive therapy, behavior therapy

Supplemental materials: https://doi.org/10.1037/ccp0000625.supp

With an estimated prevalence of about 8.5%, insomnia is the most common sleep disorder (Ohayon, 2002). The recommended treatment for insomnia is cognitive behavioral therapy (CBTI; Qaseem et al., 2016; Riemann et al., 2017). Meta-analyses have demonstrated the efficacy of CBTI in both the short and long term (van der Zweerde et al., 2019; van Straten et al., 2018).

The two main pillars in CBTI are the cognitive and behavioral treatment. In cognitive therapy (CT) for insomnia, perpetuating and maintaining cognitive factors of insomnia are targeted. The treatments may differ between protocols, but these usually include aspects such as worry, selective attention, misperception of sleep, and dysfunctional beliefs about sleep (Jansson-Fröjmark & Norell-Clarke, 2018). Behavior therapy (BT) can consist of sleep restriction and/or stimulus control (Bootzin et al., 1991; Spielman et al., 1987). In sleep restriction, patients restrict their time in bed to their self-reported sleeping time. If the percentage of time spent asleep is high

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enough, the time in bed is slowly increased (Maurer et al., 2018). In stimulus control, the main instruction is to leave the bed when not able to fall asleep. Both sleep restriction and stimulus control advise fixed rising times to regulate the circadian system. The treatment effect of the full CBTI package is thought to be mediated by both cognitive and behavioral factors (Schwartz & Carney, 2012). Not surprisingly, both CT and BT are thought to specifically manipulate these factors (Harvey et al., 2017).

Interestingly, CT and BT are based on different theoretical backgrounds. CT is based on the cognitive model of insomnia (Harvey, 2002) which proposes that the interplay of excessive cognitive activity, selective attention, distorted perception, unhelpful beliefs, and safety behaviors, results in a vicious cycle that leads to (more) distorted sleep and daytime complaints. CT aims to break through this cycle. BT is designed to reduce perpetuating factors of insomnia through sleep restriction (Spielman et al., 1987) and to re-condition bed to sleep using stimulus control (Bootzin et al., 1991), thereby increasing sleep pressure and regulating the circadian system for optimal sleep to occur. In this vein, CT could predominately affect cognitive processes such as worry and daytime complaints, while BT would manipulate behavioral processes. For BT, it was shown that restricting the bedtime is central in reducing insomnia symptoms and consolidating sleep (Maurer et al., 2020).

Unfortunately, because CBTI is generally investigated as a full package surprisingly little is known about what specific factors are targeted by either CT or BT. There is one study reporting that behavioral processes specifically mediated the treatment effect of BT on insomnia severity, and that cognitive processes mediated both the effects of BT and CT (Harvey et al., 2017). In another study (Sunnhed et al., 2020), cognitive mediators of CT and BT were investigated. The authors found that dysfunctional beliefs, monitoring, and safety behaviors mediated the effects of CT and BT on insomnia severity.

Both CT (Harvey et al., 2014; Harvey et al., 2007; Sunnhed et al., 2020) and BT (Harvey et al., 2014; Miller et al., 2014; Sunnhed et al., 2020) are effective in a stand-alone format. Two studies directly compared the effects of CT and BT and observed few differences at post-treatment (Harvey et al., 2014; Sunnhed et al., 2020), although one study provided some support that improvements in BT occurred faster, whereas the improvements associated with CT seemed to occur slower but lasted longer (Harvey et al., 2014).

These studies evaluated the efficacy of CT and BT only at the overall severity of insomnia. However, following the theoretical underpinnings, the treatments are thought to target specific and different factors *over time* that should result in a reduction of the overall severity. It could thus be that while we observe no differential effects on overall severity, we would find differential treatment effects at the more detailed symptom level. To investigate whether the treatments differ according to their theoretical underpinnings, we should study the treatment effects (a) at the more detailed, symptom level that is supposed to be targeted; (b) over the course of treatment; and we should (c) take the relationships among symptoms into account, as the treatment targets are thought to spread to other symptoms (e.g., CT targets cognitive activity and thereby aims to bring down sleep onset latency).

The network theory of mental disorders postulates that disorders arise because of the direct interaction among symptoms (e.g., loss of sleep results in concentration loss; Borsboom, 2017), and thus fits the theoretical underpinnings of both insomnia treatments. Over recent years, network analysis has been applied to many disorders (Robinaugh et al., 2020) and led to valuable insights (Fried et al., 2017). More recently, Network Intervention Analysis (NIA) was developed that allows to follow symptom-specific effects over the course of treatment (Blanken et al., 2019). NIA estimates a network of symptoms and identifies, at each point in time, which of these symptoms are most directly affected by treatment, while taking the interdependency among symptoms into account. NIA thus allows us to identify how specific treatment components (CT vs. BT) influence specific aspects of insomnia (e.g., "worry" or "sleep efficiency") and to distinguish symptoms that are directly affected from those that are only indirectly affected. Such findings would enable a more fine-grained understanding of what symptoms are targeted by which treatment components. Additionally, this may give an underpinning for the theoretical assumptions of the specific treatment components. In recent studies, NIA was shown to be a valuable technique to identify these sequential and symptom-specific treatment effects for various disorders and treatments (e.g., Blanken et al., 2019, Cervin et al., 2020).

In the current study, we applied NIA to a sample of people with insomnia who were treated with either internet-delivered CT or internet-delivered BT. In this study, both CT and BT showed large effects on the Insomnia Severity Index (ISI; primary outcome; Cohen's *d* of 2.1 and 2.0, respectively) and proved equally effective compared to a wait-list control group (WLC; reference left out for masked review). Using NIA we investigated whether even though CT and BT may be equally effective on insomnia severity at post-treatment, they might still affect different symptoms over the course of treatment. We were specifically interested to see whether, in line with their theoretical underpinnings, they would initially affect different type of symptoms related to either behavioral processes (sleep efficiency, hypothesized to be a marker for sleep consolidation effects of BT) or cognitive processes (worry, daytime consequences).

Method

Study Design and Procedure

The data were collected in a randomized controlled trial to compare the effects of internet-delivered CT or BT for insomnia against WLC (Sunnhed et al., 2020). The original study was registered at clinicaltrials.gov (NCT02984670) and was approved by the "Regional Ethical Board in Stockholm, Sweden (2016/856-31)." Participants were recruited between August 2016 and February 2017 through advertisements in the daily press, social media, and an internet platform for ongoing CBT studies. To be eligible for the study, three screening phases (questionnaire on the web, telephone interview, 7-day sleep diary) had to be completed, each with its own in- and exclusion criteria (see Sunnhed et al., 2020 for details). The inclusion and exclusion criteria follow expert recommendation for the assessment of insomnia and The Diagnostic and Statistical Manual of Mental Disorders 5th Edition. Participants allocated to the treatment conditions received internet delivered treatment for 10 weeks. All participants completed sleep diaries daily and the ISI biweekly.

Sample

A total of 219 participants met the inclusion criteria and were randomized to receive CT ($n = 72$), BT ($n = 73$), or WLC

($n = 74$). For the current study, we only selected the $n = 145$ participants who received active treatment (73.1% female, mean age = 51.6, $SD = 13.5$). There were no differences in use of sleep medication and psychiatric or somatic comorbidities between the two conditions.

Treatments

The treatment was delivered online for 10 weeks and consisted of weekly self-help modules and exercises. In addition, participants were offered 15 min of telephone support each week. The first week consisted of an introduction and the treatment rationale for either CT or BT. BT focused on sleep restriction (starting in Week 2), stimulus control (Week 4), and sleep hygiene (Week 6). CT focused on cognitive processes involved in maintaining insomnia: unhelpful beliefs about sleep (Week 2), sleep-interfering or sleep-related worry (Week 4), attentional bias and monitoring of sleep-related threats (Week 5), misperception of sleep (Week 6), and safety behaviors (Week 7). For a detailed description of the treatment, please see Sunnhed et al. (2020).

Outcomes

Participants in the CT and BT conditions completed sleep diaries daily and the ISI to measure insomnia complaints biweekly. The ISI contains seven items that are rated on a five-point scale (0–4), where higher scores indicate more severe insomnia complaints (Bastien et al., 2001). The weekly average sleep efficiency was derived from the sleep diary (Carney et al., 2012) and is the percentage of time spent asleep of the total time spent in bed.

Statistical Analyses

We used NIA (Blanken et al., 2019) to investigate the differential and symptom-specific effects throughout treatment for CT and BT. Specifically, NIA estimates, for each biweekly assessment, a Mixed Graphical Model (MGM; Haslbeck & Waldorp, 2020) including all ISI symptoms and sleep efficiency (continuous) as well as a treatment allocation variable (binary). The networks are estimated on the available data for each week, resulting in slight variations in sample size for the different assessments.[1] To prevent the inclusion of spurious edges due to sampling variation, we applied LASSO regularization (Epskamp & Fried, 2018). Finally, we assessed the accuracy and stability of the estimated networks (Epskamp et al., 2018). All analyses were performed in R (version: 3.6.2) with the package *mgm* (version 1.2-7). More details on the regularization settings and stability analyses are given in the Supplementary Materials.

Interpretation

In the networks, all variables are included as nodes (symptoms and sleep efficiency as circles, and treatment allocation as a square) that are connected by edges. An edge represents the unique association among two variables after conditioning on all other variables in the network (i.e., *conditional dependence* relationships). Contrasting the two active treatment conditions allows us to identify the symptoms that are uniquely affected by one of the treatments, thereby delineating treatment-specific effects. When the network model includes an edge between treatment and a symptom, this indicates the symptom is more strongly affected by one of the treatments, i.e., there is a larger direct symptom-specific effect for one of the treatments ("yellow" edges indicate positive treatment effects for BT, whereas "green" edges indicate positive treatment effects for CT). In the interpretation of these edges, it is important to note that treatment effects that are shared by the two treatments will not be included into the network model. Thus, the absence of an edge between treatment and the symptoms cannot be interpreted as the absence of a treatment effect, but merely as the absence of a *different* treatment effect for CT and BT. In interpreting the networks, we specifically focus on the links between the treatment node and symptoms. Potential differences in network structure among the symptoms themselves could be highly interesting and might reflect treatment effects as well. However, before interpreting such differences we should formally test these, for which the current study has too little power.

Results

The weekly scores on the ISI items and sleep efficiency are shown in Figure 1. Figure 2 shows the six network models corresponding to baseline, Week 2, Week 4, Week 6, Week 8, and Week 10. The first baseline network shows that there were two baseline differences, indicated by the two direct links to the treatment node T, where "sleep efficiency" was higher in the CT condition (green link), and "dissatisfaction with sleep" was rated lower in the BT condition (yellow link). After 2 weeks of treatment, there were no symptom-specific differences between the two treatments, as no link between treatment and any of the symptoms is retrieved in the network. The first treatment-specific differences commenced after the fourth week of treatment, where both "sleep efficiency" was higher and "difficulty maintaining sleep" was rated lower in the BT condition (indicated by the yellow links). The beneficial effect of BT on "sleep efficiency" persisted in Week 6. After 8 weeks of treatment, "sleep efficiency" was still higher in the BT condition (yellow link), and now the first CT-specific treatment effect emerged on "interference with daily functioning" (green link). Finally, at 10 weeks, we see most treatment-specific effects with unique effects of BT on "sleep efficiency" and "dissatisfaction with sleep" (yellow links), and unique effects of CT on "difficulty initiating sleep," "early morning awakenings," "interference with daily functioning," and "worry about sleep" (green links).

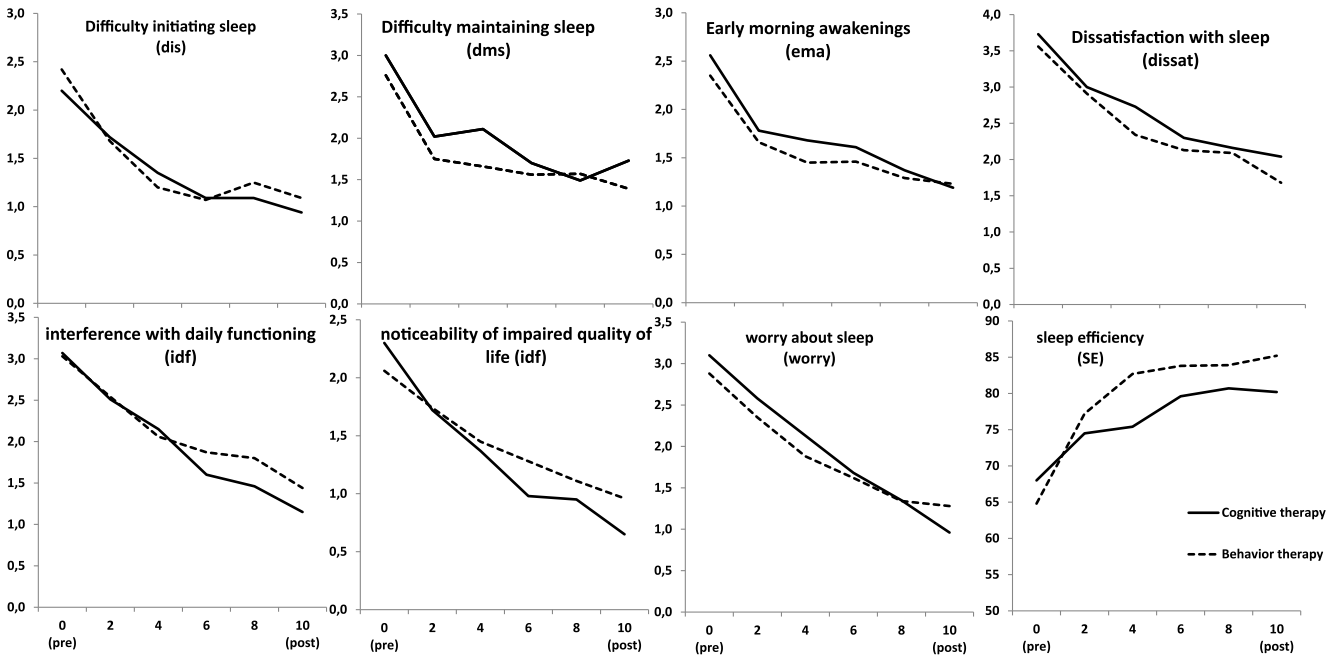
Discussion

In the current study, we investigated the differential symptom-specific treatment effects of CT and BT throughout treatment. We observed that BT showed a larger effect than CT on both "sleep efficiency" (Week 4–8) and "difficulty maintaining sleep" (Week 4). The symptom-specific effects of CT were less pronounced with the first symptom-specific effect only emerging at Week 8 (on "interference with daily functioning"). The symptom-specific treatment

[1] Week 0: $N = 143$, CT = 71, BT = 73; Week 2: $N = 133$, CT = 65, BT = 68; Week 4: $N = 126$, CT = 62, BT = 64; Week 6: $N = 118$, CT = 57, BT = 61; Week 8: $N = 113$, CT = 57, BT = 56; Week 10: N = 105, CT = 48, BT = 57. Note that the varying sample sizes between the two conditions are driven by different completion rates in sleep diary, not drop out, which did not differ between the two conditions ($\chi^2 = 0.28$, $p = 0.59$).

Figure 1

Means of the ISI Symptoms and Sleep Efficiency Over 10 Weeks. Note that the Symptom Severity Depicted On The Y-Axis Varies Across Plots In Order to Clearly Show The Differences Between The Two Treatment Conditions



effects are generally in line with the theoretical backgrounds of either CT (Harvey, 2002) or BT (Bootzin et al., 1991; Spielman et al., 1987). Interestingly, they show the same pattern as an earlier study where predominately BT showed treatment-specific mediational effects (Harvey et al., 2017). It is important to note that the current analyses only reflect *differences* in the observed treatment effects. This means that when both treatments target a specific symptom equally, no direct link will be observed.

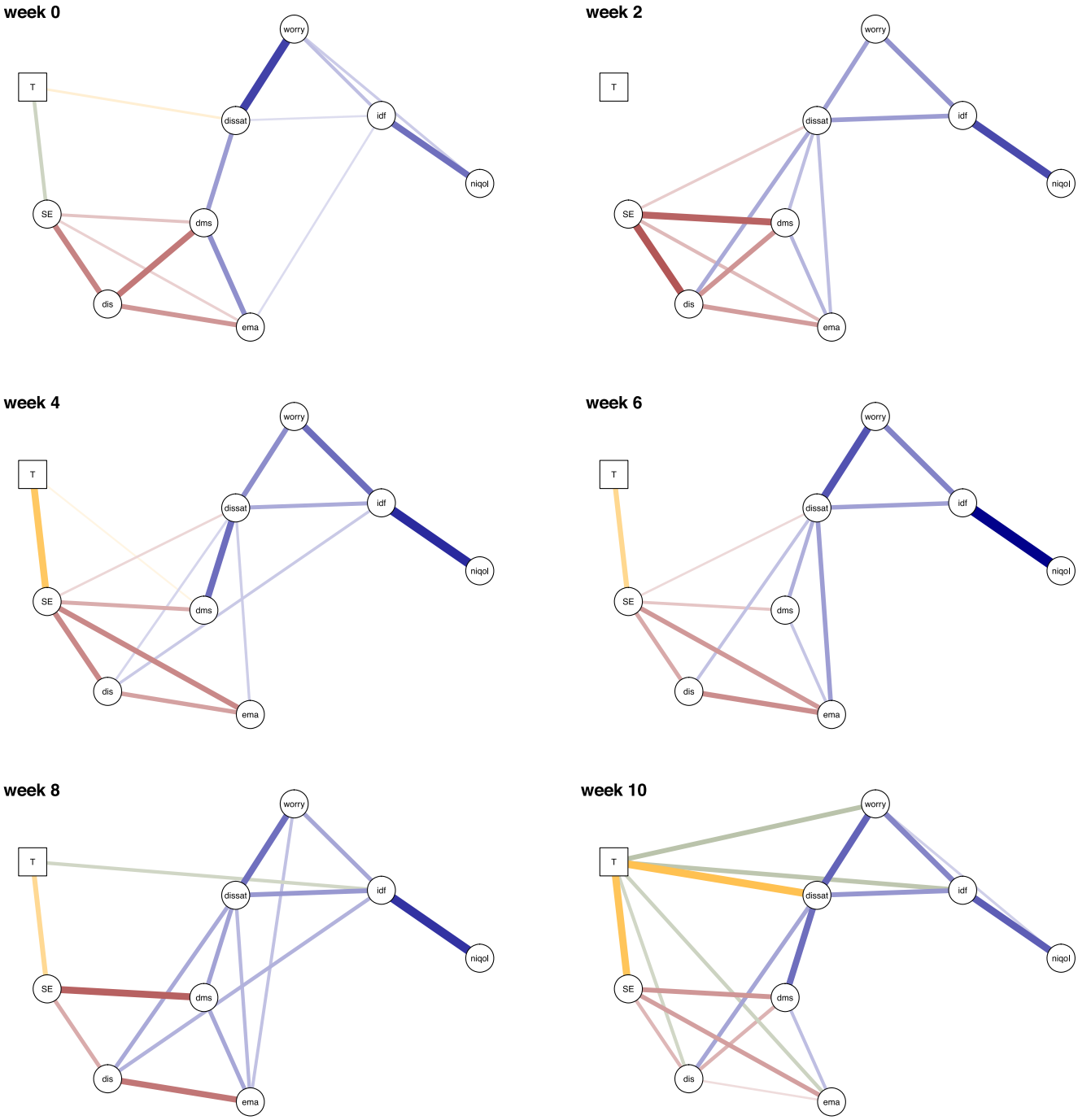
At the post-test, the differences between CT and BT were most pronounced. Some of these effects were in line with the expectations, i.e., a larger effect on "sleep efficiency" for BT and a larger effect on "worry" and "interference with daily functioning" for CT. At the same time, however, the symptom-specific treatment effect on "dissatisfaction with sleep" may have fitted to either treatment and "difficulty initiating sleep" and "early morning awakening" could have been attributed to BT. It is important to note that even though both CT and BT are thought to have a different point of engagement, they both aim to target similar end points. For instance, BT would affect sleep onset latency by increasing the sleep pressure, whereas CT would affect onset latency by decreasing the excessive cognitive activity before bedtime. In other words, through different routes, the same end points could have been expected for both. To this end, it is interesting to highlight that throughout treatment and at post-treatment (Week 10) the ISI total scores do not differ across treatment groups, even though NIA identifies differences in the specific symptom patterns across treatment groups.

There were also some limitations to this study. First, this network study was carried out retrospectively. Only after the study was finished, we formed a collaboration to apply these analyses on the data. Such a post-hoc procedure may have biased our expectations and choices during the analyses. Second, since we only had biweekly measures and a relatively small sample size we may have missed specific relationships to either CT or BT. Additionally, there were minor baseline differences on two symptoms that may have influenced the symptom-specific effects slightly. Third, we decided to estimate the difference between BT and CT and not compare it to WLC because this enabled us to directly visualize the difference between CT and BT. Fourth, while we see differential effects between CT and BT it is important to keep in mind that other factors may also be in play. For example, participants in the BT condition reported more adverse effects such as fatigue and extreme sleepiness than participants in the CT condition. It could be that these side effects may be an explanation of the difference in daytime symptoms between BT and CT. Fifth and finally, even though the direction of the effect can be interfered by the starting point in the network (treatment node), these analyses are still of a correlational nature. Given these limitations, it is clear that a well-powered study specifically designed to infer such effects is much needed.

In summary, despite some limitations, this study identified for the first time different points of engagement of CT and BT, in line with their theoretical underpinnings, and showed symptom-specific treatment effects of CT and BT throughout treatment. These findings further embed the theoretical underpinnings of these treatments in empirical data and provide an opportunity to develop these treatments based on their symptom-specific effects. A first step would be to replicate these findings. If the findings are replicated, it may guide clinicals in fine-tuning CBTI. For instance, treatment manuals may explicitly focus on the expected symptom-specific effects trying to amplify them or, alternatively, highlight the other symptoms that are not currently in the pathway trying to enhance the overall treatment

Figure 2

Estimated Networks Pre-Treatment (Week 0), During Treatment (Weeks 2, 4, 6, 8), and Post-Treatment (Week 10). The Nodes in the Network Represent the Seven Items of the Insomnia Severity Index and Sleep Efficiency (Circles), and Treatment (Square). The Edges Represent the Unique Association Between Two Variables, After Conditioning on All Other Variables in the Network. Blue Edges Represent Positive Associations, Red Edges Represent Negative Associations, and the Width and Color-Saturation of the Edges Are Proportionate to the Strength of the Association and Can Be Compared Across Networks. Associations Between the Treatment Variable and a Symptom Indicate that Symptom to Be More Directly Affected by Only One of the Treatments. Green Edges Indicate a Positive Treatment Effect for CT, and Yellow Edges Indicate a Positive Treatment Effect for BT



Abbreviations: dis = difficulty initiating sleep; dms = difficulty maintaining sleep; ema = early morning awakenings; dissat = dissatisfaction with sleep; idf = interference with daily functioning; niqol = noticeability of impaired quality of life; worry = worry about sleep; SE = sleep efficiency; T = treatment.
Note. See the online article for the color version of this figure.

effect. Moreover, these findings could have clinical implications as they can help to select the optimal treatment based on the symptoms someone suffers from, thereby opening up the ways for personalized treatment. For example, if CT indeed targets daytime consequences to a larger extent, a patient predominantly suffering from these maybe best be helped by first receiving CT. In conclusion, this paper elucidates potential differential treatment effects of CT and BT that could transcend beyond insomnia treatment and provide opportunities to further develop these treatments based on the specific symptom effects.

Narrative Descripting Concerning Data Transparency

The outcome data from this randomized controlled trial have been reported in an earlier manuscript. There will be another manuscript (soon to be submitted) that will focus on cognitive mediators; this manuscript will focus on sum scores and will concern specific cognitive mediators (e.g., dysfunctional beliefs). The current manuscript is different because it focusses on symptom-specific effects on the ISI and sleep efficiency.

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