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Insomnia and Cognitive Performance

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Insomnia is one of the most common subjective sleep complaints in the general and clinical adult populations,^{1,2} and is characterized by persistent difficulty with the initiation and/or maintenance of sleep or non-restorative sleep, with daytime functional impairment and distress as one of the core diagnostic features.³ Prevalence estimates for insomnia symptoms range between 30%-50%⁴ in the general adult population and up to 80%² in patients with psychiatric illnesses. Although prevalence rates are high, only about 6%-10% of adults have insomnia that meets full diagnostic criteria for insomnia disorder.^{3,5,6} Daytime functional impairment is part of the diagnostic criterion for insomnia; however, the exact nature of the relation between insomnia and daytime cognitive impairments is not completely understood, and the few studies to investigate this relationship have produced inconsistent findings.

Collectively, the insomnia literature has primarily focused on cognitive domains of attention, memory, and executive function (see Table 1), and to a lesser degree concentration. Here we provide a succinct summary of these findings.

Insomnia and Cognitive Domains of Functioning

Insomnia and Attention

Attention is the most extensively studied neurobehavioral domain in relation to insomnia.

However, understanding the findings are difficult to synthesize due to the various attentional

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tasks that have been employed (i.e., focused, sustained, or shift).² *Focused attention* requires the selection of targeted information for additional processing, often at the expense of focusing on other stimuli.⁷ *Focused attention*, known as simple attention, tasks require the subject to respond to a specific stimulus while ignoring the distractor stimuli. There have been some studies to report significant group differences on *focused attention* tasks;⁸ however, the majority of the studies examining *focused attention* in insomnia patients compared to controls found no significant group differences.^{9–12}

Sustained attention, known as vigilance, involves the capacity to maintain alertness or vigilance over a period of time.⁷ *Sustained attention* tasks place a greater demand on anticipatory readiness than focused attention, and the capacity of an individual to maintain attention declines over time.² In contrast to *focused attention*, the results are less conclusive for *sustained attention*. There is discordance regarding findings of speed and accuracy on *sustained attention* tasks in insomnia patients versus controls. For instance, some studies report that insomnia patients are less accurate and slower on *sustain attention* tasks,^{13–15} while other studies have not shown this relationship.^{9,15} Some of the discordance may be attributed to the type of vigilance tasks incorporated, particularly those including distractor stimuli.

The most complex attentional task is *Shifting Attention*, which requires the ability to be flexible and adaptable in order to modify the focus of attention.⁷ Compared to focus and sustained attention, *shifting attention* requires a greater degree of cognitive involvement due to the responses requiring adaptations based on the stimulus presented.² The findings regarding *shifting attention* in insomnia patients and good sleepers have been mixed. Some studies report significant group differences, with insomnia patients reporting greater performance deficits than good sleepers^{11,16} while other studies found no significant group differences between insomnia patients and controls.^{17,18}

More recently, studies have investigated the functioning of attentional networks and vigilance in insomnia patients. One study concluded that there were no significant group effects between insomnia patients versus controls on tasks assessing alertness, orientation, and executive function.¹⁹ In a systematic review examining sleep-related attentional bias, six of the nine studies revealed statistically significant differences between insomnia patients and controls, with medium to large effects.²⁰ Not surprisingly, these studies found that individuals with insomnia demonstrate a greater attentional bias towards sleep-related stimuli than good sleepers. However, the review concluded that the role of sleep-related attentional bias in the development and maintenance of insomnia needs further investigation.

Insomnia and Memory

Several studies have investigated group differences between insomnia patients and good sleepers on memory tasks. The most commonly evaluated memory tasks in the insomnia literature are *working memory*, and *implicit* and *explicit memory*. *Working Memory* tasks are active tasks requiring an individual to hold and manipulate information in their mind over brief intervals.² *Implicit (procedural) Memory* tasks require an individual to learn new skills or abilities, while *Explicit (declarative) Memory* tasks require an individual to learn new material and recall the information after either a short or long delay.²¹ Collectively,

findings are mixed, with some studies reporting impaired memory performance in insomnia patients compared to good sleepers,^{4,16,22} while others reported no significant group differences.^{8,9,14,23,24}

One study provided an explanation for the group differences in insomnia patients versus controls on memory tasks, suggesting that insomnia patients may have a susceptibility to declarative memory interference.²⁵ A recent meta-analytic review reported mild but not definitive working memory deficits in insomnia patients compared to controls.²⁶ The review suggested several methodological concerns regarding the selected studies, including non-matched demographic characteristics, level of expertise in the administration of the neurobehavioral tests, the comparability of findings among different studies, and the generalizability to subjects with acute versus chronic insomnia.²⁶

Insomnia and Concentration

The insomnia literature has been limited in scope regarding concentration problems (or the inability to ‘think clearly’) in insomnia patients compared to good sleepers. Difficulty concentrating is one of the most common daytime complaints reported by individuals with insomnia.²⁷ The inability to concentrate might indicate problems with sustained attention or shifting attention. Some studies suggest there are subjective daytime impairments related to concentration problems. For example, one study found decreased mental concentration related to work performance in insomnia patients compared to controls.²⁸ Using a single-item to assess for concentration, another study found that insomnia patients had difficulty concentrating during the day compared to good sleepers.²⁹ One of the limitations regarding the insomnia literature and its relation to concentration problems is that majority of the studies have reported on subjective complaints, and there is limited evidence regarding objective cognitive measures to assess for difficulties with concentration.

Insomnia and Executive Function

The neurobehavioral domain of executive functioning is an emerging area of focus in the insomnia literature and includes several cognitive processes (to include aspects of attention and memory). The literature suggests that executive function does not represent a single cognitive ability but rather a number of distinct cognitive components focused on three core functions: inhibition (e.g., inhibitory control, selective attention), working memory (e.g. manipulation of information related to execution of task), and cognitive flexibility (e.g., ability to make an adaptation based on action or thought).³⁰ The domain of executive function is responsible for higher order cognitive processes such as planning, reasoning, inhibitory control, cognitive flexibility, and multitasking.^{2,30,31}

The insomnia literature has provided mixed findings in regard to the three cognitive components of executive function. For instance, some studies have reported significant group difference between insomnia patients and controls on tasks measuring inhibitory control,^{4,16,32} while the majority of studies reported no significant group differences.^{18,33,34} A similar pattern of mixed findings has been observed on tasks of executive function assessing working memory, with some studies showing significant group differences between insomnia patients and controls^{24,35} and other studies indicating no group effects.

22,36 Executive function tasks assessing cognitive flexibility have been more consistent with the majority of findings reporting no significant group differences between insomnia patients and controls.³¹

Summary of Findings

To date, there have been two meta-analyses and one review of the daytime cognitive impairments seen in patients with insomnia, primarily focusing on attention and working memory, and some aspects of executive function. The review concluded that the studies provided limited evidence for a single and consistent reported cognitive impairment among patients with insomnia versus good sleeper controls.² However, the review provided some generalizations centered on attentional tasks with a high cognitive load and tasks of working memory, suggesting cognitive impairments in patients with insomnia compared to controls.² The first meta-analysis reported small to moderate effects in insomnia patients for tasks assessing episodic memory, problem solving, manipulation in working memory, and retention in working memory.²¹ Although there were significant group differences on some measures of memory, the meta-analysis also concluded that no significant group differences were found on several measures assessing attention and aspects of executive function (i.e., verbal fluency, cognitive flexibility).²¹ Finally, this meta-analytic review concluded that further research focused on ecologically valid measures and normative data is necessary to more definitively establish the clinical relevance of cognitive impairments in insomnia.

The second published meta-analysis reported cognitive deficits of small to moderate magnitude in insomnia patients versus good sleepers in reaction times of inhibitory control and cognitive flexibility tasks; however, no group differences were found regarding accuracy rates.³¹ Working memory impairments were also found among insomnia patients compared to controls. In contrast to the meta-analysis, a recent review reported no significant group differences between insomnia patients and controls on executive functioning tasks.³⁰ The review concluded that there were several methodological concerns relating to the variability of the methods used, the types of neurobehavioral tests that were administered, and the inconsistency in diagnostic criteria for primary insomnia across the various studies.³⁰

Challenges with the Interpretation of Cognitive Findings in Insomnia

Several challenges and limitations have been proposed regarding the interpretation of cognitive findings in the insomnia literature. In general the findings have been inconsistent regarding cognitive deficits in insomnia patients compared to good sleeper controls. Many factors may account for the discrepancies between studies. Collectively, these challenges and limitations are focused on three key areas: methodology, definition of the insomnia group, and varying neurobehavioral tasks used to assess for cognitive function. First, methodological differences related to heterogeneity of the test population, small sample sizes, comparability of results across studies and their ability to generalize to individuals with insomnia have all been issues with interpretation of findings.²¹ Second, many of the studies have used qualitative and quantitative criteria to characterize insomnia patients; however, the operational definition significantly differ across studies, and the varying selection criteria and assessment modalities used to confirm these criteria further limits insomnia findings.^{2,21,31,37} Further, one issue that hasn't been raised is the timing of those

individuals with acute versus chronic insomnia, and how the timeline of the disorder may impact cognitive performance. Third, several concerns focused on the administration and interpretation of cognitive measures have been noted. Specifically, regarding testing selection (e.g. incompatibility/different classifications of cognitive tasks), testing protocols and conditions to include repeat testing and timing of tests have all been reported as barriers and potential confounds that could interfere with interpretation of study findings.² Standardization in cognitive measures are warranted to strengthen the interpretability of insomnia findings. Another plausible limitation is that many of the cognitive tasks employed were developed and validated to assess for major deficits in individuals with traumatic brain injuries or neurological disorders.²¹ Therefore, the cognitive tasks used may not provide sufficient sensitivity to detect the subtle differences that are commonly reported in patients with insomnia.

Conclusion:

Insomnia is a major public health concern associated with daytime cognitive complaints. In general, the insomnia literature has been mixed regarding cognitive impairments in attention, memory, and executive function. Small to moderate effects have shown impairment on some attentional and working memory tasks in individuals with insomnia. However, these findings should be interpreted with care given the inconsistent methods employed across studies.

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Key Points:

- Standardization in cognitive measures are warranted to strengthen the interpretability of insomnia findings
- The use of normative data is recommended to further examine the clinical significance of cognitive impairments in insomnia
- A detailed description of diagnostic procedures and measures for the classification of insomnia would increase generalizability of study findings

SYNOPSIS:

Insomnia is the most commonly endorsed sleep problem with estimates ranging between 30%-50% in the general adult population. Insomnia is characterized by difficulty initiating and maintaining sleep, along with complaints of dissatisfaction with sleep quality or quantity. Further, insomnia complaints are linked to clinically significant distress or impairment in key areas of functioning, in particular, daytime cognitive performance. Cognitive impairments related to insomnia are fairly subtle, and may represent distinct differences from those cognitive impairments seen in other sleep disorders. The aim of this review is to provide an update as well as to summarize the recent literature investigating cognitive impairments in individuals with insomnia, and to identify which cognitive domains of functioning are consistently impaired in this population.

Table 1.

Neurocognitive Domains and Functions Assessed in Insomnia

Neurocognitive Domain	Cognitive Functions Assessed	Test/Dependent Variables
Attention	Focused	Simple Vigilance Test Simple Alertness Test Simple Reaction Time Continuous Performance Test Digit Span (Forward) Visual Tracking Word Detection Letter Search Simple Auditory Reaction Time Go/No Go Task
	Sustained	Persistence of Vigilance Task Continuous Performance Test Vigilance Detection Test Wilkinson's Auditory Vigilance Test Visual Vigilance Simple Psychomotor Vigilance Task Complex Psychomotor Vigilance Task
	Shifting	Switching Attention Ask Complex Reaction Time Divided Attention Wilkinson Four Choice Reaction Time Four Choice Serial Reaction Time Test
Memory	Working	Digit Span (Backward) Letter Number Sequencing Memory And Search Task Addition (2 Digit) 2-Back Memory Task
	Implicit/Explicit	Episodic Memory Audioverbal Learning Test Hopkins Verbal Learning Test Verbal Paired Associates Visual Reproductions Word Recognition Visual Recognition Work Memory Test of Free Recall Procedural Memory (Consolidation) Declarative Memory (Consolidation)
Executive Function	Cognitive Flexibility Inhibitory Control	Trail Making Test B Controlled Oral Word Association Task Semantic Memory Stroop Test Wisconsin Card Sorting Test Logical Reasoning Proof Reading Verbal Fluency (Phonemic) Verbal Fluency (Semantic) Go/No Go Task Switching Attention Task Stop-Signal Task Color-Word Interference Task