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ORIGINAL INVESTIGATION

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Association between memory impairment and insomnia among older adults

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Abstract Chronic insomnia and memory impairment are both common complaints among older adults. Even so, only a few studies to date have examined the effects of chronic insomnia on memory processes among older people, and the results of these studies are contradictory. Therefore, in the current study we examined whether late-life insomnia is associated with the memory status of older adults. The study population comprised two groups: 50 older adult subjects without sleep disorders, and 23 older adult insomniacs. Memory processing for each of the two groups was evaluated using the Rey Auditory Verbal Learning Test (AVLT). The results demonstrate that chronic insomnia in older adults is associated with impairment in memory. Specifically, we found that older people suffering from late-life insomnia exhibit significantly reduced performance in learning rate and in temporal order judgment as well as significantly reduced resistance to proactive interference. The present findings suggest that late-life insomnia may be one of the factors contributing to the decline in memory processing seen among older people.

Keywords Ageing · Cognitive impairment · Insomnia · Memory

Introduction

It is generally accepted that sleep disturbances constitute one of the most ubiquitous health problems among older adults. Whereas only 9% of individuals between the ages of 20 and 30 complain of insomnia, some 35–50% of those over the age of 65 voice this complaint. Compared to young adults, healthy older people require more time to fall asleep, awaken more frequently during the night, have difficulty returning to sleep after mid-sleep awakenings, and do not feel rested in the morning (Ancoli-Israel 2004; Ancoli-Israel and Cooke 2005; Foley et al. 1999; Ohayon 2002). These alterations in sleep structure often lead to daytime sleepiness, fatigue, and frequent daytime napping (Carskadon et al. 1982). Late-life insomnia among older adults can have a significant negative impact on quality of life, may be a risk factor for poor health, depression, and mortality, and is associated with increased cardiovascular risk (Kripke et al. 2002; Kryger et al. 2004).

In addition to primary insomnia, complaints of insomnia in the older adult population can be secondary to five other factors. These include medical and psychiatric illnesses (Benca et al. 1992; Foley et al. 2004; Gillin et al. 1981), medication use (Foley et al. 2004), changes in circadian rhythm (Czeisler et al. 1992; Gillin et al. 1981), specific sleep disorders [i.e., sleep-disordered breathing (sleep apnea) (Cohen-Zion et al. 2004), restless legs syndrome (RLS) and periodic limb movements during sleep (PLMS) (Hornyak and Trenkwalder 2004; Rothdach et al. 2000)], and psychosocial factors (Ancoli-Israel 2000; Naylor et al. 2000; Tanaka and Sirakawa 2004).

It is well documented that along with the changes in sleep structure accompanying the ageing process, ageing is also associated with deteriorating performance on various cognitive tasks: speed of processing information, perceptual speed, executive functioning, concentration and attention, inhibition functioning, and memory. Nearly half of persons aged 60 years and older dwelling in the community express concern about declining mental abilities (Jolles et al. 1995; Park 2000).

Empirical evidence indicates that one of the most prominent impairments in the cognitive performance of older adult persons is a decline in memory processes (Light 1991; Verhaeghen and Salthouse 1997; Vakil et al. 1997, Lindenberger and Baltes 1997; Nilsson et al. 1997; Craik and Anderson 1999; Park et al. 2002). Studies evaluating the effects of ageing on memory abilities have shown that ageing is associated with deteriorating

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performance in declarative memory, particular in episodic memory (Light 1991). Age-related episodic memory changes have been reported on a variety of measures, including learning rate, free recall, cued recall, and recognition of verbal and nonverbal material (Burke-Light 1981; Light 1991). Naveh-Benjamin et al. (2000) have reported that temporal order tests also present a special challenge to older adults.

In conjunction with studies demonstrating the effects of ageing on memory abilities, it is generally accepted that there are individual differences in memory impairment among older adults (Schaie 1990). These individual differences have been explained by various psychosocial variables, such as education (Anstey et al. 1993; Avolio and Waldman 1994), good health (Perlmutter and Nyquist 1990), visual and auditory abilities (Baltes and Lindenberger 1997; Salthouse et al. 1996, Asplund 2004), and depression (Fuhrer et al. 1992; Devanand et al. 1996; Kliegel and Zimprich 2005). Taken together, these findings argue for the great potential benefit derived from identifying risk factors contributing to cognitive decline, especially those that are potentially malleable. A better understanding of the risk factors contributing to cognitive decline among older adults can facilitate more effective intervention strategies.

A recent and growing body of evidence has indicated that sleep is associated with cognition abilities (Empson and Clarke 1970; Fishbein et al. 1974; Salzarulo and Cipolli 1979; Smith 1985; Tilley and Warren 1984; Szelenberger and Niemcewicz 2000; Wetzel et al. 2003). Moreover, studies of young adults and animals have demonstrated a specific facilitating effect of sleep on memory (Roehrs and Roth 2000; Steenary et al. 2003: Hornung et al. 2005; Walker and Stickgold 2006). Much of the early work investigating sleep and memory in humans focused on declarative memory tasks. A substantial body of evidence indicates that both Slow Wave Sleep and REM sleep contribute to the consolidation of declarative memories embedded in networks of previously existing associative memories. For example, De Koninck et al. (1989) demonstrated significant increases in post-training REM sleep after intensive foreign language learning, where the degree of successful learning correlated with the percentage increase of REM sleep. Such findings suggest that REM sleep plays an active role in memory consolidation and that the post-training increases in REM sleep reflect a homeostatic response to increased demands for REM-dependent consolidation. In addition, Gais et al. (2000) demonstrated that both early (mainly Slow Wave Sleep) and late (mainly REM) sleep are needed to achieve optimal performance. Likewise, the reliance of procedural memory on sleep is a robust and consistent finding across a wide variety of functional domains, including visual, auditory, and motoric systems (for a review see Walker and Stickgold 2004). Taken as a whole, these studies suggest that sleep is crucial for the acquisition of new memories and that the role of sleep in the consolidation of memory traces is obligatory rather than secondary (Maquet 2001).

In addition, studies of young adults found that compared with good sleepers, young insomniacs reported decreased daytime functioning, low performance, attention difficulties, greater difficulty with concentration and memory, and diminished ability in coping with minor problems and accomplishing important tasks during the day (Golan et al. 2004; The Gallup Organization 1991; Salzarulo 1995; Sadeh et al. 2002).

Although the relationship between sleep and memory has been investigated extensively in young adults over the past two decades, the interaction between sleep disturbances and cognitive functioning among older adults remains unclear, and the results of studies are controversial. Mazzoni et al. (1999) demonstrated a correlation between sleep structure and reduction in memory processes among older people. Jelicic et al. (2002) found a correlation in older adults between sleep complaints and decreased cognitive abilities. In a longitudinal study of seven thousand older adult participants, Cricco et al. (2001) showed that chronic insomnia independently predicts incident cognitive decline in older adults. The results of the Cohen-Zion et al. (2004) study indicate that among older patients with mild to moderate Sleep Breathing Disorders, reductions in neurocognitive performance are associated with increasingly severe Sleep Breathing Disorders over time. In contrast, results of other studies showed no significant association between sleep and performance on cognitive tests among older adults (Dealberto et al. 1996; Hayward et al. 1992).

Despite the importance of the finding that ageing is associated with deteriorating memory performance, particularly episodic memory, and despite the many implications of this finding for daily life, little is known about the mechanism underlying these age-related changes. The present study aims to assess whether late-life insomnia, independent of its underlying etiology, is associated with the memory status of older adults, when other factors known to influence cognition are controlled (e.g. education, chronic medical condition, vision ability, hearing ability, major depression and dementia). We hypothesized that late-life insomnia, which may be a chronic condition existing over the course of many years, affects episodic memory capacity. As a result, older adult non-insomniac subjects would demonstrate better performance on episodic memory tests than older adult insomniac subjects. Additionally, we evaluated which stages of episodic memory are particularly affected by disturbed sleep among older adults. Based on adult sleep insomnia studies and the existing knowledge on sleep we further hypothesized that only highly demanding tasks requiring a high level of attention resources would show association with late-life insomnia as opposed to the more simple memory tasks.

Method

Participants

The study population comprised 73 older adult participants: 45 males and 28 females, mean age 70.4 years, SD = 5.8. All of the participants were living independently in the community and were in good clinical condition. Likewise, all participants had been living in Israel for at least 10 years, and all spoke Hebrew fluently.

These 73 participants were recruited through advertisements and talks given at community senior centers. An initial phone interview was used to eliminate volunteers who exhibited visual or hearing impairments. Applicants were then asked to complete several questionnaires. Based on a standard clinical history questionnaire, subjects were eliminated if they had a significant medical, neurological, or psychiatric illness that might bring about cognitive change. More specifically, subjects were excluded from the study for any of the following reasons: (a) They had significant major medical diseases including cancer; diabetes; liver, kidney, heart, or lung disease; alcoholism or other drug abuse. (b) They were taking any medication known to affect central nervous system functioning. (c) They had historical evidence suggesting significant psychiatric disease such as depression or psychosis or neurologic disease. In order to rule out sleep apnea syndrome or periodic leg movement (PLM), participants completed the Mini Sleep Questionnaire (MSQ; Zomer et al. 1985) and the Technion sleep questionnaire (Haimov et al. 2006). Applicants were also eliminated if they complained of sleep apnea syndrome or PLM. In order to eliminate subjects exhibiting dementia or depression, the older adult participants completed the mini-mental state examination (MMSE; Folstein et al. 1975) and the geriatric depression scale—short form (GDS; Zalsman et al. 1998). None of the older adult subjects who participated in the study met any criteria for dementia (none had a mini-mental score less that 26 out of 30) (mean MMSE = 28.5, SD = 1.1) or depression (mean GDS = 2.4, SD = 1.5).

For the purpose of evaluating participant sleep, all subjects were asked to complete two questionnaires that recorded the subject's subjective evaluation of his/her sleep patterns: (1) a qualitative questionnaire—the Mini Sleep Questionnaire (MSQ; Zomer et al. 1985), and (2) a quantitative questionnaire—the Technion Sleep Questionnaire (Haimov et al. 2006). According to their responses to the sleep questionnaires, the 73 participants were divided into two groups: (1) older adult non-insomniac subjects who did not complain of sleep disorders according to their results on the Technion sleep questionnaire and who scored less than four on the insomnia sub-scale of the Mini Sleep Questionnaire (with a grade of four representing the median on the questionnaire scale), and (2) older adult insomniac subjects who met DSM- IV criteria for chronic insomnia according to their results on both Sleep Questionnaires. That is, on the Technion sleep questionnaire they reported that they had difficulties in initiating and maintaining sleep at least three nights per week and that their insomnia had lasted for a minimum of 6 months. Volunteers also had to report that their insomnia was not caused by chronic pain or by any known medical disease and that they did not use either alcohol or any sedative medication. Likewise, participants had to score 4 and above on the insomnia sub-scale in the Mini Sleep Questionnaire. After the assessments were completed, 23 older adult participants were assigned to the insomniac group (32% of the subjects, similar to the percentage of insomniacs in the older adult population), and 50 older adult participants were assigned to the non-insomniac group (68% of the study subjects). The older adult insomniac group consisted of 15 males and 8 females between the ages of 65 and 83 (mean age = 70.8, SD = 5.8; mean education = 11.6, SD = 2.9; mean MMSE = 28.1, SD = 1.3; mean GDS = 2.9, SD = 1.4), and the older adult non-insomniac group consisted of 30 males and 20 females between the ages of 65 and 86 (mean age = 70.2, SD = 5.9; mean education = 12.4, SD = 3.2; mean MMSE = 28.6, SD = 1.0; mean GDS = 2.2, SD = 1.5).

Procedure

The Rey Auditory Verbal Learning Test (AVLT) (Lezak 1983; Vakil and Blachstein 1993) seems to be an ideal tool to aid in clarifying the effect of late-life insomnia on various episodic memory processes. The Rey AVLT test is widely used for clinical and research purposes (Vakil and Blachstein 1997). One of its major advantages is that it simultaneously provides several measures of learning and memory. These measures include immediate and delay recall, learning rate, recognition, proactive interference (the ability to learn a new list of words despite the interference with the earlier list of word), and retroactive interference (the ability to learn a list of words despite the interference with a new list of word), and temporal order.

The Hebrew version of the Rey AVLT (Vakil and Blachstein 1993) was used. Administration was standard, as described by Lezak (1983). Each participant was tested individually, at home, during the afternoon hours (16:00–19:00). This enabled us to monitor cognitive performance under natural circumstances, with minimal distortions, while the effect of the circadian clock on cognitive performance was controlled.

The test consisted of 15 common nouns, which were first read to the subject at the rate of one word per second in five consecutive trials (Trials 1–5); each reading was followed by a free recall task. In Trial 6, an interference list of 15 new common nouns was presented, followed by free recall of these new nouns. In Trial 7, participants were asked to again recall the first list

without an additional reading. Twenty minutes later, and again without an additional reading, participants were once again asked to recall the first list (Trial 8). Next, in Trial 9, they were given a list of 50 words (15 from the first list, 15 from the second list, and 20 new common nouns) and were asked to identify the 15 words from the first list. An extra trial (Trial 10) was added to the standard administration to measure ability to remember temporal order (Vakil et al. 1991). In this extra trial, which followed the recognition task, participants were presented with a written list of the 15 words in List A, but with the presentation order differing from the one used in the oral trials. Participants were asked to rewrite the word list to match the order of words in the original list as they heard them.

Results

General data. Preliminary analyses revealed no significant differences between the older adult insomniacs and the older adult non-insomniacs in participant age [$t(71) = 1.68$, $P = 0.09$]; gender [$\chi^2(1) = 0.18$, $P = 0.67$]; education [$t(71) = 1.43$, $P = 0.32$]; mean MMSE [$t(71) = 1.88$, $P = 0.07$]; and mean GDS [$t(71) = 1.85$, $P = 0.07$]. A significant difference was, however, found between the older adult insomniacs and the older adult non-insomniacs on the insomnia scale [$t(71) = 11.3$, $P = 0.001$].

Rey AVLT task analysis. To test whether late-life insomnia may account for the disproportionate decline in memory among older people, performance of the two groups (i.e. older adult insomniacs and older adult non-insomniacs) on the Rey AVLT was compared. Ten different scores were derived from the Rey AVLT for further analyses. These scores are frequently used in the literature to reflect different aspects of episodic memory (Vakil and Blashtein 1993, 1994). The results are presented in five sections, with each section representing a different category of memory. The tests were administered in the following order: learning, interference, delayed recall, recognition, and temporal order judgment. Means and standard deviation for the raw scores on the nine test trials and for the additional three scores reflecting Trial 10 for each group are presented in Table 1.

In addition, graphical display of the Rey AVLT raw scores for each experimental group is presented (Fig. 1).

Learning

In this section, the different learning measures extracted from the Rey AVLT are analyzed. These measures involve recall scores on the first five learning trials expressed as: learning curve (Trial 1 score to Trial 5 score), total learning (sum of the scores of Trials 1–5) representing the capacity to recall and accumulate words across learning trials, and immediate memory (Trial 1).

Table 1 Means and standard deviation of the raw memory scores for each experimental group

Trial	Older people without sleep disorders ($N = 50$)	Older insomniacs ($N = 23$)
T1 (List A)	4.72 (1.88)	4.70 (1.26)
T2	7.12 (2.26)	6.61 (1.83)
T3	7.89 (2.62)	7.22 (2.61)
T4	9.28 (2.89)	8.30 (2.60)
T5	10.24 (2.72)	9.22 (2.94)
T6 (List B)	4.64 (1.74)	3.74 (1.57)
T7 (List A)	7.86 (3.43)	7.30 (2.90)
T8 (DR)	7.67 (3.66)	7.39 (3.06)
T9 (RC)	11.76 (2.63)	11.91 (2.63)
T10 (Hits)	2.41 (1.84)	2.35 (1.72)
T10 (CO)	0.55 (0.20)	0.44 (0.27)
T10 (AD)	10.97 (0.87)	10.4 (1.20)

DR delayed recall; *RC* recognition; *CO* correlation score; *AD* absolute deviation

Immediate memory (Trial 1)

For the immediate memory measure, a two-tailed t test for independent samples revealed no significant difference in immediate memory score between older adult insomniacs and older adult non-insomniacs [$t(71) < 1$].

Learning curve (Trials 1–5)

Learning curve represents the learning ability of the participants (Mitrushina et al. 1991). A mixed design ANOVA was conducted with sleep group (older adult insomniacs and non-insomniacs) as a between-subjects factor and learning trials (Trials 1–5) as within-subjects factor. A significant effect was found for learning [$F(1, 66) = 7.89$, $P = 0.004$], indicating that there is an overall increase in the number of words recalled from trial to trial. Group effect did not reach significance [$F(1, 66) < 1$]. The learning × sleep group interaction was significant [$F(1, 66) = 3.01$, $P = 0.043$], suggesting that

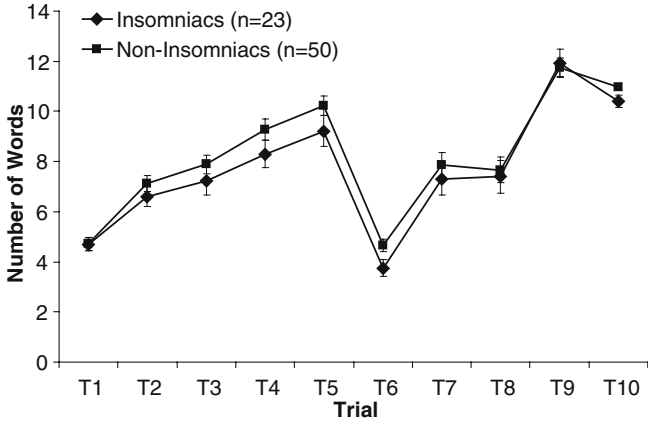

Fig. 1 Means of the raw memory scores for each experimental group. *Error bars* indicate SEM

the learning rate of older adult non-insomniacs is steeper than that of older adult insomniacs. However, the clinical relevance of this result is restricted since the older adult insomniacs recall one word less than the older adult non-insomniac subjects on the fifth trail.

Total learning (Trials 1–5)

The total learning measure consists of the sum of words recalled in all five learning trials, and it reflects the capacity to recall and accumulate words throughout learning trials (Moses 1989). A two-tailed t test for independent samples revealed that although older adult non-insomniacs tended to recall more words than insomniacs, this difference was only marginally significant [$t(71) = 1.31$, $P = 0.09$].

Interference

In this section, the different interference measures extracted from the Rey AVLT are analyzed. These measures include the number of words recalled from the interference list (i.e., Trial 6) and from the first list following the interference (i.e., Trial 7). In addition, the recall of this list as compared to the recall of the first list, enable the derivation of proactive and retroactive interference measures.

Proactive interference (List B, interference list; Trial 6)

A mixed-design ANOVA was conducted with sleep group (older adult insomniacs and non-insomniacs) as a between-subjects factor and proactive interference (Trial 1 score minus Trial 6 score) as a within-subjects factor. No significant effect was found for proactive interference or for sleep group {[$F(1, 66) < 1$; $F(1, 66) = 1.07$, $P = 0.15$], respectively}. However, the proactive interference × sleep group interaction was significant, [$F(1, 66) = 2.89$, $P = 0.047$], suggesting that resistance to proactive interference among older adult non-insomniacs is stronger than among older adult insomniacs. That is, despite the interference of the first list, older adult non-insomniacs recalled more words from the new list than did older adult insomniacs.

Retroactive interference (List A, following the interference list; Trial 7)

A mixed-design ANOVA was conducted with sleep group (older adult insomniacs and non-insomniacs) as a between-subjects factor and retroactive interference as within-subjects factor (Trial 5 score minus Trial 7 score). The main retroactive effect did not reach significance [$F(1, 66) = 2.29$, $P = 0.07$]. Group effect also did not reach significance [$F(1, 66) < 1$], nor did the retroactive interference × sleep group interaction [$F(1, 66) < 1$].

Delayed recall (Trial 8)

Delayed recall performance (Trial 8) was compared with performance on Trial 5. A mixed-design ANOVA was conducted to analyze the effect of sleep group (older adult insomniacs and older adult non-insomniacs) and delayed recall (Trial 5 score minus Trial 8 score). The main effect of delayed recall did not reach significance [$F(1, 66) = 2.32$, $P = 0.07$]. Group effect also did not reach significance [$F(1, 66) < 1$]. The delayed recall × sleep group interaction did not reach significance [$F(1, 66) = 1.77$, $P = 0.09$].

Recognition (Trial 9)

Two-tailed t test for independent samples revealed no significant difference between the groups on the number of recognition words [$t(71) < 1$]. However, some investigators have argued that success on a memory test requires effective inhibition of related, but non-target, memories (Zacks et al. 2000). Indeed, failure to achieve such inhibition may result in production of false memories, a problem prevalent among older adults (Norman and Schacter 1997; Tun et al. 1998). In order to correct the recognition score for a positive criterion (the tendency to give a positive answer), we used an additional measure, comprised of the proportion of words correctly identified from list A (hit rate) and the number of false positive responses. The t test showed no significant differences on this score between the groups [$t(71) = 1.16$, $P = 0.12$]. In addition, we compared recognition score (Trial 9) to delayed recall score (Trial 8). A mixed-design ANOVA was conducted with sleep group (older adult insomniacs and non-insomniacs) as a between-subjects factor and recognition (Trial 9 score minus Trial 8 score) as within-subjects factor. The main effect of recognition reached significance [$F(1, 66) = 5.09$, $P = 0.02$]. Group effect did not reach significance [$F(1, 66) < 1$]. The recognition × sleep group interaction did not reach significance [$F(1, 66) < 1$], suggesting that no significant difference in recognition was found between non-insomniacs and insomniacs. That is, older adult insomniacs and non-insomniacs exhibit a similar increase in the number of words recognized compared to words recalled.

Temporal order (Trial 10)

A recently introduced supplementary measure to the Rey AVLT for assessing temporal order (Vakil et al. 1997) proposes three alternative scores for measuring temporal order. These measures are: (1) *Hits*: the number of words correctly placed at their original serial position; (2) *Correlation*: the Pearson correlation, calculated for each participant, between the listed order and the true order; (3) *Absolute deviation*: a score calculated by summing the absolute deviation of each word

from its original position. The score for each deviation ranges from 0 to 14 (Vakil 1985). Table 1 presents the results for the two groups on these temporal order measures. The hits score showed no significant difference between the groups on the number of words that were written in the correct place [$t(70) < 1$]. The correlation score was found to approach significance [$t(44) = 1.44$, $P = 0.08$], while the absolute deviation score reach significance [$t(43) = 1.79$, $P = 0.04$], suggesting that the temporal order judgment of older non-insomniacs is more accurate than that of older insomniacs.

Taken together, the two groups (i.e. older adult subjects without insomnia and older adult insomniacs) were found to differ significantly from one another on their scores for learning rate, proactive interference and temporal order judgment. Furthermore, although significance was found on these measures only, a tendency of older adult non-insomniacs to remember more words than older adult insomniacs can be found for all memory categories. A brief summary of the test results for the different memory measures is presented in Table 2.

Discussion

The present study demonstrates that chronic insomnia in older adults is associated with their episodic memory status. The results reveal significant differences between older adult insomniac subjects and older adult non-insomniac subjects on three memory processes—learning rate, resistance to proactive interference, and temporal order judgment—all of which have many implications for daily life. The findings of the present study are consistent with results of other studies that show a particularly pronounced age-related decline in the ability to learn (Kessels et al. 2003), the ability to inhibit irrelevant information (Persad et al. 2002) and the ability to temporally code information (Naveh-Benjamin et al. 2000).

In order to determine whether the relation that we found between sleep quality and memory performance is a causal relation and not due to other factors, we sought to establish a dose–response analysis between sleep quality and memory performance for the 73 participants. Unfortunately, we found the sample size insufficient to establish dose–response between the different Rey AVLT measures and insomnia scale.

Some aspects of the memory tests did not reveal significant differences between insomniac and non-insomniac older adult subjects. For example, there was no significant effect of insomnia on the number of recalled words in resistant to retroactive interference task and in delayed recall task. A possible explanation for these results may lie in the finding that older adult insomniacs showed significantly lower resistance to proactive interference, and as a result were less successful in learning a second list of words. Therefore, information from the second list was less intrusive to the older adult insomniacs comparing to the non-insomniac subjects. As a consequence, there was no significant difference between the two groups when asked to recall the first list of words immediately after learning the second list (i.e. resistant to retroactive interference task) or when they had to recall the first list of words 20 min later (delayed recall task).

Likewise, on immediate memory and recognition tasks no significant differences were found between the groups. These results are consistent with those of Szelenberger and Niemcewisz (2000), which show a correlation between insomnia score and impaired learning but did not show a correlation between insomnia score and immediate memory. In their study, Szelenberger and Niemcewisz revealed that although insomniacs did not differ from non-insomniacs on immediate recall tasks, insomniacs required a greater number of repetitions to learn all the test items. A possible reason for our findings that insomnia does not affect immediate memory ability and recognition performance may lie in the relative simplicity of these tasks. Perhaps only highly demanding tasks requiring a high level of attention resources, such as learning, resistance to interference, and temporal order judgment, will more directly underscore the restorative value of sleep. Another explanation for the result that insomnia does not affect immediate memory ability and recognition performance may lie in the finding that those two tasks do not decline in older adults as drastically as do other cognitive aspects (Craik 1977; Howe 1988; Poon 1985; Verhaeghen et al. 1997).

The association between chronic insomnia and the episodic memory status of older adults may be the result of interrelationships between age-related changes in sleep and memory probably involving mechanisms of memory consolidation during sleep, i.e., chronic insomnia in the older adults can be a risk factor for memory decline. Changes in sleep characteristics in late-life insomnia may lead to impaired memory consolidation during sleep, thereby affecting daytime memory performance in older adults with insomnia. Many sleep parameters of relevance for sleep-related memory processing in young adults decline in late-life insomnia, such as REM sleep and SWS percentages (Vitiello et al. 2004). These age-related changes in

Table 2 Comparison between the two experimental groups in performance across the different episodic memory measures

Measure	Test	*P*
Immediate memory	$t(71) < 1$	NS
Learning curve	$F(1,66) = 3.01$	0.043
Total learning	$t(71) = 1.31$	NS
Proactive interference	$F(1,66) = 2.89$	0.047
Retroactive interference	$F(1,66) < 1$	NS
Delayed recall	$F(1,66) = 1.77$	NS
Recognition	$t(71) < 1$	NS
Temporal order		
Hits score	$t(70) < 1$	NS
CO score	$t(44) = 1.44$	NS
AD score	$t(43) = 1.79$	0.04

NS not significant; *CO* correlation score; *AD* absolute deviation

sleep may affect sleep-related memory processing in older adults suffering from insomnia, leading to impaired daytime memory performance in these patients.

Another potential explanation for the decline in memory functioning with late-life insomnia is that disturbed sleep may result in fatigue and decreased alertness during the day, which in turn may lead to disturbed memory functioning. This decreased alertness may reduce performance in attention-demanding processes. An additional consequence of the decreased alertness during the day is that it can lead to reduced exposure to cognitively challenging situations which help maintain cognitive abilities (Ball et al. 2002). For instance, fatigue can result in decrease interest in reading, hobbies, social involvement, physical activity, and other engagement with one's environment (Bassuk et al. 1999; Simonsick et al. 1999).

The fact that risk factors contributing to cognitive decline (i.e., education, physical health status, depression and auditory and visual ability) were controlled in the present study supports the conclusion that sleep may be one of the factors contributing to the decline of episodic memory functioning in older adults. Since our findings suggest that poor-quality sleep may contribute to the episodic memory status of older adults, and as a result make the insomniac elderly population more susceptible to cognitive deficiency, it is important that insomnia symptoms be taken seriously by practitioners and treated appropriately. The findings of this study offer hope that treatment of insomnia in older adults could have beneficial effects in improving cognitive functioning in these patients.

Thus, attention to and effective treatment of chronic insomnia in older persons may not only improve the quality of their nighttime sleep, but conceivably may also help maintain their cognitive function, thus improving their overall quality of life. Both the safety and the effectiveness of sleeping pills for treatment of insomnia in chronic older adult insomniacs are questionable (Endeshaw 2001; Morin et al. 1991; Ray et al. 2000). Daytime carryover effects observed with longer-acting sleep medications (Johnson and Chernik 1982) are likely to produce additional, potentially serious, decrements in daytime function among chronic older adult insomniacs. Thus, it is recommended that emphasis be placed on non-pharmacological interventions to improve sleep hygiene among chronic older adult insomniacs (Morin et al. 1991, 1999).

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