Published in final edited form as:
J Am Geriatr Soc. 2018 July ; 66(7): 1318–1324. doi:10.1111/jgs.15413.

Chronic pain and attention in older adults living in the community

Guusje van der Leeuw, MD[1,2], **Suzanne G. Leveille, RN, PhD**[1,3], **Zhiyong Dong, MS**[3], **Ling Shi, PhD**[1], **Daniel Habtemariam, BA**[4], **William Milberg, PhD, ABPP-ABCN**[5,6], **Jeffrey M. Hausdorff, PhD**[7,8,9], **Laura Grande, PhD, ABPP**[10,11], **Peggy Gagnon, RN, BSN**[4], **Robert R. McLean, DSc, MPH**[3,12], and **Jonathan F. Bean, MD, MS, MPH**[5,13,14]

[1]College of Nursing and Health Sciences, University of Massachusetts Boston, Boston, MA [2]Department of General Practice and Elderly Care Medicine, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands [3]Department of Medicine, Beth Israel Deaconess Medical Center, Boston, MA [4]Institute for Aging Research, Hebrew SeniorLife, Boston, MA [5]New England Geriatric, Research, Education and Clinical Center, VA Boston Healthcare System, Boston, MA [6]Department of Psychiatry, Harvard Medical School, Boston, MA [7]Center for Study of Movement, Cognition and Mobility, Department of Neurology, Tel Aviv Sourasky Medical Center, Tel Aviv, Israel [8]Department of Physical Therapy, Sackler Faculty of Medicine, and Sagol School of Neuroscience, Tel Aviv University, Tel Aviv, Israel [9]Rush Alzheimer's Disease Center and Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Il [10]Psychology Service, VA Boston Healthcare System, Boston MA [11]Department of Psychiatry, Boston University School of Medicine, Boston MA [12]Department of Medicine, Harvard Medical School, Boston, MA [13]Department of Physical Medicine & Rehabilitation, Harvard Medical School, Boston, MA [14]Spaulding Rehabilitation Hospital, Boston, MA

Abstract

BACKGROUND—Maintenance of optimal cognitive functioning during aging is essential for almost every aspect of independent living. Chronic pain is a frequently observed problem in older adults that may interfere with cognitive functioning, especially in the domain of attentional

---

Corresponding author: Suzanne G. Leveille, College of Nursing and Health Sciences, University of Massachusetts Boston, 100 Morrissey Blvd, Boston, MA 02125 (Suzanne.leveille@umb.edu).

Conflict of Interest: None.

Author's contributions:
G. van der Leeuw performed data analyses and prepared the initial draft of the manuscript. S.G. Leveille was responsible for the study concept, oversight of the data analysis and interpretation of the findings and, critically reviewed and revised the manuscript. Z. Dong performed data analyses. L. Shi gave statistical advice throughout the data analyses and contributed to the manuscript. D. Habtemariam prepared analytic data and contributed to the manuscript. W.M. Milberg and L. Grande provided expertise on the subject of cognitive functioning and critically reviewed the manuscript. J.P. Hausdorff gave more insight in the neuropsychological test and the interpretation of the data. M. Gagnon was responsible for the data collection and assisted in preparation of the manuscript. R.R. McLean oversaw the study recruitment and data collection and provided expertise in revieweing all sections of the manuscript. J.F. Bean provided expertise in interpretation of the findings and revised the manuscript. All authors were responsible for revisions of the manuscript.

Sponsor's role: The funding source had no influence on the conduct and design of the study, neither on the data collection, analysis, the interpretation of the data, the approval of the manuscript or in the decision to submit the article for publication.

capacity in the elderly. The purpose of this study was to examine the cross-sectional relationship between chronic pain and complex attention in a population of community-living older adults.

DESIGN—Prospective cohort study, cross-sectional.

SETTING—Population based Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston Study II (MOBILIZE Boston Study).

PARTICIPANTS—354 participants aged 71 to 101 years old.

MEASUREMENTS—Chronic pain was measured using the pain severity and interference subscales of the Brief Pain Inventory. Four subscales of the Test of Everyday Attention (TEA) were used to measure domains of attention switching, selective, sustained and divided attention.

RESULTS—Before and after multivariable adjustment, pain severity was associated with poorer scores in measures of selective and sustained attention. Pain interference scores also were significantly inversely associated with selective attention.

CONCLUSION—The results of this study show that chronic pain is associated with poorer performance in the domains of selective and sustained attention in community-dwelling older adults. Further research is needed to determine whether effective pain management could lead to improved attentional performance in older adults. Older adults who live with chronic pain, often undertreated, are potentially at increased risk for cognitive difficulties and related functional consequences.

Keywords

Cognitive function; epidemiology; neuropsychology; pain interference; pain severity

Introduction

Maintenance of intact cognitive functioning is essential, especially in advancing age, to maintain mobility and independent functioning of daily activities [1–3]. Impaired cognitive functioning is a risk factor for physical disability, hospitalization and death [4,5]. Decline of cognitive functioning also makes older adults more susceptible to other problems threatening functional independence such as falls and frailty [6,7].

Rates of cognitive decline in aging vary with cognitive abilities and among different people [8]. Several factors can influence the relationship between cognition and aging, including chronic pain. Our previous research showing a modest cross-sectional relationship between pain and cognitive function suggests that chronic pain may compete with the performance of cognitive tasks [9]. Eccleston and colleagues proposed that pain demands attention and that pain will emerge over other demands for attention [10]. It has also been suggested in healthy young and middle aged adults that attention-demanding cognitive tasks can also be used to self-manage the pain, leading to reduced pain intensity [11].

Attention is defined as a person’s information processing capacity [12,13]. Beyond the hearing and vision changes that impact perceptual abilities, basic auditory and visual attention typically remain intact with age. In contrast, when greater demands are placed on attention, age-related decrements are commonly observed. These complex attentional abilities include:

shifting attention between stimuli, sustaining attention over periods of time and selective attention in which specific stimuli are identified for processing and other stimuli ignored [14,15].

The high prevalence of chronic pain, coupled with heightened vulnerability to cognitive problems in this older population, points to an urgent need for research to understand the chronic pain-attention relationship. Therefore, we investigated whether chronic pain is associated with poorer performance on tests of complex attention in older adults. We hypothesized that older adults experiencing the most pain in terms of severity and pain interference with activities will have poorer cognitive performance on the attentional domain compared to those without pain.

Methods

The population-based cohort for the Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston Study (MOBILIZE Boston Study, MBS) was recruited from 2005 to 2008 in the Boston area. Details of the study were published previously [16]. Briefly, 765 adults aged 70 years and older, and eligible spouses aged 65 and older were enrolled. Eligibity required communication in English and ability to walk across a small room without personal assistance. Persons were excluded for diagnosis of a terminal illness or evidence of moderate to severe cognitive impairment assessed as Mini Mental State Exam (MMSE) score of 17 or lower [17,18]. The current wave of the study, referred to as the MBSII, consented 354 participants who were continuing to live in the community and agreed to participate in this new phase of the study from 2012 to 2014, approximately 6 to 8 years following original recruitment (MOBILIZE I). Study protocols were approved by the institutional review boards of Hebrew SeniorLife and the University of Massachusetts Boston.

Measurements

The MBSII assessment consisted of a 45-minute health interview by telephone followed by a 3 hour study clinic visit for a health assessment and physical and cognitive performance . For 43 participants (12.1%) who were unable to come to the study clinic, in-home assessments were conducted.

Test of Everyday Attention

We measured complex attention using the Test for Everyday Attention (TEA) [19], designed to measure attentional abilities during tasks resembling everyday activities. The TEA has been validated in persons aged 18–80 years old [20] and an evaluation of utility and missingness of the TEA in persons aged 80 years and older in the MBSII was published previously [21]. This study included 4 subscales measuring attentional switching, visual selective attention, sustained attention, and divided attention. Following the standardized TEA testing guidelines, participants completed a practice session in advance of each test. For people with vision problems, magnifying glasses were provided; for those with hearing problems, use of an audio amplifier with headphones was offered though none of the participants used it.

Attention switching was measured using the Visual Elevator test, which also measures mental flexibility [20]. The Visual Elevator test is a self-paced task where participants are asked to imagine that they are in an elevator and need to count up and down using a series of cards depicting up and down arrows, representing floors on an elevator. The timing score is calculated to determine the time taken for each correctly performed switch (where the elevator switches a number of times going up or down on each card shown to the participant).

Selective attention was measured using the Map Search test, where participants are shown a map of Philadelphia that includes common symbols representing restaurants, gas stations, and other services. Participants are given 2 minutes to circle as many gas station symbols as they can find on a large paper copy of the map. The total score is calculated according to the total number of gas pump symbols circled within two minutes with the higher score reflecting better performance (in contrast to the scores of the other domains).

The Telephone Search Test, another *selective attention measure*, uses pages from a telephone book that are modified to include simple geometric symbols besides the names of various businesses. Participants are asked to identify as many correctly matching symbols as they can find as they proceed through the columns on the pages. If they have not completed the task within 4 minutes, the test is ended. The score (time-per-target score) is based on the total time divided by the number of correctly detected symbols.

The Telephone Search While Counting Test measures *sustained attention* and resembles the previous test. Participants additionally are asked to count audio tones from a recording while performing the Telephone Search. The score is based on the average time per correctly identified symbols.

Divided attention was measured using the Dual Task Decrement score. The score was calculated by subtracting the time-per-target score from the prior Telephone Search task from the time per target score weighted for accuracy of tone counting.

Chronic pain

The Brief Pain Inventory (BPI) subscales measured global pain severity and pain interference [22,23]. The BPI has been validated as a measure of chronic non-malignant pain in older adults and shows good reliability (coefficient alphas > 0.70) [24,25]. For the BPI severity subscale, participants are asked to rate their pain, described as pain “you have today that you have experienced for more than just a week or two”. For the 4-item severity scale, participants rate their pain in the previous week on a numeric rating scale from 0–10, where 0 reflects ‘no pain’ and 10 reflects ‘severe or excruciating pain, as bad as you can imagine’, in terms of pain at its worst, least, on average in the previous week, and at present. The BPI severity score is the average of the 4 ratings.

Using the BPI pain interference subscale, interference in daily activities was rated for general activity, mood, walking ability, normal work, relations with other people, sleep and enjoyment of life. Rating for each item was on a 0–10 numeric rating scale, with 0 indicating no pain interference and 10 indicating complete interference; the score was the average of the 7 item ratings.

Sociodemographic and Health Characteristics

We selected sociodemographic and health characteristics that were possible confounders and could potentially interfere with test performance. Sociodemographic characteristics assessed at baseline included age, gender, race and educational level. Education level was assessed as number of years of formal education. Health characteristics assessed in the telephone interview and clinic exam included body mass index (BMI), heart disease (self-reported) and diabetes and depression, assessed by disease algorithms, described previously [16]. Obesity was determined based on body mass index (BMI) of 30 or greater. Following a musculoskeletal assessment using clinical criteria for osteoarthritis of the hand and knee, arthritis was categorized into 4 groups: no arthritis, hand only, knee only and both (hand and knee) [26,27]. Vision was assessed using the Good-Lite Chart light box, where participants were asked to read text at a 10-foot distance [28]. The lowest performing quartile was classified as poor vision. Self-reported hearing difficulties were assessed during the health interview on a binary scale (yes/no). Medications used in the previous 2 weeks were assessed using the brown bag method. Psychiatric medications included anxiolytics, sedatives and hypnotics, antidepressants, and antipsychotics. Analgesic medications include opioid and non-opioid classes as well as medications for neuropathic pain (i.e. gabapentin and pregabalin).

Statistical analysis

Participant characteristics were examined according to BPI pain severity tertiles (none or least pain: BPI severity score <1, mild pain: score 1 to 3.9, and moderate to severe pain: BPI≥4). Similarly, BPI interference scores were grouped into tertiles. Between-group differences according to baseline characteristics were tested using Chi-square tests for categorical measures and ANOVA for ordinal and continuous measures.

Attention scores of the TEA subscales were investigated according to BPI pain severity and interference scales. TEA subscale scores were highly skewed and subsequently winsorized at the 99th percentile to control for outliers. We used unadjusted general linear models (GLM) to test potential linear relationships between BPI pain score groupings and TEA scores (dependent variables).

Multiple linear regression modeling was used to investigate relationships between pain measures and TEA subscales. We performed two models, initially adjusting for sociodemographic measures (age, sex, race, education), then extending the model by adding variables that could potentially interfere with the TEA test performance (hand arthritis and vision), heart disease, diabetes, BMI and adding psychiatric medication use. The magnitude of the effect of chronic pain on attention is expressed in unstandardized regression coefficients.

All analyses were performed with SAS v 9.4 (SAS Institute, Cary, NC).

Results

Study Sample Characteristics

Study participants (n=354) had an average age of 84.5 years (SD=4.7) including approximately two-thirds women (65.8%), similar to the older population of the Boston area. Participants had an average of 14.8 years (SD=2.8) of education and 79.9% were white and 14.4%, African-American. Participants with moderate to severe pain were more likely to have fewer years of education, be female, African-American, have obesity and arthritis, and use analgesics and psychiatric drugs, compared to people with none or mild pain (Table 1).

TEA subscales

Participants with moderate to severe pain severity or interference had poorer performance than those with none or less pain in the domain of selective attention (Telephone Search and Map Search tests; Table 2). After adjustment for age, gender, race and education, pain severity was associated with lower scores on one domain of complex attention; selective attention (Telephone Search: p-value 0.04, Map Search: p-value 0.03; Table 3). In addition, after adjustement for health factors and psychiatric medication use, pain severity was associated with sustained attention (Telephone search while counting, p-value 0.04). Pain interference was inversely associated with the Telephone Search score (p-value 0.03).

Discussion

This is among the first studies of an older population to examine the possible impact of chronic pain on selected domains of attentional capacity in older adults. The results demonstrate that chronic pain is associated with attentional challenges in community-living older adults. Before and after multivariable adjustment, pain severity was associated with poorer selective and sustained attention, and pain interference also was significantly associated with poorer selective attention.

Our results are in line with earlier clinical studies of adults with chronic pain, where chronic pain was associated with selected cognitive impairments [29–32]. In a previous MBS report, we observed modest associations between pain and other cognitive domains among the original cohort of 765 participants [9]. In that analysis, MBS partcipants experiencing more severe pain or pain interference performed worse on executive functioning and memory tests, compared to participants with less or no pain. Additionally, pain interference was associated with impaired attentional capacity, measured using the Trailmaking test Part A. However, many of the observed associations attenuated after other factors including chronic conditions, behaviors and psychiatric medication were taken into account. In addition, adjusting for performance in tests of attention diminished the association between pain and general cognitive functioning, supporting the idea that attention may explain previously reported associations between pain and general cognitive decline [9]. The current study findings are not only consistent with previous MBSI results, but suggest that chronic pain in older adults may be particularly detrimental to domains of selective and sustained attention. It is possible that impaired selective attention contributes to previous findings of reduced executive functioning and memory. A previous study also suggested that the influence of pain on memory processes is secondary to the influence of pain on attention rather than primarily on memory [32] . Others have suggested that selective attention plays a role in the executive control aspect of the working memory system [33]. Therefore our findings may not only present new information about the relation between pain and attention, but also may have broader implications for the existing evidence describing associations between pain and other cognitive domains.

No relation was found between pain severity or interference and attentional switching. The absence may be explained in part by the difficulty of the Visual Elevator test for older adults. Our previous work showed that this test was probably the most difficult test for those aged 80 and older, resulting in more incomplete tests (19% of participants had incomplete tests of attentional switching versus 8% on the selective attention tests). We reported previously that 69% of participants with incomplete Visual Elevator tests had low MMSE scores [21]. Nonetheless, additional analysis addressing the problem of missingness using multiple imputation for the Visual Elevator test did not change our findings (data not shown).

A review evaluating the effect of chronic pain on neuropsychological performance identified cognitive impairment among patients with chronic pain irrespective of age, particularly in the domains of attention, processing speed and psychomotor speed [30]. However, the authors suggest that multiple factors, yet to be identified, may mediate or explain the relation between chronic pain and cognitive functioning [30]. Iezzi and colleagues identified that factors such as education, can influence this relationship. They initially observed associations between chronic pain and attention in clinical adult patients [29]. However, after controlling for the effect of education, the assocation was diminished. In our study of very old adults living in the community, the relationship of pain and attention was independent of education.

Our results are consistent with Eccleston's theory that pain demands attention and takes precedence over other attention-demanding cognitive tasks [10]. This effect might be greater for older adults with chronic pain, in part because of distracting effects of pain but also because, with aging, there is reduced ability to handle more than one task at a time [34]. In our study, nearly all participants with chronic pain reported they were experiencing pain on the day of the cognitive testing (data not shown).

Additional evidence can be found by reviewing the brain regions involved in both pain and complex attention. In older adults with chronic back pain, MRI studies reveal losses in brain volumes in the cingulate cortex area, which is involved in the processing of pain and also in attentional challenges [31]. Other imaging studies showed activation of the prefrontal cortex during pain experience as well as during complex attentional processing [35,36]. Therefore, the effect of chronic pain may be related to chronic interruption of current attentional engagement [10]. It is possible that chronic pain may have a cumulative negative effect on cognitive functioning, contributing to cortical reorganization due to brain plasticity. While plasticity is typically viewed as advantageous, in the presence of chronic pain, plasticity may lead to changes in brain morphology, with loss of gray matter volume, such as in the insular cortex, anterior cingulate cortex, and dorsolateral prefrontal cortex [31,37,38]. In a review on pain and cognition, Moriarty and colleagues proposed potential mechanisms involved in pain-related cognitive impairment: division of limited resources in the brain, adverse neuroplastic changes that occur in the brain of chronic pain patients, and neurochemical mediators released during chronic pain [38]. One or more of these mechanisms may have contributed to the associations we observed between chonic pain and attention in the older population.

Older adults who have pain may be particularly vulnerable to impairment in selective attention, which involves not only the selection of appropriate stimuli, but also, the inhibition of distracting stimuli. Poor selective attention is typically associated with the poor inhibition aspect of selective attention. Pain might impair inhibition, when it becomes difficult to ignore it. Participants who had more severe pain generally performed worse than those without pain on other TEA subscales, however the decrements in the other attentional domains were not consistently significant.

This study has some notable strengths, including use of two different global pain measures. Another strength is that the TEA assesses several domains of attention and may provide a more ecologically valid assessment of complex attention compared to the commonly employed clinical measures (e.g., Stroop; Trail Making). Previously we reported that TEA scores correlated with other cognitive tests in the MBS II, and that, in general, very elderly participants were able to complete most of these challenging attentional tasks, except for the visual elevator test [21]. Lastly, our study is population-based, thus our findings are more representative than other studies involving patient volunteer samples.

Our findings overall of the fully adjusted models are modest. This could be in part due to the sample size or it could be that other factors not accounted for in our analysis could explain the observed associations. Further research is needed to better understand the impact of chronic pain on cognition in older adults. Another limitation of this study was its cross-sectional design. Therefore, we cannot determine the temporality and directionality of the relationship between pain and attention. Longitudinal research on this topic is needed. Also, we were not able to describe the nature and source of the pain. Furthermore, we did not adjust for analgesic use or specifically, opioid use, because use of these medications is strongly associated with pain severity. Thus, we cannot be certain whether the observed associations between pain and attentional deficits are completely independent of medications used for pain management. Another possible limitation is that the TEA is a challenging test, especially in older adults. Our previous report addressed the problem of missingness of the TEA and suggestions for modifications in very old adults [21]. Future studies need to investigate the suggested modifications.

In conclusion, our findings support that chronic pain may compromise complex attention in older adults. There is growing evidence that maintenance of cognitive functioning including attention in older adults is essential to mobility and daily function [1,39]. Also attentional demands for postural control increase with aging as sensory information decreases [12,40]. Thus, decreased attentional capacity in older adults could lead not only to decreased cognitive functioning overall, but also to imbalance, mobility decline and falls. Research is needed on the long term effects of pain on attentional processes and other cognitive functions and mobility with aging. Perhaps most importanty, we need to determine whether improved pain management reduces the attentional burden of pain and its functional consequences in this vulnerable population.

Acknowledgments

Funding sources: National Institute on Aging (Grant numbers P01AG004390, R01AG041525). Drs. van der Leeuw's effort was additionally supported by the "Fundatie van Beijeren van Schagen".

The authors would like to thank the MOBILIZE Boston research team and study participants for their time, effort, and dedication. We also would like to thank professor J. Verghese for reviewing the manuscript.

References

1. Cahn-Weiner DA, Farias ST, Julian L, et al. Cognitive and neuroimaging predictors of instrumental activities of daily living. J Int Neuropsychol Soc. 2007; 13(5):747–757. DOI: 10.1017/S1355617707070853 [PubMed: 17521485]
2. Royall DR, Palmer R, Chiodo LK, Polk MJ. Declining executive control in normal aging predicts change in functional status: The freedom house study. J Am Geriatr Soc. 2004; 52(3):346–352. [PubMed: 14962147]
3. Leveille SG, Jones RN, Kiely DK, et al. Chronic musculoskeletal pain and the occurrence of falls in an older population. JAMA. 2009; 302(20):2214–2221. DOI: 10.1001/jama.2009.1738 [PubMed: 19934422]
4. McGuire LC, Ford ES, Ajani UA. Cognitive functioning as a predictor of functional disability in later life. Am J Geriatr Psychiatry. 2006; 14(1):36–42. 14/1/36 [pii]. [PubMed: 16407580]
5. Smits CH, Deeg DJ, Kriegsman DM, Schmand B. Cognitive functioning and health as determinants of mortality in an older population. Am J Epidemiol. 1999; 150(9):978–986. [PubMed: 10547144]
6. Lundin-Olsson L, Nyberg L, Gustafson Y. Attention, frailty, and falls: The effect of a manual task on basic mobility. J Am Geriatr Soc. 1998; 46(6):758–761. [PubMed: 9625194]
7. Yogev-Seligmann G, Hausdorff JM, Giladi N. The role of executive function and attention in gait. Mov Disord. 2008; 23(3):329–42. quiz 472. DOI: 10.1002/mds.21720 [PubMed: 18058946]
8. Schaie W. Intellectual development in adulthood. the seattle longitudinal Study. New york: Cambridge University Press; 1996.
9. van der Leeuw G, Eggermont LH, Shi L, et al. Pain and cognitive function among older adults living in the community. J Gerontol A Biol Sci Med Sci. 2016; 71(3):398–405. DOI: 10.1093/gerona/glv166 [PubMed: 26433218]
10. Eccleston C, Crombez G. Pain demands attention: A cognitive-affective model of the interruptive function of pain. Psychol Bull. 1999; 125(3):356–366. [PubMed: 10349356]
11. Valet M, Sprenger T, Boecker H, et al. Distraction modulates connectivity of the cingulo-frontal cortex and the midbrain during pain--an fMRI analysis. Pain. 2004; 109(3):399–408. DOI: 10.1016/j.pain.2004.02.033 [PubMed: 15157701]
12. Shumway-Cook A, Woollacott M. Attentional demands and postural control: The effect of sensory context. J Gerontol A Biol Sci Med Sci. 2000; 55(1):M10–6. [PubMed: 10719767]
13. Mirsky AF, Anthony BJ, Duncan CC, Ahearn MB, Kellam SG. Analysis of the elements of attention: A neuropsychological approach. Neuropsychol Rev. 1991; 2(2):109–145. [PubMed: 1844706]
14. Filley CM, Cullum CM. Attention and vigilance functions in normal aging. Appl Neuropsychol. 1994; 1(1–2):29–32. DOI: 10.1080/09084282.1994.9645327 [PubMed: 16318558]
15. Madden DJ. Aging and visual attention. Curr Dir Psychol Sci. 2007; 16(2):70–74. DOI: 10.1111/j.1467-8721.2007.00478.x [PubMed: 18080001]
16. Leveille SG, Kiel DP, Jones RN, et al. The MOBILIZE boston study: Design and methods of a prospective cohort study of novel risk factors for falls in an older population. BMC Geriatr. 2008; 8:16-2318-8-16.doi: 10.1186/1471-2318-8-16 [PubMed: 18638389]

17. Escobar JI, Burnam A, Karno M, Forsythe A, Landsverk J, Golding JM. Use of the mini-mental state examination (MMSE) in a community population of mixed ethnicity. cultural and linguistic artifacts. J Nerv Ment Dis. 1986; 174(10):607–614. [PubMed: 3760851]
18. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975; 12(3):189–198. [PubMed: 1202204]
19. Robertson I, Ward T, Ridgeway V, Nimmo-Smith I. The test of everyday attention. London, England: Pearson assessment; 1994.
20. Robertson IH, Ward T, Ridgeway V, Nimmo-Smith I. The structure of normal human attention: The test of everyday attention. J Int Neuropsychol Soc. 1996; 2(6):525–534. [PubMed: 9375156]
21. van der Leeuw G, Leveille SG, Jones RN, et al. Measuring attention in very old adults using the test of everyday attention. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. 2016; :1–12. DOI: 10.1080/13825585.2016.1226747
22. Cleeland C. Measurement of pain by subjective report. In: Chapman C, Loeser F, editorsAdvances in pain research and therapy. Vol. 12. New York: Raven Press; 1989. 391–403. Issues in Pain Measurement
23. Cleeland CS, Ryan KM. Pain assessment: Global use of the brief pain inventory. Ann Acad Med Singapore. 1994; 23(2):129–138. [PubMed: 8080219]
24. Tan G, Jensen MP, Thornby JI, Shanti BF. Validation of the brief pain inventory for chronic nonmalignant pain. J Pain. 2004; 5(2):133–137. DOI: 10.1016/j.jpain.2003.12.005 [PubMed: 15042521]
25. Keller S, Bann CM, Dodd SL, Schein J, Mendoza TR, Cleeland CS. Validity of the brief pain inventory for use in documenting the outcomes of patients with noncancer pain. Clin J Pain. 2004; 20(5):309–318. [PubMed: 15322437]
26. Altman R, Asch E, Bloch D, et al. Development of criteria for the classification and reporting of osteoarthritis. classification of osteoarthritis of the knee. diagnostic and therapeutic criteria committee of the american rheumatism association. Arthritis Rheum. 1986; 29(8):1039–1049. [PubMed: 3741515]
27. Altman R, Alarcon G, Appelrouth D, et al. The american college of rheumatology criteria for the classification and reporting of osteoarthritis of the hand. Arthritis Rheum. 1990; 33(11):1601–1610. [PubMed: 2242058]
28. Wood KM, Edwards JD, Clay OJ, Wadley VG, Roenker DL, Ball KK. Sensory and cognitive factors influencing functional ability in older adults. Gerontology. 2005; 51(2):131–141. 82199 [pii]. [PubMed: 15711081]
29. Iezzi T, Duckworth MP, Vuong LN, Archibald YM, Klinck A. Predictors of neurocognitive performance in chronic pain patients. Int J Behav Med. 2004; 11(1):56–61. DOI: 10.1207/s15327558ijbm1101_7 [PubMed: 15194520]
30. Hart RP, Martelli MF, Zasler ND. Chronic pain and neuropsychological functioning. Neuropsychol Rev. 2000; 10(3):131–149. [PubMed: 10983898]
31. Buckalew N, Haut MW, Morrow L, Weiner D. Chronic pain is associated with brain volume loss in older adults: Preliminary evidence. Pain Med. 2008; 9(2):240–248. DOI: 10.1111/j.1526-4637.2008.00412.x [PubMed: 18298708]
32. Gijsen CP, Dijkstra JB, van Boxtel MP. Recurrent pain is associated with decreased selective attention in a population-based sample. Pain. 2011; 152(1):188–193. DOI: 10.1016/j.pain.2010.10.029 [PubMed: 21122991]
33. Vandierendonck A. Symbiosis of executive and selective attention in working memory. Front Hum Neurosci. 2014; 8:588.doi: 10.3389/fnhum.2014.00588 [PubMed: 25152723]
34. Verhaeghen P, Steitz DW, Sliwinski MJ, Cerella J. Aging and dual-task performance: A meta-analysis. Psychol Aging. 2003; 18(3):443–460. DOI: 10.1037/0882-7974.18.3.443 [PubMed: 14518807]
35. Luerding R, Weigand T, Bogdahn U, Schmidt-Wilcke T. Working memory performance is correlated with local brain morphology in the medial frontal and anterior cingulate cortex in fibromyalgia patients: Structural correlates of pain-cognition interaction. Brain. 2008; 131(Pt 12):3222–3231. DOI: 10.1093/brain/awn229 [PubMed: 18819988]

36. Baliki MN, Geha PY, Apkarian AV, Chialvo DR. Beyond feeling: Chronic pain hurts the brain, disrupting the default-mode network dynamics. J Neurosci. 2008; 28(6):1398–1403. DOI: 10.1523/JNEUROSCI.4123-07.2008 [PubMed: 18256259]
37. Apkarian AV, Sosa Y, Sonty S, et al. Chronic back pain is associated with decreased prefrontal and thalamic gray matter density. J Neurosci. 2004; 24(46):10410–10415. 24/46/10410 [pii]. [PubMed: 15548656]
38. Moriarty O, McGuire BE, Finn DP. The effect of pain on cognitive function: A review of clinical and preclinical research. Prog Neurobiol. 2011; 93(3):385–404. DOI: 10.1016/j.pneurobio.2011.01.002 [PubMed: 21216272]
39. Royall DR, Palmer R, Chiodo LK, Polk MJ. Normal rates of cognitive change in successful aging: The freedom house study. J Int Neuropsychol Soc. 2005; 11(7):899–909. [PubMed: 16519269]
40. Woollacott M, Shumway-Cook A. Attention and the control of posture and gait: A review of an emerging area of research. Gait Posture. 2002; 16(1):1–14. S0966636201001564 [pii]. [PubMed: 12127181]

Impact statement

We certify that this work is confirmatory of recent novel clinical studies describing a negative effect of chronic pain on cognition in older adults (references below).

However, it is novel that we look at two aspects of pain (severity and interference) and several domains of complex attention (selective, sustained, divided and attentional switching). Lastly, our study population consists of very old community-living adults, who are most at risk for cognitive changes related to chronic pain.

Table 1

Demographic and health characteristics according to pain severity clinical cutpoint groups, adults aged 71 and older, MOBILIZE Boston Study II

Characteristics		**Total**	**None or least pain (n=126)**	**Mild pain (n=165)**	**Moderate to severe pain (n=63)**	**p-value**[*]
				Mean (SD)		
Age(years)		84.54(4.72)	84.07 (4.78)	84.78 (4.76)	84.84 (4.47)	0.38
Education(years)		14.78(2.82)	15.30 (2.59)	14.79 (2.61)	13.73 (3.45)	0.001
				Percent		
Women		65.82	57.14	68.48	76.19	0.02
Race	White	79.94	79.37	85.45	66.67	
	Black	14.41	13.49	10.91	25.40	
	Other	5.65	7.14	3.64	7.94	0.03
Chronic conditions				Percent		
Obesity (BMI ≥30)		20.62	16.67	18.18	34.92	0.01
Arthritis:						
None		68.71	85.83	60.54	54.24	
Knee only		11.04	6.67	14.29	11.86	
Hand only		13.50	7.50	17.69	15.25	
Hand and Knee		6.75	0	7.48	18.64	<.0001
Heart disease		45.19	38.52	47.20	53.33	0.13
Diabetes		13.56	12.70	13.33	15.87	0.83
Depression		5.65	2.38	7.27	7.94	0.14
Psychiatric drugs [a]		20.06	13.49	20.00	33.33	0.01
Analgesic drugs [b]		29.10	15.87	27.27	60.32	<.0001
Low vision		22.36	18.49	24.50	25.00	0.44
Limited hearing		57.06	59.20	59.51	45.76	0.16

[a] Used (anxiolytics, sedatives and hypnotics, antidepressants, and antipsychotics) in the previous two weeks.

[b] Used opioid or non-opiod analgesics in the previous two weeks.

[c] BPI Pain Severity clinical cutpoint groups:

none or least pain, 0–0.99; mild pain, 1–3.99; moderate to severe pain, 4–10.

[*] Chi-square test for categorical variables and ANOVA test for continuous variables significance level at 0.05

Table 2

Attention scores according to BPI pain severity clinical cutpoint groups and interference subscales [a] in adults aged 71 and older, MOBILIZE Boston Study II

		BPI Pain Severity			
TEA Subtests [c]		**None or least pain**	**Mild pain**	**Moderate to severe pain**	**p-value**[a]
	N	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	
Telephone Search Test	335	4.83 (2.34)	5.54 (3.62)	5.87 (3.48)	0.03
Map search	334	38.22 (16.41)	33.54 (15.50)	31.22 (13.75)	0.002
The Telephone Search While Counting Test	309	11.26 (14.22)	9.72 (10.52)	14.31 (19.98)	0.37
Dual task decrement score	306	6.78 (13.43)	4.66 (9.61)	9.26 (18.65)	0.52
Visual elevator	298	4.32 (1.16)	4.58 (1.84)	4.50 (1.35)	0.33
		BPI Interference			
		None or least interference	**Mild interference**	**Moderate to severe interference**	**p-value***
	N	Mean (SD)	Mean (SD)	Mean (SD)	
Telephone Search Test	335	4.83(2.23)	5.85(3.97)	6.41(4.37)	0.001
Map search	334	37.66(15.53)	31.45(16.02)	29.67(13.77)	0.001
The Telephone Search While Counting Test	309	10.25(12.57)	10.82(12.04)	14.42(20.05)	0.09
Dual task decrement score	306	5.63(11.72)	5.57(11.18)	9.16(18.72)	0.16
Visual elevator	298	4.38(1.43)	4.64(1.81)	4.57(1.52)	0.27

[a] Generalized linear models tested unadjusted associations between BPI clinical cut-points and TEA scores; P-value, test for trend (F test) entering pain severity and interference tertiles as ordinal variables in the models.

[b] TEA subtests, 5 scales: selective attention (Telephone Search Test, Map search), sustained attention (The Telephone Search While Counting Test), divided attention (Dual task decrement score) and attentional switching (Visual elevator test).

For all subscales, lower scores indicate better performance except the Map search.

[c] BPI Pain Severity clinical cutpoint groups

0–0.99: none or least pain; 1–3.99: mild pain; 4–10: moderate to severe pain

Table 3

Associations between BPI pain severity and interference scores and attention scores adults aged 71 and older, MOBILIZE Boston Study II

TEA Subtests	**Mean (SD)**	**BPI Pain Severity Score**			
		Model 1[a]		**Model 2**[b]	
		Coefficient	**p-value**	**Coefficient**	**p-value**
Telephone Search Test	5.34 (3.21)	0.18	0.04	0.18	0.04
Map search	34.81 (15.72)	−0.98	0.03	−0.84	0.07
The Telephone Search While Counting Test	11.05 (13.90)	0.77	0.06	0.88	0.04
Dual task decrement score	6.17 (12.96)	0.65	0.10	0.74	0.08
Visual elevator	4.47 (1.55)	0.03	0.56	0.02	0.67
TEA Subtests	**Mean (SD)**	**BPI interference score**			
		Model 1[a]		**Model 2**[b]	
		Coefficient	p-value	Coefficient	p-value
Telephone Search Test	5.34 (3.21)	0.19	0.03	0.19	0.03
Map search	34.81 (15.72)	−0.75	0.08	−0.65	0.15
The Telephone Search While Counting Test	11.05 (13.90)	0.59	0.14	0.52	0.23
Dual task decrement score	6.17 (12.96)	0.56	0.14	0.49	0.23
Visual elevator	4.47 (1.55)	0.01	0.92	−0.01	0.76

[a] Multiple linear regression models, TEA scores were dependent variables; Model 1 adjusted for age, gender, race,education,

[b] Model 2 additionally adjusted for vision, hand arthritis, diabetes, heart disease, BMI and use of psychiatric drugs