<table>
<thead>
<tr>
<th>Title</th>
<th>The effect of pain on cognitive function: a review of clinical and preclinical research.</th>
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<tbody>
<tr>
<td>Author(s)</td>
<td>Moriarty, Orla; McGuire, Brian E.; Finn, David P.</td>
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<table>
<thead>
<tr>
<th>Cognitive variable affected</th>
<th>Cognitive tests sensitive to impaired performance</th>
<th>Type of chronic pain</th>
<th>Pain assessment method</th>
<th>Correlation between pain and cognitive performance</th>
<th>Other parameters investigated</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>Numerical interference</td>
<td>Chronic intractable benign pain of lower back, limb or other n=22</td>
<td>VAS, PPI of MPQ, NRS, pain intensity descriptor scale</td>
<td>No significant correlation between numerical interference task performance and pain scores</td>
<td>No association between age, pain chronicity, gender, anxiety, depression, medication or site of pain and cognitive performance. Cognition not affected in low pain subgroup</td>
<td>Eccleston (1994)</td>
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<tr>
<td>Attention</td>
<td>Stroop task</td>
<td>Chronic intractable benign pain of lower back and other n=33</td>
<td>VAS</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>No association between trait-anxiety or depression and cognition, no association between pain and response accuracy</td>
<td>Grisart and Plaghki (1999)</td>
</tr>
<tr>
<td>Attention</td>
<td>TEA</td>
<td>Fibromyalgia, rheumatoid arthritis and musculoskeletal pain n=60</td>
<td>VAS</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>Age, depression, anxiety, somatic awareness and catastrophizing were accounted for statistically. Opioid use did not affect TEA performance</td>
<td>Dick et al. (2002)</td>
</tr>
<tr>
<td>Attention</td>
<td>Probe task</td>
<td>Chronic low back pain, failed back surgery syndrome, radiculopathy, pain in lower limbs, neuropathy, painful scarring</td>
<td>VAS</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>Chronic pain patients had significantly lower IQ scores than controls on adapted National Adult Reading Test</td>
<td>Veldhuijzen et al. (2006a)</td>
</tr>
<tr>
<td>Attention, maintenance of a working memory trace</td>
<td>TEA, spatial span test (mirror task)</td>
<td>Chronic pain of joints back, limbs or other n=24</td>
<td>NRS, MPQ</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>A subset of patients showed no impairment on TEA, no effect of pain on spatial span orientation test or reading span test</td>
<td>Dick and Rashiq (2007)</td>
</tr>
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<tr>
<td>Attention, working memory, immediate and delayed verbal memory, broad cognitive functioning</td>
<td>Bourdon-Vos test, Digit-span backward test, Story recall subtest of the Rivermead Behavioural Memory Test, MMSE</td>
<td>Chronic visceral, musculoskeletal or neuropathic pain or other (e.g. migraine)</td>
<td>VAS</td>
<td>Significant correlation between working memory performance and pain intensity (r= -0.38, P&lt;0.05)</td>
<td>No association between pain intensity and semantic memory, immediate or delayed verbal memory, or visuospatial memory. Sleep quality and depression did not correlate with cognitive performance. Opioid use and recruitment procedure did not affect task performance. Correlation was significant after adjusting for age.</td>
<td>Oosterman et al. (2010)</td>
</tr>
<tr>
<td>Immediate verbal memory, delayed memory and sustained concentration</td>
<td>WMS-R, PASAT</td>
<td>Fibromyalgia n=30</td>
<td>MPI-PS</td>
<td>Significant correlation between WMS-R general memory (r= -0.35, p&lt;0.05) and PASAT scores (r= -0.36, p &lt;0.05) and MPI-PS pain scores</td>
<td>No association between pain and auditory verbal learning, visual memory. Anxiety and self-reported cognitive complaints were correlated with cognitive performance</td>
<td>Grace et al. (1999)</td>
</tr>
<tr>
<td>Working memory capacity, free recall, and recognition memory</td>
<td>Computer based reading span test, word list recall and recognition tests</td>
<td>Fibromyalgia n=23</td>
<td>MPQ, AIMS pain subscale</td>
<td>Significant correlation between working memory capacity (r= -0.466, p=0.022) free recall (r= -0.607, p=0.002) and recognition memory (r= -0.555, p=0.005) and AIMS pain scores. Significant correlation between free recall (r= -0.441, p=0.031) and MPQ scores</td>
<td>Female subject cohort. No association between pain and information-processing speed or verbal fluency. No association between depression or anxiety and cognitive performance. Self-reported cognitive complaints were correlated with cognitive task performance</td>
<td>Park et al. (2001)</td>
</tr>
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<td>Spatial working and long-term memory</td>
<td>Corsi Block span test, Rey Visual Design Learning test</td>
<td>Fibromyalgia n=20</td>
<td>MPQ, pain experience scale</td>
<td>No significant correlation between Corsi Block span test and Rey Visual Design Learning test performance and pain scores</td>
<td>No association between pain and verbal working or long-term memory, or attention. No association between depression and cognitive performance</td>
<td>Luerding et al. (2008)</td>
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<tr>
<td>Psychomotor efficiency</td>
<td>Grooved pegboard test, Digit vigilance test, Embedded figures test, WAIS-R digit symbol test</td>
<td>Diabetic neuropathy n=42</td>
<td>Clinical examination</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>No association between pain and spatial processing, verbal intelligence, learning, memory, problem solving, or simple motor speed</td>
<td>Ryan et al. (1992)</td>
</tr>
<tr>
<td>Psychomotor efficiency, sustained attention, visual scanning and decision making, mental flexibility</td>
<td>Grooved pegboard test, Digit Vigilance Test, Embedded Figures Test, Trail Making Test</td>
<td>Diabetic neuropathy n=58</td>
<td>Clinical examination</td>
<td>No correlation analysis performed for cognition and pain ratings but diagnosis of neuropathy was correlated with impaired performance on Digit Vigilance Test ($r^2=0.062$, $p&lt;0.05$), Embedded Figures Test ($r^2=0.046$, $p&lt;0.05$), Grooved Pegboard test ($r^2=0.087$, $p&lt;0.05$) and Trail Making test ($r^2=0.027$, $p&lt;0.05$)</td>
<td>No association between neuropathy and memory</td>
<td>Ryan et al. (1993)</td>
</tr>
<tr>
<td>Speed of information processing, attention</td>
<td>P300 latency and amplitude</td>
<td>Fibromyalgia n=34</td>
<td>ACR diagnostic criteria, SF-36 pain subscale</td>
<td>No significant correlation observed between SF-36 pain subscale score and the P300 latency or amplitude</td>
<td>Female subject cohort. No correlation between disease duration or tender point count and P300</td>
<td>Alanoglu et al. (2005)</td>
</tr>
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<td>Cognitive variable affected</td>
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<td>Psychomotor efficiency</td>
<td>Grooved pegboard test</td>
<td>Diabetic neuropathy</td>
<td>Clinical examination</td>
<td>No correlation analysis performed for cognition and pain ratings but diagnosis of neuropathy was correlated with performance on the Grooved Pegboard test (r and p values not quoted)</td>
<td>Retinopathy, vascular disease, nephropathy, coronary artery disease systolic blood pressure and duration of diabetes also affected psychomotor efficiency, no association between pain and problem solving, learning and memory and verbal working memory</td>
<td>Ryan (2005)</td>
</tr>
<tr>
<td>Psychomotor efficiency, broad cognitive functioning, immediate and delayed memory, language and mental flexibility</td>
<td>Grooved pegboard test, MMSE, RBANS immediate and delayed memory and language subtests, Trail Making Test</td>
<td>Chronic Low Back Pain n=163</td>
<td>MPQ-SF</td>
<td>Significant correlation between neuropsychological test scores and MPQ scores (r= -0.17, P&lt;0.001), most strongly between mental flexibility and psychomotor efficiency</td>
<td>Older adult patient cohort. Attention and visuospatial memory were negatively correlated with pain scores but were not significantly impaired in chronic pain patients compared with controls. Depression and presence of comorbidities were not correlated with cognitive performance</td>
<td>Weiner et al. (2006)</td>
</tr>
<tr>
<td>Psychomotor efficiency, working memory</td>
<td>WAIS-III digit-symbol test</td>
<td>Undiagnosed chronic widespread pain</td>
<td>ACR diagnostic criteria, number of pain sites</td>
<td>Significant correlation between digit-symbol test performance and pain status (P=0.04), and between digit-symbol test performance and number of pain sites (P=0.048, r values not quoted)</td>
<td>Male patient cohort. No effect of pain on visual memory, visual constructional ability or recognition memory. Age, education, test centre, smoking, frequency alcohol consumption of depression, number of comorbidities, BMI, physical function and medication affected cognitive performance, but correlation was significant after adjusting for these factors</td>
<td>Lee et al. (2010)</td>
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<tr>
<td>Psychomotor efficiency, working memory, mental flexibility</td>
<td>WAIS-III digit-symbol test, Trail Making Test</td>
<td>Chronic low back pain</td>
<td>SF-36</td>
<td>No significant correlation observed between cognitive performance and SF-36 pain subscale score</td>
<td>No non-pain comparative group included. No effect of gender, height, weight, depression or opioid medication dose on cognitive performance. Opioid treatment improved cognitive performance over study period</td>
<td>Jamison et al. (2003)</td>
</tr>
<tr>
<td>Psychomotor efficiency, working memory, attention, mental flexibility</td>
<td>WAIS-III digit-symbol test, Stroop interference test</td>
<td>Chronic low back pain, lombosciatica, spinal cord injury, osteoarthritis, cervicobrachial neuralgia, postsurgical nerve lesion, multiple sclerosis, CRPS, pachypleuritis n=18</td>
<td>VAS, MPQ</td>
<td>Significant correlation between pain ratings and Stroop interference performance (P= 0.01, r value no quoted)</td>
<td>No non-pain comparative group included. No effect of gender, psychotropic medication use, category of chronic pain or morphine dose on cognitive performance. Morphine treatment improved cognitive performance over study period</td>
<td>Tassain et al. (2003)</td>
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<td>Reaction time</td>
<td>Visual reaction time task</td>
<td>Migraine (interictal) n=60</td>
<td>Diagnosis of migraine according to IHS criteria</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>No effect of pain on attention, verbal and visual memory, perceptual-motor coordination, visual perception or abstract reasoning. No effect of anxiety on cognition. Duration of illness and number of migraine attacks per month correlated with cognitive performance</td>
<td>Calandre et al. (2002)</td>
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<tr>
<td>Reaction time and working memory</td>
<td>Verbal and spatial reaction time and working memory tasks</td>
<td>Chronic whiplash-associated disorder n=30</td>
<td>VAS</td>
<td>Significant correlation between verbal reaction time (r &gt; - 0.80, p &lt;0.05) and VAS score (rated after task)</td>
<td>Medication discontinued for 16hrs before testing</td>
<td>Antepohl et al. (2003)</td>
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<tr>
<td>Reaction time, psychomotor speed</td>
<td>Continuous reaction time test, finger tapping test</td>
<td>Chronic non-malignant pain n=155</td>
<td>VAS</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>No association between pain and PASAT or MMSE performance. Age, gender, education, sedation and type of medication also influenced cognitive performance</td>
<td>Sjogren et al. (2005)</td>
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<tr>
<td>Reaction time, and visuospatial awareness</td>
<td>Performance assessment battery (Manikin test, psychomotor vigilance and 4CRT test)</td>
<td>Persistent spinal pain n=20</td>
<td>MPQ</td>
<td>Significant correlation between Manikin test accuracy and MPQ pain rating index score ( r = -0.301, p = 0.019 )</td>
<td>No association between pain anxiety on cognitive performance</td>
<td>Harman and Ruyak (2005)</td>
</tr>
<tr>
<td>Perceptual learning ability</td>
<td>2-point discrimination</td>
<td>Complex regional pain syndrome n=12</td>
<td>Medical interview</td>
<td>Significant correlation between two-point discrimination thresholds on affected side and MPQ pain rating index score</td>
<td>Edema and stimulus evoked pain did not affect two-point discrimination thresholds</td>
<td>Maihofner and DeCol (2007)</td>
</tr>
<tr>
<td>Executive function</td>
<td>Process dissociation procedure applied to a cued recall task</td>
<td>Chronic musculoskeletal pain and various peripheral neuropathic pain syndromes n=18</td>
<td>NRS</td>
<td>No correlation analysis of task performance and pain rating performed</td>
<td>Medication use did not affect cognition. Pain catastrophising, kinesophobia, pain anxiety symptoms and anxiety scores were negatively correlated with cognitive performance</td>
<td>Grisart and Van der Linden (2001)</td>
</tr>
<tr>
<td>Divided and selective attention, verbal learning and memory and spatial memory</td>
<td>Stroop task, PASAT, CVLT, Rey-Osterrieth Complex Figure Test</td>
<td>Chronic whiplash-associated disorder n=31</td>
<td>Quebec task force on Whiplash-associated Disorder classification</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>Whiplash patients had high hypochondriasis and hysteria scores</td>
<td>Bosma and Kessels (2002)</td>
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<td>Mental flexibility</td>
<td>D-KEFS Trails Number-Letter Switching test</td>
<td>Chronic lower back pain, osteoarthritis, fibromyalgia, peripheral neuropathy, myofascial pain, osteoporosis, spinal stenosis, headache, gout, vulvodynia, carpal tunnel syndrome, costochondritis, oesophagitis, post-herpetic neuralgia, rheumatoid arthritis, trigeminal neuralgia n=56</td>
<td>SF-MPQ</td>
<td>No significant correlation between D-KEFS Trails Number-Letter Switching and SF-MPQ rating (p=0.056)</td>
<td>Older adult subject cohort. No effect of pain on MMSE score, free or paired recall, or psychomotor speed. No effect of depression, opioid use, sleep disturbances, Cumulative Illness Rating Scale score or education on cognition</td>
<td>Karp et al. (2006)</td>
</tr>
<tr>
<td>Executive function and emotional decision making</td>
<td>WCST, IGT</td>
<td>Fibromyalgia n=36</td>
<td>WHYMPI</td>
<td>Significant correlation between WCST (r=-0.23, p=0.03) and IGT (r=-0.25, p=0.02) and pain intensity scores. Significant correlation between WCST (r=-0.25, p=0.02) and IGT (r= -0.25, p=0.02) and pain interference scores</td>
<td>Female subject cohort. Pain patients showed significantly greater harm avoidance but this did not affect cognition. Years since FM diagnosis and duration of pharmacological treatment were correlated with IGT performance</td>
<td>Verdejo-Garcia et al. (2009)</td>
</tr>
<tr>
<td>Emotional decision making</td>
<td>IGT</td>
<td>CRPS, chronic back pain n=38</td>
<td>SF-MPQ</td>
<td>Significant correlation between SF-MPQ rating in chronic back pain group only (r=-0.75, P&lt;0.003)</td>
<td>Pain did not affect WCST performance, attention, short-term memory or general intelligence. Correlation was significant after adjusting for age and pain chronicity</td>
<td>Apkarian et al. (2004a)</td>
</tr>
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<tr>
<td>Broad cognitive functioning</td>
<td>MMSE, CCSE</td>
<td>Migraine, cluster headache and chronic daily headache (during headache intervals) n=196</td>
<td>Diagnosis of migraine and cluster headache according to IHS criteria, chronic daily headache met migraine criteria for individual headaches and incidence exceeded 15 days per month</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>No effect of depression on cognition. MMSE and CCSE rating decreased only during headache intervals (within subjects design). Gender and age significantly affected cognitive performance</td>
<td>Meyer et al. (2000)</td>
</tr>
<tr>
<td>Broad cognitive functioning</td>
<td>MMSE</td>
<td>Diabetic neuropathy, trigeminal neuralgia, CRPS, post-herpetic neuralgia, entrapment syndromes, post-stroke pain, peripheral neuropathies and neuralgias, radiculopathy, lumbar pain, slipped disc, spinal canal stenosis, spondylitis, spondylothesis, surgical trauma, musculoskeletal pain and rheumatologic causes n=1519</td>
<td>VAS, SF-MPQ</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>Type of pain, age, anxiety, depression and obesity also affected cognition but effect of pain was significant after adjusting for these factors. Gender and time since diagnosis were also accounted for</td>
<td>Povedano et al. (2007)</td>
</tr>
<tr>
<td>Broad cognitive functioning</td>
<td>MMSE</td>
<td>FM n=46</td>
<td>SF-MPQ</td>
<td>No correlation analysis performed for cognition and pain ratings</td>
<td>Age, pain severity and presence of anxiety and depression did not affect frequency of cognitive impairment but anxiety and depression scores were higher in FM patients with impaired cognition</td>
<td>Rodriguez-Andreu et al. (2009)</td>
</tr>
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</table>