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ASSOCIATION BETWEEN SUBJECTIVELY EVALUATED COGNITION AND PERFORMANCE IN COMPUTERIZED COGNITION TESTING AMONG AGING WORKERS

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Cognition can be measured with objective tests, but also subjective evaluation is used. This study aimed to examine how subjectively evaluated cognition is comparable to objective test results observed in computerized test pattern. Such association would be significant for quick and reliable cognitive screening in clinical use.

The study population consisted of 283 participants (mean age 62,4 years, SD 1,0, 82% females) from the Finnish Retirement and Aging Study. Self-evaluation of cognition was conducted by questions concerning memory, learning and concentration and objective evaluation with a computerized assessment of cognition; Cambridge Neuropsychological Test Automated Battery (CANTAB). Five CANTAB sub-tests assessing memory, executive function, attention and information processing, were included. Sleep difficulties were measured with Jenkins Sleep Problem Scale and depressive symptoms with Beck Depression Inventory, and they were controlled for the analysis. Analysis of variance was used to compare subjective and objective results.

In subjective evaluation, very good and good answers formed a majority. Memory was evaluated as moderate by 18 % and poor by 2 % of the participants, concentration moderate by 21 % and poor by 3% and learning skills moderate by 32 % and poor by 4 % of the participants. In the analysis, poor self-perceived memory was associated with poorer performance on spatial working memory test. No statistically significant association was found between self-perceived learning or concentration and the cognitive tests.

In conclusion, on aging workers subjective memory concerns were weakly linked to poorer performance in computerized test, that focus on executive function and working memory.

Keywords: aging worker, cognition, memory, concentration, learning

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1 Introduction

On G8 dementia summit in London 2013 it was estimated that dementia affects 35 million people worldwide and the number nearly doubles every 20 years [1]. In Finland over third of people aged over 65 report memory complaints and there are almost 400 000 people having different stage of decrease in cognition. Yearly 14 500 Finns are diagnosed with dementing disorders, and many stay undiagnosed. [2] Early diagnosing of cognitive impairment has gain more importance since the development of neuroprotective drugs. Neuroprotective drugs may not only delay the decrease of cognition but also provide healthy life years, whereas patients without medication may lose independence fairly early and need domiciliary care, assisted living or care in nursing home. The response to medications indisputably varies and the current medications on the market will not solve the problems alone.

Statistics Finland forecast that in 2030 26 % of the population of Finland is aged over 65 and till 2070 the number will rise up to 34% [3]. The aging of population and increasing number of people with dementing disorders will be a challenge to our health care system and therefore there will be need for quick and reliable screening and follow-up systems for the state of cognition. In the modern medical research computerized cognition tests are gaining more importance in comparison to current golden standard paper and pencil tests such as Mini Mental State Examination (MMSE) and Consortium to Establish a Registry for Alzheimer's Disease neuropsychological battery (CERAD). A review article of cognitive testing for older adults identified 17 different computerized test batteries [4]. Computerized tests are expected to be more accurate and comparable, faster to perform, non-dependant of the conducting person and also reasonable in costs. CANTAB, which is used in this study, is one of the many computerized neuropsychological tests, it has been published to be sensitive to separate healthy controls, patients with early-stage Alzheimer's disease (AD) and Parkinson's disease patients [5]. Later it was detected that especially in Paired Associate Learning test both mild cognitive impairment (MCI) and Alzheimer's disease (AD) patients performed significantly poorly [6]. Alongside effective screening, self-perception of memory has raised its importance. It is important for clinical purposes to know how reliable subjective memory complaints are, to be able to react sufficiently.

This paper aimed to examine how subjectively evaluated cognition is comparable to objective test results observed in computerized test pattern. Such association would be significant as the need for quick and reliable cognitive screening in clinical use is rising.

2 Literature review

2.1 Different domains of cognition and it's measurement

Cognition can be divided into several domains and sub-domains and there are several ways for categorisation. Typically, cognitive performance is considered with domains of function. [7] DSM-5 (The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition) defines six key domains of cognitive function which are complex attention, executive function, learning and memory,

language, perceptual motor function, and social cognition. Complex attention includes sustained, selective and divided attention and processing speed. Executive functions consist of planning, decision making, working memory, ability to react to error correction, overriding inhibition, and mental flexibility. Learning and memory; immediate, recent, long-term and semantic memory and implicit learning. Language domain contains expressive and receptive language, grammar and syntax. Perceptual motor function includes abilities under the terms visual perception, visuoconstructional, perceptual-motor, praxis, and gnosis. Social cognition means identification of emotions and mental states. [8]

Cognitive assessment on computerised CANTAB (Cambridge Neurophysiological Test Automated Battery) tests is mainly based on similar classification of cognitive domains as the one defined by DSM-5. It is designed to test visual memory, executive function, attention, verbal/semantic memory, decision making and response control and social cognition. For each examined domain there are more than one test [9].

From the structural point of view organisation of cognition in brain is complex. Cerebral cortex is associated with higher lever processes. Whereas frontal lobe regulates executive functions and short-term memory, it also has connection to limbic systems which makes integration between emotions and cognition possible. Temporal lobe processes auditory information and language and it is responsible for long-term memory with hippocampus. Parietal lobe takes part in language, perception and attention. Occipital lobe is responsible for visual functions.

2.2 Comparison between subjective cognitive complaints and cognitive testing

The validity of subjective memory complaints in comparison to objective evaluation has been researched in many studies. Some studies have detected clear association between self-reported cognitive concerns and poorer performance in cognitive tests [10-14]. In other studies, no significant association between subjective memory symptoms and objective measures was found [15,16]. Summary of the studies, that have compared self-reported cognitive concerns and cognitive test results, are presented in **Table 1**.

Studies differ in many aspects which makes it hard to compare their results directly. Of the studies one was longitudinal with a three-year follow-up time [13], whereas other studies were cross-sectional. In addition, inclusion criteria and recruiting system varied between studies; one study included patients with mild cognitive impairment from database [12], two of the studies included chronic paint patients [10,11], one recruited the participants from clinic patients [14], one used epidemiological data [13]. Participant age varied a lot between studies, youngest participants were in Australian pain patient study (from 22 to 65 years) [10] and the oldest participants were in Chinese study from 65 to 98 years [13]. Self-reported cognition was often asked by simple questions about memory or forgetfulness and in some cases questionnaires, such as The Cognitive Failures Questionnaire or Subjective Memory Complaint, were used. The objective test formats differed between studies.

An Australian study of 41 chronic back pain patients with self-reported cognitive concerns studied the association between subjective and objective performance and found them to be associated on

their data. Participant's age ranged from 22 to 65 years (mean 42.97). Self-reported cognition was evaluated by The Cognitive Failures Questionnaire (CFQ), The Everyday Memory Questionnaire (EMQR) and The Behavior Rating Inventory of Executive Function (BRIEF-A) and compared to non-computerised cognitive tests The Trail-Making Test, The Symbol Digit Modalities Test (SDMT), The Stroop Color and Word Test (Stroop), The Wisconsin Card Sorting Test (WCST) and The Test of Premorbid Functioning (TOPF). Pain, sleep, depression, anxiety, catastrophizing, age and education were taken into consideration. [10] Similarly in another study with chronic pain patients there was found association between poor performance on objective cognitive tests and self-reported cognitive impairment. Study consisted of 72 Norwegian participants with mean age of 43.1 years. Great number of participants showed neurocognitive impairment on objective test. For subjective evaluation participants answered Everyday memory questionnaire (EMQ). Objective testing was conducted using general intelligence test (Wechsler Adult Intelligence Scale – Third Edition (WAIS-III)), Stroop Test for psychomotor speed and attention, the Paced Auditory Serial Addition Task (PASAT) and partly WAIS-III for working memory and verbal learning and some aspects of memory by the California Verbal Learning Test-Second edition (CVLT-II). [11]

Three bigger studies, from USA, China and Turkey, all involving more than 300 participants, described shortly. An USA based study including 397 participants with mild cognitive impairment (MCI) from the Alzheimer's disease Neuroimaging Initiative (ADNI) found cognitive complaints to be related to immediate and delayed episodic memory performance but no association to other cognitive measures or neuroimaging markers was found. Alzheimer disease diagnose acted as an exclusion criterion, whereas as an entry criterion was, that participant had cognitive concern reported by the participant, the informant or the clinician. Study group was aged between 65-84 years. For all participants neuroimaging was conducted and objective cognition was researched with following tests; for episodic memory The Rey Auditory Verbal Learning Test (RAVLT), for executive functions and information processing Wechsler Adult Intelligence Scale-III (WAIS-III) and Trail Making and for language Boston Naming Test, animal and vegetable naming. Analyses were adjusted for age, gender, race, education, MMSE, mood, and apolipoprotein E-4 status. [12] A study on Chinese population, from the Kinmen Neurological Disorders Survey (KINDS) cohort, subjective memory concern (SMC) was related with poorer objective memory performance although no fast cognitive decline or dementia diagnosis was detected in three-year follow-up. Study population consisted of 543 people aged from 65 to 98 years (mean 75.4), included both SMC and non-SMC participants, but participants with dementia or Alzheimer disease were excluded. Memory concerns were asked and for objective assessment of cognition the Cognitive Abilities Screening Instrument (CASI) was conducted. In addition, the Geriatric Depression Scale-Short Version was assessed. Participants with subjective memory concerns scored significantly lower in the CASI and significantly higher in the depressive symptoms than the group without memory concerns. [13] In Turkish study with 405 participants, aged from 55 to 85 years (mean 64.64), the participants with complaint of forgetfulness performed statistically significantly lower in objective cognitive tests (SMMT and VTF). Study population consisted of patients from Physical Therapy and Rehabilitation outpatient with certain excluding criteria concerning mental, neurological, terminal illness. Memory was surveyed by

questioning the participants of forgetfulness and by Subjective Memory Complaint (SMC), objective cognitive tests included, Standardised Mini Mental Test (SMMT), Verbal Fluency Test (VFT) and Clock Drawing Test (CDT). 42% of the participants stated memory concerns. Depressive symptoms were assessed by Geriatric Depression Scale (GDS), and it was found GDS scores to be higher on participants with memory complaint. [14]

In difference to former mentioned studies, two studies found no significant association between subjective evaluation and objective measures. One is a retrospective United Kingdom based study with 800 participants from Whitehall II Cohort, aged between 60.3−84.6 (mean 69.8 years). It found no association between subjective memory concerns and objective assessed cognition. Subjective cognition was studied with questions about memory, concentration, forgetfulness, trouble expressing thoughts, finding words, figuring things or solving problems and speed of thinking. Summary score of cognition was compared to brain MRI result and objective cognition tests, which were following; MMSE, Wechsler Adult Intelligent Scale IV tests (WAIS-IV), lexical and semantic fluency, Boston Naming Test (BNT) and Test of Premorbid Function (TOPF). In this study participants with subjective cognitive complaints were more likely to have self-reported depressive symptoms and many had a history of major depressive disorder. No group differences were found when considering socio-demographics, education, social class, FSIQ (Full Scale Intelligence Quotient), vascular risk, or alcohol consumption. [15] Other study of the two is a longitudinal three-wave study with 331 Australian participants aged over 70 years (between 70-87 years). It studied subjective memory complaints and discovered them to be an early sign of memory impairment and perception of past memory performance. Still, memory complaints were not in line with current memory performance. Association between memory complaints and studied negative affects anxiety and depression was seen, though negative affects were not associated to memory performance. For subjective evaluation of memory participants were asked simple questions and for objective measurements Word recognition, Address recall and Recall of three items were conducted. Anxiety and depression were surveyed by the scales of Goldberg. [16]

2.3 Factors confounding the association between subjective cognitive complaints and cognitive test results

Subjective memory complaints are considered to be affected by several confounders. Depression is often mentioned and found as one of the most important confounders, but also age, sex, occupation, education, sleep, anxiety, catastrophizing and neuroticism have taken into consideration in studies. In Turkish population female gender and low education were found to be risk factors for subjective memory complaints [14], where as in a longitudinal Australian study anxiety and depression were associated to subjective memory complaints but not to performance in objective measurement [16]. Study from United Kingdom found participants with subjective cognitive complaints more likely to have self-reported depressive symptoms or to have a history of major depressive disorder but no group differences, between those with and without subjective complaints, when considering socio-demographics, education, social class, FSIQ (Full Scale Intelligence Quotient), vascular risk, or

alcohol consumption was found [15]. Similarly in Chinese population patients with subjective memory concerns had more depressive symptoms compared to the group without memory concerns. In addition, there was a tendency between subjective memory concerns and female gender, older age, and lower education but no consistent association was found. [13] Self-reported cognitive concerns on chronic pain patients were reported to be in line with objective measurement, independent of age, education and catastrophizing, though must be noted that on patients with anxiety the subjective-objective association was even clearer [10].

3 Materials and methods

3.1 Participants and procedures

The study population consisted of participants of the Finnish Retirement and Aging (FIREA) study, an ongoing longitudinal cohort study of older Finnish adults established in 2013. Detailed description of the FIREA study design has been reported in former research paper .[17] Shortly, the aim of the FIREA study is to follow aging workers from work to full-time retirement to determine how health behaviors and clinical risk factors change during transition to statutory retirement. Participants were first contacted 18 months prior to their estimated retirement date by sending a questionnaire, which is thereafter sent annually four times in total. After responding to the questionnaire participants who live in the Southwest Finland and who were still working, were invited to participate in the clinical sub-study. Baseline measurements for the clinical sub-study were conducted between September 2015 and December 2017 and 287 participants were included. For the current study information on subjective evaluation of cognition and cognition testing was available of 283 participants. The memory statements in the questionnaire were answered fully by 245 participants, in each question there were 37 to 38 non-answering participants. The FIREA study was conducted in accordance with the Helsinki declaration and was approved by the Ethics Committee of Hospital District of Southwest Finland.

3.2 Cognitive tests

Self-perception of memory was conducted by three statements as a part of the questionnaire. The statements were: “My memory is working__.”, “My ability to assimilate new information and learn is__” and “Most often I can concentrate on things__. “. The participants were asked to answer the closest one to their self-perception from options very well, well, moderately, poorly or very poorly. The study population was then re-categorized into four groups: very good, good, moderate and poor. The last group included answers poorly and very poorly.

Cognitive function was measured with six computerised tests from Cambridge Neurophysiological Test Automated Battery (CANTAB). The tests were conducted by trained study nurse during a clinical study visit. Participants arrived fasting due to the blood work but were provided a light snack before cognitive testing.

CANTAB is a computer-based assessment tool including tests for attention and psychomotor speed, executive function, memory and social and emotional cognition. Tests are performed on a touch-

screen computer. The tests selected for FIREA clinical sub-study were motor screening task (MOT) for the general assessment as an initial test; paired associates learning (PAL) for visual memory and new learning; spatial working memory test (SWM) for retention, manipulation of visuospatial information, executive function and strategy use; reaction time test (RTI) for motor and mental response speeds; rapid visual information test (RVP) for sustained attention; and attention switching task (AST) for executive function. The used tests in specific are described in another research paper under FIREA study [18]. In this data motor screening task test (MOT), which is mainly used as an introduction test to familiarize participants to touch screen tasks, did not differentiate the participants and was therefore removed from the statistical analyses.

3.3 Confounders

In this study age, sex, occupation, sleep, and depressive symptoms are taken into consideration as confounders. Participants' date of birth, sex and occupational status were obtained from the pension insurance institute for the municipal sector in Finland (Keva). The occupations were titled in accordance with the International Standard Classification of Occupations (ISCO) and categorized into following three groups: managers and professionals (ISCO classes 1- 2), associate professionals and office workers (ISCO classes 3-4) and service and manual workers (ISCO classes 5-9) [19]. Depressive symptoms were assessed with Beck Depression Inventory (BDI), a widely used 21-item questionnaire to evaluate the severity of depression [20]. Sleep problems were evaluated with Jenkins Sleep Problem Scale which is a four-question survey of the occurrence of sleep related difficulties [21]. Based on the answers the study population was categorized into three groups: 'no sleeping problems', 'some sleeping problems' and 'severe sleeping problems'.

3.4 Statistical analyses

Characteristics of the study population were presented in percentages for categorical variables and in mean values and standard deviations for continuous variables. Analysis of variance (ANOVA) was used to compare computerised test results to self-evaluation of cognition. In addition, trend test was conducted. The association between self-evaluation of cognition and computerized test was examined in two models. In the model 1 age and gender as confounders were taken into consideration. In the model 2 moreover to age and gender also occupation, sleep difficulties and depression symptoms were observed as confounders. Statistical analyses were run on SAS software, SAS version 9.4 (SAS Institute Inc).

4 Results

The characteristics of the study population are shown in the **Table 2**. The mean age of study population was 62,4 years (SD 1,0). Majority of the participants, 83 %, were females. The occupational distribution was following: 35 % upper-grade non-manual, 35 % lower-grade non-manual, 30 % service and manual work. Based on the Jenkins Sleep Problem Scale and re-categorization 26 % of the participants had mild or moderate and 28 % severe sleeping problems. Signs of depression were detected on BDI on 16% of the participants.

Table 2. Baseline characteristics of the study population

		N	%
Gender	Male	49	17
	Female	234	83
Occupation	Upper-grade non-manual	100	35
	Lower-grade non-manual	98	35
	Service and manual work	85	30
Depression	No	236	84
	Yes	46	16
Sleep difficulties	No	130	46
	Mild or moderate	73	26
	Severe	78	28
		Std dev	Mean
Age		1,0	62,4

In **Figures 1 a-c** the study population is divided into groups by the cognition questions asked in the questionnaire. **Figure 1a** shows that 59 % of the participants evaluated their memory good and 20 % very good, only close to 19 % of the participants evaluated their memory moderate and 2% poor. In the evaluation of learning skills, **Figure 1b**, moderate and poor answers appeared more in comparison to memory. 9 % of the participants evaluated their learning skills very good and 55 % good, whereas 32 % moderate and 4 % poor. Answers on ability to concentrate, on **Figure 1c**, were again closer to memory answers. 15 % evaluated their concentration very good, 61 % good and moderate answers were 21 % and poor 3%. In all three categories very good and good answers formed a clear majority.

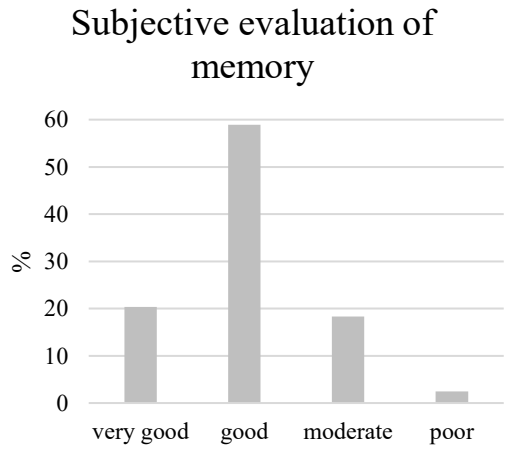

Figure 1a. Distribution of study population by subjective memory evaluation

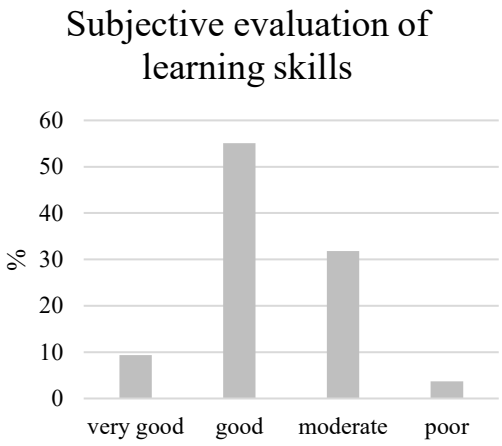

Figure 1b. Distribution of study population by subjective evaluation of learning

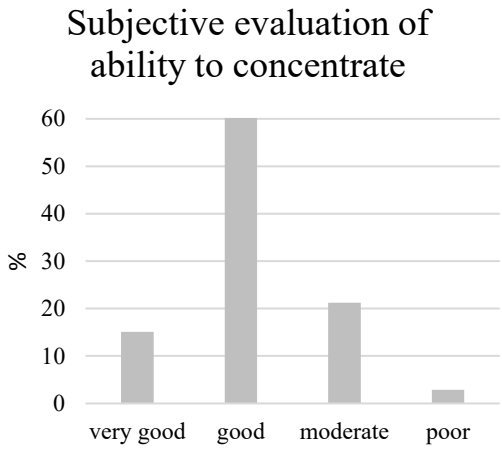

Figure 1c. Distribution of study population by subjective evaluation of concentration

The performance on computerized cognition test in association to self-perception of concentration is shown in the **Table 3**. There was a trending towards poorer performance with poorer rate in self-evaluation of concentration in AST test in Model 1 but not in Model 2. However, no statistical significance was seen in AST test as p-value was 0.75 in Model 1 and 0. 83 in Model 2. In PAL, RVP, RTI and AST tests there was no tendency nor statistical significance to be seen.

Table 4 describes the association between self-perception of memory and the performance in cognition tests. In SWM test there was a tendency with poorer self-evaluation to poorer performance. In Model 1 p-value is 0.03 and in Model 2 p=0.09 which suggest that results were close to statistical significance. Associations with other tests to self-evaluation did not arouse.

Table 5 shows that no association between self-evaluation of learning and any of the cognitive tests were observed.

5 Discussion

On aging workers a weak trend towards poorer performance with poor self-perception of memory on spatial working memory test was observed. Spatial working memory test tests mainly working memory and executive functions. Slight suggestive trend was also detected between poor self-perception on concentration and poor performance in attention switching task test. Similarly to spatial working memory test, attention switching test focuses on executive functions, working memory and planning. It was observed that the more confounders are taken into consideration, the weaker was the subjective – objective association. In other used CANTAB sub-tests, Paired associates learning test, Rapid visual information test, Reaction time test, there was no tendency nor statistically significant differences to be seen. No trend was found between subjective evaluation of learning and any of the CANTAB test.

Both aroused tests (spatial working memory test and attention switching test) that were somewhat sensitive for self-perceived cognitive problems, test executive function and working memory. Executive functions include cognitive flexibility and inhibitory control, they are responsible for several skills like paying attention, organizing, planning, prioritising, focusing and completing tasks, self-monitoring and regulating emotions. To sum it up, executive functions are considered higher-lever cognitive skills and they are needed in different tasks of working life. Similarly working memory is highly needed in tasks from simple to complicate. These days in many fields work is cognitively demanding whereas uncomplicated tasks can be machined. We need executive functions to survive the everyday work tasks and it might be that slight changes in cognition can be noticed for example in use of new computer programs or machines or when adapting some changes in practises. These subtle changes might be then understood for example as bad memory, lack of concentration or poor learning. Executive functioning is considered as part of human's higher-order cognition and located in prefrontal regions of frontal lobe with connections several brain regions. Because of the wide importance on many functions and connections on many brain areas it might be why it aroused in this study with rather little subjective cognitive impairment.

The results of this study suggest that with certain cognition tests subjective evaluation can be linked to objective performance, similar to stronger findings were made in other studies with different cognition assessment tools [10-14]. In comparison there were also studies lacking such findings. [15,16] Different studies and used assessment tools are listed in **Table 1**. Main differences to the compered studies were age-distribution, employment status, frequency of subjective memory concerns and used assessment tools. In this study all participants were in their early 60s (mean 62,4 years, SD 1.03), whereas in other studies age ranged wider from 22 to 65 years [10] to a range between 65 and 98 years [13]. No other study included only employed participants but in comparison some study populations included high amount of illiterate participants [13,14], whereas others had participants with mild cognitive impairment (MCI) [12] and in two studies the study population was outlined only to pain patients [10,11].

This study assessed cognition with three simple statements on a questionnaire; "My memory is working__.", "My ability to assimilate new information and learn is__" and "Most often I can

concentrate on things__. ". Each statement was left empty by around 13 % of participants that attended the clinical phase of the study (37 to 38 people). This rather big number of non-answers rouses a question whether changes of cognition are too personal to talk about or hard to evaluate and what would be a best way gather self-perception of cognition. Subjective cognition was assessed very differently between the other studies, at the simplest with one question "Do you have trouble with your memory?" [13], or "Do you feel you have more problems with your memory than most?" [12] but some studies included one to few questions and a certified survey. Everyday memory questionnaire (EMQ) was used as only questionnaire [11], and with The Cognitive Failures Questionnaire (CFQ) and The Behavior Rating Inventory of Executive Function (BRIEF-A) [10]. One study assessed cognition by asking "Do you have forgetfulness?" and by conducting Subjective Memory Complaint (SMC) Scale [14]. The studies that found no subjective-objective association evaluated subjective cognition with basic questions without certified polls. "Do you have more trouble remembering things that have happened recently?", "Are you worse at remembering where belongings are kept?", "Do you have trouble recalling conversations a few days later?" and "Do you have more trouble remembering appointments and social arrangements?" [16]. "In the past month, have you noticed any problems with forgetting things?", "In the past month, have you had any problems in concentrating on what you are doing?" were asked and in the later phase of the study participants were asked to assess whether they have forgetfulness, poor concentration, trouble expressing thoughts, trouble finding the right word, slow thinking speed or trouble figuring things out or solving problems during the last week [15].

Similarly to subjective evaluation also objective evaluation of cognition differed widely between the studies. There is a trend towards using more computerised assessment but still many established paper and pencil tests are being used. When it comes to computerised cognition testing few other studies have similarly found computerized tests useful for identifying memory problems. Compered to this study, different sub-test of CANTAB arouse to be indicative for assessing memory complainers. Italian study with 72 subjective memory complainers were assessed with three CANTAB tests; Paired associates learning (PAL), Spatial working memory (SWM) test and Pattern recognition memory (PRM). By the result PAL test was considered being sensitive for identifying people with subtle cognitive deficits [22]. In addition Finnish study, that examined the diagnostic accuracy of the Paired associates learning (PAL) in differentiating between normal aging, mild cognitive impairment (MCI) and Alzheimer's disease (AD), similarly suggested PAL test to be useful for finding AD-typical memory impairment [23].

Among this study population there was only low percentage of participants who reported poor or very poor memory (2 %), concentration (3 %) or learning (4 %). It is interesting if the first signs of impairment of cognition are discreet enough not to be noticed subjectively or wouldn't there be more cognitive impairment to be found. Also all participants were in their last years of work career which leads to thinking weather learning, memory and concentration skills are in similar use than in earlier working years and is there association with the low percentage of self-reports. In other research papers, studying the subjective objective association, the number of subjective complaints was higher. Among chronic pain patients all had subjective cognitive concerns [10], the USA study included only

participants with mild cognitive impairment (MCI) [12], and in the Chinese study around half of the participants subjectively evaluated having memory problems [13] where as in the Turkish study 42.5% of participants complained of forgetfulness [14]. Also in the study that found no subjective – objective association there was a high percentage of memory complainers (41%) [15]. These differences can be explained by the including and excluding criteria between studies but also by the rather young age (early 60s) in this study population and by the fact that all participants were during study still employed. The ones retired for cognitive problems or other severe health issues are missing from this study population. In addition, a comparison between FIREA survey responders and clinical study participants showed clinical sub-study participants to be healthier, younger, with higher occupational position than the FIREA survey responders but no difference in self-reported memory difficulties was detected [18].

There are many strengths in this study. The clinical study population was homogenous in age and participants were similar in relation to cognitive complaints and health issues in comparison to the survey attendees. Objective assessment of cognition was conducted with a modern and widely researched computerised test (CANTAB). As limitations must be noted the small number of cognitive complaints, rather high number of non-answers in cognitive questions and the lack of follow-up measurements of cognition in this study paper.

6 Conclusion

A weak trend towards poorer performance with self-reported memory concerns was found when testing for working memory and executive functions. The findings suggest that in relatively healthy population of aging workers, the first subtle changes of cognition can be noticed on executive functions and working memory by participants themselves. Further studies will hopefully offer more information on how cognitional changes will evolve and are they linked to the early concerns of cognition.

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Table 1. Overview of the research papers studying subjective objective association of cognition.

Author	Study population	Age range (mean)	Self -reported measure	Cognitive tests	Main results
Baker et al, 2018	41 Australian chronic back pain patients	22 to 65 (42.97)	The Cognitive Failures Questionnaire (CFQ), The Everyday Memory Questionnaire (EMQ), The Behavior Rating Inventory of Executive Function (BRIEF-A)	The Trail-Making Test, The Symbol Digit Modalities Test (SDMT), The Stroop Color and Word Test (Stroop), The Wisconsin Card Sorting Test (WCST), The Test of Premorbid Functioning (TOPF)	Association between subjective and objective performance was found.
Landrø, et al., 2013	72 Norwegian chronic pain patients	30 to 63 (43.1)	Everyday memory questionnaire (EMQ)	Wechsler Adult Intelligence Scale – Third Edition (WAIS-III), Stroop Test, the Paced Auditory Serial Addition Task (PASAT), the California Verbal Learning Test-Second edition (CVLT-II)	Association between poor performance on objective cognitive tests and self-reported cognitive impairment was found on chronic pain patients.
Gifford et al., 2015	397 American participants with MCI	65 to 84 (not reported)	Reported by participant, informant or clinician.	The Rey Auditory Verbal Learning Test (RAVLT), Wechsler Adult Intelligence Scale-III (WAIS-III), Trail Making, Boston Naming Test, animal and vegetable naming.	Subjective cognitive complaints were associated to immediate and delayed episodic memory performance.
Wang et al., 2000	543 Chinese participants	65 to 98 (75.4)	Reported by participant.	Cognitive Abilities Screening Instrument (CASI).	Subjective memory concern was associated with poorer objective memory performance.
Acikgoz et al., 2014	405 Turkish participants	55 to 85 (64.64)	Question about forgetfulness, Subjective Memory Complaint (SMC)	Standardised Mini Mental Test (SMMT), Verbal Fluency Test (VFT), Clock Drawing Test (CDT)	Participants with subjective forgetfulness complaint performed lower in objective cognitive tests.
Topiwala et al., 2021	800 participants from United Kingdom	60 to 85 (69.8)	Questions about memory, concentration, forgetfulness, trouble expressing thoughts, finding words, figuring things or problem solving and speed of thinking.	Montreal Cognitive Assessment (MoCA), Trail Making Test, ReyOsterrieth Complex Figure (RCF) copying, RCF immediate and delayed recall, Hopkins Verbal Learning Test (HVLT-R, HVLT DR, HVLT TR), Wechsler Adult Intelligent Scale-IV, lexical and semantic fluency, Boston Naming Test (BNT), Test of Premorbid Function (TOPF) and Mini Mental State Examination (MMSE).	No association was found between subjective memory concerns and objective assessed cognition.
Jorm et al, 2001	331 Australian participants	70 to 87 (74.82)	Questions about everyday memory.	Word recognition, Address recall, Recall of items.	Subjective memory complaints were not associated with current memory performance. Subjective memory complaints were discovered to be an early sign of memory impairment and perception of past memory performance.

Table 3. The performance on computerised cognition tests in association to self-evaluation of concentration.

Concentration															
	PAL			SWM			RTI			RVP			AST		
Model 1	Mean	95% Cl		Mean	95% Cl		Mean	95% Cl		Mean	95% Cl		Mean	95% Cl	
very good	0,01	-0,34	0,36	0,21	-0,14	0,56	0,01	-0,34	0,35	0,33	-0,01	0,66	0,23	-0,11	0,58
good	-0,06	-0,25	0,14	0,04	-0,15	0,24	0,03	-0,17	0,22	0,14	-0,05	0,32	0,20	0,01	0,39
moderate	0,01	-0,28	0,31	0,08	-0,22	0,38	-0,14	-0,43	0,16	0,07	-0,22	0,35	0,18	-0,11	0,47
poor	0,10	-0,65	0,85	0,16	-0,59	0,92	0,14	-0,60	0,89	0,44	-0,28	1,15	0,13	-0,60	0,87
p-value	0,80			0,74			0,63			0,49			0,75		
Model 2															
very good	-0,03	-0,43	0,37	0,07	-0,34	0,47	0,20	-0,20	0.59	0,26	-0,11	0,63	0,11	-0,28	0,50
good	-0,07	-0,31	0,18	-0,03	-0,28	0,22	0,15	-0,09	0.27	0,16	-0,07	0,38	0,18	-0,06	0,41
moderate	-0,01	-0,32	0,30	0,07	-0,24	0,38	-0,08	-0,39	0.22	0,11	-0,17	0,40	0,14	-0,16	0,44
poor	0,20	-0,56	0,95	0,27	-0,49	1,04	0,01	-0,74	0.89	0,60	-0,10	1,30	0,28	-0,46	1,01
p-value	0,71			0,73			0,22			0,93			0,83		

Model 1. Analyses are adjusted for age and gender.

Model 2. Analyses are adjusted for age, gender, occupational position, depression, and sleep difficulties.

PAL= paired associates learning, SWM= spatial working memory test, RTI= reaction time test, RVP= rapid visual information processing, AST= attention switching task

Table 4. The performance on computerised cognition tests in association to self-evaluation of memory.

Memory															
	PAL			SWM			RTI			RVP			AST		
Model 1	Mean	95% Cl		Mean	95% Cl		Mean	95% Cl		Mean	95% Cl		Mean	95% Cl	
very good	-0,07	-0,38	0,23	0,30	0,00	0,60	-0,04	-0,34	0,26	0,14	-0,14	0,43	0,20	-0,09	0,50
good	-0,01	-0,21	0,20	0,11	-0,09	0,31	0,00	-0,20	0,20	0,25	0,06	0,44	0,21	0,01	0,40
moderate	-0,08	-0,38	0,22	-0,23	-0,53	0,07	-0,07	-0,37	0,23	-0,09	-0,37	0,20	0,17	-0,13	0,46
poor	0,25	-0,55	1,06	0,18	-0,63	0,98	0,53	-0,27	1,33	0,59	-0,16	1,35	0,39	-0,39	1,17
p-value	0,76			0,03			0,62			0,62			0,97		
Model 2															
very good	-0,14	-0,50	0,22	0,23	-0,14	0,59	0,10	-0,26	0,46	0,13	-0,20	0,46	0,12	-0,23	0,46
good	-0,03	-0,27	0,21	0,08	-0,16	0,32	0,08	-0,16	0,32	0,27	0,05	0,49	0,18	-0,05	0,41
moderate	-0,08	-0,40	0,24	-0,23	-0,55	0,10	-0,02	-0,34	0,30	-0,01	-0,30	0,28	0,15	-0,16	0,45
poor	0,33	-0,48	1,15	0,21	-0,61	1,03	0,45	-0,37	1,26	0,55	-0,20	1,30	0,37	-0,41	1,15
p-value	0,55			0,09			0,87			0,82			0,74		

Model 1. Analyses are adjusted for age and gender.

Model 2. Analyses are adjusted for age, gender, occupational position, depression, and sleep difficulties.

PAL= paired associates learning, SWM= spatial working memory test, RTI= reaction time test, RVP= rapid visual information processing, AST= attention switching task

Table 5. The performance on computerised cognition tests in association to self-evaluation of learning.

Learning														
	PAL			SWM			RTI			RVP			AST		
Model 1.	Mean	95% Cl		Mean	95% Cl		Mean	95% Cl		Mean	95% Cl		Mean	95% Cl	
very good	-0,08	-0,52	0,36	0,10	-0,34	0,54	0,00	-0,44	0,43	0,33	-0,09	0,75	0,27	-0,17	0,70
good	-0,03	-0,23	0,18	0,09	-0,12	0,29	-0,02	-0,22	0,18	0,12	-0,08	0,31	0,17	-0,03	0,37
moderate	-0,03	-0,27	0,21	0,05	-0,19	0,30	0,01	-0,23	0,24	0,14	-0,08	0,37	0,23	-0,01	0,46
poor	0,01	-0,66	0,68	0,07	-0,61	0,75	0,04	-0,63	0,71	0,53	-0,10	1,17	0,16	-0,51	0,82
p-value	0,86			0,82			0,86			0,86			1,00		
Model 2															
very good	-0,14	-0,63	0,35	-0,07	-0,57	0,43	0,19	-0,30	0,68	0,21	-0,25	0,67	0,11	-0,37	0,59
good	-0,04	-0,29	0,22	0,00	-0,26	0,27	0,09	-0,16	0,35	0,13	-0,11	0,37	0,14	-0,11	0,39
moderate	-0,05	-0,31	0,21	0,03	-0,23	0,29	0,06	-0,19	0,32	0,16	-0,08	0,40	0,19	-0,07	0,44
poor	0,04	-0,63	0,71	0,13	-0,56	0,82	0,02	-0,66	0,69	0,68	0,05	1,30	0,26	-0,39	0,92
p-value	0,77			0,65			0,63			0,50			0,65		

Model 1. Analyses are adjusted for age and gender.

Model 2. Analyses are adjusted for age, gender, occupational position, depression and sleep difficulties.

PAL= paired associates learning, SWM= spatial working memory test, RTI= reaction time test, RVP= rapid visual information processing, AST= attention switching task