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Are subjective cognitive complaints related to memory functioning in the working population?

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Abstract

Background: Cognitive functioning is important for managing work and life in general. Some experience problems with cognitive functioning, often referred to as subjective cognitive complaints (SCC). These problems are rather prevalent in the working population and can be coupled with both lowered well-being and work ability. However, the relation between SCC and memory functioning across the adult age-span, and in the work force, is not clear as few population-based studies have been conducted on non-elderly adults. Thus, the present study aimed to test the relation between SCC and actual declarative memory functioning in a population-based sample of employees.

Methods: Participants were 233 employees with either high (cases) or low (controls) levels of SCC. Group differences in neuropsychological tests of semantic and episodic memory, as well as episodic memory performance during higher executive demands (divided attention) were analysed through a set of analyses of covariance tests.

Results: Significantly poorer episodic memory performance during divided attention (i.e. high executive demands) was found in the group with high SCC compared to controls with little SCC, while no group differences were found in semantic memory. No group differences were found in immediate or delayed episodic memory during focused attention conditions. Furthermore, depressive symptoms, chronic stress symptoms and sleeping problems were found to play a role in the relation between SCC and episodic memory during divided attention.

Conclusions: This study contributes to an increased understanding of what characterizes SCC in the work force and suggests a relation to poorer executive cognitive functioning.

Keywords: Subjective cognitive complaints, Subjective cognitive impairment, Subjective memory impairment, Declarative memory, Memory performance, Population-based, Employed, Semantic memory, Episodic memory, Executive cognitive functioning

Background

Proper cognitive functioning is essential for adequate performance in working life and for managing life in general. However, some individuals experience problems with cognitive functioning, such as frequent forgetfulness and difficulties concentrating, making decisions and thinking clearly. The subjective experience of having problems with cognitive function is often referred to as subjective cognitive complaints (SCC).

SCC are common among elderly people and may be attributable to cognitive aging processes that are natural or pathological (Geerlings et al. 1999; Jonker et al. 2000; Jonker et al. 1996; Lam et al. 2005; Treves et al. 2005; Stewart 2012). However, SCC are also present among non-elderly adults (Lozoya-Delgado et al. 2012; Podewils et al. 2003; de Leon JM et al. 2010; Scholtissen-In de Braek et al. 2011; Vestergren & Nilsson 2011; Stenfors et al. 2013).

Approximately 10% of the Swedish work force report having at least one type of cognitive difficulty "often" (Stenfors et al. 2013).

While SCC may be troublesome to the individual, the relationship between SCC and actual cognitive function is not clear. A better understanding of what SCC represent is important for the prevention and treatment of SCC.

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Previous research among elderly adults (approximately 65+ years) has shown a relatively mixed picture of the relationship between SCC and cognitive functioning. Some studies have demonstrated a weak relationship or even a zero correlation (e.g., Reid & Maclullich 2006), while others have found relations to cognitive functional decline, (e.g., Jessen et al. 2010; Reisberg et al. 2010).

When it comes to non-elderly adults, relatively few studies exist on SCC in relation to actual cognitive functioning. SCC in this age-group has been found related to poorer episodic memory in a general population sample (Podewils et al. 2003), middle-aged employees (Rijs et al. 2012; Reid et al. 2012) and a community sample (de Leon JM et al. 2010) where SCC were also related to poorer executive functioning. But others have found little association between SCC and cognitive function (Scholtissen-In de Braek et al. 2011; Bassett & Folstein 1993), except among those that were retarded or demented. However, the measures in Bassett and Folstein's (Bassett & Folstein 1993) study were limited to one question about subjective memory and one test of delayed episodic recall (limited to three object names).

Thus, findings from previous studies of non-elderly adults are still inconclusive.

The aetiology of SCC among younger adults may differ from that in the elderly to some extent. Non-elderly adults more often report stress and related constructs like tension and emotional problems as causes of their SCC, while elderly more often report aging as the cause (Vestergren & Nilsson 2011; Ponds et al. 1997). SCC among younger adults have also been related to work stressors (Stenfors et al. 2013; Albertsen et al. 2010) and other stress symptoms (Lozoya-Delgado et al. 2012). Many other lines of research have shown detrimental effects of acute and chronic stress and related allodynamic processes on cognitive and brain functioning especially in prefrontal cortical and medial temporal (hippocampal) regions, e.g. (Juster et al. 2010; McEwen & Gianaros 2011; Liston et al. 2009; Qin et al. 2009; Sandström et al. 2012).

Related problems that are common in the working population and that are also associated with SCC and cognitive functioning in the domains of episodic memory and executive functioning are depressive symptoms (Reid et al. 2012; Murrough et al. 2011) and sleeping problems (Stenfors et al. 2013; Walker 2008; Walker 2009). Thus, stress-related processes, affective problems and sleep are plausible factors affecting SCC and memory functioning in the working population.

Thus, the aim of the present study was to test the relationship between SCC and declarative memory functioning, as well as the role of chronic stress, depressive symptoms and sleeping problems in relationships between SCC and declarative memory functioning. Declarative long term memory is usually divided into two subcomponents, episodic and semantic memory, respectively, with different functions and different localization in the brain (Tulving 1992). Episodic memory concerns memories of the personal past. It requires a conscious recollection of a previous event or episode defined in time and space. Semantic memory concerns memory of general knowledge and facts in the world and the personal past of the individual not related to time and place of a study episode. Episodic memory processing has been structurally localized to the medial-temporal lobe, including hippocampus and with supporting pathways from executive functional networks in prefrontal cortical (PFC) regions (Tulving 2002; Kim et al. 2009), while semantic memory functioning has been associated with the posterior cortices and left frontal regions (Kompus et al. 2009).

It was predicted that those cognitive functions that depend more on hippocampal and PFC brain structures and have been found more sensitive to both stress exposure, affective and related problems, as well as the development of dementia (i.e. age-related), would be related to the level of SCC among employees.

Specifically, it was predicted that a higher level of SCC would be related to poorer episodic memory performance.

Since semantic memory has been found to be less prone to decline from degenerative processes (Kaufman & Horn 1996; Salthouse & JINS 2010) and instead is related to education and pre-morbid intellectual ability (Almkvist & Tallberg 2009; Almkvist et al. 2007), it was predicted that the level of SCC would *not* be related to semantic memory performance.

Moreover it was predicted that the effect of SCC level on episodic memory performance would be more pronounced during divided attention (DA) conditions that tap more prefrontal cortical dependent executive cognitive functioning, than during focused attention (FA).

Since considerable co-occurrence has been observed between SCC, frontal lobe functioning and other common symptoms of chronic stress, depression and sleeping problems (Stenfors et al. 2013; McEwen & Gianaros 2011; Sandström et al. 2012; Murrough et al. 2011; Walker 2009), additional analyses testing the potential role of these symptoms in any relations between SCC and declarative memory function were also performed.

Method

Participants and study design

Participants were recruited from the 2010 wave of the Swedish Longitudinal Occupational Survey of Health (SLOSH)- a longitudinal study of work environment and health among Swedish employees conducted biennially.

The SLOSH 2010 sample is based on the respondents to the nationally representative Swedish Work

Environment Surveys (SWES) conducted biennially. (See, e.g., Magnusson Hanson et al. 2008; Leineweber et al. 2012). Participants from SWES 2003, 2005 and 2007 are included in SLOSH 2010 and the age range of the sample is 16-64 years.

A total of 11525 subjects participated (57% response rate) in SLOSH 2010 and 9132 of the participants were gainfully employed- i.e. they were in gainful employment during the past three months at a level of 30% of full time or more.

Gainfully working participants in Stockholm county and the counties surrounding the city of Gothenburg were invited to the study based on their recently reported levels of SCC.

An experimental case group was defined, consisting of those reporting a "high" level of SCC with a mean level of ≥3.25 (scale 1-5/Never-Always). This corresponds to reporting that at least one of the 4 cognitive problems is experienced "Often" or more, and the other three problems at least "Sometimes". This cut-off was based on face validity and on the distribution of SCC in the gainfully working part of the SLOSH population (8943 people), where a SCC score ≥3.25 corresponds to approximately the top decile of the distribution of SCC. The experimental control group on the other hand consisted of people with a "low" level of SCC defined as a SCC score ≤2.0. This corresponds to experiencing the 4 cognitive problems "Seldom" or less on average, and belongs to approximately the bottom 50% of the distribution of SCC scores in the gainfully working part of the SLOSH population.

All 352 identified cases and 941 case-matched controls were invited. Controls were matched to the cases on geographical area, age, sex, and educational level. More controls were invited in order to increase the possibilities to get matching controls for each case deciding to participate.

A total of 233 participants took part in the study, out of which 116 (30 men, 86 women) were cases, and 117 (26 men, 91 women) were controls.

Seven individuals were excluded from the study due to known possible brain injury, such as prior head trauma, stroke, or chemical poisoning, as well as psychotic illness, or other illness conditions at the time of testing. The sample of eligible participants thus consisted of 112 cases and 114 controls.

Cases were 25-67 years and controls were 29-66 years of age. See Table 1 for sample characteristics of the case and control groups.

Test scores potentially affected by insufficient vision and Swedish language proficiency were excluded.

Those consenting to participate were given an appointment in Stockholm or Gothenburg for neuropsychological testing within approximately 4-16 weeks of responding to the SLOSH questionnaire.

Neuropsychological tests of declarative memory

Episodic memory

Face Recognition (Nilsson et al. 2004; Nilsson et al. 1997): Participants were presented with 16 colour photographs of faces of 10-year-old children, and given a delayed free choice (yes/no) recognition test. The performance score was the number of hits (i.e. a yes response to a target face- i.e. a face that had been shown at encoding) minus false alarms (a yes response to a non-target face that had not been shown at encoding), i.e. the d prime score.

Immediate free recall (IFR) of words, during FA and DA (Nilsson et al. 2004; Nilsson et al. 1997): In this test participants were presented auditorily with four word lists with 12 items in each list that were presented at a rate of 1 word every 2 seconds. Immediately after each word list had been presented, the participants were asked to recall as many of the words from the presented list as possible in any order (i.e. *free* recall) during 45 seconds. Participants were instructed to say aloud one recalled word for each ticking sound (i.e. each 2 second interval), without paying attention to if they cannot recall a word for each time interval. A concurrent card-sorting task, forcing the division of attention (DA), was given for conditions 2 (at encoding), 3 (at recall) and 4 (both at encoding and recall), while condition 1 was performed without any concurrent card-sorting (i.e. with FA). The card-sorting task consisted in sorting a deck of cards with a square in the centre coloured either red or black into two piles- one "red" and one "black" pile- sorting one card every 2 seconds.

A time indicator (giving a small ticking sound every 2 seconds) was used to standardise the rate of presentation and the magnitude of distraction for all of the words at encoding or recall both within and across the four conditions. The order of the four word lists was counterbalanced across participants in each SCC group.

In all four conditions, the performance score was the number of correctly recalled words from the study list.

Delayed free recall of words: In this test the participants were asked to freely recall (i.e. in any order) as many words as possible from the previously studied word lists from the test *IFR*. Participants had 2 minutes for recall. The delay period between encoding (i.e. completion of the test *IFR*) and the testing of *delayed free recall of words* was approximately 5 minutes long, during which another unrelated test without word material was administered. The performance score was the total number of correctly recalled words.

Semantic memory

Vocabulary: A revised, 30-item multiple-choice synonym test (Dureman 1960) was used as an index of semantic

Table 1 Characteristics of groups with a low vs. high level of SCC

Measure (scale)	Low SCC				High SCC				t-test	Pearsons chi^2
	N	% within low SCC	Mean	SD	n	% within high SCC	Mean	SD	t $^{sign.\ level}$	Chi$^{2\ sign.\ level}$
N	114	100			112	100				
Sex:										.53
Male	26	22.8			27	24.1				
Female	88	77.2			85	75.9				
Age	114		48.66	10.08	112		48.69	10.66	-.02	
Education:										1.98
Upper secondary or lower	37	32.5			40	35.7				
Univ.studies < 2 years	9	7.9			14	12.5				
Univ. studies ≥ 2 years	68	59.6			58	51.8				
Yearly income (1000's SKR)	114		389.79	190.94	112		334.82	153.99	2.38*	
SCC (1-5)	114		1.56	.39	112		3.72	.47	-37.80***	
Emotional exhaustion index (1-6)	114		1.66	0.79	111		3.56	1.34	-12.89***	
Depressive symptoms index (1-5)	114		1.49	0.56	111		3.16	1.04	-14.98***	
Disturbed sleep, prevalence	8	7			59	52.7				60.50***
Awakening problems, prevalence	20	17.5			57	50.9				29.76***
CVD, prevalence	3	2.6			6	5.4				1.10
Diabetes, prevalence	3	2.6			4	3.6				.17
Non-specific psych. illness, prevalence	1	0.9			15	13.4				13.76***
SMBQ[†]	114		2.33	0.94	112		4.50	1.33	-14.12***	
Mental fatigue/cognitive subscale	113		2.04	0.91	112		4.50	1.40	-15.69***	
Depressive symptoms index[†]	114		1.55	0.64	112		3.40	0.71	-12.51***	
MDI score[†]	114		4.78	4.59	112		16.71	10.55	-10.99***	
Mild, prevalence	1	0.9			14	12.5				
Moderate, prevalence	1	0.9			14	12.5				
Severe, prevalence	0	0			14	12.5·				

SKR = Swedish crowns; SMBQ = Shirom Melamed burnout questionnaire; MDI = major depression inventory.
[†]Collected at the laboratory test occasion.
*p < 0.05 **p < 0.01 ***p < 0.001.

knowledge. The task involved selecting the synonym of each target word from among five alternatives within 7 minutes. The performance score was the number of correctly identified synonyms.

Semantic Fluency: Two fluency tasks were administered in which the participants were instructed to generate aloud as many words as possible in 1 min. The first task was to produce words beginning with the letter A. The second task was to produce professions beginning with the letter B (Nilsson et al. 2004; Nilsson et al. 1997). While fluency tests tap semantic memory functioning, it should be pointed out that (especially letter-) fluency tasks also rely on executive processes and associated prefrontal cortical brain regions (e.g., Birn et al. 2010). This has been most evident in patients with severe/manifest prefrontal brain damage becoming severely impaired on fluency tasks. However, in the present study with participants that do not have any known brain damage, the fluency tests were used primarily as measures of semantic memory functioning.

The performance score for each fluency test was the number of correctly generated words.

Questionnaire measures from SLOSH 2010

Subjective cognitive complaints (SCC) were measured by four questions about difficulties during the past 3 months with concentration, memory, decision-making, and ability to think clearly (e.g. *Have you had difficulties with remembering?*) on a scale of 1-5/'Never'-'Always'. The scale was adopted from the Copenhagen Psychosocial Questionnaire (Kristensen et al. 2005) originally from The Stress Profile questionnaire (Setterlind & Larsson 1995). An index was created from the mean score of the four questions. The case and control groups were defined based on this SCC index into a high SCC group having a SCC score ≥3.25, corresponding to the presence of at least one of the SCC 'always' or 'often' on average, and a low SCC group having a SCC score ≤2.0, corresponding to the presence of SCC 'seldom' or 'never' on average.

Chronic stress symptoms were measured by the Maslach Burnout Inventory General Survey, using the subscale of *emotional exhaustion* measured by 5 items (in the form of propositions, e.g. *I feel completely worn out at the end of a working day*) on a scale of 1-6/'A few times a year or less'-'Every day'. The subscale has proved to be the most robust and reliable (Schaufeli & Enzmann 1998; Vingård et al. 2001).

Depressive symptoms were measured by six items (e.g. *How much have you been troubled by feeling blue?*) on a scale of 1-5/Not at all-Very much, selected from the Hopkins Symptom Checklist depression subscale (SCL-90, Lipmann 1986). Mean scores were used (see Magnusson Hanson et al. 2009).

Sleeping problems The established and validated measures Disturbed sleep index (DSI) reflecting lack of sleep continuity (e.g. *How often have you been disturbed by repeated awakenings with difficulties going back to sleep?*) and the Awakening index (AI) reflecting feelings of being insufficiently restored (e.g. *How often have you been troubled by not feeling rested at wake-up?*) during the past 3 months, were used. Dichotomised variables were used indicating the presence or absence of sleep disturbances and awakening problems, based on four and three items respectively (Åkerstedt et al. 2002; Kecklund & Åkerstedt 1992; Åkerstedt et al. 2008).

Other potential confounders considered Age, gender, attained educational level ('upper secondary school or lower', 'undergraduate studies <2 years', 'undergraduate studies >2 years); yearly income from work; and the presence of cardiovascular disease, diabetes or (unspecific) psychiatric illness.

Indices based on mean scores of items on the respective scales were used, where applicable, and some scales were computed into dichotomous variables as indicated. High values on any measure indicate a high level of the construct, e.g. high level of depressive symptoms.

Data analysis

Differences in cognitive functioning domains between groups with a high versus low level of SCC were analysed using Analysis of Covariance (ANCOVA), adjusting for effects of age, gender, education and income by adding these as covariates in the analysis.

The dependent measures tested were performance scores for each of the semantic memory and episodic memory (delayed recall and recognition, as well asIFR during DA versus during FA).

The alpha level used to evaluate the significance of the statistical results was 0.05.

Since the significance tests were used to evaluate a set of a priori hypotheses, individual test results were not corrected for multiple significance testing.

Data analyses were performed using SPSS 19 software.

Ethics statement

The study has been approved by the Regional Research Ethics Board in Stockholm (Dnr 2010/397-31).

All study participants have given their informed consent. Data were analysed anonymously.

Results

Demographic characteristics and prevalence of other psychological symptoms and medical conditions in the groups with a high and a low level of SCC are presented in Table 1.

Means and standard deviations of the memory measures are presented in Table 2.

Table 2 Descriptive statistics for test performance in groups with a low vs. high level of SCC

Test scores	Low SCC			High SCC		
	n	Mean	SD	n	Mean	SD
Vocabulary	113	24.48	2.98	107	23.93	3.28
Letter fluency	114	14.17	3.96	110	14.18	5.00
Category fluency	114	6.04	2.36	110	5.59	2.49
Face recognition	114	8.13	2.59	112	7.46	2.49
Delayed free recall words	112	8.90	4.34	112	8.49	3.71
IFR, FA	114	5.78	1.70	111	5.65	1.70
IFR, DA at encoding	114	4.11	1.27	111	3.62	1.34
IFR, DA at recall	114	4.99	1.77	111	4.55	1.48
IFR, DA at encoding + recall	114	4.04	1.23	110	3.81	1.39

Separate ANCOVAs were conducted for the memory tests, using age, gender, education level and income as covariates in each analysis (Table 3).

No significant group differences were found on the semantic memory measures, nor on the episodic measures of delayed recall and recognition.

Thus, these results indicate that differences in cognitive complaints were not clearly related to semantic memory performance, nor to delayed recall or recognition of episodic memory content.

However, in the IFR test with either FA or DA conditions, the results were in line with the prediction that participants with high levels of SCC would be more vulnerable to memory deficits when they have to engage the executive functions more heavily to manage the distraction task that forces the division of their attention, than the participants with low levels of SCC (see Table 3).

Results from conducting one-way ANCOVAs for word recall during FA and DA conditions showed that memory performance between the two SCC groups did not differ in the FA condition, while the high SCC group performed significantly poorer in the condition with DA during encoding, $F(1, 218) = 5.42$, $p = 0.021$. A trend was also found towards poorer performance in the high SCC group in the condition with DA during recall.

No group difference was seen in the most difficult condition with DA at both encoding and recall.

Table 3 ANCOVA results for all declarative memory measures in groups with low versus high levels of SCC†

Source	*Dependent measure*	SS	df	MS	F	p	η_p^2
SCC level	Vocabulary	5.54	1	5.54	0.60	.439	.003
Error	Vocabulary	1973.66	214	9.22			
SCC level	Letter fluency	5.38	1	5.38	0.27	.602	.001
Error	Letter fluency	4308.85	218	19.77			
SCC level	Category fluency	12.03	1	12.03	2.03	.156	.009
Error	Category fluency	1293.25	218	5.93			
SCC level	Face recognition	13.15	1	13.15	2.27	.133	.010
Error	Face recognition	1272.85	220	5.79			
SCC level	Delayed recall of words	0.80	1	0.80	0.06	.813	.000
Error	Delayed recall of words	3121.58	218	14.32			
SCC level	IFR, FA	0.06	1	0.06	0.02	.878	.000
	IFR, DA at encoding	8.69	1	8.69	5.42	.021	.024
	IFR, DA at recall	7.01	1	7.01	2.72	.100	.012
	IFR, DA at encoding & recall	1.63	1	1.63	0.98	.323	.004
Error	IFR, FA	539.87	218	2.48			
	IFR, DA at encoding	349.30	218	1.60			
	IFR, DA at recall	561.74	218	2.58			
	IFR, DA at encoding & recall	360.88	218	1.66			

†Including age, gender, education & income as covariates. SS = sum of squares MS = mean square η_p^2 = partial eta squared.

Table 4 ANCOVA results of differences in the cognitive test measures between groups with high versus low levels of *SCC excluding individuals reporting an unspecified psychiatric illness*†

Source	*Dependent measure*	SS	df	MS	F	p	η_p^2
SCC level	Vocabulary	14.81	1	14.81	1.57	0.211	0.01
Error	Vocabulary	1875.52	199	9.43			
SCC level	Letter fluency	9.86	1	9.86	0.49	0.485	0.00
Error	Letter fluency	4086.50	203	20.13			
SCC level	Category fluency	13.13	1	13.13	2.36	0.126	0.01
Error	Category fluency	1131.82	203	5.58			
SCC level	Face recognition	13.51	1	13.51	2.34	0.127	0.01
Error	Face recognition	1176.25	204	5.77			
SCC level	Delayed recall of words	0.57	1	0.57	0.04	0.843	0.00
Error	Delayed recall of words	2931.16	202	14.51			
SCC level	IFR, FA	0.03	1	0.03	0.01	0.907	0.00
SCC level	IFR, DA at encoding	6.68	1	6.68	4.14	0.043	0.02
SCC level	IFR, DA at recall	10.07	1	10.07	3.95	0.048	0.02
SCC level	IFR, DA at encoding & recall	1.86	1	1.86	1.19	0.276	0.01
Error	IFR, FA	488.24	203	2.41			
Error	IFR, DA at encoding	327.53	203	1.61			
Error	IFR, DA at recall	517.70	203	2.55			
Error	IFR, DA at encoding & recall	317.48	203	1.56			

†Including age, gender, education & income as covariates. SS = sum of squares MS = mean square η_p^2 = partial eta squared.

Performance deteriorated heavily in both groups in this condition, suggesting floor effects in this condition.

As can be seen in Table 1, a number of participants reported having an unspecified psychiatric illness (15 in the high SCC group and 1 in the low SCC group). As this could be affecting both cognitive functioning negatively, as well as self-perceptions of cognitive functioning (with either relatively more SCC or less SCC due to potentially poorer ability to assess own functioning level), the above analyses were also after excluding these participants from the study sample.

The results from these analyses for all of the test measures are shown in Table 4. Similar to the results in the first set of analyses, no group differences were seen in semantic measures or delayed episodic recall or recognition. Again, the high SCC group showed significantly poorer performance in IFR during DA at encoding, $F(1, 203) = 4.14$, $p = 0.043$, as well as in the condition with DA at recall, $F(1, 203) = 3.95$, $p = 0.048$.

As can be seen in Table 1, participants with high levels of SCC also showed more chronic stress/exhaustion symptoms, depressive symptoms and sleeping problems than those participants with low levels of SCC, as expected. Thus, separate one-way ANCOVAs adding one of the covariates at a time, comparing the SCC groups on memory performance during DA, were also conducted. Adjusting for all or either of symptoms of depression, chronic stress and sleeping problems reduced the significant effect that SCC group has on IFR performance during the DA conditions to non-significance. Results after controlling for all of these factors are shown in Table 5.

For complete ANCOVA tables for each test measure, after excluding participants with reported unspecified psychiatric illness, see Tables 6, 7, 8, 9, 10, 11.

Discussion

In this study the relationship between SCC and objective cognitive functioning in declarative semantic memory, episodic memory, as well as episodic mnemonic ability under conditions of DA- that involve a higher load on executive functioning- were tested in a sample of the general working population.

A trend toward poorer episodic memory performance on tasks of delayed verbal recall and non-verbal recognition was found among individuals with high levels of SCC, compared to controls with low levels of SCC whom were matched to the cases on age, gender, education and geographical area.

It was found that memory performance in IFR under DA conditions was significantly poorer among individuals experiencing high levels of SCC compared to the controls with low levels of SCC whom were matched to the cases on age, gender, education and geographical area. No differences were found in semantic memory measures between the two SCC groups, suggesting that

Table 5 Results for immediate free recall of words (IFR) during focused (FA) versus divided attention (DA), excluding individuals reporting an unspecified psychiatric illness, controlling for symptoms of exhaustion, depression and sleeping problems

Source	Dependent measure	SS	df	MS	F	p	η_p^2
Corrected model	IFR, FA	120.20[a]	9	13.36	5.44	0.00	0.20
	IFR, DA at encoding	41.91[b]	9	4.66	2.89	0.00	0.12
	IFR, DA at recall	53.85[c]	9	5.98	2.33	0.02	0.10
	IFR, DA at encoding & recall	29.50[d]	9	3.28	2.17	0.03	0.09
Intercept	IFR, FA	63.26	1	63.26	25.76	0.00	0.12
	IFR, DA at encoding	86.39	1	86.39	53.56	0.00	0.22
	IFR, DA at recall	92.92	1	92.92	36.20	0.00	0.16
	IFR, DA at encoding & recall	55.27	1	55.27	36.55	0.00	0.16
SCC level	IFR, FA	0.01	1	0.01	0.00	0.95	0.00
	IFR, DA at encoding	0.22	1	0.22	0.13	0.71	0.00
	IFR, DA at recall	1.88	1	1.88	0.73	0.39	0.00
	IFR, DA at encoding & recall	0.01	1	0.01	0.01	0.93	0.00
Gender	IFR, FA	34.02	1	34.02	13.85	0.00	0.07
	IFR, DA at encoding	0.01	1	0.01	0.01	0.94	0.00
	IFR, DA at recall	0.15	1	0.15	0.06	0.81	0.00
	IFR, DA at encoding & recall	4.07	1	4.07	2.69	0.10	0.01
Age	IFR, FA	35.31	1	35.31	14.38	0.00	0.07
	IFR, DA at encoding	19.93	1	19.93	12.36	0.00	0.06
	IFR, DA at recall	15.62	1	15.62	6.09	0.01	0.03
	IFR, DA at encoding & recall	8.47	1	8.47	5.60	0.02	0.03
Educational level	IFR, FA	7.78	1	7.78	3.17	0.08	0.02
	IFR, DA at encoding	0.63	1	0.63	0.39	0.53	0.00
	IFR, DA at recall	0.84	1	0.84	0.33	0.57	0.00
	IFR, DA at encoding & recall	0.26	1	0.26	0.17	0.68	0.00
Yearly income	IFR, FA	33.71	1	33.71	13.72	0.00	0.07
	IFR, DA at encoding	7.34	1	7.34	4.55	0.03	0.02
	IFR, DA at recall	6.43	1	6.43	2.51	0.11	0.01
	IFR, DA at encoding & recall	3.25	1	3.25	2.15	0.14	0.01
Exaustion	IFR, FA	2.98	1	2.98	1.21	0.27	0.01
	IFR, DA at encoding	0.13	1	0.13	0.08	0.78	0.00
	IFR, DA at recall	1.11	1	1.11	0.43	0.51	0.00
	IFR, DA at encoding & recall	1.45	1	1.45	0.96	0.33	0.00
Depressive symptoms	IFR, FA	1.87	1	1.87	0.76	0.38	0.00
	IFR, DA at encoding	2.30	1	2.30	1.42	0.23	0.01
	IFR, DA at recall	1.38	1	1.38	0.54	0.46	0.00
	IFR, DA at encoding & recall	1.46	1	1.46	0.97	0.33	0.01
Disturbed sleep	IFR, FA	2.08	1	2.08	0.85	0.36	0.00
	IFR, DA at encoding	0.70	1	0.70	0.43	0.51	0.00
	IFR, DA at recall	10.23	1	10.23	3.99	0.05	0.02
	IFR, DA at encoding & recall	7.78	1	7.78	5.15	0.02	0.03

Table 5 Results for immediate free recall of words (IFR) during focused (FA) versus divided attention (DA), excluding individuals reporting an unspecified psychiatric illness, controlling for symptoms of exhaustion, depression and sleeping problems *(Continued)*

Awakening problems	IFR, FA	3.36	1	3.36	1.37	0.24	0.01
	IFR, DA at encoding	1.99	1	1.99	1.23	0.27	0.01
	IFR, DA at recall	9.42	1	9.42	3.67	0.06	0.02
	IFR, DA at encoding & recall	4.77	1	4.77	3.16	0.08	0.02
Error	IFR, FA	471.57	192	2.46			
	IFR, DA at encoding	309.66	192	1.61			
	IFR, DA at recall	492.75	192	2.57			
	IFR, DA at encoding & recall	290.33	192	1.51			
Total	IFR, FA	7173.00	202				
	IFR, DA at encoding	3449.00	202				
	IFR, DA at recall	5128.00	202				
	IFR, DA at encoding & recall	3504.00	202				
Corrected total	IFR, FA	591.77	201				
	IFR, DA at encoding	351.57	201				
	IFR, DA at recall	546.59	201				
	IFR, DA at encoding & recall	319.82	201				

[a]R Squared = ,203 (Adjusted R Squared = ,166).
[b]R Squared = .119 (Adjusted R Squared = .078).
[c]R Squared = .099 (Adjusted R Squared = .056).
[d]R Squared = .092 (Adjusted R Squared = .050).
SS = sum of squares.
MS = mean squares.
η_p^2 = partial eta squared.

the matching on educational level was effective. Importantly, this is also an indicator that the groups did not differ in "premorbid" general intellectual ability (in the event of acquired cognitive deficits), since verbal crystallized intellectual ability is generally robust to cognitive decline and is highly correlated with premorbid general intellectual ability (Kaufman & Horn 1996; Salthouse & JINS 2010).

However, there were no group differences in episodic memory performance on tasks of delayed verbal recall and delayed non-verbal recognition, contrary to our prediction.

Table 6 Results for vocabulary, excluding individuals reporting an unspecified psychiatric illness

Source	SS	df	MS	F	p	η_p^2
Corrected model	191.43a	5	38.29	4.06	0.002	0.09
Intercept	1460.31	1	1460.31	154.95	0	0.44
SCC level	14.81	1	14.81	1.57	0.211	0.01
Gender	4.01	1	4.01	0.43	0.515	0.00
Age	35.44	1	35.44	3.76	0.054	0.02
Educational level	22.73	1	22.73	2.41	0.122	0.01
Yearly income	65.79	1	65.79	6.98	0.009	0.03
Error	1875.52	199	9.43			
Total	121978.00	205				
Corrected total	2066.96	204				

Complete ANCOVA table.
a R Squared = ,093 (Adjusted R Squared = ,070).
SS = sum of squares.
MS = mean squares.
η_p^2 = partial eta squared.

Table 7 Results for letter fluency, excluding individuals reporting an unspecified psychiatric illness

Source	SS	df	MS	F	p	η_p^2
Corrected model	138.95a	5	27.79	1.38	0.233	0.03
Intercept	464.14	1	464.14	23.06	0	0.10
SCC level	9.86	1	9.86	0.49	0.485	0.00
Gender	30.47	1	30.47	1.51	0.22	0.01
Age	0.25	1	0.25	0.01	0.911	0.00
Educational level	10.26	1	10.26	0.51	0.476	0.00
Yearly income	96.01	1	96.01	4.77	0.03	0.02
Error	4086.50	203	20.13			
Total	46801.00	209				
Corrected total	4225.46	208				

Complete ANCOVA table.
a R Squared = ,033 (Adjusted R Squared = ,009).
SS = sum of squares.
MS = mean squares.
η_p^2 = partial eta squared.

Table 8 Results for category fluency, excluding individuals reporting an unspecified psychiatric illness

Source	SS	df	MS	F	p	η_p^2
Corrected model	21.74a	5	4.35	0.78	0.565	0.02
Intercept	95.50	1	95.50	17.13	0	0.08
SCC level	13.13	1	13.13	2.36	0.126	0.01
Gender	0.77	1	0.77	0.14	0.711	0.00
Age	6.48	1	6.48	1.16	0.282	0.01
Educational level	0.29	1	0.29	0.05	0.82	0.00
Yearly income	4.00	1	4.00	0.72	0.398	0.00
Error	1131.82	203	5.58			
Total	8182.00	209				
Corrected total	1153.56	208				

Complete ANCOVA table.
a R Squared = ,019 (Adjusted R Squared = -,005).
SS = sum of squares.
MS = mean squares.
η_p^2 = partial eta squared.

Table 10 Results for delayed recall of words, excluding individuals reporting an unspecified psychiatric illness

Source	SS	df	MS	F	p	η_p^2
Corrected model	481.53a	5	96.31	6.64	0	0.14
Intercept	287.87	1	287.87	19.84	0	0.09
SCC level	0.57	1	0.57	0.04	0.843	0.00
Gender	110.44	1	110.44	7.61	0.006	0.04
Age	246.24	1	246.24	16.97	0	0.08
Educational level	52.93	1	52.93	3.65	0.058	0.02
Yearly income	47.64	1	47.64	3.28	0.071	0.02
Error	2931.16	202	14.51			
Total	19198.00	208				
Corrected total	3412.69	207				

Complete ANCOVA table.
a R Squared = ,141 (Adjusted R Squared = ,120).
SS = sum of squares.
MS = mean squares.
η_p^2 = partial eta squared.

Thus, the results in this study suggest that high levels of SCC are primarily associated with poorer executive cognitive ability in the general population of working adults.

These results are compatible with more recent study findings of SCC among non-elderly adults being related to poorer executive cognitive functioning (de Leon JM et al. 2010).

Executive functioning and related brain regions also appear to be particularly sensitive to impairments from stress-signalling in acute and chronic stress (e.g., Liston et al. 2009; Sandström et al. 2012; Arnsten 2009; Karlson et al. 2012), depressive symptoms (Murrough et al. 2011) and sleeping problems (Walker 2009), which are all common among non-elderly adults.

Table 9 Results for face recognition (d′ scores), excluding individuals reporting an unspecified psychiatric illness

Source	SS	df	MS	F	p	η_p^2
Corrected model	187.35a	5	37.47	6.50	0	0.14
Intercept	227.47	1	227.47	39.45	0	0.16
SCC level	13.51	1	13.51	2.34	0.127	0.01
Gender	35.58	1	35.58	6.17	0.014	0.03
Age	82.84	1	82.84	14.37	0	0.07
Educational level	16.05	1	16.05	2.78	0.097	0.01
Yearly income	29.07	1	29.07	5.04	0.026	0.02
Error	1176.25	204	5.77			
Total	14140.00	210				
Corrected total	1363.60	209				

Complete ANCOVA table.
a R Squared = ,137 (Adjusted R Squared = ,116).
SS = sum of squares.
MS = mean squares.
η_p^2 = partial eta squared.

In the present study too, SCC are highly co-occurring with exhaustion symptoms, depressive symptoms and sleeping problems, which could statistically explain some of the relationship between SCC and executive functioning in the present study. Specifically, adjusting for depressive symptoms or sleeping problems alone reduced the effect of SCC on memory performance during DA to non-significance. Adjusting for exhaustion symptoms also reduced the effect of SCC, but to the least extent.

The overlap between SCC and these other types of symptoms was expected and these symptoms may also have a common or overlapping underlying aetiology, even if individual differences in vulnerabilities can make people more or less prone to the different types of problems.

It is possible that a stronger relation between SCC and episodic memory functioning seen in another population study including younger adults (Podewils et al. 2003) would be found had the cases with high levels of SCC in the present study been more severely affected by their SCC (see also de Leon JM et al. 2010). The present study only included those healthy enough to be in gainful employment.

However, a relation between SCC and cognitive functioning has not always been observed and may be due to several factors already mentioned concerning design.

Some have also suggested that subjective SCC may be accurate perceptions of underlying degenerative processes. Recently, various neuroimaging studies on elderly participants have found SCC (even without manifest cognitive impairments) to be related to altered neuronal/brain functioning that may be non-pathological or

Table 11 ANCOVA results of group differences in immediate free recall (IFR) during focused attention (FA) vs. divided attention (DA) conditions, excluding individuals reporting an unspecified psychiatric illness

Source	Dependent measure	SS	df	MS	F	p	η_p^2
Corrected model	IFR. FA	114.55[a]	5	22.91	9.53	0.00	0.19
	IFR. DA at encoding	34.92[b]	5	6.98	4.33	0.00	0.10
	IFR. DA at recall	40.34[c]	5	8.07	3.16	0.01	0.07
	IFR. DA at encoding & recall	18.94[d]	5	3.79	2.42	0.04	0.06
Intercept	IFR. FA	80.51	1	80.51	33.48	0.00	0.14
	IFR. DA at encoding	85.74	1	85.74	53.14	0.00	0.21
	IFR. DA at recall	114.08	1	114.08	44.73	0.00	0.18
	IFR. DA at encoding & recall	68.83	1	68.83	44.01	0.00	0.18
SCC level	IFR. FA	0.03	1	0.03	0.01	0.91	0.00
	IFR. DA at encoding	6.68	1	6.68	4.14	0.04	0.02
	IFR. DA at recall	10.07	1	10.07	3.95	0.05	0.02
	IFR. DA at encoding & recall	1.86	1	1.86	1.19	0.28	0.01
Gender	IFR. FA	35.64	1	35.64	14.82	0.00	0.07
	IFR. DA at encoding	0.01	1	0.01	0.00	0.95	0.00
	IFR. DA at recall	0.31	1	0.31	0.12	0.73	0.00
	IFR. DA at encoding & recall	4.23	1	4.23	2.71	0.10	0.01
Age	IFR. FA	36.82	1	36.82	15.31	0.00	0.07
	IFR. DA at encoding	17.05	1	17.05	10.57	0.00	0.05
	IFR. DA at recall	18.47	1	18.47	7.24	0.01	0.03
	IFR. DA at encoding & recall	9.93	1	9.93	6.35	0.01	0.03
Educational level	IFR. FA	11.04	1	11.04	4.59	0.03	0.02
	IFR. DA at encoding	2.26	1	2.26	1.40	0.24	0.01
	IFR. DA at recall	1.94	1	1.94	0.76	0.38	0.00
	IFR. DA at encoding & recall	0.28	1	0.28	0.18	0.67	0.00
Yearly income	IFR. FA	33.92	1	33.92	14.10	0.00	0.07
	IFR. DA at encoding	6.67	1	6.67	4.14	0.04	0.02
	IFR. DA at recall	6.77	1	6.77	2.66	0.11	0.01
	IFR. DA at encoding & recall	4.34	1	4.34	2.78	0.10	0.01
Error	IFR. FA	488.24	203	2.41			
	IFR. DA at encoding	327.53	203	1.61			
	IFR. DA at recall	517.70	203	2.55			
	IFR. DA at encoding & recall	317.48	203	1.56			
Total	IFR. FA	7367.00	209				
	IFR. DA at encoding	3564.00	209				
	IFR. DA at recall	5257.00	209				
	IFR. DA at encoding & recall	3593.00	209				
Corrected total	IFR. FA	602.79	208				
	IFR. DA at encoding	362.45	208				
	IFR. DA at recall	558.05	208				
	IFR. DA at encoding & recall	336.42	208				

[a]R Squared = ,190 (Adjusted R Squared = ,170).
[b]R Squared = ,096 (Adjusted R Squared = ,074).
[c]R Squared = ,072 (Adjusted R Squared = ,049).
[d]R Squared = ,056 (Adjusted R Squared = ,033).
SS = sum of squares.
MS = mean squares.
η_p^2 = partial eta squared.

pathological (i.e. progressive Alzheimer's disease: AD) (see e.g., Stewart 2012; Erk et al. 2011; Scheef et al. 2012; Striepens et al. 2010; Hohman et al. 2011). This suggests that people may have awareness of changes in cognitive and brain functioning even when these are not detectable from conventional neuropsychological assessments.

This leads on to a related aspect of cognitive performance that can obscure the overt relationship between SCC and objective cognitive performance, namely the ability of individuals to engage in cognitive compensatory activities and strategies that may prevent overt signs of cognitive functional decline, e.g. (Stern & JINS 2002). A high cognitive reserve (e.g. high educational attainment) has been particularly associated with a lack of clinical cognitive functional impairments (such as Mild Cognitive Impairment: MCI) even in the instance of SCC, while SCC is more often associated with manifest cognitive impairments (e.g. MCI) in persons with a lower cognitive reserve (Stern & JINS 2002; Caracciolo et al. 2012; Stern 2009). SCC has also been found to be associated with the use of more compensatory strategies such as increased effort, cognitive strategies and use of external aids/tools (Garrett et al. 2010). These reported phenomena converge with others' findings of compensatory neural activation patterns during episodic (Erk et al. 2011) and working memory tasks (Sandström et al. 2012) in individuals with SCC (compared to controls) even when no decrements in task performance are seen.

Hence, further studies of the relation between SCC and cognitive functioning should investigate the role of cognitive reserve and compensatory processes in more detail.

It is likely that there are costs to the compensatory activities, such as greater fatigability and loss of energy that hamper cognitive functionality across longer time spans and that this is perceived by the individual. In light of (1) the research on compensatory activities that can uphold momentary cognitive performance when cognitive problems are self-perceived (Erk et al. 2011; Stern 2009), and (2) the aging literature that is converging on the importance of SCC (*even without detectable cognitive impairments*) as an early marker of actual underlying functional brain changes (Stewart 2012), then the present findings of cross-sectional relationships between SCC and cognitive functioning (IFR during DA) may be an important indicator that actual neurocognitive functioning is implicated also in non-elderly adults with SCC.

However, it is important to keep in mind that multiple factors could lead to SCC also without any actual deficits in cognitive functioning being present, which could explain some of the variance in SCC that is not be explained by actual cognitive impairments that are stable rather than momentary. For example, cognitive overload and temporary resource depletion could lead to the perception of cognitive problems which may be accurate observations of cognitive failures in daily life without reflecting low cognitive functioning per se. However, the experience of cognitive overload and resource depletion under certain levels of pressure can lead to stress reactions and low mood that are suboptimal for executive cognitive function. Negative affectivity and poor self-regard could also colour the self-rated cognitive functioning level negatively without any actual cognitive impairments being present, although such conditions are also related to actual cognitive performance decrements due to hyper-arousal, ruminations and cognitive biases that can obstacle performance in certain situations and certain cognitive tasks (Murrough et al. 2011).

Strengths and Limitations

The current study was performed on a sample of cases and controls that is approximately representative of the general working population in Sweden, with well case-matched controls, and utilizing well validated tests of memory functioning.

The study participants were mainly women, due to a higher prevalence of high SCC among women in the working population. This means that the study results may be more representative of gainfully employed women than men.

The cross-sectional design of this study does not allow for causal inferences about which types of symptoms may be the causes of other symptoms and of poorer cognitive functioning, when considering the overlap between executive cognitive function, SCC, exhaustion symptoms, depressive symptoms and sleeping problems.

Furthermore, more studies of SCC among employees are needed which investigate executive cognitive functioning in more detail, utilizing several different executive cognitive tests, to confirm that SCC among employees are in fact related to poorer functioning of executive cognitive processes.

Conclusions

The current findings showed that working adults presenting with a high level of SCC had poorer memory performance during DA conditions- which is the common conditions under which people have operate in their work. The finding suggests that executive cognitive functioning may be implicated in this group and that this could be targeted in curative and preventive interventions for SCC among employees.

The findings add to the understanding of what characterizes subjective cognitive complaints in the work force and can help to guide preventive measures and interventions at different levels of society (health care, human resource management and work design) that can ease

problems with cognitive complaints and the specific implicated cognitive functioning deficits. This is particularly relevant with an aging work force that need to stay working for longer, while at the same time many jobs and work environments increasingly involve high cognitive demands.

Additionally, as these deficits may partly stem from one or several problems with depressive symptoms, chronic stress/exhaustion and sleeping problems, these factors should also be considered in prevention and interventions for SCC.

Abbreviations

SCC: Subjective cognitive complaints; IFR: Immediate free recall; FA: Focused attention; DA: Divided attention.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Conception and design: CUDS, LGN, TT, LMH, PM. Acquisition of data: CUDS, Analysis and interpretation of data: CUDS, LGN. Drafting of the manuscript: CUDS. Critical revision of the manuscript and approval of the manuscript for publication: CUDS, LGN, TT, LMH, PM. All authors read and approved the final manuscript.

Authors' information

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