Understanding subjective measures of olfaction and cognition

A study on the occurrence of subjective olfactory and/or cognitive decline and their effect on future behavioral performance

Andrea Maria Mikaela Aejmelaeus-Lindström

Department of Psychology
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Supervisor: Professor Jonas K. Olofsson
Co-supervisor PhD Nira Cedres

Stockholms universitet

Abstract

Dementia is a growing burden for society, and it is of interest to discover it at an early stage. Both subjective cognitive decline (SCD) and subjective olfactory decline (SOD) has been associated with future cognitive decline and dementia. However, subjective measures have often been criticized and are still not fully understood. I aimed to examinate the frequency of SCD and SOD and whether they are likely to measure different things and what their longitudinal effects are. The baseline sample (N=784, 35-90 years, 51% female) were split into reported SCD, SOD, combined subjective olfactory and cognitive decline, and controls. Between-subjects and within-subjects statistical tests were conducted on a subset of participants (N=307, 45 to 90 years, 52% female) comparing SCD and SOD and their olfactory ability, cognitive performance, and demographics. In the baseline sample, a total of 21.1% reported a SOD whereas only 9.9% reported a SCD, only 2.7% reported both. SOD individuals had an emerged olfactory decline at follow up, their olfactory performance was associated with performance in several cognitive tests, this was not the case for the SCD individuals. The SOD and the SCD groups differ from each other, and they appear to be rather independent from each other. They might be complementary in understanding the aging brain.

Keywords: subjective olfactory decline, subjective cognitive decline, olfaction, anosmia, cognition, aging

The brain develops and changes throughout life, at older age it changes both on a molecular and a morphological level (Peters, 2006). The older brain goes through changes in neurotransmitters and in hormones as well as putting the person at an increased risk for stroke, white matter lesions and neurological diseases. Memory is a cognitive function that seems to be strongly diminished in aging, particularly affected is the episodic and semantic memory (Peters, 2006). The increased risk of cognitive decline can affect the person at different levels of cognitive and functional impairment ranging from mild cognitive impairment (MCI) to more severe levels as dementia (Jessen et al., 2020).

Dementia is affecting approximately 5-8% of people above 60 years, corresponding to approximately 50 million people worldwide. Individuals with dementia has a deterioration in memory, thinking, behavior and ability to perform everyday activities (Pan American Health Organization, 2021). The most common form of dementia is Alzheimer’s disease which stands for 60-70% of the dementia cases. Dementia has a large impact, physically, psychologically, socially, and economically both for the people suffering from it but also the next of kin. Additionally, dementia creates large costs for society. Despite of no existing cure for dementia, it is important to detect it early and understand the process behind it and to be able to ease the situation.

Furthermore, aging affects the olfactory system, about half of the population between 65 and 80 years old have a distinct olfactory dysfunction (Doty et al., 1984). Olfactory decline is seen as a normal aging process, but it has also been associated with poorer cognitive abilities and as a risk factor to predict cognitive decline (Olofsson et al., 2009). Research show that an impaired olfactory ability is commonly present in several of the different types of dementias (Alves, 2014; Stanciu et al., 2014). There is an association between olfaction and memory decline, suggesting that they are valuable predictors combined (Josefsson et al., 2017). Several longitudinal studies have shown that performance on odor identification tasks predict a decline in episodic memory functioning and in perceptual speed, supporting the idea that odor identification functioning is closely associated with several cognitive domains (Swan & Carmelli, 2002; Wilson et al., 2006).

With an increasing age, people tend to perceive deficits in abilities, e.g., perceived loss in certain area of cognition and olfaction. In this thesis I focus on subjective cognitive decline (SCD) and subjective olfactory decline (SOD). SCD and SOD means that the individual self-perceived a decline in cognition or olfaction compared to what it used to be or what is considered normal. Having a reliable and valid way of measuring self-perception of ability could be useful to understand the health of people, without having to do complicated, expensive, or invasive tests.

In the past 40 years, the association between subjective decline in cognition, aging, objective performance, and risk for future cognitive decline has been a topic of interest. Finally, in 2014 the SCD-initiative (SCD-I), a group of researcher and clinicians came up with a common framework for subjective cognitive decline (SCD), thus giving it a standardized terminology and criteria (Jessen, 2014). The SCD criteria has two major aspects. First, the individuals with SCD must themselves have a self-experienced decline in cognitive ability compared to previous normal cognitive status, a decline that is not related to any acute unrelated event.

The SCD status does not include the observed decline by others around the individuals as it is their perception that counts. Second, the performance on standardized cognitive tests used to classify mild cognitive impairment (MCI), adjusted for age, sex, and education, meaning that the individuals are objectively speaking unimpaired. MCI and dementia are both defined by objective cognitive impairment and are distinct from SCD which does not include objective decline (Jessen et al., 2020). SCD can be an indicator to predict future cognitive decline as research suggest that on average, SCD occurs 10 years before the diagnosis of dementia. Additionally, in a longitudinal study it was found that subjective memory impairment could represent markers of conversion to dementia (Rönnlund et al., 2015). It should however also be noted that the presence of SCD can be due to several different medical causes and that SCD does not indicate a future cognitive decline for most individuals (Jessen et al., 2020).

Meanwhile, SOD is a less researched phenomenon. As olfactory input is less important in our daily lives than other sensory inputs, such as auditory input or visual input, it is probable that a decline in olfaction goes unnoticed whereas a decline in the other sensory modalities is more likely to get noticed. Nevertheless, Ekström and colleagues (2019) found that older people with a SOD was associated with having a decline in objective odor identification over time. Furthermore, Stanciu and colleagues (2014) found that subjects who rated their olfactory ability as "worse than normal" were at higher risk of getting diagnosed with dementia within a 10-year span compared to those who judged their olfactory ability as functioning normally.

However, it cannot be denied that subjective assessment is an often-debated topic, how people perceive and are aware of their abilities are not always accurate. Adams and colleagues (2016) showed that self-reported olfactory function is not necessarily in line with the objectively tested olfactory ability and that people are often not aware of their deficits in olfactory ability (Wehling et al., 2011). Research indicates that in a sample of individuals between 53-97 years old that only 9.4% reported having an impaired olfactory ability, however, when tested objectively with an odor identification task 24.5% of the sample were identified as having an impaired olfactory function (Murphy et al., 2002).

Nordin and colleagues (1995) found that 70% of elderly that reported having a normal sense of smell were not correct and had either a reduced sense of smell and issues detecting odors (hyposmia) or the rarer condition which is a complete lack of smell (anosmia). That people's own perception of their ability is wrong has also been found in patients from smell and taste disorder clinics where the 42% of the self-reported beliefs did not match the objectively tested ability (White & Kurtz, 2003).

Wehling and colleagues (2011) investigated the accordance of objectively assessed olfactory ability with self-reported olfactory ability, and additionally compared the cognitive ability of subjects correctly and incorrectly aware of their olfactory ability. The participants that were unaware of their dysfunction also performed worse on several neuropsychological measures like memory function, processing speed and attention compared to those aware of their ability (Wehling et al., 2011). They also investigated middle aged and old adults to compare subjectively judged (self-reported through a questionnaire) and objective tested olfactory abilities through the Scandinavian Odor Identification Test (SOIT; Nordic et al., 1998). In the sample, 24% were classified as having an olfactory dysfunction, of these 81% reported themselves having a functioning olfactory system.

Despite the perhaps dark view on self-report, the research on subjective and objective olfactory and cognitive decline is scarce and needs to be further looked upon. It could be a useful and economically efficient tool to discover cognitive decline early on to ease the process and possibly in the future come up with interventions to slow the outcome with e.g., smell training. There is increasing evidence that the olfaction can be trained and improved and Olofsson et al. (2021) even found that olfactory training could yield cross-sensory performance increases (an increased performance in a visual task).

In this thesis I aim to fill this gap in subjective and objective olfactory and cognitive decline. The first part of this study is to apprehend the occurrence of SOD and SCD and the overlap in the general population. If the overlap between SOD and SCD is high, it could mean that SOD is not a valid measure as it could be simply due to a tendency to report decline. However, if SOD and SCD are different from each other and is associated with specific outcomes it would support the importance to also look at SOD in health assessment. The second part is to look at the longitudinal effect of SOD and SCD on performance in olfaction and cognition at a 10-year follow-up. Subjective measures are measured by self-report and has been criticized, suggesting that people who complain about having a poor memory capacity also complains about the sense of smell and therefor do not measure different things. I aimed to investigate the validity behind measuring SOD and to understand if it is different from SCD. If SOD and SCD do not overlap and SOD gives different outcomes than SCD, it would underline the importance of measuring them both and that SOD would be an interesting and valid measurement for sense of smell and risks for the future. To investigate SOD and SCD I have used project data from the Betula study as it is suitable for the aim, a big dataset including the variables needed during a longer time frame.

Method

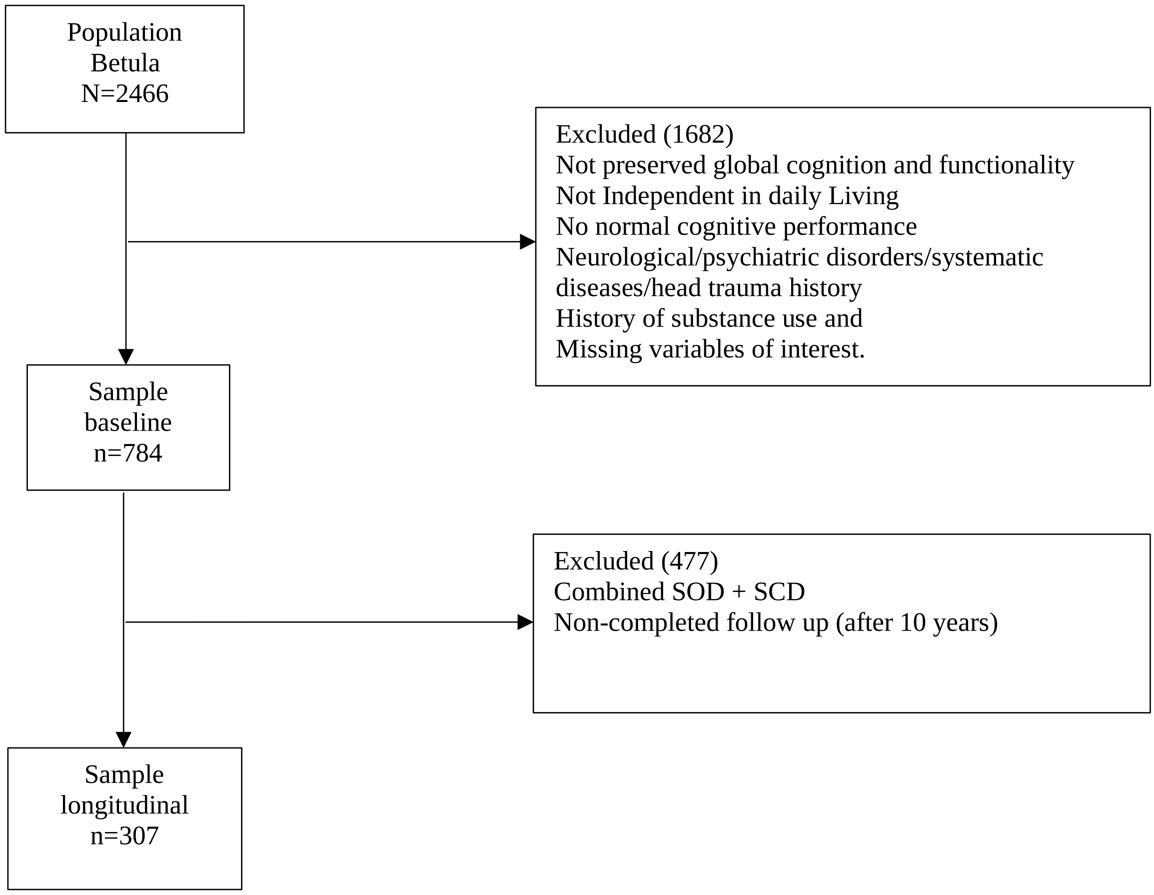
Participants

The participants in the thesis derived from a pool of 2466 participants of the longitudinal Betula Study (Umeå University, n.d.).

The baseline sample included 784 (51% female) participants aged 35 to 90 years at baseline. The inclusion criteria at baseline sample were that the participants should have preserved global cognition and functionality (assessed by MMSE, score ≥24 and Betula Activities of Daily Living (ADL) Index score =1 i.e., independent), normal cognitive performance in neuropsychological testing. Additionally, no background of medical history of neurological and/or psychiatric disorders, systematic diseases or head trauma or any history of substance use and no missing variables of interest.

For the longitudinal part of the study 307 (52% female) subjects from the baseline sample met the inclusion criteria, aged 45 to 90 years at baseline. The population-based sample was split into controls (C), subjective olfactory decline (SOD) and subjective cognitive decline (SCD). All subjects had their general cognitive status tested through Mini-Mental state examination (MMSE) and their olfactory ability through the Scandinavian odor identification test (SOIT). The follow up time was ten years.

Table 1.
Participants



Note. The participants included and excluded in the studies, starting from the population sample to the baseline sample to the longitudinal study sample. Exclusion criteria are listed in the two boxes to the right. In the longitudinal study the combined SOD and SCD group was excluded due to the small amount of participants in this group (n = 8).

Written consent was obtained in accordance with the Declaration of Helsinki (BMJ 1991; 302: 1194) and the study was approved by the Regional Ethical Vetting Board at Umeå University (Approval number 870303, 97-173, 221/97, 97-173, 03-484, 01-008, 169/02, 02-164, 05-082M, and 08-132M).

The Betula study

This thesis is based on data from The Betula Project, a longitudinal study on aging, memory, and dementia in Umeå, and the data has been collected during a period of 25 years (Umeå University, n.d.). The participants were tested, interviewed, and medically examined during six occasions, started in 1988 with follow ups every five years. Every participant was at every test occasion going through a careful health control with blood sample testing by a nurse and an extensive examination of memory by an experienced experimenter. The aim of The Betula Project was to study how memory and health develops in adults and older aged people, to identify early signs and biological markers for dementia and determine the critical factors of successful aging. The Betula Project is a relatively unique project as it has a long follow-up time and scope considering both the population studied and the big amount of data collected. The project includes individual data from more than 4500 individuals that fulfill the inclusion criteria (although not all participants were tested at the same time points). The individuals were excluded if they had severe sensory disabilities, dementia, intellectual disables, serious mental illnesses, and other native language than Swedish. The Betula Project has been awarded status as a "strong research environment" by the Swedish Science Council.

Tests

Health and memory tests

At both baseline and follow up, participants were examined at two occasions with about a week between them, during this week the participants were given a battery of self-assessment forms to fill in.

The first occasion was dedicated for the health examination (health interview, questionnaire, and sampling of Hb, glucose, SR, urine, and research samples), also examination of blood pressure, heart rate, height, weight, waist and buttocks, grip strength, vision, hearing, smell etc. were conducted. The health interviews and questionnaires data aimed to reflect education level, alcohol habits, smoking, leisure activities, stress, sleep problems, drug use, medical history, family relationships and social relationships.

The second testing occasion aimed to investigate cognitive functions, where the participants were given a battery of cognitive tests that were extensive and consisting sub-tests to evaluate numerous memory systems as episodic memory, semantic memory, working memory, prospective memory and other cognitive function as perceptual speed, visuospatial ability, and decision-making. In addition, mini mental tests (MMT / MMSE) were assessed and additionally questions to assess subjective experiences in memory function and experience of memory loss.

Objectively assessed mental state

The Mini-Mental State Examination (MMSE) is a 30-point questionnaire that assesses general cognitive function (Folstein et al., 1975). MMSE tests various cognitive functions as arithmetic, episodic memory, orientation, and language skills.

Subjectively assessed cognitive ability

Self-report on subjective cognitive ability was measured with a single Likert scale asking about the self-perceived episodic memory performance. The SCD group contains the participants judging their memory as "somewhat worse" or "much worse" whereas the others ("normal" and "better than normal") fell under the category of control.

Objectively assessed olfactory ability

Olfactory assessment was performed with the Scandinavian odor identification test (SOIT), an olfactory test specifically adapted to the Scandinavian and Finnish population (Nordin et al., 1998). The test normally includes 16 odorants, but three of the stimuli (peppermint, ammonia, and vinegar) are considered effective trigeminal stimulants and not predominately olfactory stimuli and were therefor not used. The 13 olfactory stimulants used were pine needle, juniper berry, violet, anise, clove, vanilla, bitter almond, orange, cinnamon, lemon, lilac, tar, and apple. The odors were meant to represent a wide range of common odor qualities in quite intense concentration, all odors except tar derived from Stockholm Ether and Essence Manufactory in Stockholm, Sweden. The participants were provided with a written list of four alternatives for the odor where one represented the correct one (Bende & Nordin, 1997).

Subjectively assessed olfactory ability

Subjective olfactory ability was assessed before the olfactory identification test. The participants were asked "how is your ability to perceive weak odors" which they had to answer with one of the following alternatives with: "no ability", "worse than normal", "normal" and "better than normal". The answers were then collapsed into two groups, "olfactory impairment" ("no ability" and "worse than normal") and "normal olfactory function" ("normal" and "better than normal"), as the main interest was olfactory impairment and as it would suit linear statistical models.

Data analysis

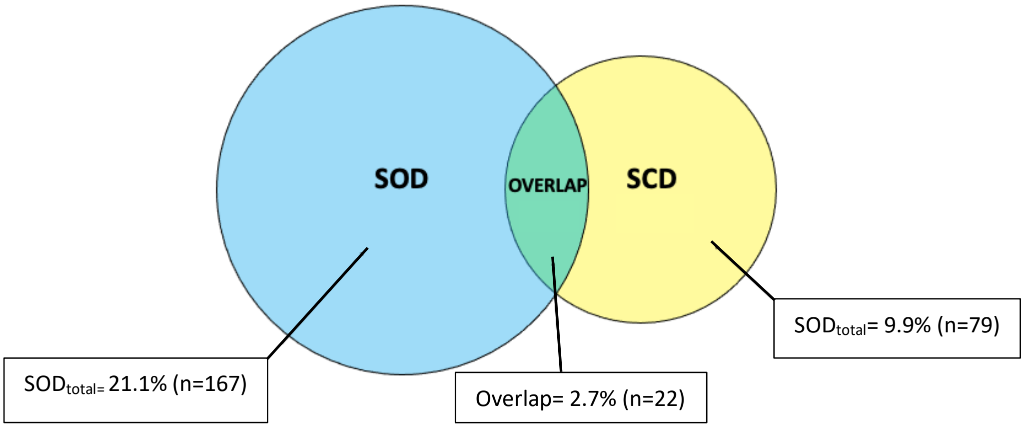
The statistical analyses were conducted in R statistical software (https://www.r-project.org/). The investigation of occurrence of SCD, SOD and their overlap was done with frequency and descriptive analyses. The comparison of study groups at baseline was done with ANCOVA including age as a covariate and chi-square analyses to compare the baseline characteristics of the groups. Within-subjects MANCOVA including age as a covariate was conducted for baseline-to-follow-up comparisons. Results are presented in boxplots with median values as it gives a clear transparent and visual view of the data.
Additionally, multiple linear regression models were conducted for each group at follow-up to test for the association between objective olfaction and cognition measured with several cognitive tests. Education and age were accounted for at follow up with Spearman correlation to assess different patterns of associations between objective olfaction and cognition across the groups.

Results

Baseline study

I investigated the frequency and the overlap between SOD and SCD in the general population. In the sample, a total of 21.1% reported a subjective olfactory decline whereas only 9.9% reported a subjective cognitive decline (see figure 1). The overlap between the groups i.e., the proportion of individuals with both SOD and SCD were only 2.7%. 13.1% among the SOD reported SCD whereas 27.9% among SCD reported SOD. Hence, the SOD is quite independent from SCD.

Figure 1.
Frequency of Subjective Cognitive Decline, Subjective Olfactory Decline, and Their Overlap in the General Population.



Note. SOD: Subjective olfactory decline; SCD: subjective cognitive decline. Overlap: the cooccurrence of SOD and SCD. The total amount of people reporting SOD was 21.1% of the baseline sample (n=167), the total amount of people reporting SCD was 9.9% (n=79). The overlap, i.e. the people reporting both SOD and SCD, between the groups were 2.7% (n=22)

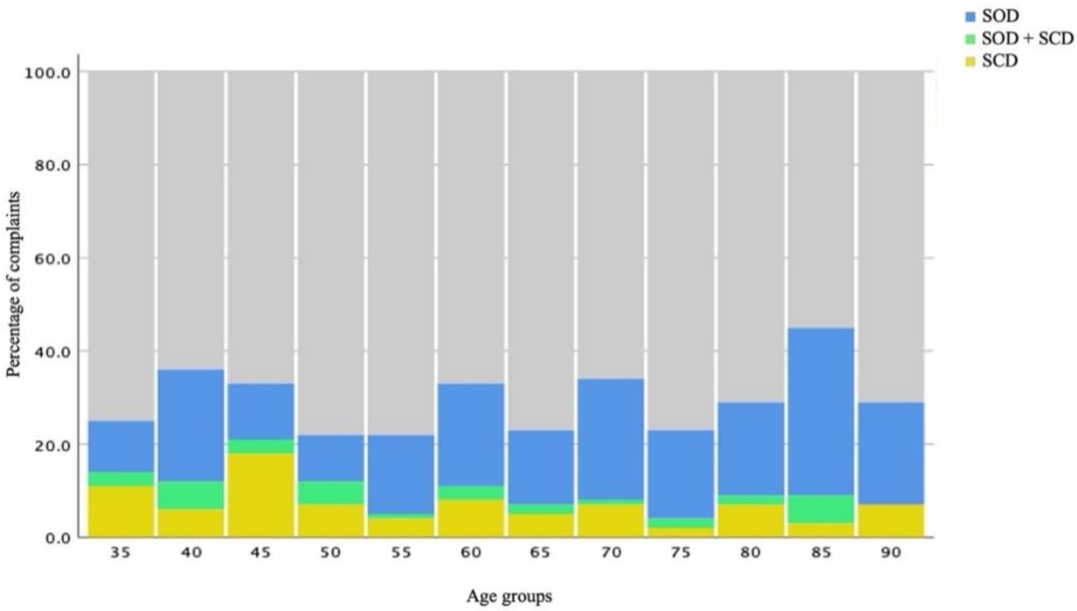
The demographics of the baseline population can be found in table 2. The SOD group were significantly older compared to the SCD. There were no differences in sex, education, or global cognition (MMSE) at baseline. There was a difference in age between the groups at baseline, SOD was present in all age groups with an increased occurrence at older age whereas SCD was mostly reported at middle age (see figure 2 for visual distribution of age and occurrence of SCD, SOD and SCD+SOD). According to a chi-square analysis SOD and SCD do not show increased probability of overlapping compared to chance (X^2 (2, N = 88) = 2.1, p = 0.35).

Table 2.
Demographics and Results of MMSE and SOIT of Baseline Participants.

	Controls	**SOD only**	**SCD only**	**SOD+SCD**
n	560	145	57	22
Age	60.5 (13.6)	64 (14.2)	57.3 (14)	57.3 (14.6)
Education	11 (4.3)	11.2 (4.5)	11.9 (3.7)	11.5 (4.7)
Sex (% female)	55.2	38.6	50.9	18.2
MMSE	27.97 (1.5)	27.91(1.6)	28.07 (1.7)	27.45 (1.2)
SOIT	7.55 (2.1)	6.89 (2.4)	8.26 (2.1)	6.18 (2.5)

Note. N=784. Values represent mean and standard deviation (SD) for continuous variables and percentages for categorical variables.

Figure 2.
Subjective Decline Distribution Across Age Groups

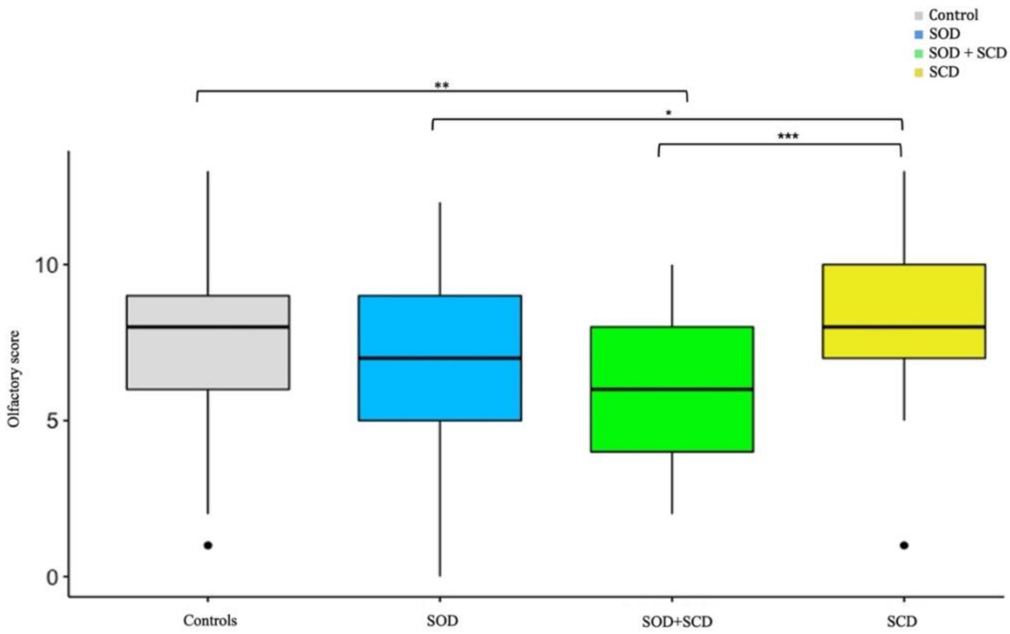


Note. The age distribution of the different declines (SOD, SCD, SOD+SCD)

The baseline differences of the groups (SOD, SCD, SOD+SCD and controls) in performance on objective olfactory performance (SOIT) and global cognition (MMSE) were investigated with help of ANCOVA including the covariate age. The group comparison for SOIT scores were significant ($F_{3,779}=7.68$; $p<0.001$), suggesting that the group with overlapping SOD and SCD has significantly lower SOIT scored compared to the controls ($P<0.001$) and SCD ($p<0.001$). The SOD group has a significantly lower SOIT performance compared to SCD ($p<0.001$) (see figure 3). The groups did not show any statistically significant difference in the performance of MMSE ($F_{3,779}=1.64$; $p=0.179$).

Figure 3.

Olfactory Performance at Baseline Across Groups.



Note. Olfactory performance measured with Scandinavian Odor Identification Task (SOIT). *p<0.05; ** p<0.01; ***p<0.001

Longitudinal study

The age of the people who attended the follow-ups in the longitudinal study were younger ($F_{1,776.29}$=21.18; p<0.001), and had a higher education level ($F_{1,774}$= 39.83; p<0.001) compared to dropouts. In the follow-up there were only 8 individuals from the combined SOD+SCD group and therefor they were excluded from the longitudinal analysis. In the longitudinal study the aim was to understand the effect of subjective decline in olfaction and cognition (the effect of SOD and SCD at 10-year follow-up). Details on demographics and results on the MMSE and SOIT of the participants, see table 2.

Table 3.

The Demographics and Results of MMSE and SOIT in a Longitudinal Sample.

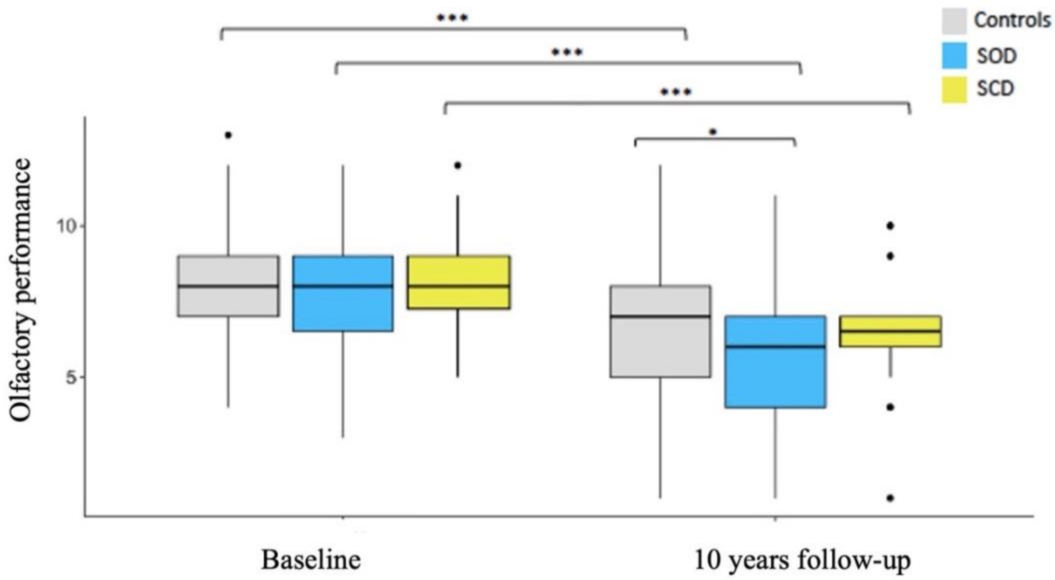
	C	SOD	SCD
n	222	58	27
Age	68.9 (10.26)	70.1 (9.6)	66.9 (9.3)
Education	11.82 (4.4)	12.86 (4.6)	12.61 (3.6)
Sex (% female)	56.8	36.3	48.1
MMSE	27.64 (1.9)	27.38 (3.8)	27.59 (1.4)
SOIT	6.59 (2.4)	5.68 (2.4)	6.31 (1.8)

Note. N=307. C: Controls; SOD: Subjective olfactory decline; SCD: subjective cognitive decline. The values represent mean and standard deviation (SD) for continuous variables and percentages for categorical variables

A within-subjects MANCOVA including age covariates showed a lower olfactory performance score (SOIT) for all groups at 10 years follow-up compared to baseline performance, the SOD groups had a significantly lower performance at the SOIT test at follow-up compared to baseline ($F_{2,280}$=3.53; p=0.031). There was no statistically significant difference in cognitive decline (MMSE) between the groups at follow up ($F_{2,280}$=1.98; p=0.140).

Figure 4

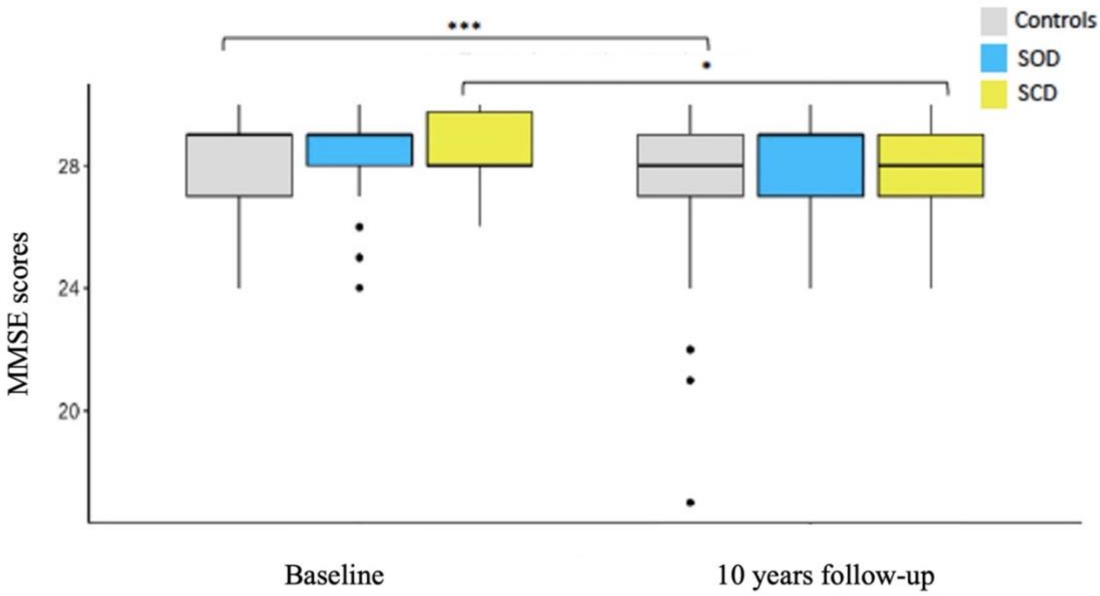
Longitudinal Differences in Olfactory Perfomance (SOIT) Between Groups.



Note. The difference in olfactory performance at 10 years follow up. *p<0.05; ** p<0.01; ***p<0.001

Figure 5.

Longitudinal Differences in Mini Mental State Examination (MMSE) Between Groups



Note. The difference in olfactory MMSE at 10 years follow up. *p<0.05; ** p<0.01; ***p<0.001

There was a weak association with olfactory performance and education and the cognitive task, “Subject Performed Task Verb” in the control group. There was a more distinct association in the SOD group of olfactory scores and the cognitive task “block design” and the Betula general orienting test (BAOTA). In the SOD group, the SOIT scores at follow-up were positively associated with some of the cognitive scores i.e., SPT verb, SPT substantives, block design, letter design and BAOTA (see table 3). There were no significant associations in the SCD group.

Table 4.

The Association Between Olfactory Performance and Different Cognitive Tests at 10 Years Follow-up.

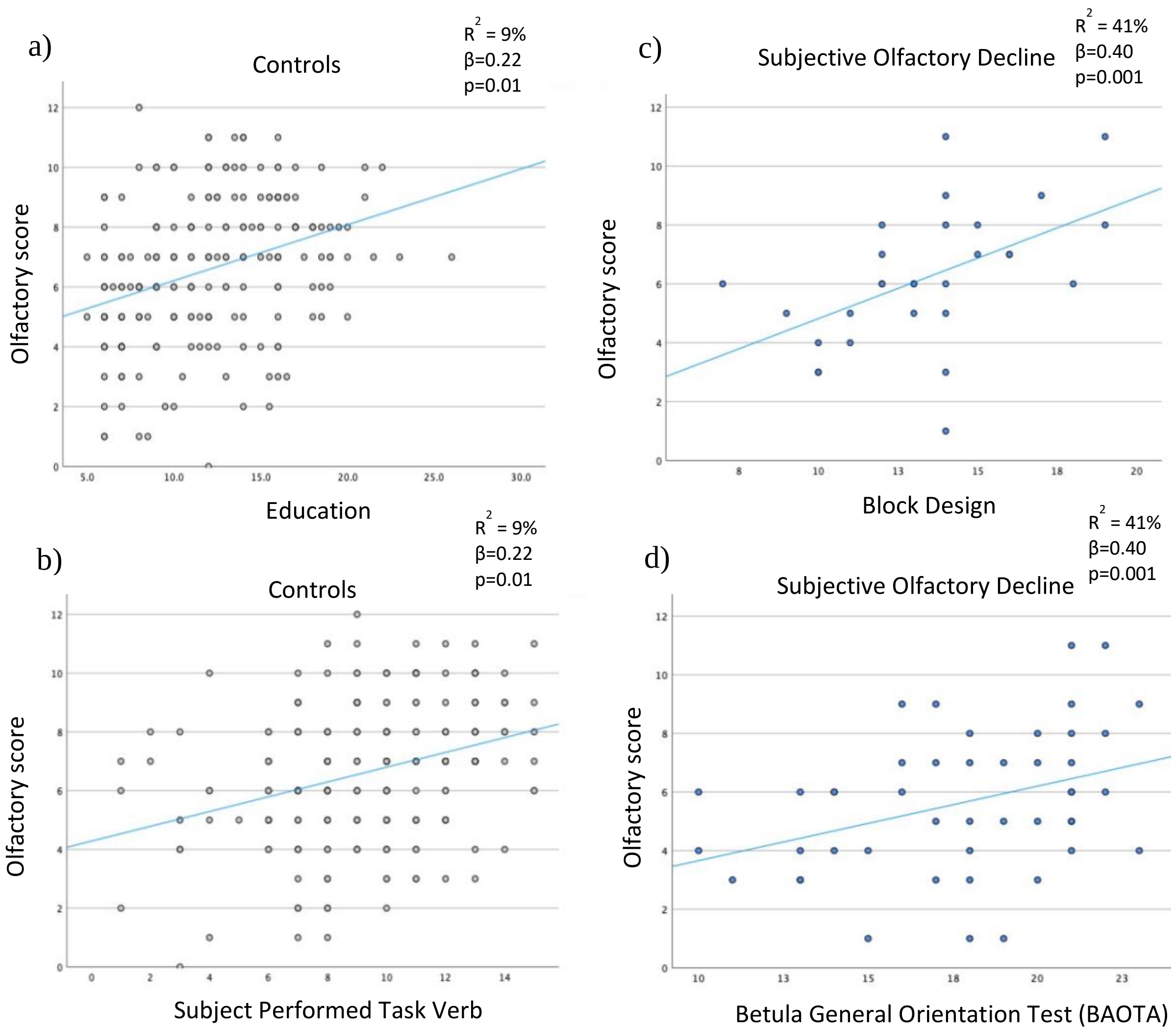
	Control group		Subjective Olfactory Decline		Subjective Cognitive Decline	
	r	p	r	p	r	p
Subject performed task verbs	**0.25**	**0.003***	**0.50**	**0.006***	-0.28	0.243
Subject performed task substantives	**0.23**	**0.008***	**0.51**	**0.005***	-0.35	0.137
Verbal Fluency	0.21	0.014	0.23	0.229	0.30	0.214
Block design	0.03	0.722	**0.51**	**0.005***	0.11	0.640
Letter digit task	0.07	0.384	**0.44**	**0.016***	0.10	0.673
Betula general orientation task (BAOTA)	0.17	0.048	**0.55**	**0.002***	0.13	0.601

Note. * Correlation is significant.

When including both age and education into the model, there was an association between cognitive tests and olfactory performance for the SOD group, this was not the case for SCD. In the control group there was a weak association between two of the tasks, see more details in figure 6. In the SOD group there was a positive association with block design and the BAOTA. The model accounted for 41% of the variance. There were no significant associations between cognition and olfactory performance at follow-up in the SCD group. This indicates that there is a difference between SOD and SCD, as the olfactory performance in the SOD is associated with cognitive performance at follow up whereas there were no associations in the SCD group.

Figure 6.

Correlations with Olfactory Score When Controlled for Age and Education.



Note. a) Association between olfactory performance and education in the control group. b) Association between olfactory performance and performance at the subjective performed task on verbs in the control group. c) Associations between olfactory performance and performance in the block design task in the SOD group. d) Associations between the olfactory performance and performance in the Betula general orientation test (BAOTA) in the SOD group.

Discussion

This thesis aimed to report the frequency of SOD, SCD and the overlap of SOD and SCD in the general population and in this way investigate the validity of SOD and whether SOD and SCD differentiate form each other. Second, investigate the effect of SOD and SCD on olfaction and cognition over time.

I found that the presence of SOD is more frequent than SCD and that the overlap between them is rare. This means that SOD and SCD are not reported by the same people, and it does indicate different things. Additionally, the SOD group has an older mean age (64 years, SD=14.2), which also goes in line with the normal development that the olfactory abilities decline with age (Doty et al., 1984).

Subjective perception of ability has been criticized because it does not correspond perfectly to objective ability. However, the research investigating the correspondence is usually investigating the current situation and not the longitudinal effect as it is done in this research.

It seems that SOD may reflect subtle olfactory deficits that later may become observable with objective testing, this future decline was significantly different from the control group, even if a decline in olfactory ability was shown across all groups. The findings support the use of subjective measures for olfaction to find people at risk of a later decline in olfaction.

Additionally, looking at the subjective olfactory ability may also be of importance as in the SOD individuals had an association between olfactory performance and several cognitive tests. The strong association with cognitive performance in memory and visuo-spatial abilities was also present when accounting for the effect of age and education. The positive association between olfaction and cognition in SOD indicates that there is a risk of developing a decline that affects both cognitive and olfactory abilities.

The associations in the SOD group were not present in the SCD group, which showed no correlations with cognitive tests in olfactory performance. This could indicate that the brain aging pattern is different in people with SCD compared to SOD. Despite the possible different brain patterns in aging in SOD and SCD, both have been linked to a risk for future cognitive decline (Jessen, 2014; Stanciu et al., 2014).

Concerning the small group with overlapping SCD and SOD, the group was too small be included in the longitudinal analysis, however, interestingly the combined group performed worse on the olfactory test than both SCD and the control group at baseline. Thus, it would be of interest to investigate further as it might indicate that having a combined decline could be a risk factor for future objective olfactory decline.

Moreover, it should be considered that there are some weaknesses with the study as well. First, the objective measure of olfaction was measured with the Scandinavian Odor identification test (SOIT). SOIT is an olfactory identification test which is also related to semantics as the task is to identify odors, this means there is some cognition needed to perform. It could be an idea to use a threshold test for future studies. When conducting a threshold test the aim is to find out people’s sensitivity. However, threshold tests are also criticized as the test usually use single molecule odors, which some people are more sensitive to than others, making this method unreliable. Multi molecular threshold would therefore be the ideal for future studies. Furthermore, the objective olfactory tests are also dependent on the subjects’ cultural background (Seok et al., 2017), this also makes it more difficult to do a general test that works on the bigger population. Nevertheless, the

Betula study used the SOIT test, which is adapted to the Scandinavian culture, which is where the participants came from.

Additionally, it can be of interest for future research to include the ApeE4 allele, as it is a good indicator of a risk factor for developing dementia. Earlier studies have shown that the risk of global functional decline over a two-year period is higher for people with one or two APoeE-e4 alleles and in individuals with odor identification impairment, when individuals had both risk factors the risk was even greater (Graves et al., 1999).

To conclude, I found that SOD and SCD are different from each other and that the overlap is small, suggesting that it does make sense to take SOD into account. This is also supported by the facts that SOD had clearer associations between olfactory performance and several cognitive tests. Asking for subjective olfactory decline can teach us more about the brain health and how the brain age. Using subjective measures in health examinations is cost-efficient and a noninvasive method and can be used as a screening tool to find people at risk for future olfactory and cognitive decline.

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