Original Article

Are Sensory and Cognitive Declines Associated in Older Persons Seeking Aged Care Services? Findings From a Pilot Study

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Abstract

Introduction: To assess the association between sensory and cognitive function, and the potential influence of visual function on cognitive function assessment, in a sample of clients accessing aged care services. Materials and Methods: We recruited 260 non-institutionalised, frail, older individuals who sought aged care services. Visual acuity was assessed using a LogMAR chart and hearing function was measured using a portable pure-tone air conduction audiometer. Visual impairment was defined as visual acuity (VA) <6/12 (<39 letters read correctly in the better eye), moderate-to-severe hearing impairment as hearing thresholds >40 decibels (better ear) and cognitive impairment as Mini-Mental State Examination (MMSE) score <24. Results: Vision and hearing assessments were randomly performed in 168 and 164 aged care clients, respectively. Visual acuity correlated weakly with MMSE scores, either including (r = 0.27, *P* <0.001) or excluding (r = 0.21, *P* = 0.006) vision-related MMSE items. After partialling out the effect of age, the association remained (r = 0.23, *P* = 0.013 including, or r = 0.18, *P* = 0.044 excluding vision-related items). No correlation was found between MMSE scores and hearing thresholds (r = -0.07, *P* = 0.375). After adjusting for age, sex and stroke, mean MMSE scores were lower in persons with visual impairment than those with normal vision (25.2 ± 0.5 versus 26.8 ± 0.4 including, or 18.2 ± 0.5 versus 19.2 ± 0.3 excluding vision-related items), but were similar between subjects with none or mild and those with moderate-to-severe hearing loss (26.3 ± 0.4 versus 26.0 ± 0.4). Conclusions: In this study sample, visual and cognitive functions were modestly associated, after excluding the influence of visual impairment on the MMSE assessment and adjusting for age. Hearing thresholds were not found to be associated with cognitive function.

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Key words: Cognition disorders, Frail elderly, Hearing loss, Visual impairment

Introduction

Many cross-sectional and longitudinal studies have reported an association between sensory and cognitive functions in the normal ageing population.[1-6] Few studies have assessed the association between sensory and cognitive impairment as most studies on cognitive ageing excluded those with sensory and cognitive impairments. Furthermore, it remains unclear if the potential influence of visual impairment on the performance of the Mini-Mental State Examination (MMSE) contributes to the association between sensory and cognitive functions.

Within the older population sector, there is a subgroup of older people who are living in communities but having difficulty in coping at home and seek help from community aged care services. This group of frail, older persons, although currently under-researched, is an important target for one of Australia's research priorities: "Healthy ageing, and ageing productively". Compared with the general, older population, this subgroup of older people has more co-morbidities, including a higher prevalence of sensory and cognitive impairment,[7,8] and consume more health and aged care services.[9]

In this study, we aimed to assess the association between sensory and cognitive functions, and the potential influence of visual function on MMSE assessment, in a sample of non-institutionalised, frail, older persons seeking aged care services.

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Materials and Methods

The Aged Care Client Study (ACCS) is a pilot for a community-based randomised controlled trial, aiming to assess potential benefits from vision and hearing testing and intervention in the oldest old and aged care assessment clients. We targeted frail, older persons who were seeking community aged care services to assist them in continuing to live at home. The study was designed to explore whether the detection of sensory impairment followed by timely provision of appropriate interventions could help older people to maintain their independent living status for a longer period, thus reducing the burden of aged care.

The pilot study was conducted in accordance with the Declaration of Helsinki and was approved by the Western Sydney Area Human Ethics Committee. Written informed consent was obtained from each participant or carer. The study procedures have been reported elsewhere.[10] In brief, we approached and recruited clients attending aged care assessment services at Westmead Hospital, Sydney. The Department of Geriatric Medicine and Aged Care Assessment Team at Westmead Hospital provide aged care assessment for residents living in 3 local government areas, which have an estimated population of almost 400,000.[11] Each elderly person living at home in this area and being assessed for their need for aged care during the study recruitment period had the same probability of being approached and recruited. The eligibility criteria were being ≥65 years of age, the ability to speak English and the absence of profound dementia to avoid unreliable responses to the questionnaire and sensory tests. Profound dementia was defined by the aged care assessment staff during their initial home visits, based on brief clinical assessment. Most of this group had MMSE scores <10, and were likely to need nursing home placement soon.

During 2003, participants were interviewed using a standardised questionnaire and randomly allocated to 1 of 4 study groups in addition to routine aged care assessment: both vision and hearing tests, vision test only, hearing test only or neither (initial recruitment group). Face-to-face interviews and/or screening tests were conducted during home visits or at Westmead Geriatric Day Hospital by one of the study investigators or an orthoptist. During the first quarter of 2004, an additional 78 participants were recruited from the same sources using the same eligibility and exclusion criteria (extended recruitment group). All additional participants underwent both vision and hearing tests in addition to routine aged care assessments (without randomisation).

Cognitive function was assessed by one of the examiners, using the standard orally administered Mini-Mental State Examination (MMSE),[12] and was defined as impaired if MMSE score <24. History of cerebrovascular disease was defined as including previous stroke or transient ischaemic attack reported by the participants or their carer.

Presenting distance visual acuity with glasses, if worn, was measured monocularly (in each eye) using a LogMAR chart (VectorVision CSV-100TM, VectorVision, Inc, Dayton, OH) and visual acuity was recorded as letters read correctly, using the modified Early Treatment of Diabetic Retinopathy Study (ETDRS-Fast) protocol.[13] Visual impairment was defined as visual acuity <6/12 (<39 letters read correctly) in the better eye.

Hearing function was measured using a portable pure-tone air conduction audiometer (AS216 Screening Audiometer, Interacoustics, Denmark) and the modified Hughson-Westlake method. The screening audiometer presented tones ranging from -10 decibels (db) to 100 db. Hearing loss was defined as mild (>25 but ≤40 dB), moderate (>40 but ≤60 dB) and severe (>60 dB), using an average of hearing thresholds over 4 frequencies (500 Hz, 1000 Hz, 2000 Hz, 4000 Hz) in the better ear.

Sociodemographic information, including marital status, living arrangements and home ownership, were recorded for all participants. We asked participants if they were able to go out alone, shop, visit someone or go to town. In addition, we collected information on their past medical co-morbidities. We defined chronic medical conditions as a history of angina, acute myocardial infarction, hypertension, stroke, diabetes, non-skin cancer, thyroid problems, gout, asthma and arthritis. Difficulty in walking, including the use of a cane, walker or wheelchair, was recorded by the examiner during the interview.

Municipal councils provide community support services for elderly persons, including home-delivered meals ("Meals-on-Wheels"); home help in cleaning, meal preparation and shopping ("Home Care"); and regular home visits by a community nurse. These services are jointly funded by the Australian Federal and State Governments and are designed to assist older persons in remaining in their homes for as long as possible.

Statistical Analyses

Statistical Analysis System (SAS, version 8.2 for Windows, SAS Institute, Cary, NY) was used for data analyses. We used Spearman correlation coefficients to assess the correlation between visual acuity, or hearing thresholds, and MMSE score. General linear model (GLM) was used to compare MMSE scores between persons with and without sensory (vision or hearing) impairment, before and after excluding 5 vision-related MMSE items, while adjusting for age, sex and a history of stroke, or two or more chronic conditions. We also compared the number of letters read correctly and hearing thresholds in persons with and without cognitive impairment after adjusting for

the same co-variates. Similar analyses were performed after excluding participants with MMSE ≤17.

Results

Over the 2 recruitment periods, we approached 490 persons, of whom 372 were eligible to participate in the study. Of those eligible, 88 (23.7%) refused, 284 (76.3%) gave written consent and 260 (69.9%) fully participated. Of participants, 168 and 164 persons, respectively, had vision and hearing assessed and had complete MMSE data collected. Figure 1 shows the flow of participants.

Table 1 compares the socio-demographic profile, use of community services, medical co-morbidities and mean MMSE scores of participants who were examined in the initial recruitment period (2003) and in the extended recruitment period (2004). Compared with the initial recruitment group, those in the extended recruitment group included a slightly lower proportion who were married but a slightly higher proportion who lived alone. The extended group also showed a lower proportion who were dependent on community nursing but a higher proportion reliant on Home Care, and a higher proportion who reported having two or more chronic conditions ($P = 0.02$). Apart from the proportions with chronic conditions, none of these differences between the 2 recruitment groups were statistically significant.

Of the 260 subjects examined, 150 (57.7%) were observed to have walking difficulty while 100 (38.5%) reported having two or more chronic conditions at the time of assessment. The main medical conditions reported by the study participants were hypertension (40.8%), cardiovascular disease (28.1%) and arthritis (18.1%).

The mean MMSE score (± standard deviation) in the study sample was 26.1 (± 4.0), range 6 to 30, and cognitive impairment (MMSE <24) was found in 49/260 (18.9%) participants. Of the 168 participants who had their vision assessed, 55 (32.7%) were found to have visual impairment; and of the 164 who had their hearing assessed, 89 (54.3 %) were found to have moderate-to-severe hearing loss. Of the 120 participants who had both vision and hearing tests, 22 (18.3%) had combined sensory impairment. Moderate-to-severe cognitive impairment (MMSE scores <17) was found in 6 subjects who had vision tests and in 4 persons who had hearing tests.

Sensory and Cognitive Association

Overall, a positive association was found between visual acuity and MMSE scores, either including or excluding vision-related items in the pilot Aged Care Client Study (Fig. 2), similar to that seen in a general older population (Fig. 3). The correlation between MMSE scores and number of letters read correctly was relatively weak (r = 0.27, P <0.001 including, or r = 0.21, $P = 0.006$ excluding the 5 vision-related items), but remained after adjusting for the effect of age (r = 0.23, $P = 0.013$ including, or r = 0.18, $P = 0.044$ excluding vision-related items). No association was found between MMSE scores and hearing thresholds (r = -0.07, $P = 0.375$).

When stratifying subjects with and without sensory impairment and after adjusting for age, sex and a history of stroke, a lower adjusted mean MMSE score was observed in subjects with visual impairment than those with normal vision, including ($P = 0.02$) or excluding ($P = 0.07$) vision-related MMSE items (Table 2). No difference in adjusted

Table 1. Comparison of Socio-Demographic Characteristics, Use of Community Services, Medical Co-morbidities and Mean MMSE Scores of Subjects Assessed in 2003 (Initial Recruitment Group) and in 2004 (Extended Recruitment Group)

Characteristics		Initial recruitment group (n = 188) (%)	Extended recruitment group (n = 72) (%)
Socio-demographic characteristics			
Age (y)	Mean age (SD)	82.4 (6.5)	81.3 (6.6)
	65-74	12.8	18.1
	75-84	46.8	47.2
	≥85	40.4	34.7
Sex	Female	62.2	68.1
Marital status	Married	45.2	34.7
Living arrangement	Alone	37.2	48.6
Income	Government pension and benefits	94.7	93.1
Housing	Owner	68.1	73.6
tenure	Rental (public/private)	15.4	11.1
	Other (includes living with relatives)	16.5*	15.3*
Use of community services			
Meals-on-wheels†		7.5	9.7
Community nurse		8.5	4.2
Home care		19.7	27.8
Medical co-morbidities			
≥2 chronic conditions‡		34	50
Walking difficulty§		58	56.9
Mean MMSE scores (SD)		26.2 (3.9)	25.7 (4.4)

MMSE: Mini-Mental State Examination; SD: standard deviation

* Not including boarding houses due to a lack of information

† Home-delivered meals

‡ Defined as history of angina, heart attack, hypertension, stroke, diabetes, non-skin cancer, thyroid problems, gout, asthma and arthritis

§ Defined as difficulty in walking, including the use of a cane, walker or wheelchair at the time of assessment.

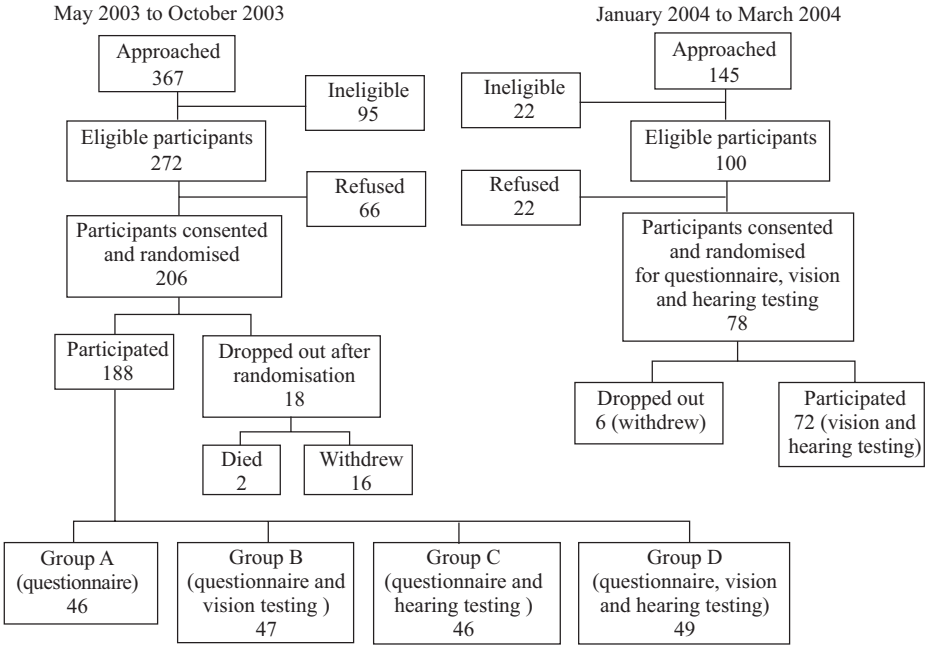

Fig. 1. Flow of study participants in the pilot Aged Care Client Study.

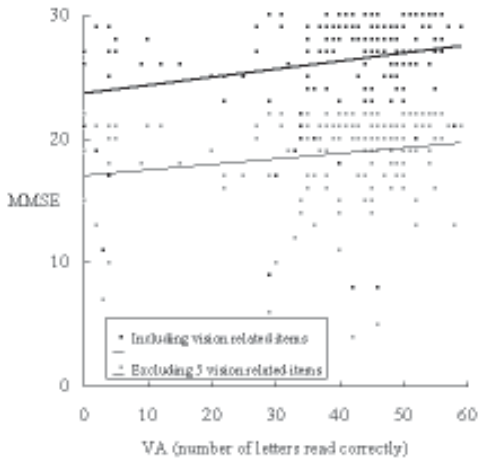

Fig. 2. Scatter plot of Mini-Mental State Examination (MMSE)* scores against visual acuity (VA)† before and after excluding 5 vision-related items in the pilot Aged Care Client Study (n = 260).

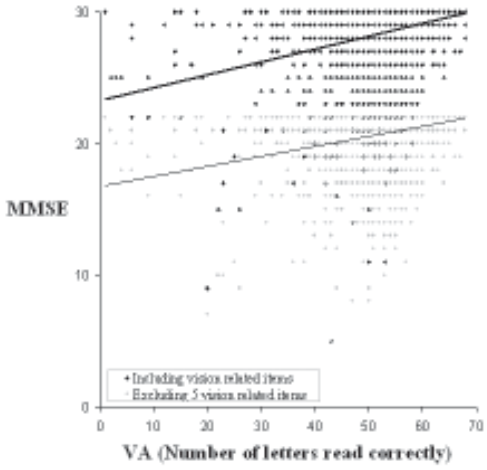

Fig. 3. Scatter plot of Mini-Mental State Examination (MMSE)* scores against visual acuity (VA)† before and after excluding 5 vision-related items in the second cross-section of the Blue Mountains Eye Study (n = 3381).

***** MMSE score ranged from 0 (at worst) to 30 (at best) when all MMSE items were included and 0 to 22 when 5 vision-related MMSE items were excluded.
† VA ranged from 0 (at worst) to 70 (at best) letters read correctly (corresponding to <6/60 to 6/3).

mean MMSE scores was observed between persons with none or mild hearing loss and those with moderate-to-severe hearing loss ($P = 0.6$) (Table 2).

After adjusting for age, sex and a past history of stroke, a non-significantly lower adjusted mean visual acuity (a difference of 2 to 3 letters read correctly) was found in subjects with cognitive impairment in both groups with and without visual impairment (Table 3). There was no clinically significant difference in the adjusted mean audiometric hearing thresholds between subjects with and without cognitive impairment in the two hearing groups with none or mild and with moderate-to-severe hearing loss.

Discussion

In this sample of non-institutionalised frail, older persons, we found a weak association between visual acuity and

Table 2. Comparison of the Adjusted* Mean MMSE Score (Standard Error) Stratified by the Presence or Absence of Visual† and Hearing Impairments‡

	Visual impairment				Hearing impairment		
MMSE items	**Range of MMSE scores**	**None (n = 113)**	**Any (n = 55)**	***P***	**None to mild (n = 75)**	**Moderate-to-severe (n = 89)**	***P***
All items	0 to 30	26.8 (0.4)	25.2 (0.5)	0.018	26.3 (0.4)	26.0 (0.4)	0.571
Excluding 5 vision-related items	0 to 22	19.2 (0.3)	18.2 (0.5)	0.067	-	-	-

MMSE: Mini-Mental State Examination

* Adjusted for age, sex and history of cerebrovascular disease

† Defined as presenting visual acuity <6/12 (fewer than 39 letters read correctly) in the better eye, where acuity ranged from 0 (at worst) to 70 (at best) letters read correctly (corresponding to <6/60 to 6/3)

‡ Defined as average hearing thresholds >40 dB measured over 4 frequencies (500 Hz-4000 Hz) in the better ear, where hearing thresholds ranged from 10 dB (best) to 100 dB (worst)

Table 3. Comparison of the Adjusted* Mean Number of Letters Read Correctly (Standard Error) and Hearing Threshold in Decibels (dB) (Standard Error) in Persons With and Without Cognitive Impairment, Measured Using MMSE Score

Sensory impairment	**Normal cognition MMSE score 24 to 30**	**Cognitive impairment MMSE score 0 to 23**	***P***
Visual impairment†			
None	48.0 (0.5)	46.3 (1.3)	0.22
Any	25.0 (2.2)	22.0 (3.9)	0.51
Hearing loss‡			
None to mild	31.1 (0.8)	30.1 (1.9)	0.61
Moderate-to-severe	55.3 (1.5)	54.8 (2.9)	0.87

MMSE: Mini-Mental State Examination

* Adjusted for age, sex and history of cerebrovascular disease

† Defined as presenting visual acuity <6/12 (fewer than 39 letters read correctly) in the better eye, where acuity ranged from 0 (at worst) to 70 letters (at best) (Snellen equivalent <6/60 to 6/3)

‡ Defined as average hearing thresholds >40 dB measured over 4 frequencies (500 Hz-4000 Hz) in the better ear, where hearing thresholds ranged from 10 dB (best) to 100 dB (worst)

cognitive functions, and a modest influence of visual impairment on MMSE assessment, due to its vision-related items. The weak association between visual acuity and MMSE scores, however, remained after excluding the influence of visual impairment on MMSE assessment, and adjusting for age, sex and history of cerebrovascular disease. Hearing threshold was not found to be associated with cognitive function in this sample.

Our findings are consistent with a number of previous reports.[2-5] Association between visual and cognitive function in older persons has been consistently demonstrated in studies on cognitive ageing.[2-5] In the Berlin Aging Study (n = 156, aged ≥70 years), Lindenberger and Baltes[2] showed an association between visual acuity and 5 intelligence domains. Hofer et al[3] reported that visual acuity was associated with a range of cognitive abilities in a cross-sectional study of 1041 persons aged 75 years. In the Australian Longitudinal Study of Ageing (ALSA) (n = 2087, aged ≥70 at baseline), Anstey et al[5] demonstrated an association between decline in visual acuity and memory decline over 8 years, after adjusting for other co-variates. These studies, however, did not make an attempt to separate the association between sensory and cognitive functions from the potential influence of visual impairment on the measurement of cognitive function. In this study, we documented a modest influence of visual impairment on MMSE assessment, but the vision-cognition association persisted after excluding the visual impairment influence on the MMSE assessment. A recent report from a 2-year follow-up of the Nurses Health Study (n = 16,197, aged ≥70 years)[14] indicated that cataract surgery prior to baseline did not make any significant difference in the risk of significant cognitive decline, after adjusting for potential confounding variables. A 2-year follow-up period, however, could have been too short to detect the difference.

The association between hearing and cognitive function has been less consistent. In the Berlin Aging Study, Lindenberger and Baltes[2] showed a modest association between hearing and cognitive functions. Hofer et al,[3] in contrast, found no association between hearing thresholds and cognitive function. In ALSA, Anstey et al[4,5] reported that hearing loss was not associated with decline in memory over a 2-year period,[4] but was weakly associated with decline in memory over an 8-year period.[5] The lack of association between hearing thresholds and MMSE scores in our study could be partly explained by insufficient sample size to detect a small difference.

Several theories have been proposed to account for the association between sensory and cognitive function in older persons.[2] First is the "common cause theory", which attributes the sensory-cognitive association to a shared, age-related factor, such as a generalised "ageing" of the brain.[2] Second is the "sensory deprivation theory", which postulates that cognitive decline results from a lack of

peripheral stimuli to the brain due to sensory impairment.[2] Third, the "resource allocation theory" has been proposed whereby those with cognitive impairment have to devote more attention to perceive sensory inputs and therefore have fewer resources to process cognitive tasks.[2,15] Fourth is the potential influence of sensory impairment on cognitive assessment because some tasks are vision- or hearing-dependent.[1] In addition to these hypotheses, Anstey et al[4,5] suggested that common pathologies in the eye and brain may partly account for the association between sensory and cognitive functions in older persons.

Limitations of our study need to be acknowledged. The study sample is relatively small, which restricts our ability to detect associations with small magnitude. This is a cross-sectional study which has no implication of causality.[1] MMSE is simply a screening tool, hence no specific underlying diagnosis can be made for the cognitive impairment. We did not measure education and depression, both factors which have been shown to influence the MMSE assessment.[16]

To summarise, we found a relatively weak association between visual and cognitive function, after excluding the influence of visual impairment on MMSE assessment and adjusting for age in this sample of aged care clients. Hearing threshold was not associated with cognitive function in this study sample. Longitudinal studies with larger sample sizes are needed to assess whether visual impairment accelerates cognitive decline in older people, or whether correcting visual impairment can delay cognitive decline. If so, this could have important management implications due to the high prevalence of remediable visual impairment in older persons.

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