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Review

# Is there a relationship between hearing loss and language impairment in patients with dementia? A systematic review

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## HIGHLIGHTS

- Hearing loss (HL) is associated with language impairment (LI) in dementia.
- The association is more evident in speech recognition and comprehension tasks.
- Peripheral HL does not explain all hearing difficulties associated with dementia.
- Cognitive load, central auditory functions, and subjective HL help predicting LI.
- Central auditory processing disorders contribute more than peripheral HL to LI.

## ARTICLE INFO

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## ABSTRACT

*Background:* Hearing loss (HL) and language impairment occur in the context of various types of cognitive impairment. There is extensive scientific literature on the relationship between HL and cognitive impairment or the risk of dementia, but its impact on language impairment is not well understood. This systematic review investigates the potential relationship between HL and language impairment in dementia patients.
*Method:* We conducted literature searches in the Scopus, Web of Science, and Medline databases from inception to May 2024 in accordance with PRISMA guidelines. Data extraction and methodological quality assessment, including risk of bias, were carried out.
*Results:* The search returned 767 articles for evaluation, which resulted in 14 that met the inclusion criteria. Overall, the results included 3676 older individuals, of whom 677 had dementia. Significant associations were observed between HL and language impairment, with a stronger association observed in comprehension than in production, although there was no evidence of causality.
*Conclusion:* Addressing hearing loss may play a role in managing language deficits in patients with dementia. Central auditory processing (CAP) and cognitive load are as critical as, if not more vital than, peripheral HL in language impairment in dementia patients. The quantification and directionality of the possible effects of language and hearing impairment on the genesis of dementia require longitudinal studies.

## 1. Introduction

According to the World Health Organization (WHO, 2018), hearing loss (HL) is a highly prevalent chronic disability that affects more than two-thirds of adults aged 70 years and older (Cardin, 2016; Lin et al., 2011). In recent years, HL has been associated with an accelerated loss of cognitive ability and an increased risk of dementia (Deal et al., 2017; Gurgel et al., 2014; Lin et al., 2011, 2013; Panza et al., 2015a; Pronk et al., 2019; Uchida et al., 2019; Zheng et al., 2017). HL may account for up to 8 % of dementia cases in those over 65 years of age (Livingston

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et al., 2020). Given the potentially modifiable nature of HL through the use of hearing aids and its positive impact on dementia prevention if corrected in middle age (Tran et al., 2023; Livingston et al., 2020; Uchida et al., 2019), attention to the association between HL and dementia has increased in recent decades. Despite extensive research, the fundamental causal connections between auditory impairment and cognitive deterioration remain inconclusive (Uchida et al., 2019).

At the anatomical level, language and hearing functions share adjacent and interconnected cortical areas (Bernstein & Liebenthal, 2014). Language is a cognitive function commonly impaired in individuals with dementia (Arvanitakis et al., 2019; Shi et al., 2023; Suárez-González et al., 2021; Varma et al., 1999). Key linguistic aspects frequently studied are word comprehension, naming/lexical access, and verbal fluency (Maseda et al., 2014; Varma et al., 1999; Weekes, 2020). Difficulty in recognising and interpreting sounds is a common challenge in dementia. This difficulty in auditory processing can originate peripherally and centrally (Jayakody et al., 2018). Central auditory processing (CAP), which refers to tasks of auditory discrimination, temporal processing, binaural interaction, sound localisation, and lateralisation, as well as interpretation of information in the presence of competing or degraded acoustic signals, dichotic listening, and low monaural redundancy (Bellis & Bellis, 2015; Musiek, 2013), appears to be directly linked to age-related hearing loss (Ruan et al., 2023), cognitive processing (Davidson & Souza, 2024) and dementia (Panza et al., 2015a; Ruan et al., 2023). Spoken language processing involves auditory, cognitive, and language mechanisms, often simultaneously via integrated neurophysiological structures with directional interactions between peripheral and central auditory pathways, as well as between the central auditory system and higher order cognitive networks within the brain Ruan et al. (2023). According to Medwetsky's model (Medwetsky, 2011), breakdowns can occur in any of the various processing stages from the initial auditory transmission of the acoustic signal, passing through temporal resolution, lexical-decoding speed, interhemispheric transfer of information, sequencing and maintaining presentation order, and short-term memory retention, to selective auditory attention. This highlights the importance of preserved auditory mechanisms.

We set out to study the possible effect of HL on language impairment in patients with dementia. This systematic review analyses whether there is a significant association between hearing impairment and language impairment in this population and, if so, whether there is evidence of causality.

## 2. Method

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021).

### 2.1. Eligibility criteria

The inclusion criteria covered studies on adults with a diagnosis of dementia that included data on the following:

1) Hearing status of the participants: evaluated by at least one standardised and specific hearing test administered by a professional.
2) Language status of the participants: objectively assessed using specific language tests (spoken or written, production or comprehension) or other tests providing information on the degree of preservation of language (such as speech comprehension or speech recognition tasks), both of which were administered by professionals.
3) Some findings or outcomes about the possible interaction between the two aspects.

The exclusion criteria were as follows: studies focusing on people without a diagnosis of dementia (e.g., healthy ageing, people at risk, and cases of mild cognitive impairment) or people with rare dementias with a prevalence <5 %, such as Pick's disease, Huntington's disease, human immunodeficiency virus (HIV)-associated dementia, Crutzfeldt-Jakob disease, Parkinsonian dementia, and Korsakoff's syndrome. People with cochlear implants or other implanted devices were excluded to avoid interference. Conventional hearing aids were not considered implanted devices.

To ensure the validity and reliability of the data, studies in which language and hearing assessments were carried out through questionnaires based on the self-perception of the participant or their caregivers were excluded. Papers on developing, adapting, or validating assessment tools, intervention studies, and papers reporting data from individuals without HL were also omitted. Finally, documents that did not appear as original articles, such as letters, commentaries, author notes, reviews, meeting proceedings, and editorial materials, were excluded.

Papers were excluded by language only after applying the other inclusion/exclusion criteria based on the English abstract.

### 2.2. Information source and search strategy

A search by title and abstract was performed in the Scopus, Web of Science, and Medline databases up to May 2024. No automatic filters were applied to maximise inclusion. Key search terms included ((((speech) OR (language) OR (communication)) AND ((hearing loss) OR (auditory loss) OR (presbycusis))) AND ((dement*) OR (Alzheimer's disease) OR (frontotemporal dementia) OR (fronto-temporal lobar degeneration) OR (vascular dementia) OR (Lewy body dementia))).

### 2.3. Quality assessment and data extraction

Data extraction and methodological quality assessment, including risk of bias, were carried out using the Joanna Briggs Institute (JBI) critical appraisal tools.

Data from each article were organised according to the following characteristics: authors, year of publication, country, study design, sample characteristics (number of participants with dementia, age), assessment tools for cognitive, language, and hearing status, research objective, and main findings related to the aim of our study. The analysis was conducted in subgroups and through narrative synthesis.

## 3. Results

As shown in Fig. 1, 747 records, plus 20 additional articles identified through references cited in the former, were examined. These records were merged into a single file, and duplicate records were removed. After all English abstracts were reviewed, four articles were excluded due to language ($n = 2$, Dutch; $n = 1$, Chinese; $n = 1$, German). Of the remaining articles for full-text inspection ($n = 338$), the principal cause for exclusion was the absence of dementia (see Supplementary material). Among the studies assessed for eligibility, 14 met the inclusion criteria for this review.

Fig. 1 presents the PRISMA flowchart showing the selection process.

Fourteen studies were selected from different countries in Europe, Asia, North America, and Australia. Diversity in research approaches was observed. Of the 14 studies, 12 were cross-sectional, while the remaining 2 were longitudinal cohorts. The JBI Critical Appraisal Checklist for Cross-Sectional Studies, which consists of 8 items, was used to assess the 12 articles. The two cohort studies were evaluated using the JBI Critical Appraisal Checklist for Cohort Studies, which comprises 11 items. The results are shown in Table 1. All cross-sectional studies were of high quality (8 points) or medium-high quality (6–7 points). The cohort studies were of medium quality (6–8 points). Given that all studies were observational, with the vast majority being cross-sectional and most involving small sample sizes, the robustness of the evidence was rated as low. Based on the certainty of evidence assessment, the

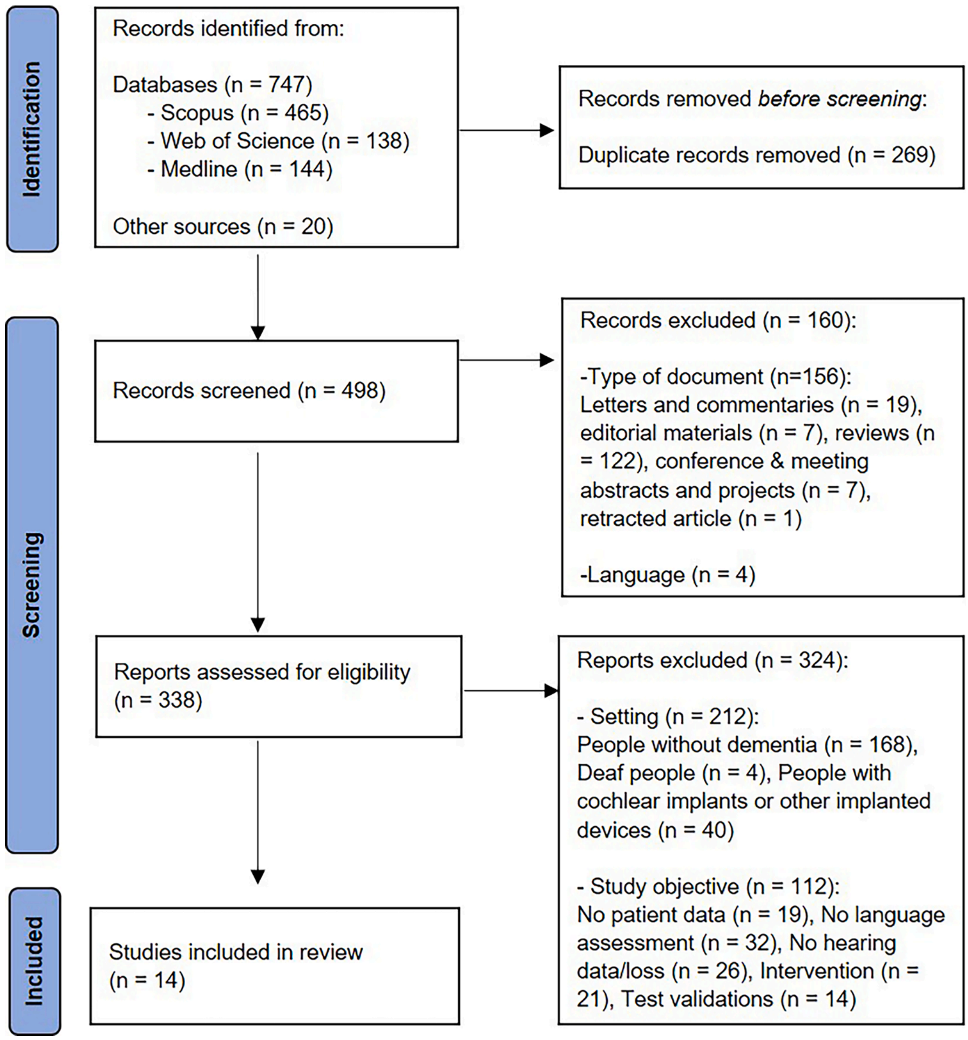


**Fig. 1.** PRISMA Flow diagram.

main impact in the strength of the evidence is indeed sample size, as 13 out of 14 studies include (very) small samples of people with dementia (< 20). Heterogeneity in the reported assessment tools follows closely, as the studies rely on different methods to determine hearing loss and language impairment. These two factors jeopardize the possibility of providing a strict account for variability, without neglecting further influence from background variables such as age, education, or the lack of evidence about premorbid language abilities. See Table 1 and supplementary materials for further details.

### 3.1. Sample characteristics

A total of 3676 individuals over 50 years of age were included in the studies (Table 1), 677 of whom were diagnosed with dementia. Most samples come from memory clinics (e.g., Regal & Lange, 2020) or AD research centres (Gates et al., 1995; McClannahan et al., 2022), where outpatients attend voluntarily. However, other studies included institutionalised (Lodeiro-Fernández et al., 2015) or hospitalised patients (Zhang et al., 2022), and a third group consisted of community-level studies (e.g., Giroud et al., 2021; Marinelli et al., 2022).

Regarding the use of hearing aids, half of the studies were unclear in this respect because they either did not indicate whether they used hearing aids (Hardy et al., 2019; Jung et al., 2021; McClannahan et al., 2022; Sardone et al., 2020; Strouse et al., 1995; Zhang et al., 2022) or reported that some participants used them but did not account for this variable in the data analysis (Giroud et al., 2021). Only 7 of the studies were explicit in this regard, considering hearing aid use as an exclusion criterion (Häggström et al., 2018; Lodeiro-Fernández et al., 2015; Regal & Lange, 2020; Wang et al., 2007), or indicating the number of users and taking this factor into account during the analysis (Coeberg et al., 2020; Gates et al., 1995; Marinelli et al., 2022).

### 3.2. Outcome measures

Pure tone audiometry and/or the calculation of the pure tone average (PTA) was the primary measure of hearing status in the 14 selected studies (Table 1) (Coeberg et al., 2020; Gates et al., 1995; Giroud et al., 2021; Häggström et al., 2018; Hardy et al., 2019; Jung et al., 2021; Lodeiro-Fernández et al., 2015; Marinelli et al., 2022; McClannahan et al., 2022; Regal & Lange, 2020; Sardone et al., 2020; Strouse et al., 1995; Wang et al., 2007; Zhang et al., 2022). In 6 of these studies, PTAs were the only auditory test (Hardy et al., 2019; Lodeiro-Fernández et al., 2015; Marinelli et al., 2022; McClannahan et al., 2022; Regal & Lange, 2020; Zhang et al., 2022). Other authors supplemented PTA with speech audiometry (Coeberg et al., 2020; Gates et al., 1995; Häggström et al., 2018; Jung et al., 2021; Strouse et al., 1995), Auditory Brainstem Responses (ABR) (Gates et al., 1995; Wang et al., 2007), CAP tests such as Synthetic Sentence Identification-Ipsilateral Competing Message (SSI-ICM), Synthetic Sentence Identification-Contralateral Competing Message (SSI-CCM) or Dichotic Digit Listening Test (DDT) (Gates et al., 1995; Häggström et al., 2018; Sardone et al., 2020; Strouse et al., 1995) and other auditory tests

**Table 1**
Characteristics of studies included in the systematic review.

| Author/year | Study design/ sample and country | Cognitive status | Language status | Hearing Status | Objective | Relationship between HL and language impairment: Main findings | Quality Score (JBI) |
|---|---|---|---|---|---|---|---|
| Coebergh et al. (2020) | Cross-sectional; n dementia = 34/ 63; Age: 59–88 The Netherlands | K-SNAP; MMSE; EF; attention & concentration; CVLT; KAIT; RFFT; Number series; MCST; Incomplete Letter test; Reverse DGS; Sound recognition | BNT; VFT; Word fluency | PTA & speech audiometry; HHIE; AES test | To know whether auditory agnosia for environmental sounds is more related to hearing or to not hearing | Peripheral HL and cognitive load increase language difficulties in AD. Groups with greater difficulty in sound recognition (AESr+/ AESn+) had worse scores on the BNT compared to groups with no difficulties (AESr-/ AESn-). This suggests that patients with auditory agnosia for environmental sounds may also experience deficits in linguistic expression. | 8/8 |
| Gates et al. (1995) | Cross-sectional; n dementia = 42/ 82 (22 questionable); Age: 67.5–84.9 USA | CDR; WMS; WAIS; SPMSQ; Short Blessed test; TMT-A; BVRT | WRT; BNT; Aphasia Battery | PTA & Speech audiometry; SSI-ICM; SSI-CCM; DPOE; ABR | Determine the prevalence and type of auditory dysfunction in mild probable AD | Significantly poorer performance in subjects with probable AD for central auditory function. No differences from controls for peripheral auditory function. Correlation between psychometric and audiological results (verbal and nonverbal tasks). Weak correlations for language tasks (e.g. BNT, aphasia Battery) except for SSIs, especially SSI-CCM, which are substantially larger. | 6/8 |
| Giroud et al. (2021) | Cross-sectional; n dementia = 21/ 135; Age: 50–90 Canada | MoCA | Reading Acuity | PTA; CDTT | To research associations between HL and neuroanatomic differences | People with peripheral HL had lower hippocampal volume (a biomarker of dementia) and greater cortical thickness in auditory and higher order language areas (which appear to be compensatory effects). | 8/8 |
| Häggström et al. (2018) | Longitudinal. Cohort. (+5–6 years); n dementia = 8/47; Age: 50–75 Sweden | Unspecified | SPQ; SPN | PTA & Speech audiometry; DDT | To investigate whether CAPD may precede the onset of AD. | Dissociation between peripheral and central auditory functions. CAPD correlates with AD. Peripheral auditory functions decrease as a function of age independent of cognitive status. | 6/11 |
| Hardy et al. (2019) | Cross-sectional; n dementia = 20/ 73; Mean age: 69.4 United Kingdom | MMSE; WASI | Word repetition (scale of 45 points). Expressive agrammatism (written sentence construction score) (scale of 25 points) | PTA | To assess peripheral hearing function in individuals with nfvPPA compared with healthy older individuals and patients with AD | People with AD and peripheral HL had worse hearing performance than the control group. People with nfvPPA and peripheral HL have a language processing disorder that goes beyond neurolinguistic impairment. Peripheral HL was related to both dementias, although more so with nfvPPA | 8/8 |

(continued on next page)

**Table 1** (*continued*)

| Author/year | Study design/ sample and country | Cognitive status | Language status | Hearing Status | Objective | Relationship between HL and language impairment: Main findings | Quality Score (JBI) |
|---|---|---|---|---|---|---|---|
| | | | | | | than in AD. However, it is not a risk factor. | |
| Jung et al. (2021) | Cross-sectional; n dementia = 65/ 112; Age: + 65 Korea | MMSE (Korean version) | Spontaneous speech; comprehension; repetition; writing ability; finger-naming; right-left orientation; body-part identification; & buccofacial praxis | PTA & speech audiometry | Evaluated the clinical factors, vascular magnetic resonance imaging markers, and cognitive impairment mechanisms on HL | Pure DLB: risk of peripheral HL and impaired comprehension. Not in the AD or mixed group. Language comprehension dysfunction was associated with more severe peripheral HL. In addition, the group of patients with pure DLB disease was found to have a higher risk of language comprehension dysfunction compared to the group of patients with pure AD, independent of PTA and K-MMSE scores. These findings suggest that HL and language impairment are related in the context of dementia. | 8/8 |
| Lodeiro-Fernández et al. (2015) | Cross-sectional; n dementia = 44/ 98; Age: 65–94 Spain | MMSE | BNT; VFT; TT | PTA | To study the possible relationship between peripheral HL and language impairment in dementia and predementia | There is an association between peripheral HL and impaired verbal comprehension in both the dementia group and, even more so, in the predementia group. Peripheral HL was not associated with TFV or BNT.<br>The results suggest that language impairment is not only associated with peripheral HL but also with other factors such as cognitive load or even the consequences of social isolation. | 7/8 |
| Marinelli et al. (2022) | Longitudinal. Cohort. (+7 years); n dementia = 159/ 1041; Age: +50 USA | Subtest of the WAIS-R & WMS-R; TMT-B; RAVLT | WRT | PTA; Informant-based reports | To investigate the association between HL and the development of dementia | Peripheral HL was not associated with verbal recognition tasks (WRT) but was associated with other cognitive tasks. It is not a predictive variable.<br>Almost 50 % of objective-peripheral HL were found to have no subjective HL. Thus, subjective HL does not correlate exactly with peripheral HL and may be related to central auditory processing. | 8/11 |
| McClannahan et al. (2022) | Cross-sectional; n dementia = 15/ 48; Age: 53–86 USA | CDR | WRT in noise & quiet | PTA | To determine the impact of mild dementia on spoken word recognition in quiet and noise | There is a relationship between peripheral HL and verbal recognition difficulties in dementia. Nevertheless, peripheral HL is not the only influencing factor (there are auditory or cognitive deficits of higher origin that hinder speech perception because symptoms persist in | 8/8 |

(continued on next page)

**Table 1** (*continued*)

| Author/year | Study design/ sample and country | Cognitive status | Language status | Hearing Status | Objective | Relationship between HL and language impairment: Main findings | Quality Score (JBI) |
|---|---|---|---|---|---|---|---|
| | | | | | | people with mild dementia and hearing aids). | |
| Regal and Lange (2020) | Cross-sectional; n dementia = 54/ 124; Age: 63–104 Australia | MMSE; MoCA; FAB; EXIT-25 | Naming Write a sentence Letter & category fluency | PTA | To explore the relationship between hearing by pure-tone audiometry and cognitive domain score | In dementia, there is a relationship between severe peripheral HL and impairment of language and other cognitive functions. | 6/8 |
| Sardone et al. (2020) | Cross-sectional; n dementia = 59/ 1647; Age: +65 (67–80) Italy | MMSE; FAB; TMT-AB; CDT; RAVLT | VFT; BNT | PTA; SSI-ICM | To explore the associations of age-related CAPD with mild cognitive impairment and dementia | There is a relationship between HL and language impairment (TFV and BNT) in CAPD-associated dementia, rather than peripheral HL. | 8/8 |
| Strouse et al. (1995) | Cross-sectional; n dementia = 10/ 10; Mean age: 71.2 USA | MMSE; Storandt Battery | WRT | PTA & Speech audiometry; HHIE-S; DPOE; SSI-ICM; DSI; DDT; PPS; DPT | To determine whether people in the early to middle phases of AD show impaired central auditory processing as compared with nondemented elderly | Peripheral HL was similar in the AD group as in the control group, but significantly worse scores were found on the CAP test and word recognition. | 8/8 |
| Wang et al. (2007) | Cross-sectional; n dementia=43/ 93; Age: +60 (Mean age=73.3) China | MMSE | WRS | PTA ABR | To evaluate peripheral auditory dysfunction in AD and its relationship with cognitive dysfunction. | In the AD group, compared to the control group, there were no significant differences in either peripheral HL or verbal recognition tasks. | 8/8 |
| Zhang et al. (2022) | Cross-sectional; n dementia = 65/ 65; Age: 56.50–69 China | MMSE; MoCA; RAVLT; CFT-imitation; TMT-A&B; SDMT; SCWT | BNT; VFT | PTA | To explore clinical features and potential mechanisms relating neuropathological biomarkers and the blood-brain barrier in AD and HL | There is a link between peripheral HL and language impairment (VFT, BNT). The AD group with HL had significantly lower scores on the MMSE, VFT, and BNT than the AD group without HL. | 8/8 |

ABR = Auditory Brain-stem Responses; AD: Alzheimer's Disease; AES = Auditory agnosia for Environmental Sounds (*r*+ recognition scores, *n*+ naming scores); BNT = Boston Naming Test; BVRT = Benton Visual Retention Test; CAPD = Central Auditory Processing Disorder; CDR = Clinical Dementia Rating Scale; CDT = Clock Drawing Test; CDTT = Canadian Digit Triplet Test; CFT = Complex Figure Test; CVLT = California Verbal Learning Test; DDT = Dichotic Digit Listening Test; DGS = Digit Span; DPOE = Distortion-Product Otoacoustic Emissions; DLB = Dementia with Lewy Bodies; DPT = Duration Pattern Test; DSI = Dichotic Sentence Identification test; EF = Executive Function; EXIT-25 = Executive Battery; FAB = Frontal Assessment Battery; HHIE(-S) = Hearing Handicap Inventory for the Elderly (-Short version); HL = Hearing Loss; JBI: Joanna Briggs Institute; K-SNAP = Kaufman Short Neuropsychological Assessment Procedure; KAIT = Kaufman Adolescent and Adult Intelligence Test; MCST = Modified Card Sorting Test; MMSE = Mini-Mental State Examination; MoCA = Montreal Cognitive Assessment; *n* = number; nfvPPA = Nonfluent Variant Primary Progressive Aphasia; PPS = Pitch Pattern Sequence test; PTA = Pure Tone Audiometry/Average; RAVLT=(Rey's) Auditory Verbal Learning Test; RFFT = Ruff Figural Fluency Test; SCWT = Stroop Color-Word Test; SDMT = Symbol Digit Modalities Test; SPMSQ = Short Portable Mental Status Questionnaire; SPN = Speech Perception in Noise; SPQ = Speech Perception in Quiet; SSI-CCM = Synthetic Sentence Identification Contralateral Competing Message; SSI-ICM = Synthetic Sentence Identification Ipsilateral Competing Message; TMT-A&*B* = Trail Making Test; TT = Token Test; VFT = Verbal Fluency Test; WAIS(-R) = Wechsler Adult Intelligence Scale(-Revised); WASI = Wechsler Abbreviated Scale of Intelligence; WMS(-R) = Wechsler Memory Scale(-Revised); WRS = Word Recognition Scores; WRT = Word Recognition Test.

involving language such as the Word Recognition Test (WRT) and corresponding Word Recognition Scores (WRS) (Gates et al., 1995; Marinelli et al., 2022; McClannahan et al., 2022; Strouse et al., 1995; Wang et al., 2007).

With respect to specific language tests, except for one study (Giroud et al., 2021), all others used tests of spoken language. The most common were the Boston Naming Test (BNT; Kaplan et al., 1983) (Coeberg et al., 2020; Gates et al., 1995; Lodeiro-Fernández et al., 2015; Sardone et al., 2020; Zhang et al., 2022) and similar naming tasks (Jung et al., 2021; Regal & Lange, 2020), which were usually supplemented with the Verbal Fluency Test (VFT; Lezak, 2004) (Coeberg et al., 2020; Lodeiro-Fernández et al., 2015; Sardone et al., 2020; Zhang et al., 2022) or comparable verbal fluency tasks (Coeberg et al., 2020; Regal & Lange, 2020). Some studies utilised other widespread assessment tests, such as the Aphasia Battery (Faben-Langendoen et al., 1988) (e.g., Gates et al., 1995; Hardy et al., 2019; Marinelli et al., 2022; McClannahan et al., 2022; Strouse et al., 1995), the Token Test (De Renzi & Vignolo, 1962) (Lodeiro-Fernández et al., 2015), or auditory verbal tasks including in Rey's Auditory Verbal Test (Marinelli et al., 2022; Sardone et al., 2020; Zhang et al., 2022).

### 3.3. *Peripheral versus central hearing impairment*

A major question is whether the hearing impairment associated with language difficulties is peripheral or central (Table 2). Most of the articles analysed in this review that found an association between HL and language difficulties focused on peripheral HL (Coeberg et al., 2020; Giroud et al., 2021; Jung et al., 2021; Lodeiro-Fernández et al., 2015; McClannahan et al., 2022; Regal & Lange, 2020; Zhang et al., 2022). Conversely, those authors who compared the results of central and peripheral tests concluded that central auditory processing disorders (CAPD), not peripheral HL, are associated with language impairment

**Table 2**
Association or no association between central and peripheral hearing and language (comprehension and production) in dementia patients.

| Author/year | Dementia subtype | Hearing impairment | | | |
|---|---|---|---|---|---|
| | | **Peripheral** | | **Central** | |
| | | *Language comprehension* | *Language production* | *Language comprehension* | *Language production* |
| Coebergh et al. (2020) | AD | ✓ | ✓ | | |
| Gates et al. (1995) | AD | × | × | ✓ | ✓ |
| Giroud et al. (2021) | AD | ✓ | | ✓ | |
| Häggström et al. (2018) | AD | × | | | |
| Hardy et al. (2019) | AD/nfvPPA | × | × | | |
| Jung et al. (2021) | AD/LBD | ✓ | | | |
| Lodeiro-Fernández et al. (2015) | Unspecified | ✓ | × | | |
| Marinelli et al. (2022) | Unspecified | × | | | |
| McClannahan et al. (2022) | Unspecified | ✓ | | | |
| Regal and Lange (2020) | Unspecified | ✓ | | | |
| Sardone et al. (2020) | Unspecified | | | | ✓ |
| Strouse et al. (1995) | AD | × | | ✓ | |
| Wang et al. (2007) | AD | × | | | |
| Zhang et al. (2022) | AD | | ✓ | | |

✓: Associated; ×: Not associated; AD: Alzheimer's Disease; LBD: Lewy-body disease; nfvPPA: nonfluent/agrammatic variant primary progressive aphasia.

(Gates et al., 1995; Sardone et al., 2020; Strouse et al., 1995). However, the longitudinal studies in this review agree that peripheral HL is not predictive of dementia (Häggström et al., 2018; Marinelli et al., 2022), unlike CAPD (Häggström et al., 2018). Subjective HL was also found to be relevant, as peripheral HL and subjective HL did not always coincide (Marinelli et al., 2022; Strouse et al., 1995).

Additionally, the limitation of cognitive resources related to mental workload or working memory seems to play a more significant role in language impairment than peripheral auditory limitations (Coebergh et al., 2020; Jung et al., 2021; Lodeiro-Fernandez et al., 2015; McClannahan et al., 2022). In this context, changes in the thickness of the auditory and language cerebral cortices were found in individuals with dementia and peripheral HL, which could be related to this compensation effect (Giroud et al., 2021).

### *3.4. Comprehension versus production deficits*

Overall, the authors found an association between hearing impairment and language difficulties in speech recognition and comprehension tasks (Coeberg et al., 2020; Gates et al., 1995; Giroud et al., 2021; Jung et al., 2021; Lodeiro-Fernández et al., 2015; McClannahan et al., 2022; Regal & Lange, 2020; Strouse et al., 1995; Zhang et al., 2022). Production results are less consistent. Among the five studies that analysed this relationship (Coeberg et al., 2020; Gates et al., 1995; Lodeiro-Fernández et al., 2015; Sardone et al., 2020; Zhang et al., 2022), four reported an association (Coeberg et al., 2020; Gates et al., 1995; Sardone et al., 2020; Zhang et al., 2022).

### *3.5. Findings across different dementia subtypes*

The most common identifiable dementia type was Alzheimer's disease (AD) (Table 2) (Coebergh et al., 2020; Gates et al., 1995; Giroud et al., 2021; Häggström et al., 2018; Hardy et al., 2019; Jung et al., 2021; Strouse et al., 1995; Wang et al., 2007; Zhang et al., 2022), which in two studies was compared with other types of dementia (Hardy et al., 2019; Jung et al., 2021). The remaining studies did not specify the type of dementia (Lodeiro-Fernandez et al., 2015; Marinelli et al., 2022; McClannahan et al., 2022; Regal & Lange, 2020; Sardone et al., 2020).

Only two studies compare dementia subtypes (Hardy et al., 2019; Jung et al., 2021). Hardy et al. (2019) report greater interaural asymmetry in nfvPPA than in AD, although the latter still differs from controls. This may be attributed to pathology of the central pathways (rather than peripheral). There were no correlations between PTA and phrase/word repetition or expressive language. Jung et al. (2021) indicated that people with pure DLB had a higher risk of language comprehension dysfunction compared to the group of patients with pure AD independent of peripheral HL. These studies highlight the importance of the dementia subtype for the characterization of the relationship between hearing and language.

## 4. Discussion

Hearing and language comprehension are complex interactive processes dependent on the bottom-up encoding of the acoustic signal and the top-down cognitive processes required to decode and interpret the spoken message (Pichora-Fuller & Singh, 2006). From this perspective, it is logical that HL hinders verbal recognition and comprehension, as supported by most studies in our review (Coeberg et al., 2020; Gates et al., 1995; Giroud et al., 2021; Jung et al., 2021; Lodeiro-Fernández et al., 2015; McClannahan et al., 2022; Regal & Lange, 2020; Strouse et al., 1995; Zhang et al., 2022). Nevertheless, a critical question is whether HL leads to irreversible language difficulties and, consequently, an impairment of language function or whether, on the contrary, these difficulties can be addressed through hearing aid use (Livingston et al., 2020; Tran et al., 2023; Uchida et al., 2019). As most studies in this review did not consider hearing correction as a variable in the analysis of the results, except for the few studies that indicated it as an exclusion criterion in sample selection (Häggström et al., 2018; Lodeiro-Fernández et al., 2015; Regal & Lange, 2020; Wang et al., 2007), a conclusive answer is still pending further investigation. However, a systematic review, reported that the beneficial effects of hearing aids on cognition relate to executive functions rather than language and may even have little or no impact on language (Sanders et al., 2021).

Together with the cochlea and the auditory nerve, the central auditory system is susceptible to age-related deterioration (Angenstein, 2024; Antunes & Malmierca, 2021; McClaskey, 2024; Ono & Ito, 2024; Sakurai et al., 2025; Slugocki et al., 2025). Central auditory pathways also appear to be involved in neurodegeneration in dementia (Sardone et al., 2020). In AD, deterioration of the brainstem and the cerebellum related to atrophy in auditory deafferentation increases the vulnerability of related brain regions (Llano et al., 2021). Central auditory pathway degeneration, whether or not linked to peripheral HL, would be more closely related to language impairment and may also be related to subjective HL.

However, is it possible to distinguish between the contributions of the peripheral and central systems to specific language difficulties? If feasible, which of the two is key? The studies in our review comparing the results of both types of auditory tests agreed that the CAP is the primary contributor (Gates et al., 1995; Sardone et al., 2020; Strouse et al., 1995). If this is the case, deficits in central mechanisms may constitute a more robust early marker of cognitive decline than peripheral hearing loss (Häggström et al., 2018). These receive further support from studies of individuals with preclinical dementia and probable AD (Gates et al., 2002, 2011). A systematic review also highlighted the positive correlation between CAP and the perception of distorted speech in noise, with working memory and processing speed (Davidson & Souza, 2024). In healthy ageing, especially in rapid speech or noisy environments, processing resources generally allocated to other cognitive functions compensate for auditory deficits resulting from auditory impairment (Harvey et al., 2017; Rudner et al., 2012; Pichora-Fuller et al., 1995). This allocation of resources limits the ability to process auditory information efficiently and negatively affects other central cognitive functions, such as storage and working memory retrieval.

According to the Ease of Language Understanding (ELU) model (Rönnberg et al., 2008), language comprehension is based on an automatic matching mechanism between the incoming auditory signal and the phonological representations stored in long-term semantic memory. The model relies on the interaction between an input buffer, Rapid Automatic Multimodal Binding of PHOnology (RAMBPHO), and three memory systems: working memory, semantic long-term memory, and episodic long-term memory. If there is a discrepancy (e.g., due to acoustic distortions or environmental noise) between the acoustic signal and the previously consolidated phonological representations, compensatory processing involving working memory and/or frontal executive functions activates in order to resolve potential ambiguities and facilitate comprehension (Rönnberg et al., 2013, 2019). From this perspective, it is logical to predict that when HL is comorbid with dementia, difficulties in word and sentence comprehension can be exacerbated, as confirmed by studies (Coeberg et al., 2020; Gates et al., 1995; Giroud et al., 2021; Jung et al., 2021; Lodeiro-Fernández et al., 2015; Marinelli et al., 2022; McClannahan et al., 2022; Regal & Lange, 2020; Strouse et al., 1995; Zhang et al., 2022).

In addition to the consequences for auditory comprehension, such an additional cognitive load may affect expressive aspects of language. Research on healthy ageing shows that HL can cause difficulties in lexical access due to a mismatch between stored and received phonological representations or increased attentional and executive requirements (Guglielmi et al., 2020). In individuals with dementia, this explanation could account for the findings of some authors in this review, who reported a link between HL and deficits in linguistic expression (Coebergh et al., 2020; Zhang et al., 2022). However, the relationship between HL and impaired language production is less clear. A recent study on the preclinical stages of AD examined possible links between HL and the biomarkers β-amyloid and p-tau181 (Martinez-Dubarbie et al., 2024). The authors reported that language (measured through tests such as the BNT, VFT, and WRT) was not a neuropsychological domain correlated with peripheral HL. This finding is consistent with some studies in our review (Lodeiro-Fernández et al., 2015; Gates et al., 1995: Sardone et al., 2020). In a study that analysed the health conditions of 59,188 older adults with and without dementia in Canada (Williams et al., 2020), language difficulties appeared to be a risk factor for HL over time, being approximately 2.5 times more likely. This finding suggests a possible bidirectional relationship between HL and language (Fig. 2). The quantification and directionality of the association between language and hearing impairment remains unclear. CAP assessments appear to be more informative than peripheral auditory tests. The role of cognitive load cannot be neglected. However, evidence should be handled cautiously, as these data were collected through a questionnaire to caregivers and professionals, which is not directly comparable to the objective measures in the studies discussed in this review, which show no indication of bidirectionality. Deterioration of central mechanisms may predict cognitive decline (Häggström et al., 2018; Marinelli et al., 2022).

With respect to methodological aspects, the results of this review indicate that, in addition to peripheral assessment, the use of central auditory tests should be generalised. The SSI-CCM, SSI-ICM, and Dichotic Sentence Identification Test have emerged as reliable tests for central auditory functions and memory decline (Aylward et al., 2021; Gates et al., 1995; Häggström et al., 2018; Sardone et al., 2020; Strouse et al., 1995). Subjective or self-reported HL could be equally determinant in the study of hearing as peripheral HL (Marinelli et al., 2022; Martinez-Dubarbie et al., 2024; Tran et al., 2023). Despite the literature associating subjective or self-perceived HL with peripheral HL (Ferrán et al., 2024; Yang et al., 2023), studies in this review did not always find correspondence between them (Marinelli et al., 2022; Strouse et al., 1995).

Considering the limitations of cross-sectional studies in exploring the nature of the relationships between variables and therefore focusing only on longitudinal studies in this review (Häggström et al., 2018; Marinelli et al., 2022), we found that the relationship between peripheral HL and dementia was not as strong as had been considered (Deal et al., 2017; Lin et al., 2013; Livingston et al., 2020) because CAPD can be as robust or even a more robust diagnostic marker than peripheral HL (Häggström et al., 2018; Panza et al., 2015b; Sardone et al., 2020; Uchida et al., 2019). In particular, compared with other auditory tests, the SSI-CCM strongly correlates with language impairment (Gates et al., 1995).

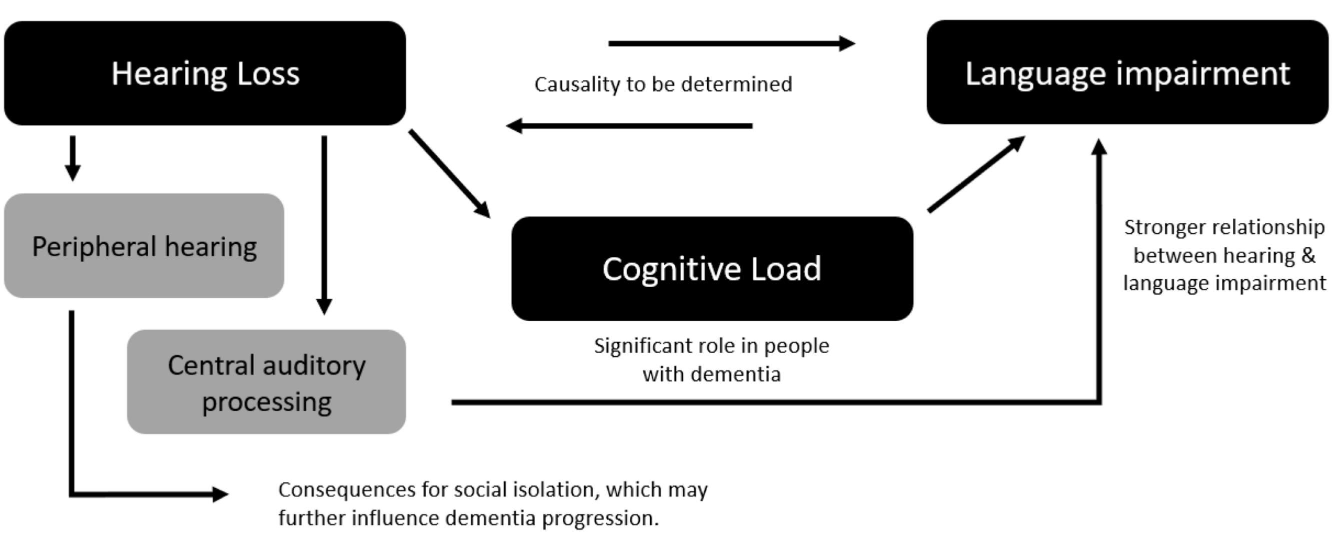


**Fig. 2.** Associations between hearing and language impairment in dementia.

One of the most salient limitations of this review is that there is insufficient research in this area to reach conclusive conclusions. The fact that most studies report data from speakers of Germanic (mostly English) and, to a lesser extent, Romance languages, adds to the ever-present risk of publication bias. Importantly, differences in experimental designs and research objectives render comparisons among studies difficult. No meta-analysis was performed in this review due to the heterogeneity of the data. Better descriptions and exhaustive control over experimental participants (e.g., age, education, premorbid linguistic background, and exhaustive neuropathological profiles) are essential, as, at this stage, it is not yet possible to draw strong conclusions about the relationship between hearing loss and language impairment across different dementia types. Among other factors, the use of assistive devices, patient participation in intervention programmes, and the degree of social inclusion must be considered as these factors could interfere with the results. For example, social isolation can worsen communication in individuals with age-related hearing impairment (Panza et al., 2015a, 2015b). Future studies should consider including analyses across the different types of dementia, as language can be differentially impaired. The main strength of this review is that it highlights key points for creating a future research agenda, as the heterogeneity and the limited data prevented a reliable meta-analysis.

## 5. Conclusion

There is evidence of a relationship between HL and language difficulties in speech recognition and comprehension, but this cannot be considered causal. The CAP assessments, especially the SSI-CCM, revealed a stronger relationship between hearing and language than peripheral auditory tests. Cognitive load also plays a significant role in language deficits in individuals with dementia. In addition, sensory deprivation has consequences for social isolation, which may further influence dementia progression. Thus, separating the interrelationship between auditory and language decline is challenging.

Despite its limitations, the results allow us to make preliminary evidence-based short-term actionable steps and longer-term research goals for researchers and clinicians working with people with dementia. Short-term objectives should include the incorporation of professionals from different disciplines, including otolaryngologists, neurologists, geriatricians, speech therapists, and clinical linguists, to future research agendas. This is essential to delve into the interrelationship between hearing loss and language, a priority question, instead of trying to dissociate between the two artificially. The quantification and directionality of a potential effect of language and hearing impairment on the genesis of dementia require long-term longitudinal research that, based on a standardised data collection protocol, allow us to provide a conclusive answer to the question raised. Given the undeniable role of hearing in spoken language processing, studies focusing on language should include standardized measures for such purpose, since dichotomous descriptions (neurotypical or corrected to normality vs. impaired) are not sufficient. Conversely, hearing studies should provide more fine-grained characterizations of language status. In addition to PTAs, assessment protocols should include CAP measures such as SSI-CCM, as well as comprehension and production tasks relevant for people with dementia (e.g., fluency tasks) instead of tasks envisioned for post-stroke aphasia that, in most cases (and languages) lack normative data for this population. Regarding clinical pathways and intervention, assessment of central auditory capacities can contribute to the early detection of cognitive impairment, allowing early implementation of customized intervention protocols, a potential short-to mid-term actionable step towards improving early diagnosis. Hearing aids can help maintain sensory stimulation and potentially delay cognitive decline.

## CRediT authorship contribution statement

**L. Lodeiro-Fernández:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **A. Maseda:** Writing – review & editing, Supervision. **L. Lorenzo-López:** Writing – review & editing. **N. Cibeira:** Writing – review & editing. **J.C. Millán-Calenti:** Writing – review & editing. **J. Leira:** Writing – original draft, Writing – review & editing. **S. Martínez-Ferreiro:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Silvia Martinez-Ferreiro reports financial support was provided by Spanish Ministry of Science and Innovation. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Supplementary materials

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