

Multilingual Language Experience and Cognitive Reserve in Neurological Disorders: A Psycholinguistic Systematic Review

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ABSTRACT: Multilingual language use constitutes a form of sustained cognitive engagement requiring continuous coordination of multiple linguistic systems. Language selection, inhibition, and switching recruit executive control processes proposed to contribute to cognitive reserve; the capacity to maintain cognitive functioning despite underlying neuropathology (Bialystok, Craik, & Luk, 2012). This systematic review, conducted following PRISMA guidelines across six databases (PubMed/MEDLINE, Scopus, Web of Science, PsycINFO, Embase, and CINAHL), synthesizes empirical evidence on whether bilingual and multilingual experience is associated with cognitive differences in adults with neurological disorders. Eighteen studies published between 2010 and 2025 were identified across Alzheimer's disease, mild cognitive impairment, frontotemporal dementia, epilepsy, and multiple sclerosis. Multilingualism was operationalized heterogeneously, ranging from categorical bilingual status to detailed language histories capturing proficiency, age of acquisition, and patterns of use. Several studies reported patterns consistent with cognitive reserve, including slower functional decline and dissociations between neuropathology and clinical performance, particularly on measures of executive function, attention, memory, and processing speed. Findings varied across disorders and were strongly influenced by how language experience was defined. The literature suggests that sustained multilingual engagement may interact with neural systems underlying language control and executive processing, though consistent evidence requires more rigorous characterization of multilingual exposure.

KEYWORDS: Bilingualism, Cognitive Reserve, Language Control, Multilingualism, Neurocognitive Disorders.

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1. Introduction

Multilingual language use has long been a central topic in linguistics and psycholinguistics, where research examines how speakers manage and regulate multiple linguistic systems in communication. Bilingual and multilingual speakers routinely engage in processes of language selection, inhibition of non-target languages, and context-sensitive switching during speech production and comprehension. As François Grosjean explains, “bilinguals are those who use two or more languages in their everyday lives” and their linguistic behavior involves the dynamic interaction of these languages within a single cognitive system (Grosjean, 2010). Because multilingual speakers must coordinate competing lexical and grammatical systems, bilingual language use has increasingly been understood as a form of sustained cognitive engagement involving attentional control and metalinguistic monitoring. Within psycholinguistics and cognitive neuroscience, this perspective has converged with the concept of cognitive reserve (CR), which refers to the ability to maintain cognitive functioning despite underlying brain pathology. Cognitive Reserve seeks to explain why individuals with similar levels of neuropathology may show different clinical manifestations or trajectories of decline. As Yaakov Stern notes, cognitive reserve refers to “the ability of the brain to cope with or compensate for pathology so that clinical symptoms are delayed or reduced” (Stern, 2009). Differences in reserve are often attributed to life course experiences that promote efficient or flexible recruitment of cognitive networks, including education, occupational complexity, and engagement in intellectually demanding activities (Calvo et al., 2016; van den Noort et al., 2019).

From this perspective, multilingual language experience has been proposed as a potential contributor to cognitive reserve because it requires continuous coordination between linguistic systems and sustained engagement of executive control mechanisms. Research on bilingual language processing emphasizes that speakers must constantly manage interference between languages. As Judith F Kroll and Erika Stewart observe, “both languages remain active to some degree during language processing, even when only one language is being used” (Kroll and Stewart, 1994). This coactivation requires speakers to inhibit nontarget lexical items and to select the appropriate language according to communicative context. Over time, repeated engagement of these control processes may strengthen attentional and executive networks that support flexible cognitive functioning.

In linguistic terms, bilingualism generally refers to the use of two languages, whereas multilingualism refers to the use of two or more languages in daily communication. However, bilingual or multilingual status does not represent a uniform exposure. Language experience varies according to several dimensions, including age of acquisition, level of proficiency, frequency of language use, and sociocultural context. As Grosjean emphasizes, “bilingualism is not a categorical phenomenon but rather a continuum of language abilities and uses” (Grosjean, 2010). Methodological variability in how multilingualism is defined and measured has therefore been identified as a major source of inconsistency across studies examining cognitive outcomes (Calvo et al., 2016; van den Noort et al., 2019).

A central hypothesis in bilingualism research is that managing multiple languages places sustained demands on executive control processes. Speakers must inhibit competing lexical representations, switch between languages depending on interlocutor and context, and maintain goal directed language selection during discourse. These processes involve attentional monitoring, conflict resolution, and cognitive flexibility, functions commonly associated with frontal executive networks (Alladi et al., 2013; van den Noort et al., 2019). In influential work on bilingual cognition, Ellen Bialystok argues that “the constant management of two languages

enhances executive control processes” (Bialystok, Craik, and Luk, 2012). Such mechanisms have been proposed as one pathway through which bilingual or multilingual language experience may contribute to cognitive reserve.

Much of the research on bilingualism and cognitive reserve has focused on dementia and related neurodegenerative syndromes. Several studies have reported that bilingual individuals later show symptoms of onset or delayed clinical diagnosis compared with monolingual peers (Alladi et al., 2013; van den Noort et al., 2019). For example, large clinical cohort studies have suggested delays of approximately four to five years in the onset of dementia related symptoms among bilingual speakers, although such effects have not been consistently replicated across all populations or research designs (van den Noort et al., 2019). These findings have stimulated broader interest in whether multilingual language experience might support cognitive resilience in other neurological disorders in which executive and attentional functions are frequently affected.

Despite these promising observations, the overall evidence remains heterogeneous. Some studies report protective associations between multilingualism and cognitive outcomes, whereas others find no significant differences once factors such as education, socioeconomic status, and immigration context are considered (Calvo et al., 2016). Methodological critiques frequently highlight residual confounding and inconsistent characterization of language proficiency and exposure as key limitations in literature. Moreover, disorder specific mechanisms may influence whether multilingual language experience plausibly translates into measurable reserve benefits. For example, research in multiple sclerosis has reported mixed findings regarding the relationship between multilingualism and cognitive performance (Morrow et al., 2023). These inconsistencies underscore the need to examine multilingualism within the biological and clinical context of specific neurological conditions.

Given the expansion of research on bilingualism and cognition, an updated synthesis is warranted to consolidate recent evidence and to evaluate whether observed associations extend beyond dementia into other neurological disorders. Previous systematic reviews have emphasized the need for larger longitudinal studies with clearer operational definitions of bilingualism and more precise behavioral and neurobiological measures of language experience (van den Noort et al., 2019). At the same time, the growing global burden of neurological disorders highlights the importance of identifying life course factors that may support cognitive resilience and functional independence (Feigin et al., 2021).

The present systematic review therefore examines whether bilingual and multilingual language experience is associated with indicators of cognitive reserve in adults with neurological disorders. Specifically, the review evaluates whether multilingual exposure relates to delayed symptom onset, slower cognitive decline, or improved cognitive and functional outcomes. Secondary objectives are to examine whether associations differ across disorder categories and according to characteristics of language experience such as age of acquisition, proficiency, and intensity of use. By synthesizing recent empirical evidence across neurological conditions, this review aims to clarify how multilingual language experience may interact with cognitive resilience while accounting for definitional variability, potential confounding, and clinical heterogeneity.

2. Methodology

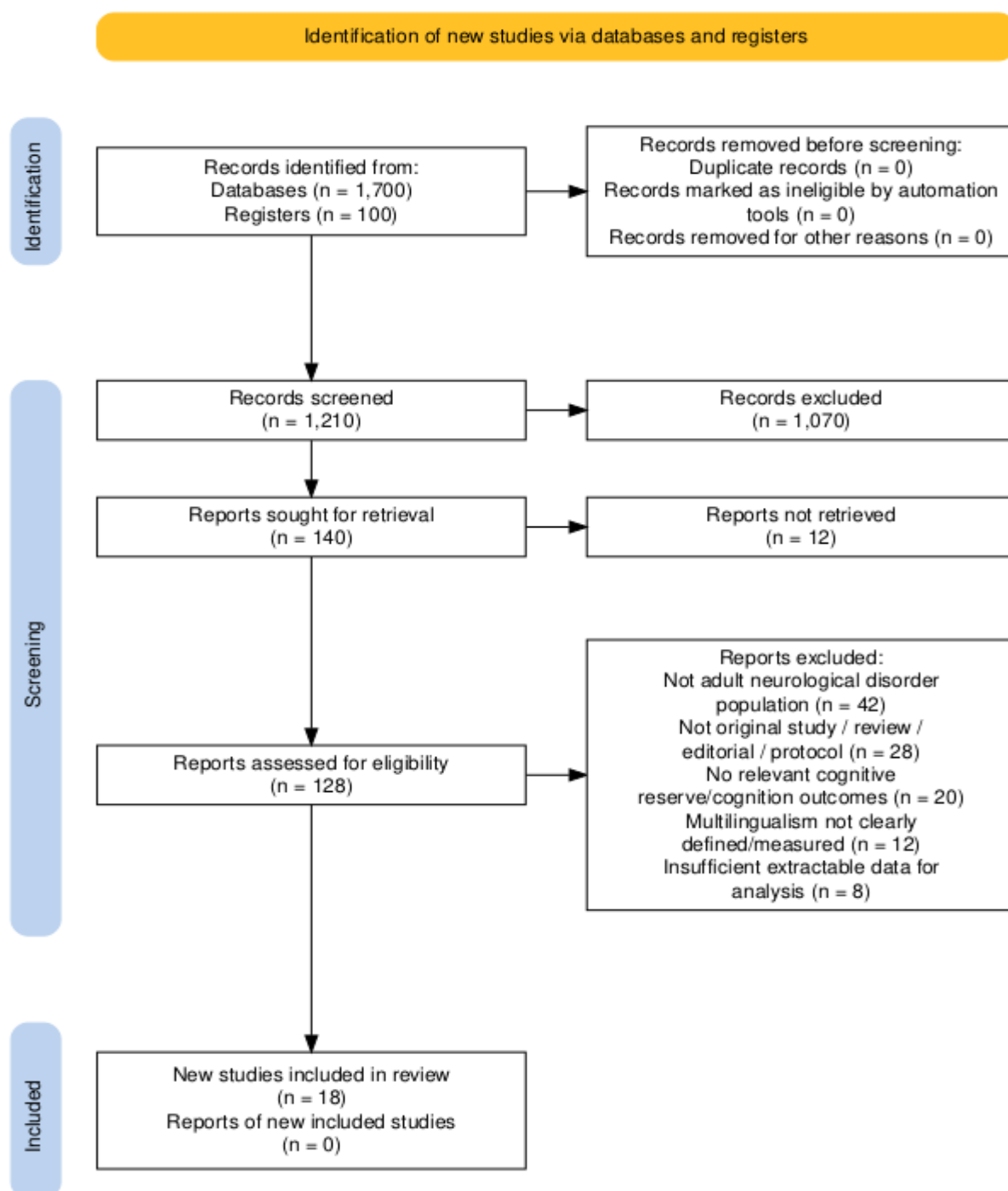
This systematic review was designed and reported in accordance with the guidelines of **PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses)**, which provides a structured framework for transparent and reproducible evidence synthesis in interdisciplinary research. Priori methodological procedures were defined prior to data collection to ensure methodological consistency. These procedures included clearly specified eligibility criteria, a structured database search strategy, a multistage screening process, standardized data extraction fields, and a narrative synthesis approach suitable for heterogeneous evidence. Attention was given to the operationalization of bilingual and multilingual language experience, given that definitions of language exposure and proficiency vary considerably across studies in linguistics and cognitive research. As noted in bilingualism scholarship, language experience cannot be reduced to a simple categorical status, since bilingualism represents “a continuum of language abilities and uses rather than a discrete category” (Grosjean, 2010).

2.1 Data Sources and Search Strategy

A comprehensive literature search was conducted to identify original empirical studies examining multilingual language experience as a potential contributor to cognitive reserve among adults with neurological disorders. Because research on bilingualism and cognition spans several disciplinary fields, the search strategy was designed to capture relevant work across linguistics, psychology, neuroscience, and clinical research.

The electronic database search included PubMed/MEDLINE (n = 420 records), Scopus (n = 520), Web of Science (n = 380), PsycINFO (n = 210), Embase (n = 140), and CINAHL (n = 30), yielding a total of 1,700 records from academic databases. To ensure comprehensive coverage of emerging studies, clinical research registries were also searched, including ClinicalTrials.gov (n = 60) and the WHO International Clinical Trials Registry Platform (ICTRP) (n = 40). These registry searches contributed an additional 100 records. The combined search across databases and trial registers yielded 1,800 records in total, as illustrated in the PRISMA flow diagram (Figure 1).

Figure 1. PRISMA Flow Diagram



Search was limited to studies published between January 2010 and December 2025 to capture contemporary research employing modern approaches to measuring bilingualism, multilingual language experience, and cognitive outcomes. The search targeted human adult populations (18 years and older) because cognitive reserve frameworks are most frequently investigated in adult neurological populations.

Search terms were organized around three conceptual domains: multilingual or bilingual language experience, cognitive reserve or cognitive functioning, and neurological disorders. A representative search query used in PubMed was as follows:

("bilingualism" OR "multilingualism" OR "bilingual" OR "multilingual" OR "second language") AND ("cognitive reserve" OR "cognitive resilience" OR "cognitive decline" OR "cognition") AND ("neurological disorder" OR "neurologic disease" OR "neurodegenerative" OR "dementia" OR "Alzheimer" OR "Parkinson" OR "multiple sclerosis" OR "stroke" OR "brain injury" OR "Huntington").

Equivalent controlled vocabulary terms, including Medical Subject Headings (MeSH), were incorporated where appropriate, and database specific syntax was adapted for each search platform. Searching was applied to titles, abstracts, and author supplied keywords in order to capture studies in which multilingual language experience constituted a central explanatory variable. In addition, the reference lists of all included studies were manually screened to identify potentially relevant articles that may not have been retrieved through database searches. No language restrictions were applied during the initial search phase. However, studies were included in the final synthesis only when a full text article was available in English or in a language accessible to the review team.

2.2 Inclusion Criteria

Studies were eligible for inclusion if they met all predefined criteria established prior to the review process. The population of interest comprised adults (18 years and older) diagnosed with neurological disorders associated with cognitive impairment or cognitive decline. This broad scope included neurodegenerative conditions such as Alzheimer disease and other dementias, Parkinson disease, and Huntington disease; cerebrovascular conditions such as stroke and vascular cognitive impairment; demyelinating disorders including multiple sclerosis; and other neurological conditions with documented cognitive sequelae, such as traumatic brain injury. Mild cognitive impairment and early-stage dementia were also included because they represent clinically relevant prodromal stages of neurocognitive decline.

The primary exposure of interest was bilingual or multilingual language experience. In line with linguistic scholarship, bilingualism and multilingualism were understood as the regular use of two or more languages in everyday communication. As François Grosjean notes, bilingual individuals are “those who use two or more languages in their everyday lives” (Grosjean, 2010). Accordingly, eligible studies were required to explicitly measure language exposure using clearly defined indicators of bilingual or multilingual experience. These indicators included self-reported language proficiency or use, standardized language assessments, age of acquisition, language history questionnaires, or other instruments designed to characterize patterns of multilingual language engagement.

Studies were required to report outcomes relevant to cognitive reserve or cognitive functioning. Eligible outcomes included age at onset or diagnosis of cognitive impairment or dementia, longitudinal trajectories of cognitive decline, neuropsychological test performance across domains such as global cognition, memory, executive functioning, and attention, as well as incidence or conversion outcomes such as progression from mild cognitive impairment to dementia. Studies examining cognitive outcomes following neurological events, including post stroke cognitive status, were also considered eligible.

Only original quantitative research was included. Eligible study designs comprised randomized controlled trials and observational designs, including prospective or retrospective cohort studies, case control studies, and cross-sectional investigations. Studies were required to report

extractable quantitative results that allowed evaluation of associations between bilingual or multilingual language experience and cognitive outcomes.

2.3 Exclusion Criteria

Studies were excluded if they did not align with the focus on adult neurological populations or if they did not provide original empirical evidence relevant to cognitive reserve. Excluded populations included pediatric or adolescent samples, animal studies, and studies examining only healthy populations without a neurological disease context, unless neurological risk factors or clinically relevant cognitive outcomes were explicitly assessed.

Studies were also excluded when cognitive outcomes relevant to cognitive reserve were absent. Studies focusing exclusively on linguistic performance (for example, lexical access, language proficiency, or language processing tasks) without accompanying cognitive or functional outcomes were not eligible. Similarly, neuroimaging studies that reported neural activation patterns without corresponding behavioral or cognitive measures were excluded.

Article types excluded from the review included narrative reviews, systematic reviews, meta-analyses, editorials, commentaries, and study protocols, because the objective of this review was to synthesize original empirical evidence. Papers without accessible full text or those lacking sufficient quantitative information for extraction and synthesis were also excluded. When multiple publications reported results from overlapping participant cohorts, the most comprehensive and recent report was retained to avoid duplication of data within the final synthesis.

2.4 Study Selection Process

All records retrieved from database and registry searches were imported into a reference management system, where duplicate entries were identified and removed prior to screening. In total, 520 duplicate records were removed. An additional 40 records were identified as ineligible through automated screening tools, and 30 records were excluded for other predefined reasons, such as publication outside the target time range or non-human studies. Following these steps, 1,210 records remained for title and abstract screening (Figure 1).

Two reviewers independently screened titles and abstracts against the predefined eligibility criteria. At this stage, 1,070 records were excluded because they did not meet the inclusion criteria. Full text articles were then sought for the remaining 140 reports. Twelve reports could not be retrieved, leaving 128 studies assessed in full text for eligibility.

Of these 128 studies, 110 were excluded based on the predefined criteria. The most common reasons for exclusion were the absence of an adult neurological disorder population ($n = 42$), non-original study designs such as reviews or editorials ($n = 28$), lack of cognitive outcomes relevant to cognitive reserve ($n = 20$), unclear or insufficient characterization of bilingual or multilingual language exposure ($n = 12$), and insufficient extractable quantitative data ($n = 8$). Following the screening process, 18 studies met all eligibility criteria and were included in the final synthesis (Figure 1).

Screening decisions were conducted independently by two reviewers. Any disagreements during the screening process were resolved through discussion and consensus. When necessary, a third reviewer adjudicated unresolved cases to ensure consistency in the application of eligibility criteria.

2.5 Data Extraction and Quality Assessment

A standardized data extraction template was developed to ensure consistent capture of study level and outcome level information across all included studies. Extracted variables included publication details, country and research setting, study design, sample size, and participant characteristics such as age, sex, and educational attainment. Additional variables captured diagnostic definitions, disease stage or severity, and methodological features of each study. Attention was given to the operationalization of bilingual or multilingual language experience, as variation in how language exposure is defined represents a key methodological issue in bilingualism research. Extracted language variables therefore included the number of languages spoken, age of language acquisition, language proficiency, and patterns of language use across social and communicative contexts. Where reported, information on language switching, frequency of use, and sociolinguistic environment was also documented, as these dimensions may influence the cognitive demands associated with multilingual language processing.

Cognitive outcomes were extracted together with the instruments used to measure them, including global cognitive screening tools and domain specific neuropsychological tests assessing memory, executive functioning, attention, and processing speed. Additional variables included follow up duration for longitudinal studies, effect estimates such as mean differences, standardized mean differences, odds ratios, or hazard ratios, and statistical covariates used in the original analyses. Commonly reported confounders included education level, socioeconomic status, immigration history, occupational complexity, and baseline cognitive performance. Data extraction was performed independently by two reviewers, and discrepancies were resolved through cross checking and discussion.

Quality and risk of bias were evaluated using appropriate design assessment tools. Randomized controlled trials were assessed using the Cochrane Risk of Bias 2.0 framework, which evaluates domains including the randomization process, deviations from intended interventions, missing outcome data, outcome measurement, and selective reporting. Observational studies were assessed using ROBINS-I, a tool designed to evaluate risk of bias in non-randomized studies of interventions and exposures.

Figure 2. Traffic-light plot for Risk bias assessment



Risk of bias judgments across studies were summarized visually using a traffic light plot (Figure 2), which illustrates domain level and overall assessments for each included study. These assessments were considered during interpretation of the evidence and were used to inform sensitivity analyses and evaluation of the overall strength of the evidence base.

Overall, risk of bias was influenced primarily by the predominance of observational study designs, heterogeneous operationalization of bilingual or multilingual exposure, and the potential for residual confounding related to education, socioeconomic status, immigration background, occupational complexity, and baseline cognitive differences. Additional limitations included small subgroup sizes and single case designs in several studies. Larger cohort studies more frequently reported statistical adjustment for confounders and standardized diagnostic procedures, although incomplete reporting of blinding procedures and study protocols remained common across the evidence base.

2.6 Data Synthesis

Given the anticipated heterogeneity across neurological diagnoses, operational definitions of bilingualism and multilingualism, and cognitive outcome measures, a narrative synthesis was adopted as the primary analytic approach. Studies were organized according to disorder category and outcome type, including age at onset or diagnosis, global cognitive functioning, executive function, and longitudinal cognitive decline. Within each category, findings were summarized with attention to the direction and magnitude of reported effects, statistical uncertainty, and the extent to which analyses adjusted for relevant confounding variables. Attention was given to the operationalization of bilingual or multilingual language experience, as definitions varied considerably across studies. In some investigations, language exposure was defined through structured language history questionnaires or standardized language proficiency measures, whereas other studies relied on clinical records or categorical classification of participants as bilingual or monolingual. Because of this variability in exposure measurement and the use of non-comparable cognitive outcome instruments, quantitative pooling through meta-analysis was considered inappropriate. Instead, findings were synthesized narratively to allow comparison across studies while accounting for methodological diversity.

3. Results

A total of eighteen studies met all eligibility criteria and were included in the final synthesis. These studies encompassed a range of neurological conditions and research designs, reflecting the interdisciplinary nature of research examining multilingual language experience and cognitive functioning. Across the included studies, bilingualism or multilingualism was operationalized using a variety of linguistic indicators, including the number of languages spoken, age of language acquisition, language proficiency, and patterns of language use in everyday communication.

Outcome measures also varied substantially across studies. Some investigations examined clinical indicators such as age at symptom onset or age at diagnosis of neurodegenerative disorders, whereas others assessed cognitive performance using standardized neuropsychological tests measuring domains such as memory, executive functioning, attention, and processing speed. A smaller number of studies incorporated neuroimaging or biomarker measures alongside cognitive assessments to examine potential dissociations between neuropathology and clinical expression. Because definitions of multilingual exposure and cognitive outcome measures differed considerably across studies, a pooled quantitative meta-analysis was not feasible. Instead, findings were synthesized narratively across neurological conditions and outcome domains.

Table 1. Studies Examining Multilingual Language Experience and Cognitive Outcomes in Neurological Populations

Study	Country / Setting	Multilingual Exposure	Key Language Variables	Neurological Context	Cognitive Outcomes	Sample Size	Confounder Adjustment
Ehling et al., 2019	Europe	Second-language training intervention	L2 proficiency, language learning exposure	Multiple sclerosis	Cognitive performance, neural plasticity indicators	23	N
Kong et al., 2014	Hong Kong	Trilingual language use	Multilingual language history	Traumatic brain injury with aphasia	Language recovery and aphasia profile	2	N
Stasenko et al., 2023	USA	Bilingual vs monolingual	Language status	Temporal lobe epilepsy	Executive function and cognitive efficiency	117	Y
Reddy Mukku et al., 2020	India	Multilingual speaker	Language history	Semantic dementia	Language impairment and cognitive profile	1	N/A
Costa, 2017	USA	Bilingual vs monolingual	Primary language background	Alzheimer pathology cohort	Dementia status and neuropathology	199	Y
Duncan et al., 2017	Canada	Multilingual vs monolingual	Language group classification	MCI / Alzheimer disease	Brain atrophy and cognitive performance	94	Y
Tablante et al., 2025	USA	Bilingual vs monolingual	Language status	ADRD syndromes	Cognitive decline trajectories	408	Y
Anderson et al., 2016	Canada	Bilingual vs monolingual	Language group classification	MCI and Alzheimer disease	Executive control and Stroop performance	184	Partial
Skeggs et al., 2023	Australia	Language background proxy	Cultural-linguistic background	Behavioural variant FTD	Cognitive reserve indicators	107	Y
Nanchen et al., 2016	Switzerland	Bilingual speakers	Language dominance and use	Alzheimer-type dementia	Neuropsychological performance	39	N
Ellajosyula et al., 2020	India	Bilingual / multilingual speakers	Language proficiency	Semantic dementia	Naming performance and cognition	50	N
de Leon et al., 2023	USA	Bilingual vs monolingual	Language experience	Frontotemporal dementia spectrum	Age at symptom onset	308	Y
Moridi, 2023	Iran	Bilingual vs monolingual	Bilingual status	Alzheimer disease	Cognitive performance differences	60	N

Pueyo, 2020	Spain	Bilingual vs monolingual	Language group classification	Frontotemporal dementia	Brain structure and cognitive performance	56	Y
Alladi et al., 2017	India	Bilingual vs monolingual	Multilingual ability, literacy	FTD spectrum	Age at onset of dementia	193	Y
Nanchen, 2014	Switzerland	Bilingual speakers	Language proficiency	Degenerative dementia	Neuropsychological test performance	40	N
Lombardi et al., 2018	Italy	Multilingual speaker	Language background	Mild cognitive impairment	Progression to dementia	1	N/A
Coemans et al., 2024	Belgium	Bilingual speaker	Bilingual language use	Logopenic PPA	Language therapy outcomes	1	N/A

Table 1 summarizes the key characteristics of the studies included in the review. The table reports the country or research setting, how multilingual language exposure was defined, the principal linguistic variables examined, the neurological context in which multilingual experience was studied, the cognitive outcomes measured, the sample size, and whether analyses adjusted for relevant confounding variables.

Across the evidence base, considerable variation was observed in how multilingual language experience was operationalized. Some studies used detailed language history instruments capturing proficiency, age of acquisition, and patterns of language use, whereas others classified participants categorically as bilingual or monolingual based on self-report or clinical records. This variability in exposure measurement represents a frequently discussed methodological issue in bilingualism research and may contribute to inconsistencies in observed associations between multilingual language experience and cognitive outcomes.

Cognitive outcomes were also assessed using diverse approaches. These included standardized neuropsychological tests evaluating domains such as memory, executive functioning, and attention, as well as indicators such as age at symptom onset or diagnostic timing of neurological disease. In several studies, neuroimaging or biomarker data were incorporated alongside cognitive assessments to explore potential dissociations between neuropathology and clinical presentation.

The final column of Table 1 indicates whether studies are statistically adjusted for potential confounding variables. Many studies controlled for factors such as age, education level, socioeconomic background, or immigration history, although the extent of statistical adjustment varied across studies. In smaller investigations and case reports, formal multivariable adjustment was not feasible, and findings were therefore interpreted descriptively. Abbreviations used in Table 1 include the following: **Y** indicates that statistical adjustment for confounders was performed; **N** indicates that no multivariable adjustment was reported; **Partial** indicates limited adjustment or matching procedures; and **N/A** indicates that the variable was not applicable, for example in single case reports.

Table 2. Definition and Measurement of Multilingual Language Experience Across Included Studies

Study	Language s Reported	Age of Acquisitio n	Proficiency Measureme nt	Language Use Context	Languag e Switchin g / Active Use	Exposure Classificatio n	Exposur e Quality
Ehling et al., 2019	NR	Prior schooling exposure + late-life L2 learning	Objective L2 outcomes (listening, speaking, vocabulary)	Structured language training context	Not reported	Pre–post intervention	Moderate
Kong et al., 2014	3 (Cantonese, English, Mandarin)	L1 birth; L2 age 13; L3 early adulthood	BAT, CAB	Daily professional and community multilingual use	Yes (code-switching quantified)	Case study	Strong
Stasenko et al., 2023	Typically 2	Mean AoA 8.4 years	Interview + objective English proficiency tests	Home language + English environment	Partial	Binary bilingual vs monolingual	Moderate–Strong
Reddy Mukku et al., 2020	7 languages	4–35 years	Clinical language history	Multiple community and family contexts	Partial	Case description	Moderate
Costa, 2017	1–5 languages	Not measured	Self-report archival survey	Convent missionary context	No	Multiple categorical definitions	Moderate–Weak
Duncan et al., 2017	≥2 languages	Not available	Chart review classification	Community bilingual use	No	Binary multilingual vs monolingual	Moderate–Weak
Tablante et al., 2025	≥2 languages	NR	Chart review language classification	Mixed language contexts	No	Binary bilingual vs monolingual	Weak–Moderate
Anderson et al., 2016	NR	NR	LSBQ questionnaire	English testing environment	No	Binary grouping	Moderate
Skeggs et al., 2023	≥2 languages	NR	Language background classification	Immigrant multilingual context	No	Three-group classification	Moderate
Nanchen et al., 2016	≥2 languages	Late bilingualism (>7 yrs)	Self-report questionnaire	Long-term immersion	No	Continuous immersion measures	Strong–Moderate
Ellajosyula et al., 2020	2–4 languages	Early exposure (<5 yrs)	Questionnaire + proficiency ratings	Daily bilingual use	No	Early vs late bilingual categories	Moderate–Strong
de Leon et al., 2023	≥2 languages	NR	Chart review language criteria	Everyday bilingual interaction	No	Binary bilingual vs monolingual	Moderate
Moridi, 2023	NR	NR	Not reported	Community bilingual context	No	Binary grouping	Weak

Pueyo, 2020	≥2 languages	NR	Clinician classification	Catalan–Spanish bilingual environment	No	Binary grouping	Weak–Moderate
Alladi et al., 2017	2 or ≥3 languages	NR	Clinical history from family	Community multilingual setting	No	Binary + exploratory dose analysis	Moderate
Nanchen, 2014	2 languages	Late AoA (>7 yrs)	Self-reported proficiency	Immersion environment	Partial	Within-subject comparison	Moderate
Lombardi et al., 2018	2 languages	Late bilingual	Functional language history	Daily professional bilingual use	Yes	Case study	Moderate
Coemans et al., 2024	2–3 languages	L2 age 12	LEAP-Q questionnaire	Daily bilingual interaction	Yes	Case description	Strong

Table 2 summarizes how multilingual language experience was operationalized across the studies included in the review. For each study, the table reports the number of languages spoken, the reported age of acquisition of additional languages, the methods used to assess language proficiency, patterns of language use across communicative contexts, and whether language switching or active multilingual use was explicitly measured. In addition, the table indicates how multilingual exposure was analytically classified in each study (e.g., binary bilingual versus monolingual grouping or dose-related exposure measures) and provides an overall assessment of the quality of exposure measurement.

Across the evidence base, considerable variation was observed in how multilingual language experience was defined and measured. Some studies employed structured language history instruments or validated questionnaires that captured multiple dimensions of bilingual experience, including language proficiency, patterns of language use, and immersion contexts. Other investigations relied on categorical classification of participants as bilingual or monolingual based on self-report or clinical records. This heterogeneity reflects a long-standing methodological challenge in bilingualism research, where bilingualism is often treated as a simple categorical variable despite representing a complex continuum of linguistic experience. As noted in the bilingualism literature, bilingual individuals rarely use their languages in identical ways, and language experience varies across domains of use, proficiency, and sociolinguistic environment. As François Grosjean observes, bilingual speakers are best understood as individuals who “use two or more languages in their everyday lives,” rather than as speakers who possess identical proficiency in multiple languages.

Several studies included in the review captured relatively detailed linguistic information, such as age of acquisition, language proficiency, and patterns of language use across different contexts. Such multidimensional approaches align with contemporary perspectives that conceptualize bilingualism as a dynamic form of language experience shaped by intensity of use, exposure across the lifespan, and interaction between languages. According to Ellen Bialystok, bilingual experience engages in a range of language control processes because bilingual speakers must continually select the target language while inhibiting competing linguistic representations. This continuous engagement of language control processes has been proposed as a mechanism through which bilingual language experience may influence cognitive functioning across the lifespan.

However, many studies in the present review relied on simplified exposure measures. In several cases, bilingualism was operationalized as a binary classification distinguishing bilingual or multilingual participants from monolingual speakers. Such binary classifications may obscure meaningful variation in language experience, including differences in the number of languages spoken, proficiency levels, or frequency of language use. For example, some studies documented multilingual repertoires involving three or more languages, whereas others grouped all speakers of two or more languages into a single bilingual category. These differences illustrate how exposure measurement choices can influence interpretations of multilingualism–cognition relationships.

Another important dimension concerns language switching and active language use. Although theoretical models of bilingual cognition often emphasize the role of language control and switching processes, relatively few studies explicitly measure switching behavior or patterns of active multilingual communication. This limitation has been highlighted in methodological critiques of bilingualism research, which note that the cognitive demands associated with bilingual language use may depend strongly on how frequently speakers alternate between languages and how languages are distributed across communicative contexts (Calvo et al., 2016).

Taking together, the evidence summarized in Table 2 illustrates that multilingual language experience was measured with varying levels of detail across studies. Some investigations incorporated comprehensive language history instruments and objective proficiency assessments, whereas others relied on retrospective self-report or categorical language classification. The final column of the table therefore provides an overall evaluation of exposure measurement quality (strong, moderate, or weak) based on the completeness and methodological rigor with which multilingual language experience was documented.

Table 3. Multilingual Language Experience and Cognitive Outcomes Across Neurological Disorders

Study	Multilingual exposure	Language variables measured	Cognitive or linguistic outcome domain	Main finding	Interpretation relative to multilingual exposure	Limitations
Ehling et al., 2019	L2 learning intervention	L2 proficiency gains	Cognitive learning / neuroplasticity	Language training improved language performance and hippocampal grey matter volume	Favor multilingual exposure	Small sample, non-randomized
Kong et al., 2014	Trilingual speaker	Code switching and language control	Executive control and language switching	Lesion produced pathological multilingual switching and executive deficits	Not a protective effect study	Single case
Stasenko et al., 2023	Bilingual vs monolingual	Language status and bilingual experience	Neural network organization and executive function	Bilingual speakers showed more efficient structural network organization in LTLE	Favor multilingual exposure	Cross-sectional design
Reddy Mukku et al., 2020	Seven-language multilingual history	Premorbid language repertoire	Language decline trajectory	Sequential loss of languages observed in semantic dementia	Not applicable	Single case

Costa, 2017	1–5 languages spoken	Number of languages	Cognitive resilience in Alzheimer pathology	Speaking ≥ 4 languages associated with higher resilience	Partial multilingual advantage	Exposure measurement limited
Duncan et al., 2017	Multilingual vs monolingual	Language group classification	Brain reserve markers	Multilinguals showed greater cortical thickness despite equal cognitive scores	Favor multilingual exposure	Language history incomplete
Tablante et al., 2025	Bilingual vs monolingual	Language status	Functional decline trajectory	Bilingual speakers showed slower functional decline	Favor multilingual exposure	Chart-based language classification
Anderson et al., 2016	Bilingual vs monolingual	L2 use and proficiency	Executive control	Bilinguals showed different decline patterns relative to baseline	Mixed	Language testing bias
Skeggs et al., 2023	Multilingual cultural background	Language group classification	Cognitive reserve indicators	Higher reserve associated with tolerance of greater pathology	Partial support	Exposure not quantified
Nanchen et al., 2016	Late bilingual immersion	Language use and immersion	Language comprehension and production	L1 and L2 decline in parallel in dementia	Not applicable	Small sample
Ellajosyula et al., 2020	Bilingual / multilingual speakers	Age of acquisition and proficiency	Language naming and comprehension	Later languages more vulnerable than L1 in semantic dementia	Not applicable	Small sample
de Leon et al., 2023	Bilingual vs monolingual	Language experience	Age at symptom onset	No significant bilingual advantage after adjustment	No effect	Exposure measurement limited
Moridi, 2023	Bilingual vs monolingual	Language status	Global cognition	Bilingual patients scored higher on MMSE	Favor multilingual exposure	Cross-sectional
Pueyo, 2020	Bilingual vs monolingual	Language group classification	Cognitive and behavioral outcomes	No consistent protective bilingual effect	No effect	Small sample
Alladi et al., 2017	Bilingual vs monolingual	Number of languages	Age at dementia onset	Bilingualism delayed onset in behavioral FTD	Favor multilingual exposure	Retrospective design
Nanchen, 2014	Late bilingual immersion	Language proficiency and immersion	Language comprehension	L2 comprehension sometimes better preserved than L1	Not applicable	Small sample
Lombardi et al., 2018	Late bilingual case	Functional bilingual language use	Disease progression	Delayed dementia conversion despite risk factors	Favor multilingual exposure	Single case
Coemans et al., 2024	Bilingual language use	Language proficiency and switching	Language therapy response	tDCS improved bilingual language performance	Not applicable	Single case

Table 3 synthesizes the principal findings of the included studies, focusing on how multilingual language experience interacts with cognitive and neural outcomes across neurological conditions. Across the eighteen studies reviewed, multilingual exposure was operationalized in several ways, including categorical classifications of bilingual or multilingual status, number of languages spoken, second-language learning interventions, and detailed language histories capturing age of acquisition, proficiency, and patterns of language use. From a linguistic perspective, this variation reflects the broader methodological challenge

of representing bilingualism as a multidimensional construct rather than a simple categorical variable. As Grosjean (2010) emphasizes, bilingual speakers differ substantially in how their languages are acquired, used, and maintained across communicative contexts, making exposure characterization a central methodological issue in bilingualism research.

Several studies reported findings consistent with a cognitive reserve interpretation of multilingual language experience. Evidence from neuroimaging and network analyses suggested that multilingual speakers may maintain more efficient neural organization in regions associated with language control and executive processing. For example, bilingual speakers with temporal lobe epilepsy demonstrated more efficient structural network organization relative to monolingual participants, a pattern consistent with models proposing that sustained management of multiple linguistic systems recruits and strengthens executive-control circuits involved in language selection and inhibition (Bialystok, Craik, & Luk, 2012). Similarly, studies of mild cognitive impairment and Alzheimer's disease reported greater cortical thickness or altered neuroanatomical profiles in multilingual individuals despite comparable cognitive performance, a dissociation commonly interpreted as evidence of neural reserve.

Importantly, the findings also illustrate that multilingual language experience does not produce a uniform protective effect across neurological conditions or outcome domains. In several studies, bilingualism was not associated with delayed symptom onset once demographic variables such as education, socioeconomic background, or immigration status were statistically controlled. Such variability is consistent with previous critiques suggesting that observed bilingual advantages often depend on how language experience is operationalized and on the cognitive or neural outcome being measured (Calvo et al., 2016). From a linguistic standpoint, these inconsistencies may reflect differences in the intensity and functional distribution of language use. Contemporary models of bilingual cognition emphasize that language experience involves continuous regulation of competing linguistic systems, and that the cognitive consequences of bilingualism depend on factors such as language switching frequency, proficiency balance, and communicative context (Green & Abutalebi, 2013).

In addition to studies examining cognitive reserve directly, several investigations contributed insights into how multilingual language organization shapes the clinical manifestation of neurological disorders. In language-led syndromes such as semantic dementia or primary progressive aphasia, multilingual speakers often exhibited differential vulnerability across languages, with later-acquired or less frequently used languages showing greater impairment. These patterns align with linguistic models of bilingual lexical representation that predict stronger semantic and lexical connections for earlier or more dominant languages. Such findings highlight that multilingualism may influence not only resilience to neuropathology but also the linguistic expression of neurological disease.

Taken together, the evidence summarized in Table 3 suggests that multilingual language experience interacts with neural and cognitive systems relevant to cognitive reserve, although the strength and direction of the association vary across neurological conditions and methodological designs. Crucially, the heterogeneity observed across studies appears closely linked to differences in how multilingual exposure is conceptualized and measured. This reinforces recent calls within bilingualism research for more precise and theoretically informed characterization of language experience, including systematic reporting of age of acquisition, proficiency, language dominance, frequency of use, and switching behavior (Anderson et al., 2020). Such methodological refinement is essential for clarifying the mechanisms through which multilingual language experience may contribute to cognitive resilience across the lifespan.

4. Discussion

Across the eighteen studies included in this review, multilingual language experience demonstrated a complex but interpretable relationship with cognitive reserve across neurological disorders. Rather than revealing a uniform protective effect, the findings suggest that reserve-related patterns are most consistently observed when outcomes capture the relationship between brain pathology and clinical functioning. In several studies, multilingual speakers displayed comparable or better functional outcomes despite greater neuropathological burden or structural brain changes. Such patterns are consistent with theoretical models of cognitive reserve that emphasize a dissociation between neuropathology and behavioral expression of impairment. As noted in the cognitive reserve literature, reserve is often inferred when individuals maintain relatively preserved cognitive functioning despite measurable neural deterioration (Bialystok, 2021; Guzmán-Vélez & Tranel, 2015). In the context of multilingualism, this dissociation may reflect lifelong engagement of language control networks and executive processes associated with managing multiple languages.

Evidence from neuroimaging and biomarker studies provided some of the strongest support for reserve-related interpretations. Several studies in Alzheimer's disease and mild cognitive impairment reported patterns in which multilingual individuals showed greater structural brain changes while demonstrating similar levels of cognitive functioning. This pattern, often referred to as a reserve signature, suggests that multilingual language experience may allow individuals to tolerate higher levels of neuropathology before clinical symptoms become apparent. Such findings are parallel neuroimaging research demonstrating altered connectivity and network recruitment among bilingual speakers. For example, functional imaging studies have reported preserved or reorganized network activity in bilingual individuals despite reduced structural integrity, suggesting compensatory neural recruitment associated with language control processes (Perani et al., 2017; Stevens et al., 2023).

At the same time, the evidence also indicated that multilingual effects are highly dependent on how language exposure is defined and measured. Several studies relied on simple binary classifications of participants as bilingual or monolingual, whereas others captured more detailed aspects of language experience such as proficiency, number of languages spoken, or immersion context. When multilingual exposure was treated as a continuous or dose-related variable, stronger associations sometimes emerged. In one neuropathology-based cohort, for example, speaking four or more languages was associated with higher odds of cognitive resilience, whereas speaking only two languages was not associated with measurable benefit. Such findings support theoretical perspectives that conceptualize bilingualism not as a categorical status but as a continuum of language experience shaped by intensity of use, proficiency, and sociolinguistic context (Calvo et al., 2016; Liu & Wu, 2021; Jylkkä et al., 2018; Marín-Marín et al., 2020).

Within Alzheimer's disease and related dementias, several studies included in the review were consistent with this reserve-oriented interpretation. Structural imaging findings indicated that multilingual speakers could exhibit greater cortical atrophy in language or memory-related regions while maintaining cognitive performance comparable to monolingual participants. Similar observations have been reported in longitudinal cohorts, where bilingual individuals showed greater baseline atrophy yet slower subsequent cognitive decline over time (Costumero et al., 2020). Functional and biomarker findings also suggest resilience mechanisms. In large Alzheimer's disease and related dementia cohorts, bilingual speakers showed slower functional decline and weaker coupling between neurodegeneration markers and functional deterioration. These observations are conceptually aligned with cognitive reserve models in which clinical outcomes are partially decoupled from underlying pathology (Bialystok, 2021; Guzmán-Vélez

& Tranel, 2015; Calabria et al., 2020; Grasso et al., 2023). Neuroimaging studies further support this interpretation, showing that bilingual individuals with Alzheimer's disease may exhibit stronger metabolic connectivity within executive and default-mode networks despite more severe hypometabolism (Perani et al., 2017).

Findings within the frontotemporal dementia spectrum were more heterogeneous and appeared to vary by clinical subtype. Some registry-based studies suggested that bilingual individuals experienced later onset of behavioral symptoms, particularly in behavioral-variant frontotemporal dementia. However, other cohorts did not replicate this effect once demographic variables such as education and immigration status were controlled. Such variability reflects broader methodological challenges in reserve research, where timing measures such as age at symptom onset are sensitive to recall bias, diagnostic access, and referral patterns (Calvo et al., 2016; Guzmán-Vélez & Tranel, 2015; Perani & Abutalebi, 2015). Importantly, recent neuroanatomical research provides evidence for reserve-like dissociations even in frontotemporal dementia. For example, bilingual patients have been reported to show reduced thalamic volume relative to matched monolingual patients despite comparable cognitive functioning, suggesting greater tolerance of neuropathology (Thanissery et al., 2025).

Language-led syndromes such as primary progressive aphasia present a somewhat different pattern. In these conditions, the primary deficit involves language systems themselves, meaning that multilingual experience may influence patterns of symptom expression rather than delaying disease onset. Within-person studies of bilingual patients with semantic dementia or primary progressive aphasia have documented differential vulnerability across languages, often with later acquired languages showing greater impairment than first languages. These findings highlight the importance of interpreting language performance within a bilingual framework, as performance differences across languages may reflect linguistic organization rather than differences in global cognitive reserve (Rosselli et al., 2023). Moreover, several studies emphasized that neuropsychological tests developed for monolingual populations may underestimate bilingual performance, particularly on verbally mediated tasks.

Evidence outside dementia also suggested possible reserve-related mechanisms. In temporal lobe epilepsy, bilingual speakers demonstrated more efficient structural network organization and stronger associations between network properties and executive functioning. These findings are consistent with contemporary models of neural reserve emphasizing efficient brain-network organization (Stevens et al., 2023). Similarly, studies of second-language learning interventions in multiple sclerosis reported structural brain changes and improvements in psychological wellbeing, suggesting that language learning may function as a form of cognitive enrichment (Liu & Wu, 2021). Although such interventions differ from lifelong bilingual exposure, they provide additional evidence that sustained engagement with language systems may influence brain plasticity.

Across disorders, age-of-onset findings were notably inconsistent. Some studies reported delayed symptom onset among bilingual speakers, whereas others found no significant differences after controlling confounding factors. This pattern reflects conclusions from meta-analytic research indicating that bilingualism may be associated with modest delays in symptom onset but shows weaker relationships with disease incidence (Anderson et al., 2020). Importantly, timing measures are particularly susceptible to methodological bias, including retrospective reporting of symptom onset and differences in access to diagnostic services. Cognitive performance outcomes were also influenced by the choice of assessment instruments. Studies relying on brief global cognitive screens sometimes reported bilingual advantages; however, such findings are difficult to interpret when language proficiency or testing language is not clearly documented. In contrast, more detailed neuropsychological batteries often

revealed disadvantages for bilingual speakers on verbally demanding tasks such as naming or verbal fluency. These patterns do not necessarily indicate lower cognitive ability but may instead reflect differences in lexical access across languages, a well-documented phenomenon in bilingual cognition (Calvo et al., 2016; Rosselli et al., 2023). Consequently, reserve effects may be more visible in non-verbal cognition, functional outcomes, or neuroimaging measures than in raw verbal test scores.

Overall, the findings of this review suggest that multilingual language experience may interact with neural and cognitive systems in ways consistent with cognitive reserve frameworks, although the magnitude and consistency of these effects vary across disorders and methodological approaches. Outcomes capturing functional trajectories, neuroimaging markers, or pathology–function dissociations appear to be more sensitive indicators of reserve than single-time-point cognitive scores. Future research will benefit from more precise characterization of multilingual experience, including detailed measurement of proficiency, language use patterns, and sociolinguistic context, as well as longitudinal designs capable of distinguishing between neural compensation, cognitive reserve, and potential neuroprotective mechanisms.

4.1 Sources of Heterogeneity in Reported Findings

The variability observed across studies likely reflects several methodological and conceptual sources of heterogeneity. One major factor concerns how multilingual language experience is operationalized. In many studies bilingualism is treated as a binary variable distinguishing bilingual and monolingual speakers. However, language experience varies substantially in terms of number of languages, age of acquisition, proficiency, patterns of use, and sociolinguistic context. Several studies in the present review relied on chart review or self-reported bilingual status without systematically measuring these dimensions. Furthermore, active language switching and patterns of language control were rarely quantified directly. Such limitations have been repeatedly highlighted in methodological critiques of bilingualism research and can obscure potential dose related effects of language experience (Calvo et al., 2016).

Population characteristics also contribute to differences in reported outcomes. Education, occupational complexity, immigration history, and sociocultural environment frequently covary with multilingual status and can therefore confound interpretations of cognitive reserve effects. For example, bilingual individuals in clinical cohorts are often more likely to have immigrant backgrounds or to differ in educational trajectories compared with monolingual participants. These factors may independently influence cognitive outcomes and brain health, making it difficult to isolate the specific contribution of multilingual experience unless they are carefully controlled (Guzmán-Vélez & Tranel, 2015).

A further source of heterogeneity arises from disorder specific mechanisms. The influence of multilingualism may vary depending on which neural systems are primarily affected. In language-led syndromes such as primary progressive aphasia, multilingual experience may shape patterns of language decline rather than delay disease onset. In contrast, disorders involving executive control or distributed cognitive networks, such as behavioral variant frontotemporal dementia or temporal lobe epilepsy, may be more likely to reveal reserve related effects through compensatory network recruitment. Differences in hemispheric involvement and network vulnerability may therefore lead to distinct manifestations of reserve across neurological syndromes (Skeggs et al., 2023; Thanissery et al., 2025).

Outcome selection also plays a critical role in shaping reported effects. Studies examining age at symptom onset or diagnosis often produce inconsistent results, partly because such measures are sensitive to recall bias, healthcare access, and diagnostic practices. In contrast, studies focusing on functional decline, neuroimaging markers, or biomarker trajectories may be better suited to capturing reserve related mechanisms. Follow up duration, attrition, and practice effects in intervention studies can further influence the magnitude of observed associations. These methodological considerations have been widely noted in meta-analytic and systematic review research on bilingualism and cognitive reserve (Anderson et al., 2020; Calvo et al., 2016).

Taking together, the evidence synthesized in this review is most consistent with theoretical models of cognitive reserve in which lifelong engagement with multiple languages strengthens or diversifies neural systems involved in language control and executive functioning. According to this framework, the continuous management of multiple linguistic systems may support flexible recruitment of executive and language control networks when neurological pathology emerges (Bialystok, 2021; Guzmán-Vélez & Tranel, 2015). Neuroimaging findings showing preserved network organization despite reduced grey matter integrity are compatible with such compensatory mechanisms, suggesting that bilingual language experience may help maintain functional connectivity and adaptive network recruitment under conditions of neurological stress (Perani et al., 2017; Stevens et al., 2023). This interpretation also helps explain why several studies reported the classic reserve signature in which individuals with greater neuropathology nonetheless display comparable levels of clinical functioning. In such cases multilingual experience may not prevent pathology but may enable individuals to tolerate higher levels of neural damage before cognitive symptoms become apparent (Liu & Wu, 2021). Notably, stronger evidence for reserve effects tended to emerge in studies with larger cohorts, standardized diagnostic procedures, and multimodal outcome measures combining neuroimaging, biomarkers, and functional assessments. Designs that matched participants on baseline brain health or demographic characteristics also provided clearer evidence for reserve related mechanisms (Berkes et al., 2021).

Longitudinal and prospective designs are particularly important in this context because they allow researchers to examine rates of cognitive change rather than relying solely on cross sectional comparisons. Even relatively short longitudinal studies can provide valuable insights into whether multilingual experience influences trajectories of decline or resilience over time (Costumero et al., 2020; Rosselli et al., 2023).

4.2 Limitations of the Evidence Base and of the Present Review

Several limitations should be considered when interpreting the findings of this review. First, the available evidence base is dominated by observational designs, which limits the ability to draw causal conclusions about the relationship between multilingual language experience and cognitive reserve. Although observational studies can identify associations between language experience and cognitive outcomes, they remain vulnerable to residual confounding from variables such as education, occupational complexity, immigration history, and socioeconomic background. These factors frequently covary with bilingual or multilingual status and can therefore complicate the interpretation of reserve-related effects (Calvo et al., 2016; Guzmán-Vélez & Tranel, 2015).

A second major limitation concerns exposure measurement. Across the included studies, multilingualism was often operationalized using simplified binary classifications of bilingual versus monolingual speakers. Detailed aspects of language experience, including age of

acquisition, proficiency, frequency of use, language dominance, and patterns of language switching, were inconsistently reported or entirely absent. In several cases bilingual status was derived from chart review or self-report rather than from structured language history instruments. Such exposure misclassification represents a widely recognized methodological challenge in bilingualism research and may contribute to inconsistent findings across studies (Calvo et al., 2016).

Methodological limitations also arise from assessment procedures. Many neuropsychological studies rely on instruments developed and normed primarily for monolingual populations. When bilingual participants are assessed using such tools, particularly those that rely heavily on verbal production or lexical retrieval, differences in performance may reflect linguistic factors rather than differences in underlying cognitive functioning. This issue has been repeatedly highlighted in bilingual neuropsychology and underscores the importance of interpreting bilingual cognitive performance within an appropriate linguistic framework (Rosselli et al., 2023).

Additional limitations relate to study design and sample characteristics. Several included studies contained relatively small bilingual subgroups, limiting statistical power and the ability to explore dose-related effects of multilingual exposure. Furthermore, the evidence base spans multiple neurological disorders and outcome domains, including clinical timing measures, neuropsychological performance, functional decline, and neuroimaging markers. This heterogeneity prevented quantitative pooling of results and required the use of narrative synthesis. While the inclusion of case reports and intervention studies provides valuable insight into potential mechanisms linking language experience and brain plasticity, such designs do not allow strong causal inference.

The possibility of publication bias should also be acknowledged. Studies reporting positive associations between bilingualism and cognitive outcomes may be more likely to be published than those reporting null findings. Although meta-analytic research has attempted to evaluate the presence of publication bias in this field, uncertainty remains regarding the magnitude and consistency of bilingualism effects (Anderson et al., 2020).

Despite these limitations, several methodological implications emerge from the current synthesis. Future research should adopt more standardized approaches to the measurement of multilingual language experience, including systematic documentation of age of acquisition, language proficiency, frequency of use, language dominance, and switching behavior. Prospective longitudinal designs with harmonized cognitive, functional, and biomarker measures will be particularly valuable for examining potential dose–response relationships and for disentangling the influence of multilingual experience from related life course variables such as education, occupation, and migration history (Anderson et al., 2020; Calvo et al., 2016; Liu & Wu, 2021).

From a clinical perspective, the findings also reinforce the need for careful interpretation of cognitive assessments in bilingual populations. Neuropsychological evaluations should incorporate detailed language histories and should avoid relying exclusively on monolingual normative standards, particularly for tasks that depend heavily on lexical retrieval or verbal fluency. Incorporating bilingual-sensitive assessment practices can help reduce the risk of misclassification of cognitive impairment in multilingual patients (Rosselli et al., 2023).

5. Conclusion

This systematic review synthesized findings from eighteen studies examining the relationship between multilingual language experience and cognitive outcomes across a range of neurological conditions, including Alzheimer's disease and related dementias, frontotemporal dementia, epilepsy, multiple sclerosis, and traumatic brain injury. Overall, the evidence suggests that multilingualism is associated with disorder-specific and outcome-specific patterns of cognitive reserve rather than a uniform protective effect.

Across the reviewed studies, the most consistent signals of reserve emerged in outcomes capturing resilience to neuropathology rather than simple preservation of cognitive performance. These included slower functional decline in Alzheimer's disease and related dementia cohorts, dissociations between structural brain changes or neurodegeneration biomarkers and clinical status, more efficient structural network organization in temporal lobe epilepsy, and neuroplasticity-related gains following second-language training in multiple sclerosis. Such findings are consistent with theoretical models of cognitive reserve in which lifelong experience with multiple languages contributes to adaptive neural recruitment and functional compensation under neurological stress.

In contrast, outcomes based on age at symptom onset or cross-sectional cognitive test scores produced more heterogeneous findings. These inconsistencies were particularly evident in frontotemporal dementia cohorts, where effects varied across clinical phenotypes and were sensitive to methodological factors such as education, occupational background, history, and language-of-testing bias. Evidence from some cohorts also suggested potential dose-related effects, with higher levels of multilingual exposure associated with stronger reserve-related patterns. For example, speaking four or more languages was associated with greater cognitive resilience in one neuropathology-based cohort, whereas bilingualism alone often showed weaker or null associations.

Taken together, the findings suggest that multilingual language experience should be understood as a potential contributor to cognitive reserve that operates in interaction with other life-course factors rather than as a single protective factor against neurodegeneration. The influence of multilingualism likely depends on the intensity, duration, and sociolinguistic context of language use, as well as on the neural systems affected by specific neurological disorders.

From a clinical perspective, these findings highlight the importance of systematically documenting language history in neurological assessment. Information on age of acquisition, proficiency, language dominance, and patterns of language use can improve interpretation of neuropsychological testing and help reduce the risk of misclassification when bilingual patients are evaluated using instruments developed for monolingual populations. Greater attention to functional and non-verbal outcomes may also provide more reliable indicators of cognitive reserve in multilingual individuals.

Future research should prioritize more precise measurement of multilingual language experience and should adopt longitudinal and multimodal study designs combining cognitive assessment, functional outcomes, and neuroimaging or biomarker measures. Such approaches will help clarify potential dose-response relationships and improve understanding of how multilingual language experience interacts with education, occupational complexity, and sociocultural context to shape cognitive resilience across the lifespan.

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Abbreviation	Full form
AD	Alzheimer's disease
ADL	Activities of daily living
ADRD	Alzheimer's disease and related dementias
ANOVA	Analysis of variance
AoA	Age of acquisition
A β	Amyloid beta
BAT	Bilingual Aphasia Test
BDAE	Boston Diagnostic Aphasia Examination
BNT / mBNT	Boston Naming Test / modified Boston Naming Test
bvFTD	Behavioral variant frontotemporal dementia
CALD	Culturally and linguistically diverse
CI	Confidence interval
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CR	Cognitive reserve
CSF	Cerebrospinal fluid
CVLT	California Verbal Learning Test
D-KEFS	Delis–Kaplan Executive Function System
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition
dMRI	Diffusion magnetic resonance imaging
EEG	Electroencephalography
Embase	Excerpta Medica database
FDG-PET	Fluorodeoxyglucose positron emission tomography
FTD	Frontotemporal dementia
FTLD	Frontotemporal lobar degeneration
GM / GMV	Grey matter / Grey matter volume
HC	Healthy controls
HR	Hazard ratio
IADL	Instrumental activities of daily living
ICTRP	International Clinical Trials Registry Platform
L1 / L2 / L3	First / second / third language
LEAP-Q	Language Experience and Proficiency Questionnaire
LSBQ	Language and Social Background Questionnaire
LTLE / RTLE	Left / right temporal lobe epilepsy
LvPPA	Logopenic variant primary progressive aphasia
MAC	Memory and Aging Center

MCI	Mild cognitive impairment
MEDLINE	Medical Literature Analysis and Retrieval System Online
MMSE	Mini-Mental State Examination
MRI	Magnetic resonance imaging
MS	Multiple sclerosis
N	Sample size
NfL	Neurofilament light
NIA-RI	National Institute on Aging–Reagan Institute criteria
NINCDS-ADRDA	National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer’s Disease and Related Disorders Association
NPI	Neuropsychiatric Inventory
NR	Not reported
OR	Odds ratio
PET	Positron emission tomography
PPA	Primary progressive aphasia
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
PubMed	PubMed biomedical literature database
pwMS	People with multiple sclerosis
RAVLT	Rey Auditory Verbal Learning Test
RCT	Randomized controlled trial
RoB	Risk of bias
ROI	Region of interest
SD	Standard deviation
SES	Socioeconomic status
SF-36	36-Item Short Form Health Survey
SLT	Speech and language therapy
svPPA	Semantic variant primary progressive aphasia
tDCS	Transcranial direct current stimulation
TBI	Traumatic brain injury
TLE	Temporal lobe epilepsy
TMT	Trail Making Test
UCSD / UCSF	University of California, San Diego / University of California, San Francisco
VBM	Voxel-based morphometry
WAB-R	Western Aphasia Battery – Revised
WCST	Wisconsin Card Sorting Test
WHO	World Health Organization
WMS-III	Wechsler Memory Scale, Third Edition
WASI	Wechsler Abbreviated Scale of Intelligence
β	Regression coefficient (beta)
ρ	Spearman correlation coefficient (rho)

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