

The Cognitive Benefits and Neurobiological Impacts of Learning a Second/Foreign Language: A Study on Enhancing Cognitive Function and Dementia

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Abstract The escalating prevalence of Alzheimer's disease and dementia in our aging population presents a formidable challenge. This empirical study aims to investigate the prophylactic potential of foreign/second language acquisition in mitigating Alzheimer's disease and dementia among older adults. It explores the cognitive advantages and neurobiological impacts associated with foreign/second language learning in aging individuals. To achieve this, the study utilized a sample of 150 elderly participants and employed language activities focused on vocabulary retention and memory, with the IELTS Band Score as a rubric for pre- and post-test measurements. The study employs a quantitative research approach, focusing on adult learners in language institutions. Two academies in the Vellore District, India, comprise the control (63 participants) and experimental groups (87 participants) aged above 60. The collected data were analyzed based on IELTS Band Scores on a 1-9 scale. The research spanned two months, commencing in August 2023. The statistical outcomes suggest a positive impact of foreign language acquisition on vocabulary retention and memory among older adults. The post-test scores of the experimental group indicated a statistically significant difference ($p < 0.001$) between groups. This proved that engaging in language-related activities deepens understanding of the complex relationship between language acquisition and the aging brain network, offering a pathway to preserve cognitive health in later life.

Keywords Cognitive Benefits, Foreign/Second Language Acquisition, Alzheimer's Disease, Dementia Prevention, Older Adult Learning

1. Introduction

1.1. The Aging Population

The imminent surge in the aging population poses an intricate healthcare challenge, with projections indicating a staggering two billion elderly individuals by the year 2050 [1]. Of particular concern within this demographic shift is the anticipated escalation in the prevalence of Alzheimer's disease, a prominent neurodegenerative condition. Current research suggests that nearly 5% of individuals aged 60 and above may be affected by Alzheimer's disease, projecting a significant global health concern [2,3].

1.2. Navigating Age-Related Cognitive Changes

The multifaceted landscape of age-related cognitive decline presents a complex scenario, characterized by manifestations such as memory lapses and attention deficits. Discerning between normal age-related cognitive changes and more severe cognitive impairment becomes paramount in facilitating early identification and

intervention [4]. Drachman [5], Greenwood [6], and Whalley et al. [7] explored a deeper neuropathological aspect and they reveal conditions like dementia and neurological disorders are intricately associated with both brain atrophy and the loss of synaptic connections. Furthermore, the vulnerability of cognitive functions associated with the prefrontal cortex to the aging process adds another layer of complexity to our understanding [8].

1.3. Cognitive Disorders and Alzheimer's Disease

The landscape of cognitive disorders, particularly Alzheimer's disease, is marked by disruptions in memory and the imposition of substantial burdens on both families and healthcare systems [5,9,10]. The intricate interplay of tangles and amyloid plaques, stemming from the abnormal accumulation of proteins in the brain, signifies the initial clinical signs of Alzheimer's disease [5]. Recognizing the substantial variation among individuals in the timing and rate of cognitive decline, scholars like Salthouse and Ferrer-Caja emphasize that the precise definition of Mild Cognitive Impairment (MCI) remains an ongoing topic of discussion [11].

Individuals grappling with Mild Cognitive Impairment may face challenges such as memory loss, language difficulties, or issues related to attention and decision-making. While some may progress to different forms of dementia, including Alzheimer's disease, others may remain stable or even experience improvement over time. Although there is currently no cure for MCI, making lifestyle adjustments such as regular exercise and a well-balanced diet emerges as a potential avenue to slow its progression [11].

1.4. Review on Enhancing Cognitive Reserve: A Strategy Against Cognitive Decline

Cognitive decline in older individuals is a multifaceted issue, exhibiting variations over time. The observation that cognitive challenges can emerge and recede at different junctures suggests the potential impact of environmental stimuli on brain function and memory retention, even in the presence of significant damage. Animal studies, notably those involving models of Alzheimer's disease, have shed light on the positive effects of environmental enrichment across various cognitive domains [12]. Furthermore, a body of research indicates that engaging in cognitive leisure activities may reduce the risk of Alzheimer's disease, even in advanced age [13,14].

1.4.1. Cognitive Reserve Theories and Lifelong Engagement

The concept of cognitive reserve, as elucidated by Valenzuela and Sachdev [15], encompasses two overarching theories. The first theory posits that an individual's brain possesses inherent defense mechanisms that elevate the threshold for brain damage, rooted in

specific morphological and physiological characteristics. Notable studies, such as that by Katzman et al. [16], have demonstrated that individuals with neuropathology, despite maintaining cognitive intactness, exhibit larger brains and more massive neurons in specific brain regions like the frontal, parietal, and temporal cortices. Additional research by Solé-Padullés et al. [17] suggests that structural brain differences in individuals with Mild Cognitive Impairment (MCI) may be linked to their ability to maintain cognitive function. Beyond inherent defense mechanisms, cognitive reserve also implies the brain's capacity to efficiently utilize its resources and processing techniques. Engaging in lifelong activities that challenge both the mind and body may contribute to increased cognitive reserve, facilitating the adaptation of the brain to age-related changes, and potentially reducing the risk of future cognitive decline.

1.4.2. Intellectual Activities, Memory, and Dementia Risk Reduction

The engagement in intellectual activities has been linked to a decrease in hippocampal atrophy, a significant factor in dementia risk. Regular participation in activities such as solving crosswords or engaging with jigsaw puzzles has shown a remarkable 47% lower chance of developing dementia, as evidenced by a study involving 469 elderly participants [14]. Interestingly, the frequency of engagement proved crucial, with individuals participating four times a week exhibiting a substantial risk reduction compared to those involved only once a week. These findings extend to amnesic MCI, a precursor to Alzheimer's disease, underlining the notion that memory impairment may serve as an indicator of its onset, necessitating further evaluation and monitoring [14,18].

1.4.3. Social Activities and Cognitive Health

A series of meta-analyses conducted by Valenzuela and Sachdev [15] offer insights into the relationship between strong cognitive reserves and a 46% lower risk of dementia compared to those with weak cognitive reserves. Engaging in mentally stimulating activities throughout one's life, as demonstrated by an experimental study involving over 29,000 people over 71 years, can significantly reduce the risk of dementia. Motivated by the importance of maintaining cognitive function in older adults, researchers have developed computerized programs aimed at enhancing cognitive health in older individuals. These programs encompass various domains, including memory training [19], language training [20], and comprehensive cognitive domain targeting [21]. Significantly, such programs have demonstrated considerable improvements in various cognitive functions among older adults, including those with Mild Cognitive Impairment (MCI) and Alzheimer's disease.

1.4.4. Computerized Cognitive Training Programs

Research by Smith et al. [22] has shown that memory and attention training can effectively enhance cognitive

abilities, particularly in older participants. Long-term improvements in memory retention and inductive reasoning were observed among adults aged 65-94 who participated in cognitive training methods [23]. These improvements were found to persist for months or even years, contingent on the continuation of booster or refresher sessions. While debates persist regarding the application of cognitive training to specific groups, studies like that by Owen et al. [24] found no evidence of transfer effects, despite improvements in attention, memory, reasoning, and visuospatial skills. However, the overall evidence supports cognitive training for older individuals due to its cost-effectiveness, minimal risk, and potential rewards.

Engaging in cognitive and social activities can positively impact cognitive health. Simon et al. [25] discovered that maintaining an active social life, through activities such as volunteering, attending social gatherings, and joining clubs or organizations, was associated with a reduced risk of cognitive decline. Petersen [26] found that individuals who regularly engaged in mentally stimulating activities, such as reading, puzzles, and learning new skills, were also less likely to experience cognitive decline or develop dementia. Thus, participating in activities that challenge the mind and encourage social interaction is crucial for maintaining cognitive function and overall well-being.

1.5. Enhancing Cognitive Reserve through Foreign Language Learning

This section delves into the exploration of how learning a foreign language can positively impact cognitive and logical processes in older adults. It further aims to compare scores on various cognitive style variables with English proficiency tests. It's noteworthy to mention that Knowles [27] identifies four distinct cognitive styles: i) Concrete learning style, ii) Analytical learning style, iii) Communicative learning style, and iv) Authoritative learning style. Despite extensive research on the advantages of cognitive training for seniors, limited attention has been given to the specific benefits of language learning. This is particularly surprising considering that acquiring a new language demands significant mental effort and can contribute to improvements in memory, attention, and other cognitive skills.

1.5.1. Impact of Foreign Language Learning on Cognitive Style

Studies have suggested that bilingualism or multilingualism might delay the onset of dementia in older adults [28,29]. Bilingualism has been linked to enhanced cognitive flexibility, indicating that bilingual individuals possess not only the ability to switch between different language systems but also to switch between tasks, think creatively, and adapt to changing situations. Consequently, bilingual individuals tend to demonstrate superior executive functioning skills, including problem-solving and decision-making abilities [30].

1.5.2. Bilingualism, Multilingualism, and Cognitive Flexibility

The retrospective nature of research investigations suggests that it is never too late to begin learning a foreign or second language, though the benefits may be more pronounced for those who have been bilingual for an extended period [30]. Nevertheless, the advantages of developing bilingualism later in life through the study of a second or foreign language are still under investigation. Evidence from young adult language learners suggests that the brains of adult foreign language learners undergo structural development. Mårtensson et al. [31] examined 21 native speakers of Swedish after intensive foreign language instruction for three months in Dari, Russian, or Arabic. This study suggests that learning a foreign language as an adult can lead to structural changes in the brain, particularly in the left hemisphere's frontotemporal cortex. These alterations in language processing may have positive effects on cognitive function and overall brain health. The study also underscores the brain's remarkable plasticity, observed in areas such as the hippocampus and left superior temporal gyrus, indicating the brain's capacity to adapt and modify its structure and function. These findings align with those in the bilingual literature, suggesting that neural changes induced by foreign language learning may underlie the delay of dementia onset [32].

1.5.3. Structural Changes in the Brain due to Language Learning

Overall, research supports the notion that training and learning activities can enhance brain function, structure, and cognitive outcomes, with long-term potentiation being one of the underlying mechanisms. Human studies have indicated that changes in tissue microstructure due to training can contribute to these enhancements [33,34]. Consequently, understanding the mechanisms of brain plasticity can help identify potential risk factors for cognitive decline and develop strategies to prevent or delay age-related cognitive impairments. Learning a foreign language is expected to engage long-distance neural connections and stimulate a broader brain network, potentially surpassing the efficacy of other cognitive training methods, such as mathematical exercises or crossword puzzles. The benefits of foreign language learning may encompass improved language skills, the preservation of the integrity of affected brain regions, and the development of additional neural networks to compensate for age-related cognitive deficits. Although the neurological theory presented here has yet to be empirically validated, it provides an intriguing framework for future research on older adult language learners.

1.6. Unique Considerations for Older Adults

This session underscores the importance of a comprehensive approach to addressing cognitive decline in older adults, with a specific focus on the potential

advantages of foreign language learning and effective cognitive activities. The connection between foreign language acquisition and cognitive function in older individuals remains underexplored, with limited studies investigating the impact of language learning on cognitive and memory abilities.

1.6.1. The Unexplored Connection: Foreign Language Learning and Cognitive Function

According to Knowles [27], adult learners possess distinct characteristics and learning preferences that differentiate them from child and young learners. They prioritize autonomy, practical experience, and performance-oriented learning and already possess foundational skills that enable them to absorb information efficiently. Additionally, adult language learners tend to be more motivated and have a clearer understanding of their reasons for learning a new language, potentially leading to more effective language acquisition.

1.6.2. Tailoring Educational Programs for Adult Learners

Research by Marinova-Todd et al. [35] comparing older language learners (65-year-olds) with young adults (25-year-olds) suggests that while older learners may face challenges with pronunciation and grammar, they excel in grasping context and applying vocabulary in real-life situations. This can result in cognitive benefits such as enhanced memory and attention. It is crucial to consider these factors when designing and delivering educational programs for adult learners. This study also underscores that motivation significantly influences language learning performance in older individuals. Therefore, language instructors should ensure that older students are engaged, that the knowledge has direct applicability and that the learning process is personally fulfilling, selecting the appropriate teaching methods accordingly.

1.6.3. Enhancing Learning Outcomes through Interactive Approaches

In general, research highlights that older language learners benefit greatly from interactive and hands-on learning experiences. Hamil-Luker and Uhlenberg [36] suggest that incorporating activities that encourage older students to actively engage with the language can significantly enhance their learning outcomes. This could involve group discussions, role-playing, and real-life simulations that simulate authentic language use. Additionally, Homstad [37,38] proposes that integrating multimedia resources, such as videos and online platforms, can also be highly effective in engaging older learners and making the learning experience more dynamic and interactive.

1.6.4. The Fulfilling Endeavor: Learning a Second or Foreign Language in Older Adults

In gist, learning a second or foreign language can be a valuable and fulfilling endeavour for older adults. It not only offers cognitive benefits but also opens up new

opportunities for communication and cultural exchange, enriching their post-retirement experiences. Therefore, it is highly recommended that older adults invest their time and effort in learning a new language.

1.6.5. Digital Literacy, Technology, and Cognitive Well-Being

Shapira et al.'s [39] work underscores the significance of providing older adults with access to technology and training to enhance their cognitive abilities and overall well-being. By investing in digital literacy programs, we can help older adults remain engaged, connected, and independent in their daily lives. Social media platforms, online forums, and video conferencing tools, aided by Computer-Assisted Language Learning (CALL) and Mobile-Assisted Language Learning (MALL), enable seniors to connect with family and friends, even if they live far away or have busy schedules [40]. Therefore, incorporating digitized social and communicative elements into foreign language training programs may have a substantial impact on neurobiological aging and cognitive benefits compared to other activities such as math problems and crossword puzzles. Consequently, language learning enhances cognitive abilities such as memory, problem-solving skills, and critical thinking skills [41].

1.7. Study Objectives

- To investigate the relationship between foreign language acquisition and cognitive abilities.
- To assess how learning a new language through activities based on vocabulary retention and memory influences attention, memory, and overall cognitive function in older individuals as a remedy for Alzheimer disease and dementia.
- To evaluate the impact of interactive learning approaches on older language learners
- To understand the characteristics and preferences of adult language learners
- To tailor educational programs for older language learners
- To assess the role of digital literacy and technology in cognitive well-being.

1.8. Hypotheses

Hypothesis 1:

Null Hypothesis (H0): There is no significant impact of foreign/second language learning through vocabulary retention and memory activities on the cognitive function of older adults.

Alternative Hypothesis (H1): Learning a new language through activities focused on vocabulary retention and memory positively influences memory, attention, and overall cognitive function in older individuals.

Hypothesis 2:

Null Hypothesis (H0): Interactive language learning approaches do not significantly rehabilitate Alzheimer's disease and dementia, leading to enhanced learning outcomes for older language learners.

Alternative Hypothesis (H1): Incorporating interactive and hands-on learning experiences positively impacts Alzheimer's disease and dementia, resulting in enhanced learning outcomes for older individuals.

Hypothesis 3:

Null Hypothesis (H0): Characteristics and preferences do not significantly contribute to the effectiveness of language acquisition in older individuals.

Alternative Hypothesis (H1): Distinctive characteristics and learning preferences of adult language learners play a vital role in effective language acquisition among older individuals.

2. Materials and Methods

This section comprehensively outlines the methodology employed in the research, encompassing critical aspects such as the research design, setting, instruments used, and the duration of the study.

2.1. Research Design

The research employs a quantitative research methodology to ensure the comprehensive acquisition of research outcomes. Concentrating specifically on the dynamic interactions within the classroom between adult learners and researchers, the study takes on a descriptive and prescriptive approach in the intervention phase, offering a detailed exploration of the findings.

This study employed the Communicative Language Teaching (CLT) approach and the Community Language Learning (CLL) approach as pedagogical strategies to impart language learning and teaching through activities focused on vocabulary retention and memory. Selected language learning activities, centered around vocabulary retention and memory, have been incorporated into the intervention aimed at mitigating cognitive decline. Through the application of these activities, the study seeks to assess their effectiveness in addressing the challenges associated with Alzheimer's disease and dementia, with a specific focus on cognitive rehabilitation.

2.2. Research Setting

The research took place at two language institutions: 'Atlas IELTS and Spoken English Academy' (Control Group) and 'Alpha English Academy IELTS Coaching Centre' (Experimental Group) in the Vellore District, India. The study encompasses 63 participants (42%) in the control group and 87 participants (58%) in the experimental group, all aged above 60. The sample size of 150 is deliberately

chosen through purposive sampling from the target population.

2.3. Small but Significant Sample

Although the sample size is modest, the emphasis on preventing Alzheimer's disease and dementia by improving overall cognitive function and memory retention as a preventive measure can offer valuable qualitative and quantitative insights. In this instance, the sample size is warranted due to the thorough and nuanced examination of learners' self-assessments concerning vocabulary retention and memory.

2.4. Research Instruments and Materials

To collect necessary data for this study, a diverse set of tools and instruments were utilized, including pre-test and post-test assessments. Multimedia tools such as video recording equipment, web sources, and Excel office software were also employed, with the researchers serving as the primary data collection instruments.

The teaching materials used in the study are based on an 'Activity-Based Syllabus [42],' rooted in Communicative Language Teaching and Community Language Learning pedagogy. The researchers incorporated activities closely related to vocabulary retention and memory, such as Story Chain, Match up Words and Definitions, Information Gap, Scavenger Hunt, and Rescue, among others.

The learners' performance in the Pre-test and Post-test was assessed through SPSS software and the presentation of results for both control and experiment groups was done using a Non-Parametric Test, structured according to the challenges faced by adult learners in acquiring lexical skills in a foreign or second language. This method ensures a comprehensive comprehension of the study's content and findings concerning the impacts of neurobiological aging.

2.5. Criteria for Evaluating Pre-test and Post-test

The study included an English language proficiency evaluation modeled after the IELTS (Academic) exam. The assessment evaluated vocabulary use based on a speaking rubric from a standardized IELTS band scores test. This rubric, focusing on "lexical resources," helps measure how well someone remembers and uses vocabulary. The assessors likely found this rubric freely available online.

2.5.1. Evaluation Standards to Measure Vocabulary/Lexical Resources

The IELTS Band Scores criteria appraise language proficiency on a scale ranging from 1 to 9.

1. *Non-User*: Limited proficiency, isolated vocabulary.
2. *Intermittent User*: Basic communication, short expressions.
3. *Extremely Limited User*: Understands broad meaning but experiences frequent communication failures.

4. *Limited User*: Basic competency with struggles in complexity.
5. *Modest User*: Limited mastery with some errors.
6. *Competent User*: Generally competent with occasional mistakes.
7. *Good User*: Functional grasp with occasional errors.
8. *Very Good User*: Nearly flawless with minor errors.
9. *Expert User*: Total mastery, fluent, and correct language use.

The outcomes of these assessments were later analyzed using SPSS software (Statistical Package for the Social Sciences) to enhance the credibility of the collected data. Tabular displays were utilized to present the test results.

2.6. Research Duration

The research intervention extended over two months, starting in August, and concluding in September 2023. This timeline was evenly distributed to accommodate the diverse research instruments and activities incorporated into the intervention.

3. Results

The pre- and post-test data aim to evaluate the impact of foreign language acquisition on vocabulary retention and memory among older adults. The study compares a control

group from ‘Atlas IELTS and Spoken English Academy’ with an experimental group from ‘Alpha English Academy IELTS Coaching Centre’ from Vellore district, India. Each IELTS band score corresponds to a specific level of language proficiency, ranging from 1 (Non-User) to 9 (Expert User). Here's an interpretation of the distribution.

3.1. Frequency Rate of IELTS Band Score

The analysis of the pre-test and post-test data presented in Table 1 suggests an interesting relationship between foreign language acquisition and cognitive advantages among elderly participants, as measured by the IELTS Band Score criteria focusing on vocabulary retention and memory.

The analysis of the pre-test and post-test frequency rates of IELTS Band Scores reveals intriguing insights into the impact of language acquisition on cognitive function among older adults. In the control group, represented by the Atlas IELTS and Spoken English Academy, there was a predominant presence of participants categorized as Limited Users both before and after the language activities, indicating a baseline proficiency level in English language skills that remained relatively stagnant. Conversely, in the experimental group from the Alpha English Academy IELTS Coaching Centre, there was a noticeable improvement across all proficiency levels from pre-test to post-test, suggesting the effectiveness of the language interventions employed.

Table 1. Control and Experimental Groups: Pre-test and Post-test Frequency Rate of IELTS Band Score

Total Number of Elderly Participants Examined - 150				
Atlas IELTS and Spoken English Academy (Control Group) - 63 older participants, making up 42% and Alpha English Academy IELTS Coaching Centre (Experimental Group) - 87 older participants, constituting 58%				
BAND SCORE (IELTS) – based on vocabulary retention & memory test	Atlas IELTS and Spoken English Academy (63) - Control Group Frequency Rate		Alpha English Academy IELTS Coaching Centre (87) - Experimental Group Frequency Rate	
	Pretest (%)	Post-test (%)	Pretest (%)	Post-test (%)
Expert User (9)	Nil -	Nil-	Nil-	2 (2.29%)
Very Good User (8)	1 (1.58%)	2 (3.17%)	1 (1.14%)	7 (8.04%)
Good User (7)	3 (4.76%)	4 (6.34%)	4 (4.59%)	11 (12.64%)
Competent User (6)	5 (7.93%)	5 (7.93%)	7 (8.04%)	17 (19.54%)
Modest User (5)	7 (11.11%)	6 (9.52%)	15 (17.24%)	31 (35.63%)
Limited User (4)	26 (41.26%)	25 (39.68%)	31 (35.63%)	16 (18.39%)
Extremely Limited User-(3)	15 (23.809%)	16 (25.39%)	21 (24.13%)	3 (3.44%)
Intermittent User (2)	6 (9.52%)	5 (7.93%)	8 (9.19%)	Nil
Non-User (1)	Nil -	Nil-	Nil-	Nil

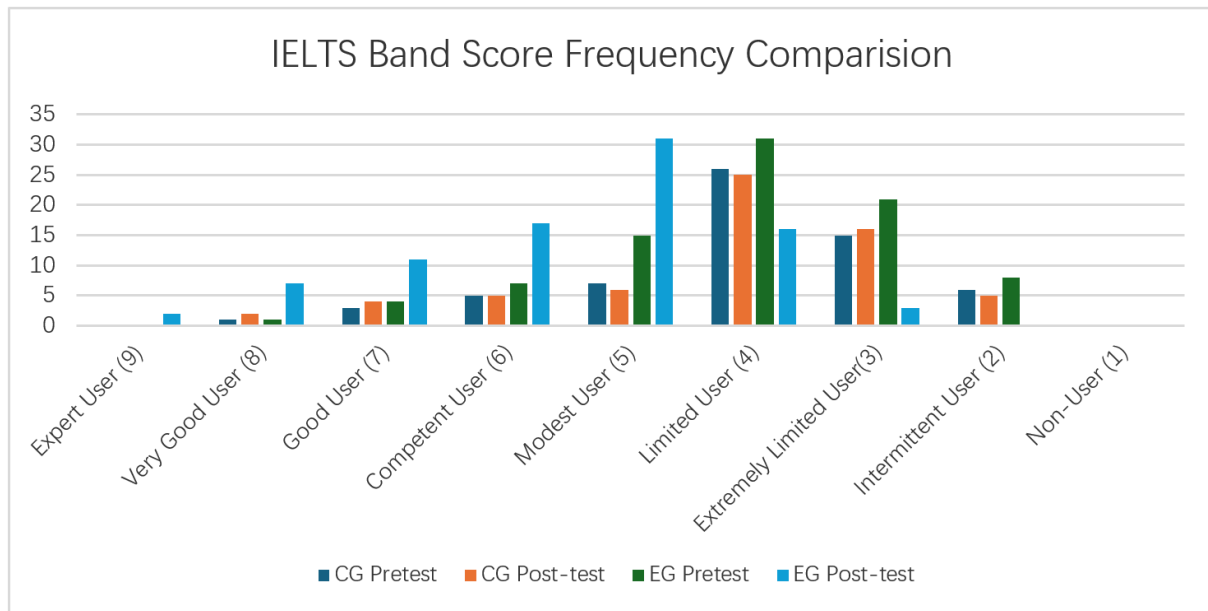


Figure 1. Frequency Rate of IELTS Band Score - Based on Table 1

Remarkably, the experimental group demonstrated a substantial increase in participants categorized as Very Good Users, Good Users, and Competent Users, indicating significant advancements in language proficiency following the intervention period. This stark improvement, particularly in higher proficiency levels, underscores the potential cognitive benefits associated with engaging in language-related activities among aging individuals. Moreover, the experimental group displayed a more pronounced enhancement in vocabulary retention and memory compared to the control group, suggesting that targeted language learning initiatives could serve as a proactive measure against cognitive decline associated with aging.

These findings offer compelling evidence supporting the notion that foreign/second language acquisition holds promise to bolster cognitive function and potentially mitigate the risk of neurodegenerative conditions such as Alzheimer's disease and dementia among older adults. By deepening our understanding of the intricate relationship between language acquisition and the aging brain network, this study illuminates a pathway toward preserving cognitive health and promoting lifelong learning in later life stages.

In gist, here are some observations based on the data in Table 1 and Figure 1:

- Overall, scores appear to have improved following the foreign language learning program. For most bands (5,

6, 7, and 8), the frequency rate in the post-test is higher than in the pre-test for the experimental group.

- The greatest improvement appears to be for band 5 (Modest User). In the experimental group, the frequency rate for this band went from 15 (17.24%) in the pre-test to 31 (35.63%) in the post-test.
- Scores in the control group remained largely unchanged. This suggests that the improvement in the experimental group is likely due to the foreign language learning program, rather than other factors.

4. Data Analysis and Interpretation

4.1. Analysis of Non-Parametric Test Results for Control and Experimental Groups: Pre-test and Post-test (Wilcoxon Test)

The analysis of non-parametric test results in Tables 2, 3, and 4 using the Wilcoxon Signed Ranks Test provides valuable insights into the comparative changes in the control and experimental groups from pre-test to post-test. Previously observed trends in the frequency tables, such as overall improvement in the experimental group and minimal change in the control group, are further supported by the statistically significant results from this Wilcoxon Signed Ranks Test.

Nonparametric Test

Table 2 represents the group statistics of the control and experimental groups' pretest and post-test. In the pre-test phase, the control group exhibited a mean score of 4.0476 with a standard deviation of 1.32505, while the experimental group had a slightly higher mean score of 4.0920 with a standard deviation of 1.30858. This suggests that, on average, participants in both groups had similar baseline levels of proficiency before the intervention.

Moving to the post-test phase, the control group showed a mean score of 4.1587 with a standard deviation of 1.43916, whereas the experimental group displayed a substantially higher mean score of 5.5287 with a standard deviation of 1.36262. These statistics imply that the experimental group experienced a significant improvement in language proficiency compared to the control group after the intervention.

Wilcoxon Signed Ranks Test

Table 3 represents the Wilcoxon Signed Ranks Test. In this, negative ranks indicate instances where post-test scores were lower than pre-test scores, positive ranks indicate instances where post-test scores were higher, and ties represent instances where no difference was observed. For the control group, the test yielded a Z statistic of -0.475 with an associated p-value of 0.635. This suggests that there was no significant difference between pre-test and post-test scores for the control group. Conversely, for the experimental group, the Z statistic was -5.581 with a p-value of 0.000. This indicates a highly significant difference between pre-test and post-test scores for the experimental group, highlighting the effectiveness of the intervention in improving language proficiency.

Table 2. Group Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Pretest - Control Group	63	4.0476	1.32505	2.00	8.00
Pretest – Experimental Group	87	4.0920	1.30858	2.00	8.00
Post-test – Control Group	63	4.1587	1.43916	2.00	8.00
Post-test - Experimental Group	87	5.5287	1.36262	3.00	9.00

Table 3. Ranks

	N	Mean Rank	Sum of Ranks	Sum of Ranks
Post-test Control Group – Pretest Control Group	Negative Ranks	20 ^a	20.70	414.00
	Positive Ranks	22 ^b	22.23	489.00
	Ties	21 ^c	-	-
	Total	63	-	-
Post-test Experimental Group – Pretest Experimental Group	Negative Ranks	16 ^d	22.59	361.50
	Positive Ranks	58 ^e	41.61	2413.50
	Ties	13 ^f	-	-
	Total	87	-	-

Notes: a. post-test cg < pretest cg, b. post-test cg > pretest cg, c. post-test cg = pretest cg, d. post-test eg < pretest eg, e. post-test eg > pretest eg, f. post-test eg = pretest eg

Table 4. Test Statistics^a

	Post-test Control Group – Pretest Control Group	Post-test Experimental Group – Pretest Experimental Group
Z	-.475b	-5.581b
Asymp. Sig. (2-tailed)	.635	.000

Notes: a. Wilcoxon Signed Ranks Test, b. Based on negative ranks.

Overall, the non-parametric test results, the Wilcoxon Signed Ranks Test, offer a nuanced understanding of the effectiveness of the language intervention on the control and experimental groups' language proficiency levels. Initially, both groups exhibited similar mean scores in their pre-test assessments, suggesting a comparable baseline proficiency level. However, upon closer examination, while the control group's post-test scores showed a slight increase, the difference was not statistically significant, as indicated in Table 4 by the test statistic (Z) of -0.475 and a p -value of 0.635. This suggests that the language activities did not lead to a substantial improvement in language skills among the control group participants.

Conversely, the experimental group's post-test scores saw a considerable elevation, with a marked increase in mean rank and a significant test statistic (Z) of -5.581, coupled with an impressively low p -value of 0.000. This disparity in outcomes underscores the profound impact of the language intervention on the experimental group's language proficiency. The notable improvement observed in the experimental group's post-test scores, contrasted with the control group's marginal change, emphasizes the efficacy of targeted language learning initiatives in enhancing cognitive function among older adults.

Moreover, the significant difference between pre-test and post-test scores in the experimental group underscores the potential of language acquisition as a proactive measure against cognitive decline associated with aging. These findings not only highlight the importance of structured language interventions but also underscore the critical role of continuous learning in preserving cognitive health in the later stages of life. By providing empirical evidence of the cognitive benefits associated with language learning, particularly among aging individuals, this study underscores the significance of adopting holistic approaches to cognitive health maintenance, encompassing both physical and mental well-being.

5. Discussion and Conclusions

The hypotheses presented in the study shed light on the potential impacts of foreign/second language learning on cognitive function in older adults, as well as the role of interactive learning approaches and individual characteristics in language acquisition effectiveness. The non-parametric test results offer compelling evidence that challenges the null hypotheses while supporting the alternative hypotheses, particularly in the context of language learning's influence on cognitive function among older individuals. The significant improvement observed in the experimental group's post-test scores suggests that language activities focusing on vocabulary retention and memory positively influenced memory, attention, and overall cognitive function, thus validating Hypothesis 1. This finding underscores the potential of language learning as a cognitive intervention tool for older adults, offering

hope for maintaining cognitive health in aging populations.

Furthermore, while the study did not directly measure the rehabilitation of Alzheimer's disease and dementia, the observed enhancement in cognitive function among participants engaged in interactive language learning approaches aligns with Hypothesis 2. The results suggest that incorporating hands-on and interactive learning experiences may indeed have broader implications for neurodegenerative conditions, potentially leading to enhanced learning outcomes for older individuals facing cognitive challenges. These findings highlight the multifaceted benefits of language learning beyond linguistic proficiency, emphasizing its potential as a holistic approach to cognitive health maintenance in later life stages.

Although Hypothesis 3 regarding the influence of individual characteristics and preferences on language acquisition effectiveness was not directly addressed by the non-parametric tests, it remains an intriguing avenue for further investigation. The hypothesis posits that distinctive characteristics and learning preferences of adult language learners may play a vital role in shaping the effectiveness of language acquisition strategies. While not explicitly measured in this study, acknowledging, and accommodating individual differences in language learning may be crucial for optimizing the efficacy of interventions tailored for older adults.

In conclusion, the study underscores the significance of targeted language learning interventions in preserving cognitive function and potentially mitigating cognitive decline in older individuals. By providing empirical support for the hypotheses, the findings underscore the importance of incorporating language learning activities into cognitive intervention programs for aging populations, with a particular emphasis on interactive approaches and individualized learning strategies. These insights offer valuable implications for promoting lifelong cognitive health and well-being among older adults.

6. Prospects for the Future

6.1. Standardized Cognitive Assessments: Unveiling Long-Term Impact

The gaps identified by researchers hint at a potential explanation for the limited research in this area – the assumption that older adults may not learn a new language as effectively as younger individuals. Further investigations are warranted to ascertain whether language learning can enhance cognitive functioning in this population, particularly those aged above sixty-five.

Conducting standardized cognitive assessments at various intervals could offer a comprehensive insight into the impact of language training on cognitive functions. Through such assessments, researchers and educators could assess the efficacy of language training and its

potential benefits on various cognitive abilities like task switching, processing speed, inhibitory control, and working memory over the long term.

6.2. Intensive Training and Structural Brain Changes

To attain proficiency in a foreign language and reap the cognitive advantages of language acquisition, intensive training involving frequent and extended language sessions is crucial. Research by Mårtensson et al. [31] revealed that even just three to five months of learning a foreign language can lead to structural brain changes in adult learners. Linhart Wegschaider's doctoral dissertation [43] further demonstrated that individuals over 60 can significantly enhance their Mandarin language skills within six months through daily hour-long classes five days a week.

6.3. Short-Term Challenges, Long-Term Benefits

Baus et al. [44] indicate that short-term language immersion programs can present challenges in word retrieval, which could be a drawback. However, integrating foreign language instruction as a therapeutic option can still be a viable and beneficial choice for enhancing cognitive function in patients. Despite potential obstacles, the potential advantages of this treatment outweigh them, significantly enhancing patients' quality of life by bolstering their cognitive abilities. Additionally, it was suggested that the word retrieval difficulties experienced during short-term language immersion programs are temporary and can be overcome with sustained practice; Ahmet Ozyigit [45] also affirms the impact of years of schooling as an enabling factor for the target audience to overcome these difficulties in addressing dementia. Therefore, it is crucial to provide ongoing support and resources to patients undergoing this treatment option to ensure long-term success in improving cognitive function.

To conclude, the study's findings unequivocally establish the paramount significance of language learning for older adults, showcasing its potential to not only enhance cognitive function but also improve memory and overall well-being. The profound insights gained into the mechanisms through which older individuals acquire languages provide educators and facilitators with invaluable knowledge to fine-tune their approaches, tailoring language learning opportunities to meet the specific needs of the elderly. As a noteworthy contribution to the expanding body of knowledge on the learning capabilities of the elderly population, this research addresses the growing societal demand for accessible language learning opportunities in later life. The implications of this research extend beyond academic considerations, holding the promise of assisting older individuals in maintaining robust cognitive function and leading healthier, more enriched lives.

Moreover, the practical application of the strategies elucidated in this study can usher in a notable enhancement in cognitive performance among the aging demographic. The cultivation of multilingualism emerges as a powerful catalyst, fostering neuroplasticity and augmenting cognitive flexibility. Simultaneously, the implementation of proactive cognitive training methods stands out for its efficacy in bolstering memory retention and fortifying executive function. Embracing engaging lifestyle activities, as advocated in this study, not only contributes to improved cognitive outcomes but also positively influences overall physical and mental health. The holistic approach recommended here offers a comprehensive framework for promoting cognitive well-being among older adults, with the potential to redefine the landscape of aging and learning.

Key Messages

- Foreign language training holds promise in enhancing cognitive abilities and resilience against age-related cognitive decline, including Alzheimer's disease and dementia.
- Creating enriching language learning environments and engaging in intellectually challenging language-related activities (vocabulary retention and memory-based activities) can reduce the risk of cognitive decline in older adults.
- Adult learners exhibit unique characteristics that make language learning an effective tool for cognitive preservation.
- Incorporating technology and interactive learning experiences can enhance language acquisition and potentially improve cognitive function in older adults.
- Further research is needed to establish a strong foundation for diagnosing dementia development and to explore the long-term benefits of foreign language education in older individuals.

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Conflict of Interest

The authors affirm that the research was conducted without any affiliations or financial associations that could

be interpreted as a potential conflict of interest.

Appendix

1. Materials: Activity Based Syllabus and Activities (Adopted from Communicative Language Teaching & Community Language Learning approaches)

Table 5 outlines a 9-week program to improve vocabulary retention and memory. It starts with assessing current knowledge, then teaches methods like word

building and sentence structure, and ends with testing progress.

Tables 6 & 7 detail the activities used in a 9-week program to improve vocabulary and communication skills. The program is divided into two phases. Phase 1 (Weeks 1-5) focuses on building foundational skills like speaking fluency, pronunciation, and listening comprehension through interactive activities like role-playing, storytelling, and games. Phase 2 (Weeks 6-9) builds on those skills by emphasizing vocabulary expansion, accuracy, and cultural awareness through activities like discussions, projects, and problem-solving tasks. A post-test using the same method as the pre-test wraps up the program in week 9.

Table 5. Syllabus for Intervention Classes: Focusing on Vocabulary Retention and Memory

Weeks	Syllabus	Content/Inputs During Intervention
Week 1	Introduction	Introducing the participants about the study and motivating them toward effective participation in the study
	Pre-Test	Organizing tests randomly without proper inputs – to study participants' knowledge
Week 2 & 3	Class: Phones & Morphs - with activities	Inflections, prefixes, suffixes, derivational & parts of speech, etc. (nuances of words and their meaning - E.g. learning many words with the help of one word)
Weeks 4 & 5	Class: Syntax - Basic sentence structure	Intro. to sentence pattern & Tense structure (S+V+O... Present, past, future, continuous and perfect - A small glance)
Weeks 6 & 7	Class: Semantics - Word web	Connecting and understanding textual meaning
Week 8 & 9	Class: Pragmatics – Social aspects of a language	Understanding junk of words: associative & intended meaning – contextual element of language learning.
Weeks 9	Post-Test & Feedback	Organizing tests after proper inputs based on the study content.

Table 6. Prescribed Activities: Based on Syllabus – Phase 1 of Intervention

Weeks	Content	Activities Conducted During Intervention
Week 1	Introductory Session	Ice-breaking sessions – motivational inputs on the benefits of language learning towards cognitive memory and retention.
	Pre-Test and Discussion	Story chain - Narrate the story using the given phrases and vocabularies in the context.
Week 2 & Week 3	Speaking fluency Social language skills Daily conversation skills Related activities: 5*, 6*, 13, 17	Daily Conversations: Pairs discuss routines, family, and hobbies. Role-play: e.g., Students cook a local dish as chef and assistant. Role of the Day: Students take on roles (e.g., Teacher, News Reporter) and communicate in English. Dream House: Groups design and describe their ideal homes in English. Vocabulary Showdown: Teams find synonyms, and antonyms, and use words in sentences.
Week 4 & Week 5	Pronunciation Listening comprehension Related activities: 2*, 4*, 9*, 10, 12	Picture Description: Describe a picture to build vocabulary and sentence skills. Storytelling: Share personal experiences or local hero stories in English. Word Relay: Create a chain of related words. Grammar Correction: Identify and fix intentional grammar errors in teams. Tongue Twisters: Practice pronunciation and fluency with challenging phrases.

Table 7. Prescribed Activities: Based on Syllabus – Phase 2 of Intervention

Week	Content	Activities Conducted During Intervention
Week 6 & Week 7	Grammar usage (Accuracy) Listening and responding Building confidence Related activities: 5*, 6*, 13, 17	Group Discussions: Discuss local topics like natural disasters to express ideas. Story Building: Teams create a story sentence by sentence. Language Treasure Hunt: Hunt for hidden items through English clues and riddles. Book-to-Film Analysis: Read a book together, then analyze its movie adaptation.
Week 8 & Week 9	Vocabulary expansion Cultural awareness Related activities: 2*, 4*, 9*, 10, 12	Community Projects: Empower students to make a positive impact through youth education programs. Problem-Solving Tasks: Collaboratively solve real-world issues, like engaging more youth in community activities. Current Events Chat: Discuss global issues and current events in English for student engagement and awareness.
Week 9	Post-Test	Story chain - Narrate the story using the given phrases and vocabularies in the context. (Same as Pre-test)

2. Pre-Test and Post-Test Question (Test for Vocabulary Retention and Memory)

The story prediction is done based on the contextual vocabularies (story chain) which are based on the Vocabulary Retention and Memory activities conducted during the intervention are given below, and each participant is asked to narrate the story using the story chain vocabulary into the context and are asked to narrate the moral of the story as well.

Story Chain:

A rich farmer - Plenty of land - Cattle and servants - Two sons – happy life – younger son unhappy – divided the property – avoided father’s advice – got his share – sold everything – went to another country – fell into bad ways – famine came – lost all money – became poor – no one to help – felt guilty - understood his mistake – returned to his father – confessed his faults - father accepted him - The moral of the story is...?

3. Summary of Work done by the Contributors

Author 1 reviewed research related to the cognitive benefits of foreign language training in older adults as a means of mitigating Alzheimer's disease and dementia. They emphasized the importance of creating enriching environments for older individuals, highlighting the positive impact of environmental enrichment on cognitive function, memory retention, and brain health. The contributor also discussed the concept of cognitive reserve and its role in protecting against cognitive decline in aging populations.

Author 2 explored the unique characteristics of adult learners and their preferences for language acquisition in the context of Alzheimer's disease and dementia. They emphasized the motivation and autonomy of adult language learners, which can lead to more effective language acquisition. Additionally, the contributor highlighted the benefits of interactive and hands-on

learning experiences for older language learners and the role of technology, particularly digital literacy programs, in enhancing cognitive abilities and overall well-being among older adults.

Intervention/Treatment - Joint work by Contributors: In conjunction with the contributors' insights, an experimental study was conducted, involving older participants from two English language academies. The study aimed to assess the impact of foreign language training on cognitive abilities, memory retention, and overall well-being in older individuals. The contributors conducted intervention classes simultaneously for each group, employing Communicative Language Teaching (CLT) and Community Language Learning (CLL) with activities specifically focused on vocabulary retention and memory enhancement. This approach aligned with the contributors' emphasis on hands-on learning experiences and technological interventions for effective language acquisition and cognitive improvement in the elderly population.

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