

Examining the Impact of Language Learning on Healthy Cognitive Aging in Older Populations

Honors Thesis

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Abstract

Dementia and its derivatives, namely Alzheimer's disease, are becoming increasingly prevalent worldwide. There are nearly 10 million new cases of dementia each year (Alzheimer's Disease International, 2026), most of which are in developing nations. Many pharmacological interventions and potentially significant lifestyle factors have been explored, yet the disease remains incurable and non-preventable. As the incidence of dementia rises, bilingualism has simultaneously become more present globally. With this, bilingualism has piqued the interest of neuroscientists and anatomists, producing research investigating the neural changes in bilingual individuals compared to monolinguals. Through a meta-analytical approach, this paper interprets the results of these studies from the perspective of dementia prevention. Furthermore, it explores language learning itself as a potential avenue for healthy cognitive aging. Finally, the researcher conducted a subjective, short-term, French language learning study on English-speaking senior citizens in the Fort Collins community. Promisingly, the study found that participants' memory improved over the language learning program, indicating the cognitive benefits of small language programs for senior communities, specifically in the clinical context of dementia.

Section I: Dementia in a Socioeconomic Context

Over the past century, medical knowledge and technologies have rapidly progressed around the world to the extent that the average life expectancy at birth has more than doubled since 1900 (World Health Organization, 2025). However, these advancements have unforeseen consequences: concurrent with the rise of aging populations, there has been a rise in the incidence of dementia, a progressive neurodegenerative disease impacting older individuals. At present, dementia is the seventh leading cause of death worldwide, and it most commonly

presents (in 60-70% of cases) as Alzheimer's disease (World Health Organization, 2025).

Dementia has seven main stages of progression as defined by the National Council of Certified Dementia Practitioners (NCCDP); initial stages present with small, mild lapses in memory that are often attributed to age-related forgetfulness, but more severe, terminal stages present with personality change, difficulty accomplishing everyday tasks, substantial memory loss, and complete dependency on caretakers (NCCDP Staff, 2026). Phases of dementia can last multiple years, and the variety in length is conditional on the degree of aggression from person to person.

Notwithstanding the high mortality of the disease, it also has a tremendous impact on the economy; in 2019, dementia cost the global economy US\$ 1.3 trillion, and approximately 50% of these costs are attributable to care provided by informal carers (World Health Organization, 2025). Furthermore, dementia as a disease is an extraordinary burden for these caregivers concerning both time commitment (usually around 5 hours a day) and physical exertion during care. Dementia also delivers emotional detriment to family members of the impacted individual and brings up ethical questions in the clinical setting with restraint usage on dementia patients with agitation and aggressive behavior.

Given the substantial economic, emotional, and ethical consequences of the disease, interventions to prevent or treat dementia have been explored. Regarding pharmacological treatment, the Mayo Clinic offers two options: cholinesterase inhibitors and memantine (2025).

Cholinesterase inhibitors, specifically acetylcholinesterase inhibitors (AChE inhibitors) function by increasing levels of acetylcholine, a neurotransmitter. In the central nervous system, acetylcholine is released post-synaptically from the nucleus basalis of Meynert, providing cholinergic activation of forebrain structures and the limbic system (Colovic et al, 2013), making the neurotransmitter essential to encoding information into memory. AChE inhibitor treatments

increase levels of acetylcholine and improve working memory by inhibiting acetylcholinesterase, the enzyme that breaks down acetylcholine. However, AchE inhibitors have known side effects such as nausea, vomiting, and diarrhea (Mayo Clinic Staff, 2025). In addition, AchE inhibitors are only effective temporarily. A study using data from the National Bureau of Insurance in Taiwan found that only 9.6% of individuals taking AchE inhibitors to treat dementia maintained stable cognitive assessment scores after 3 years of using the drug (Sun et al, 2008).

The other viable pharmacotherapy option is memantine. Memantine is a drug that reduces the amount of glutamate in the brain while maintaining a healthy level of the neurotransmitter for proper brain functioning. Individuals with AD are believed to have increased levels of glutamate in cortex, causing damage to neuronal tissue (InformedHealth, 2022). Memantine reduces excessive glutamate in the cerebrum, therefore reducing neuronal cell damage and slows the progression of dementia. While well-tolerated and with minimal side effects, the National Library of Medicine declares that “Memantine was able to delay the worsening of mental performance over a period of six months in about 1 out of 10 people” (InformedHealth, 2022), thus indicating that memantine only slows the progression of dementia for around six months at most.

Aside from pharmacological interventions, there are other lifestyle-based recommendations to adapt to living with dementia. These interventions include reducing stressors, such as retiring if the individual is still working; enhancing communication and breaking large tasks into smaller, more easy-to-understand steps; exercising regularly and attending physical therapy; establishing daily routines and planning activities; and finally, picking up creative enrichment activities such as painting, dancing, or music. While these methods are not a treatment for the disease, participating in these activities create a means for

families to adapt to the individual suffering from dementia to be able to spend quality time with their loved one even as the disease progresses.

It is apparent that dementia is incurable, and that current pharmacological treatments are only effective for a couple years at most. What other means are available to address this growing problem? Language learning is a promising developmental and lifestyle-based avenue for reducing the incidence of dementia in modern society.

Section II: The Mechanism of Language Learning

Until the twentieth century, it was thought that learning a second language at a young age and being bilingual as a young person had a detrimental effect on a child's intelligence. This was due to bilingual children having seemingly delayed cognitive development, smaller vocabulary in both languages, and concerns for mental confusion. This sentiment was eventually overruled with the publishing of the Peal and Lambert study in 1962, in which they astoundingly discovered that bilingual children (who spoke French and English) outperformed monolingual children on verbal and nonverbal intelligence tests (Kuhl, 2010). With this discovery, the association between bilingualism at a young age and development became advantageous instead of burdensome.

Language acquisition is easiest at a young age, making bilingualism easier to acquire beginning in early childhood. In a study examining early childhood second language acquisition, nine-month old American infants listened to four different native speakers of Mandarin over the course of twelve sessions of four to five weeks. They were instructed using books and interactive toys in an unscripted environment. Conversely, a control group of the same age was also present,

with only English-speaking teachers. At the end of the twelve sessions, the children were exposed to audio samples containing Mandarin phonetic sounds and contrasts that are foreign to American phonemes. Simultaneously, their brain activity was measured by monitoring their outward behaviors but also using event-related potential (ERP) signals directly from cortical areas that records cortical electrical activity in response to stimuli. The test group outperformed the control group in distinguishing the sounds, to the extent that their ERP measurements were comparable to those of Taiwanese infants of the same age, who had been exposed to Mandarin since birth. Additionally, upon re-testing thirty-three days after the conclusion of the twelve sessions, the infants demonstrated the same behavioral discrimination test results, indicating that the infants' retained the information that they had learned weeks prior (Kuhl, 2010).

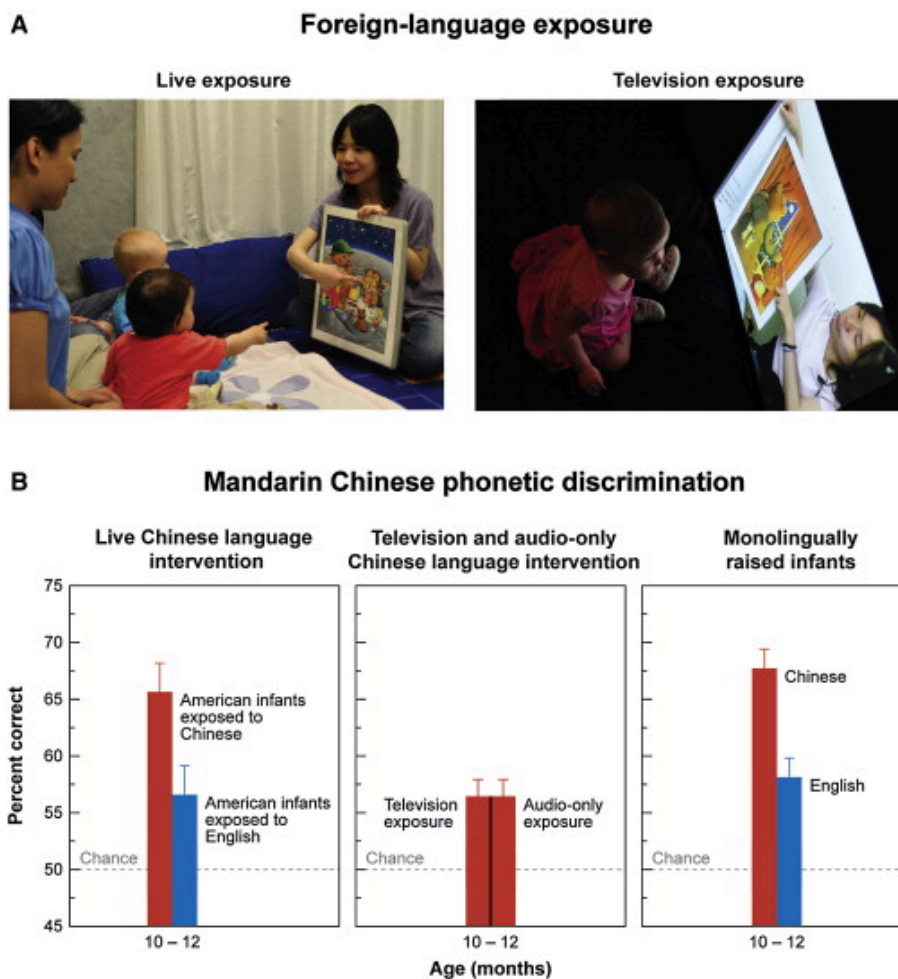


Figure 1. Test results of Mandarin Chinese phonetic discrimination of American children after twelve sessions of Mandarin language exposure across four to five weeks. American infants exposed to Chinese exhibited similar test results to those of monolingually-raised Taiwanese infants; whereas American infants exposed to English and televised lessons demonstrated lower phonetic discrimination. From Kuhl, 2010.

Interestingly, these results were only true of infants that had in-person instruction. Another test group was instructed with an online, televised approach and had the same results as those in the control group, with no phonetic discrimination of the Mandarin contrast stimuli (Kuhl, 2010). This demonstrates that language learning, especially at younger ages, is social. Additionally, the infants' language retention was highly dependent on interactivity with the

instructors and their sense of relationship. As children made eye contact and followed the gaze of instructors, their attention rose, thus enhancing the encoding of information from the lessons and increasing retention. In the televised lessons, infants lacked contact with in-person instructors and felt no sense of relationship with little to no gaze shifts, thus explaining the lower discrimination test results in the televised learning group from the previous study.

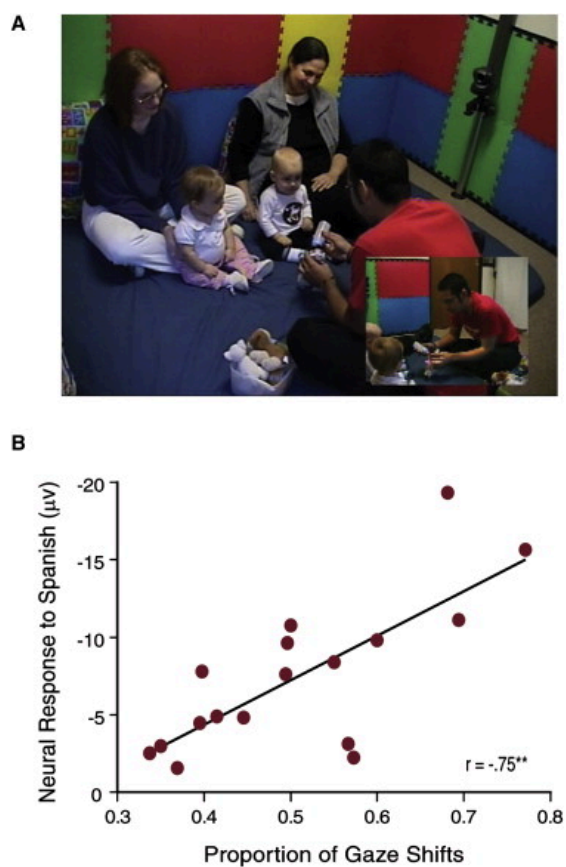


Figure 2. Scatterplot line graph depicting the strong positive correlation between proportion of gaze shifts in infants to neural response to Spanish phonemes. From these results, it is evident that with greater attentiveness and gaze shifts, infants demonstrated greater neural retention to Spanish (R value = 0.75). From Kuhl, 2010.

In addition to children's increased attentiveness through eye contact and following gaze of instructors, infants learn language within the 'critical period' timing of second language acquisition. Aspects of learning and development have certain critical periods, or ideal periods of

time to acquire a new skill in the most efficient manner. Language learning as a skill has a very narrow critical period, the first 2-4 years of life, and is characterized by a large amount of brain plasticity that allows infants to master languages in a short period of time (Fornells et al, 2009). As individuals age, their brain plasticity decreases and therefore they outgrow the critical period for language acquisition.

However, why is language learning capacity not equal at all ages? While still a heavily-debated topic in modern literature, a couple hypotheses provide viable explanations for decreased language learning capacity past early childhood.

Newport's hypothesis states that children have limited cognitive capacity and working memory, acting as a blank slate to soak up extensive amounts of language-related information easily. Since so little information is encoded in the infantile brain, it is able to pick up new phonetic patterns and sounds to a greater degree than an adult brain that already has significant amounts of information stored.

Another theory provided by language specialist Patricia Kuhl, titled the native language magnet(NLM) theory, asserts that early language learning deals with neural commitment. Neural commitment occurs in early childhood to identify and adhere to one's native language to master it as quickly as possible. Infants in the process of developing their neural architecture can commit to learning one or multiple different phonetic patterns belonging to different languages, leading to native fluency in several languages at a young age (Kuhl, 2010). This language architecture doesn't remain adaptable and becomes fully established as one ages in order to speak native languages fluently. Consequently, adults have difficulties learning a new language since it doesn't conform to the already-established native language architecture that was developed during early childhood.

The NLM theory also supports why it is easier to learn languages similar to one's native language as an adult. Choosing to learn a typologically similar language to one's native language exhibits rapid learning due to linguistic commonalities and cognates (Antoniou & Wright, 2017). For instance, learning a romance language of French, Spanish or Italian, would be easier to learn if native fluency in another romance language was already acquired.

While adults are no longer within the critical period to learn languages, they are still able to do so because they maintain an extent of neuroplasticity. Neuroplasticity is the brain's propensity to alter, create, or build upon neural pathways to develop a more efficient neural network. Neuroplasticity directly builds upon cognitive reserve, which scientists from the University of Chieti-Pescara in Italy define as cognitive activities performed throughout a lifetime that boost the brain's resilience and resistance to damage due to neurodegenerative diseases such as dementia (Bubbico et al, 2019). Language learning programs targeted at older populations are an ideal approach for building cognitive reserve, because language engages an extensive brain network and cortical regions that are negatively impacted by aging.

Section III: Neuroanatomical Correlates to Language and Bilingualism

What are the primary language-related cortical areas? In the vast majority of individuals, the language dominant cerebral hemisphere is on the left side, meaning that the language machinery used to understand and produce speech is located on the left aspect of their brain (Vanderah et al, 2026). Of this left hemisphere, there are three primary neuroanatomical areas involved in language learning, production, and comprehension. The dorsolateral prefrontal cortex(DLPFC), whose function is supportive of executive functioning and declarative memory

in adults; Broca and Wernicke's Areas, responsible for language production and comprehension, respectively; and the gyri of the temporal lobe that are involved in auditory processing and meaning attribution. In addition, individuals that learn foreign languages experience increased activation of these areas, leading to white and gray matter changes associated with enhanced neural networking and efficiency.

The DLPFC of the frontal lobe fully develops in adulthood and is responsible for higher executive functioning and declarative memory. Declarative memory develops later in childhood (along with the DLPFC) and is helpful in voluntary, intentional learning of information and facts, as well as recalling events as adults. Conversely, infants utilize procedural learning. Procedural learning is implicit and subconscious, repetition-based, and is ideal for learning languages and motor learning. In a study performed by Eleonore Smalle and others, participants' left, language dominant DLPFC was disrupted by repetitive transcranial magnetic stimulation (TMS) to disrupt the activity of the DLPFC and observe its impact on lexical learning (Smalle et al, 2017). From there, the test group underwent Hebb repetitive learning; a control group without TMS disruptive stimulation was also present and was exposed to the same word sequences as the test group. Smalle and others found that the DLPFC inhibition group had diminished executive functionality but with a higher Hebb learning score (Smalle et al, 2017). This study proves that the developed DLPFC in adults competes with procedural, repetition-based learning that is most useful for language learning.

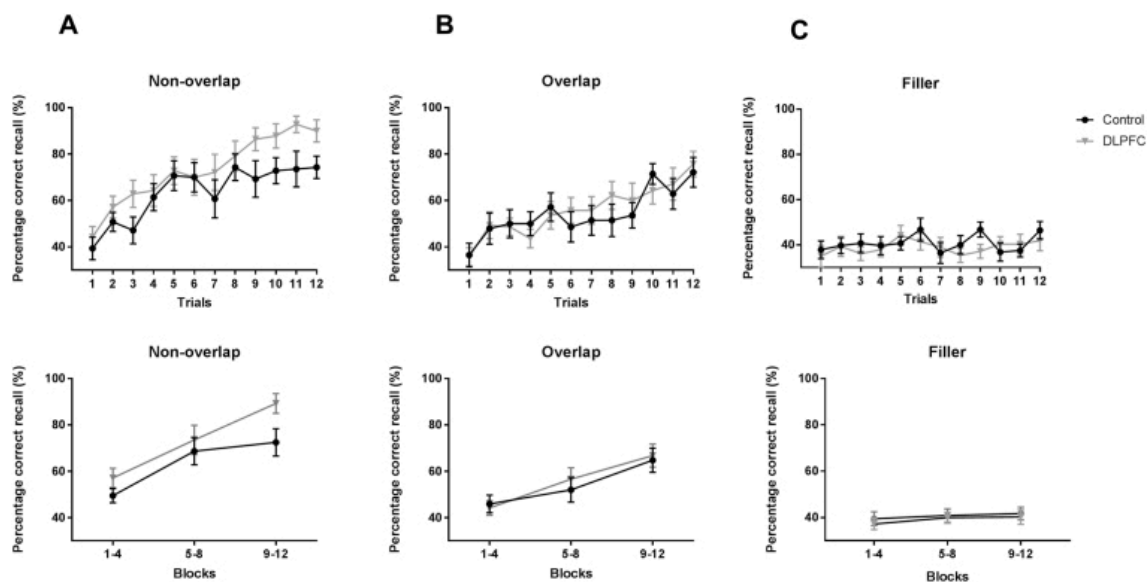


Figure 3. Line graph results of the study performed by Smalle et al. Non-overlap sequences (section A) were learned through procedural learning, and demonstrate significantly better results in the DLPFC interventional group compared to the control group. Overlap and filler sequences were the then-repeated sequences from section A whose learning accuracy increased in all groups with increased repetition.

Broca's and Wernicke's areas are two specialized language centers on the language-dominant hemisphere (largely the left side) involved in language production and comprehension, respectively. The two main components of Broca's area are pars opercularis (Brodmann area 44) and pars triangularis (Brodmann area 45), and they are located on the inferior aspect of the frontal lobe and functional in producing and sustaining motor speech. Alternatively, Wernicke's area, Brodmann area 22, is located more posteriorly at the edge of the lateral sulcus of the cerebrum. Wernicke's area is composed of the supramarginal and angular gyri, and is involved in language processing.

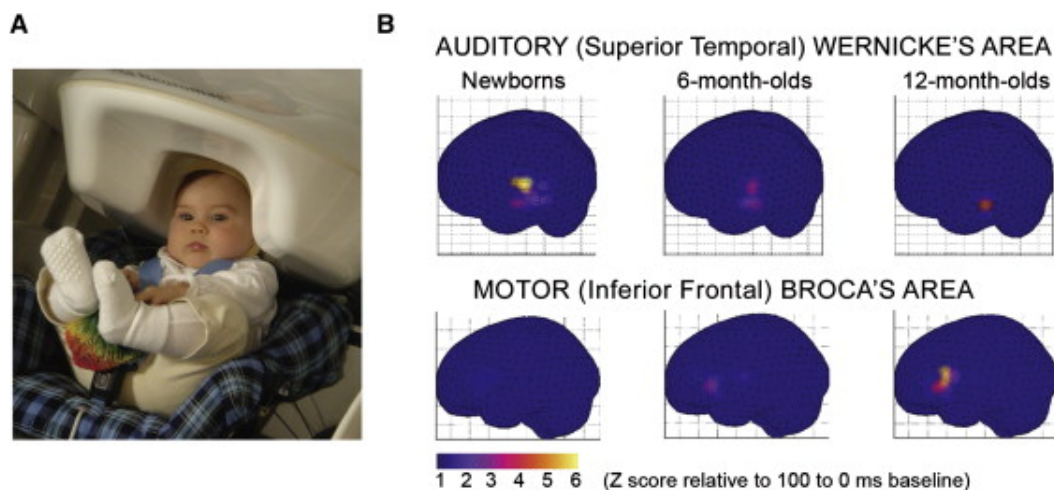


Figure 4. Magnetoencephalography (MEG) of the infant brain when exposed to speech from the left aspect of the cerebrum (language dominant). Newborn cortical activity was centralized in the temporal region as it recognized auditory stimuli with little processing of auditory input occurring. However, as the child aged Broca and Wernicke's areas began to fire, demonstrating speech processing and comprehension as early as six months old.

While Broca's and Wernicke's areas are involved with speech comprehension and understanding, the surrounding temporal gyri are also active in language processes. These temporal gyri are involved in processing language but also attributing meaning to words and formulating more complex aspects of language such as complex sentence structure. The superior temporal gyrus (STG), which is continuous to Wernicke's area, is the cortical region that recognizes auditory stimuli as speech, and is associated with phrase production and intelligibility (Kuhl, 2010). The transverse temporal gyrus (TTG), or Heschl's gyrus, is the primary auditory cortex that performs high-level processing and computation of incoming speech information. The middle and inferior temporal gyri (MTG and ITG) are also involved in word-level processing, but connect with more complex neural pathways of language to assign lexical meaning to words. The MTG is also involved in creating visual representations of vocabulary in cortex, and is the location of long-term storage of conceptual information (Fornells et al, 2009). The temporal gyri

comprise the primary auditory cortical region that are responsible for processing language and auditory stimuli, but also to infer meaning from extralinguistic cues, such as facial expressions and body language. Due to the multifaceted and integrative nature of meaning attribution to lexical information in the brain, the neurological mechanistic pathways behind this process aren't well understood and require further research.

Section IV: Dementia in the Context of Bilingualism

Bilinguals exhibit a 'bilingual advantage' in cortical areas involved with language such as the DLPFC and frontal lobe, and temporal gyri; these structures experience degradation during the aging process in monolingual individuals, resulting in reduced mental fitness and symptoms associated with dementia, such as memory loss. The 'bilingual advantage' is an increase in cognitive functioning directly attributable to bilingualism, specifically in the DLPFC and frontal lobe, and temporal gyri. This presents as improved executive functioning, lexical memory, creative thinking, even metalinguistic awareness (Antoniou & Wright, 2017). Language learning and bilingualism provides increased integrity of these cortical areas associated with the 'bilingual advantage', and can be protective against the onset of symptoms in dementia. For instance, the gray matter within the DLPFC degrades with age, especially with dementia and other neurodegenerative conditions. Therefore, to perform memory tasks as an older individual requires greater cortical recruitment in the DLPFC than a younger person (Taylor et al, 2022). Therefore, through lifelong language learning or bilingualism, individuals' DLPFC is more integrous and more resistant to damage from neurodegenerative diseases, making language learning protective in preserving cortical thickness in the DLPFC during the aging process. Regarding white matter, bilinguals have higher white matter integrity than monolinguals in the

corpus callosum, as well as the superior and inferior longitudinal fasciculi (Antoniou & Wright, 2017). With more developed white matter regions, neuronal tissue has greater interconnectivity, leading to more efficient neural pathways for communicating information between different areas of cortex. Additionally, further development of white matter tracts and gray matter areas leads to increased cognitive reserve in bilinguals and the building of alternative tracts to carry information throughout the cerebral cortex.

Unfortunately, this ‘bilingual advantage’ is dependent on a number of factors, most notably age of acquisition and proficiency in the second language. White and gray matter changes are positively associated with proficiency and negatively correlated to age of acquisition (Taylor et al, 2022). Benefits of bilingualism are present in highly proficient individuals that acquired their second language at a young age; nevertheless, learning a foreign language at an older age still confers this bilingual advantage, though potentially to a lesser degree. Encouragingly, proficiency has a greater impact on neural efficiency and the ‘bilingual advantage’ than age of acquisition, meaning that even if the language was learned at a more advanced age, if the individual is still highly proficient, the ‘bilingual advantage’ will still be present.

The neural correlates of the ‘bilingual advantage’, reflected in bilinguals’ maintained density of white and gray matter even in old age has clinical applications. Bilingual patients with Alzheimer’s disease exhibited brain atrophy to a greater degree than monolingual patients at the same symptomatic phase of the disease, specifically in the temporal regions (Antoniou & Wright, 2017). While these findings seem to be disadvantageous for the bilingual individual, it is actually proof of the efficacy of the ‘bilingual advantage’. This is for the reason that this patient developed more efficient and alternative pathways to carry information with their bilingualism,

building their cognitive reserve to the point that it required a greater degree of cortical damage from the disease to manifest symptoms equal in severity to that of a monolingual patient.

Importantly, another longitudinal study examined the impact of lifelong bilingualism on maintaining healthy cognitive functioning, and found that bilingualism is effective in preventing the onset of symptoms in dementia by multiple years. Out of 228 test patients, 51% were bilingual and 184 individuals were diagnosed with dementia. Researchers found that bilingual individuals had an average delay of the onset of Alzheimer's disease by 4.3 years compared to the monolingual subjects. Regarding other forms of dementia, there was also an average delay in the onset of the disease by 3.5 years (Bialystok et al, 2007). This study has been repeated in 2014 and 2015, with delays in the development of Alzheimer's disease by 5 and 4.6 years compared to monolinguals, respectively (Antoniou & Wright, 2017). The five year delay found in the 2014 study was performed on a sample of multilingual patients, who spoke between two to four languages. This indicates that speaking multiple languages has a compounding effect in slowing the onset of the symptoms of dementia; the more languages spoken, the later symptoms will present in patients. It is also important to refer to the aforementioned pharmacotherapies of cholinesterase inhibitors and memantine, whose interventions have no comparable effect to the substantial delay in symptoms found with bilingual populations.

Despite the fact that learning a foreign language doesn't eliminate the risk of developing dementia or its incidence, nor does it cure the disease, it delays the onset of symptoms by a significant margin of four years. Bialystok and researchers of the initial study indicate that the potential impact of this delay in the disease is considerable. They project that "a 2-year delay in onset of Alzheimer's disease (AD) would reduce the prevalence in the United States by 1.94 million after 50 years, and delays as short as 6 months could have substantial public health

implications” (Bialystok, 2007). In slowing the onset of the disease, there will be tremendous advancements from personal, socioeconomic, and ethical lenses.

However, these studies were performed on lifelong bilinguals; is there hope for developing cognitive reserve through language learning in monolingual older populations? One study performed intensive Scottish Gaelic language learning lessons of fourteen hours for one week on an experimental population aged 18-78. Classes were in-person, with interactive worksheets and homework, conversational groups, and entertainment in the target language. After the week of lessons, improved attentional switching was observed across all age groups, which, reassuringly, indicates that even one week of foreign language training can provide cognitive benefit for older learners (Antoniou & Wright, 2017). While this particular language learning study was quite intense, even two hours a week of interactive language learning lessons would be beneficial for older learners in building cognitive reserve. However, there are no programs in the Fort Collins region to provide language learning lessons specialized for the older members of the community.

Section V: Independent Research - Language Learning Study

The researcher developed a language learning program for the Fort Collins and Windsor local areas. Lessons were hosted at the Fort Collins Senior Center and Windsor Recreational center, respectively. Lessons were offered once a week for two hours, in a total of a four week session (8 hours of language learning total). Guided notes with an outline of content and recommendations, extra practice questions, and vocabulary were provided each week, and lessons were taught in a conversational, social style. Upon completion of the class, students were

asked to complete a cognition survey of how their mentation changed over the course of the four weeks. The study included fifteen English-speaking, monolingual participants above 65 years of age in the two regions, and the target, instructed language was French.

The collage consists of several educational materials for a French course:

- French Guided Notes Week 4:** A table with two columns: 'Questions' and 'Notes: negations, restaurant French'. The questions listed are: 'Quelle est la date aujourd'hui?', 'Aujourd'hui =', 'Ne + pas =', 'D'accord =', 'Installez-vous =', 'Que voudriez-vous?', 'Quoi d'autre?', 'Et pour vous madame/monsieur?', 'Je voudrais... =', 'Combien coûte...?', 'Je suis allergique à... =', 'À la volée =', 'Oui =', 'Non =', 'Quoi? =', 'Je ne comprends pas =', 'Répétez, s'il vous plaît =', and 'Plus lentement ='. The notes column is currently empty.
- Negations: Ne + Pas:** A slide explaining the 'ne...pas' sandwich rule. It includes the text: 'How do you say "don't"? Introducing the "ne...pas" sandwich! "ne" and "pas" negate the verb sandwiched between them to mean "don't" or "not".' Examples: 'ex. Je suis heureuse = I am happy' and '* Je ne suis pas heureuse = I am not happy'. It also features a cartoon of two people, one saying 'I am dumber' and the other 'I'm not as dumber'.
- Comment dit-on:** A slide explaining the phrase 'comment dit-on'. It states: 'This phrase is super important in class! when you aren't sure what a word is in French, simply ask "comment dit-on _____?".' It provides the pronunciation 'pron. koh-moh(n) deet-on' and explains it as 'the word you would like to know'. Another note says: 'This phrase literally translates to: "how does one say _____?".' A final instruction reads: 'Please use this as a resource throughout this class!'.
- French Course Week 1:** An introductory slide with a floral background and a butterfly. It includes the text 'French Course' and 'Week 1'.
- je cherche..:** A slide with a central graphic that says 'je cherche..' and 'The looking for'. It lists four categories: 'LIVRES' (the book), 'FILMS' (the movie), 'LIEUX' (the place), and 'PERSONNES' (the person). Below the graphic, it asks: 'person, zhe shayr- sh. may also use on to trouve...? (where's... located?)'.
- AVOIR VIDEO:** A slide featuring a video player with a woman speaking. A small white rabbit icon is in the bottom left corner.
- Extra Practice Crossword Week 1 Answers:** A slide titled 'French Week 1 : Crossword' showing a crossword puzzle grid with the text 'This key will also be included in the weekly email to give you another way to access this information!'.
- French Class Survey:** A survey form with the title 'French Class Survey' and the text: 'Hello! Thank you for taking this French class with me at the Weber Historical Center. Please answer the following questions as a reflection of your experience. It helps me a lot!'. It includes questions: 'Why did you choose to take this class? Write some goals you had going into this class (3-4 goals).', 'Your answer:', 'Was this class helpful in achieving your goals?', and radio buttons for 'Yes' and 'No'.
- LET'S PRACTICE! CONJUGUEMOS PRACTICE:** A slide with a floral border and the text 'LET'S PRACTICE!' and 'CONJUGUEMOS PRACTICE'.
- Quelle est la date aujourd'hui?:** A slide with a floral border and the text: 'Marty McFly and Doc Brown just landed their bodacious DeLorean in Windsor! These totally tubular dudes need some help, but first, they need to know the date today! They want to know the day of the week and d/m/m/yy know how to say it in French, and for an extra challenge, write it out non-numerically!'. It includes a photo of Marty McFly and Doc Brown from the movie 'Back to the Future'.
- Week 2 Summary of Content / Recommendations:** A slide with the text: '1. The French alphabet is identical to that of the English alphabet, only differing with pronunciation of some letters. a. "U" is (in my opinion) the hardest letter in the French alphabet, since its sound does not exist in English. Practice the pronunciation of this letter and listen to recordings or videos on how to pronounce it if you're stuck. i. Helpful video: <https://www.youtube.com/watch?v=82e-cf8b6> b. "R" is also difficult to pronounce, here's a helpful video: i. https://www.youtube.com/watch?v=McM0L_P3dBE c. Practice at home by spelling out words (English or French) using the French pronunciation. d. When you encounter a new French word, try to sound it out using the alphabet!'

Figures 5 & 6. Images of French course content. From left to right, top to bottom: French Cornell-style guided notes vocabulary portion for lesson four; grammar lesson slideshow page; introductory, opening slide, and vocabulary lesson slides. The second collage of content includes: conjugation music video for french verb 'avoir',

take-home crossword homework answer key, online version of the final cognition survey, practice activity slide, review activity slide, and course content review on a guided notes document.

This language study was the first of its kind, and is a late language learning, interventional study on cognition, with results provided entirely from the subject's subjective opinion and reflection after taking the course. 50% of participants self-reported improved memory recall, and 62.5% of participants experienced an increase in self-confidence after taking the French course. Other areas participants' reported improvements included creativity, thinking speed, and focus and productivity.

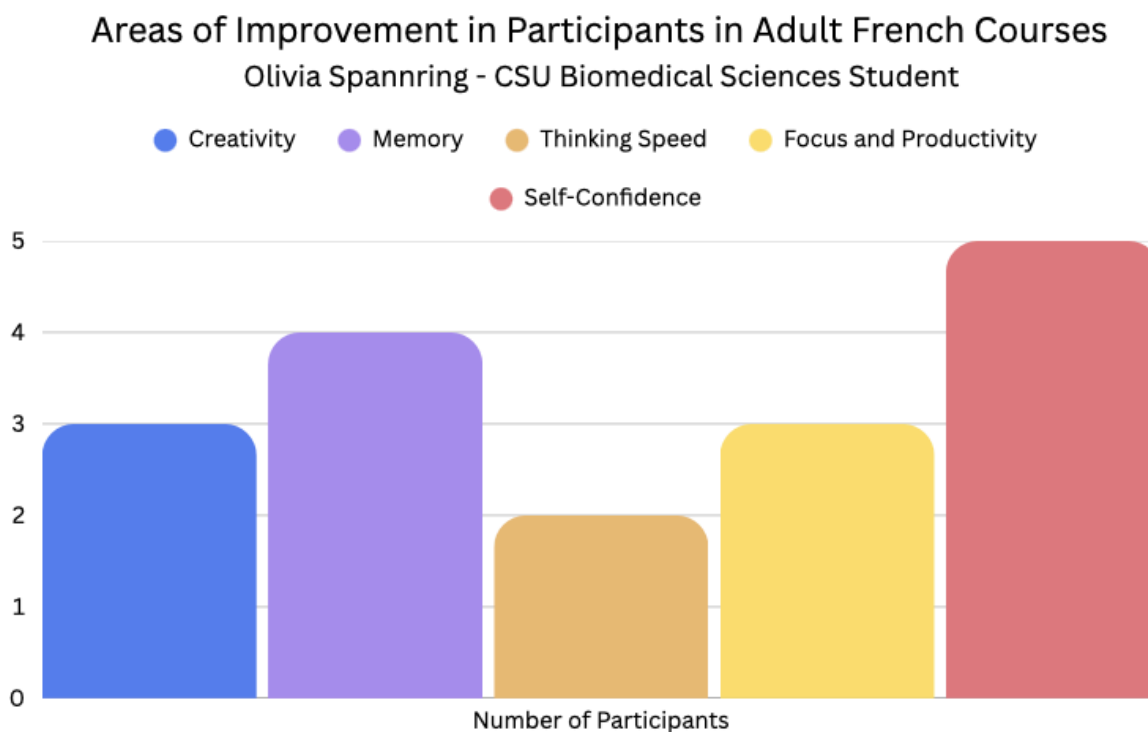


Figure 7. Bar graph depicting subjective areas of improvement experienced by participants of the study. Cognitive improvement was reported in areas of creativity, memory, thinking speed, focus and creativity, and self-confidence. Importantly, memory and self-confidence were the areas with the most observed improvement. Note

that only 8 out of 15 participants took the cognition survey, creating the previously mentioned statistics of 50% (4 out of 8) and 62.5% (5 out of 8) of participants reporting memory and self-confidence improvement, respectively.

This study has promising results indicating memory improvement in half of participants, however it has some limitations. Firstly, results were purely subjective and based on the opinion of participants and their mentation, due to lack of access to fMRI or other neuroanalytical technologies. Additionally, some students had prior exposure to the French language, possibly impacting results of the cognition study.

Concluding Remarks and Future Directions

Language learning may be the pivotal piece in the modern day fight to defeat the beastly disease that is dementia. While current pharmacotherapies of cholinesterase inhibitors and memantine are only effective for a couple years at most, language learning has proven to impede the onset of dementia. Through a meta-analysis of recent academia surrounding the clinical connection between dementia and bilingualism, language learning and fluency delay the onset of symptoms in dementia by a large margin of 4.3 years. In the researcher's independent study, 50% of subjects experienced improved memory skills and 62.5% of participants felt more self-confident after four weeks of French language learning sessions of two hours. Many people anxiously await the seemingly unpreventable and inevitable diagnosis of dementia, ignorant to the benefits of language learning for better cognitive aging, specifically in delaying symptoms of this formerly unstoppable disease. It is important that language learning becomes more readily available not just in the educational system for building highly proficient bilinguals in younger generations, but also to the adult and senior community through programs offered at recreational or senior centers. In hosting these programs and instructing languages to older community

members, it provides an optimal means of building cognitive reserve as protection against dementia and its derivatives in older, more vulnerable populations.

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