

Language and Communication Deficits in Alzheimer's Disease: A Review of the Literature on
the Progression, Prevention, and Mediation of Language Barriers Experienced by Individuals
with Alzheimer's Disease

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ABSTRACT

Alzheimer's disease (AD) poses a significant societal problem with regard to the quality of life in the aging population worldwide (Alzheimer's Association, 2021). One ability that is affected early on in the disease is language processing, which can result in feelings of isolation due to its significant impact on one's relationships, overall communicative ability, and quality of life (Szatloczki et al., 2015). Thus, it is of great importance to identify evidence-based interventions and preventative measures, as well as communication strategies, helpful to patients and their caregivers. In this review of literature, we examined language difficulties pertaining to semantic verbal fluency, word finding, and discourse markers, while also identifying the neural mechanisms likely responsible (e.g., Arnoff et al., 2006; Chapman et al., 1998; Eriksson et al., 2015; Pakhomov et al., 2018). In addition, we present research on the theory of cognitive reserve as a preventative measure, with a special emphasis on the influence of bilingualism (Bialystok et al., 2007; Gold, 2016; Perani et al., 2017) and music training (Chaddock-Heyman et al., 2021; Lyu et al., 2018). The research supports the efficacy of various interactive music therapies to allow extended communication between caregivers and AD patients, especially since later life music therapy can help preserve or enhance memory and language ability in patients with moderate or severe AD (Clare et al., 2020; Lyu et al., 2018; Wong et al., 2019). Future research could further investigate the long-term effects and applications of language and music interventions. Importantly, incorporating increasingly diverse samples is necessary to increase generalizability of the research described (Brewster et al., 2018; Ferretti et al., 2018).

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According to the United Nations Department of Economic and Social Affairs (2017) , the world's population of older adults has not only been on the rise but is projected to continue to increase throughout the next couple of decades. In 2017, they reported that the population of individuals over the age of 60 was recorded as 962 million, nearly doubling the amount recorded in 1980. It is projected that by the year 2050, this population will double again, rising to nearly 2.1 billion. As the older adult population increases, it is imperative that academic research unique to this population increases as well, particularly research that contributes to the well-being and quality of life of older adults. Alzheimer's Disease (AD), which is characterized by the progression of memory decline and other cognitive impairment, poses a unique risk to the older adult population, warranting a need for in-depth attention to the details of risk, prevention, care and cause of this disease (Alzheimer's Association, 2021). Additionally, it should be understood that dementia is an umbrella term that describes the symptoms of neurodegenerative diseases that are distinct from normal aging, the most common of which is AD. Currently, AD and other dementias have no cure.

The Alzheimer's Association (2021) provides important insight into the severity of AD in their yearly Facts and Figures report. In their most recent 2021 report, they indicate that, worldwide one in three seniors die as a result of AD or another dementia, with more people dying from dementia than breast cancer and prostate cancer combined. As a result of the COVID-19 pandemic, they report that the deaths of Americans by AD increased by 16%. The Alzheimer's Association (2021) points toward a strong potential concern regarding the

implications of race and ethnicity of AD in the United States. While Black Americans and Hispanic Americans are more likely to develop AD, they are less likely to be diagnosed with it. Additionally, only 53% of Black Americans believe that a future cure for AD would be shared equally regardless of race, color, or ethnicity. For the United States, treatment and care for seniors with AD and other dementias cost the nation over \$355 billion in 2021, and by 2050, it could cost the nation as much as \$1.1 trillion. Because interventions for these diseases are not likely to come from pharmaceuticals alone, the Alzheimer's Association stresses that successful intervention involves helping people maintain mental functioning, managing behavioral symptoms, and delaying the progression of symptoms of the disease. Therefore, it is of the utmost importance to identify the early signs of AD and engage in early interventions because adults who have received early risk identification are much more likely to be successful in mitigating the symptoms of these neurodegenerative diseases. Some of these precursor signs to detect AD include memory loss that affects daily activities, challenges in planning or completing familiar tasks, withdrawal from work or social activities, and, for the interest of this paper, problems with speaking or writing—across *all* languages that one speaks.

Fortunately, recent research has discovered many known protective factors that can reduce the likelihood of getting dementia or other neurodegenerative diseases, as well as improve the management of behavioral symptoms from dementia, such as bilingualism, music therapy, and cognitive reserve in general (Stern, 2012; Tsoi et al., 2018). While we believe the focus of research on AD and other dementias should always be towards finding a cure, much of the research should also continue to identify the activities and lifestyles the average person can participate in to possibly protect themselves from or delay the onset of AD and other neurodegenerative diseases.

The focus of this current project is consistent with this latter goal by emphasizing the neural underpinnings and language deficits that are concurrent with the onset of AD, as well as the qualities of various lifestyle factors that may contribute to cognitive reserve as a protective factor in older age. To do this, we review some of the research about the nature of language difficulties faced by older adults who are experiencing early symptoms of AD before and soon after a diagnosis. While in this transitional stage, individuals may also start to exhibit brain abnormalities consistent with pathological AD, such as the presence of beta-amyloid plaques and neurofibrillary tangles (Reilly, 2011). Second, some research regarding the implications of preventative factors on the expression and progression of AD and other dementias is discussed, particularly in relation to cognitive reserve with a particular emphasis on music training and bilingualism (Bialystok et al., 2007; Chaddock-Heyman et al., 2021; Gold, 2016; Harvard Health Publishing, 2017; Peck et al., 2016; Perani et al., 2017; Stern, 2012; Tsoi et al., 2018). We conclude by discussing how our research may be utilized in facilitating communication between caregivers and patients with AD, as well as the general limitations and possible future directions for research.

Neuropathology of Alzheimer's Disease

Reilly (2011) describes several key components in the neuropathology of Alzheimer's Disease (AD). Patients with AD suffer from significant brain atrophy "in frontal, parietal and temporal gyri, particularly entorhinal cortex and hippocampus, with commensurate ventricular enlargement" causing a decrease in brain weight and volume (Reilly, 2011, p. 18). Such damage commonly results in executive, behavioral, visuospatial and language impairments. Other major components of AD pathology are the presence of amyloid plaques and neurofibrillary tangles. Patients with AD have amyloid deposits in areas such as the limbic cortex, basal forebrain,

substantia nigra, raphe nuclei, locus coeruleus and in cerebral arterioles. These extracellular neuritic plaques can effectively disrupt communication between nerve cells.

The neurofibrillary tangles observed in pathological AD patients have a distinct “paired helical structure and are quantitatively highly correlated with dementia severity” (Reilly, 2011, p.18). The neurofibrillary pathology of AD begins in the medial perirhinal cortex (mPRC) before spreading to the entorhinal cortex and hippocampus in the anterior medial temporal lobe (mMTL; Hirni et al., 2013). Such tangles consist of the hyperphosphorylated proteins tau and ubiquitin, which actively disrupt memory systems in the brain leading to memory loss and potentially neuronal death. Another major hallmark of pathological AD is widespread cortical neuronal loss. This is seen predominantly in the hippocampus, temporal neocortex and in the basal forebrain nuclei, as well as in several subcortical structures as well. Lastly, synaptic destruction is another indicator of pathological AD. In fact, synaptic destruction may be the major proximate cause of early cognitive decline (Reilly, 2011).

These pathological components of AD are the underlying mechanisms responsible for the manifestations of the disease observed in patients' daily lives. Progressive memory dysfunction may be the most apparent, but other notable effects of AD pathology include amnesia, aphasia, agnosia, apraxia, and prominent visuospatial impairment. The cognitive decline observed in individuals with AD often involves issues with working memory functioning. Dynamic interactions between different brain regions cause working memory to play a huge role in temporary information processing and guiding behaviors in daily life. Specifically, the prefrontal cortex and the parietal cortex are critical regions in working memory functioning.

Eriksson and colleagues (2015) report that spatial working memory tasks activate both the prefrontal cortex and parietal cortex bilaterally. Further, they report that several studies have

shown the left ventral prefrontal cortex is more involved in verbal working memory as compared to the right dorsal prefrontal cortex, which is more involved in spatial working memory (Eriksson et al., 2015). Additionally, the superior parietal cortex is associated with executive aspects of working memory, attentional control, and working memory capacity. Eriksson and colleagues also note that “brain regions involved in maintaining information in working memory will vary with the type of information to be maintained” (Eriksson et al., 2015). For example, lesions to the temporal cortex affect visual working memory, and lesions to the parietal cortex affect spatial working memory. Importantly, lesions to the lateral temporal lobes and temporoparietal cortex result in reduced verbal memory performance.

The dorsolateral prefrontal cortex (DLPFC) is a region of the frontal lobes that plays a crucial role in tasks such as working memory, executive function, attention, and reasoning (Liang et al., 2011). Its local dysfunction and roles in various neural circuits relevant to the physiological mechanism of cognitive impairment are important pathological features when considering AD. The DLPFC is connected to a variety of brain areas, including the thalamus, basal ganglia, the orbitofrontal cortex and primary and secondary association areas of the neocortex, including posterior temporal, parietal, and occipital areas (Liang et al., 2011).

Liang et al. (2011) examined the functional connectivity of the DLPFC in patients with mild cognitive impairment (MCI). MCI refers to the stage between normal aging and early AD, when individuals start to exhibit symptoms of cognitive decline. In fact, “MCI has a high probability of evolving toward AD at a rate of 10-15% per year” (Petersen et al., 1999). Therefore, studying neurological abnormalities in patients with MCI is extremely useful in furthering our knowledge of the early onset of pathological AD. In the study done by Liang et al. (2011), it was hypothesized that the effects of functional disconnection of the fronto-parietal

and cingulo-opercular circuits and compensation within lobes coexisted in AD could be detected in its early stage, MCI, by using DLPFC-functional connectivity analysis. Liang et al. collected structural and functional MRI data from 28 right-handed participants (14 MCI patients and 14 demographically matched healthy controls). Functional connectivity patterns during rest were analyzed as well as the impact of grey matter atrophy on the functional results. A voxel-based morphometry analysis was performed to show the differences in grey matter volume between the MCI patients and healthy controls and revealed significant grey matter atrophy in the frontal, temporal, parietal, occipital and subcortical regions. Functional connectivity analyses indicated that the bilateral DLPFC showed reduced functional connectivity with the inferior parietal lobule, superior/medial frontal gyrus and subcortical regions in the MCI patients when compared with healthy controls; yet enhanced functional connectivity was found between the left DLPFC and the right prefrontal cortex in MCI patients. These findings provide for the coexistence of functional disconnection and a compensatory mechanism in MCI patients. Moreover, the DLPFC connectivity with the inferior parietal lobule and thalamus showed significant positive correlations with the cognitive performance of patients as measured by the Mini-Mental state examination, clock drawing test, and California verbal learning test scores. Liang et al. suggest disconnections in the DLPFC are an underlying cause of cognitive impairments in MCI patients, which supports a previous study (Dosenbach et al., 2007) identifying the DLPFC as having a key role in neural circuits in MCI and enables further research into the biological mechanisms of AD. The correlation with performance on the California verbal learning test, which measures intermediate recall, short delayed recall, and long delayed recall, also demonstrates the role of DLPFC connectivity in language processing.

Language Capacities in Alzheimer's Disease

Identifying language difficulties may be useful in the early detection of cognitive impairment. Language has been demonstrated to be a valuable marker for distinguishing between Alzheimer's Disease (AD) and normal cognitive aging during screening and during early or pre-symptomatic stages of disease progression (Szatloczki et al., 2015). Patients with pathological AD often demonstrate significant impairment in word-finding ability (Chapman et al., 1998 ; Nebes, 1989; Venneri et al., 2005), trouble recalling names, difficulty constructing an informative and coherent narrative (Chapman et al., 1998; Venneri et al., 2005), and frequent pauses (Pistono et al., 2019). Semantic memory deficits experienced by those with pathological AD affect language in different ways. These individuals may have trouble describing pictures, recalling names of people or objects, or generating words to fit a certain category (Nebes, 1989). The language characteristics that tend to be good indicators of a future diagnosis include increased pauses, recurrent perseverations on semantic fluency, naming and word-finding problems, and reduced discourse markers (Jourbert et al., 2010; Pakhomov et al., 2018; Pistono et al., 2018; Pistono et al., 2019).

Pakhomov et al. (2018), testing the hypothesis that semantic verbal fluency is a good indicator of a future diagnosis of cognitive impairment, sought to identify the specific aspects of semantic verbal fluency at play as semantic verbal fluency tasks, and verbal fluency tasks in general, rely on several brain regions typically affected by early Alzheimer's Disease (Silverberg et al., 2011), including atrophy of the entorhinal cortex and hippocampus. Verbal fluency tasks involve producing words belonging to a specific semantic category. Typical errors in verbal fluency measures include out-of-category words and perseverations (repeated correct words). Pakhomov et al. (2018) focused on recurrent perseverations including those that might be

separated by other words. The initial pool of participants was from the Mayo Clinic Study of Aging. Pakhomov and colleagues (2018) narrowed down the pool to a sample of 1,376 participants, all of whom were cognitively normal at baseline; 51% were male and 49% were female. The longitudinal nature of the study allowed for follow-ups every 15 months for up to 6 visits. Each neurocognitive assessment included semantic verbal fluency tasks in 3 categories: animals, fruits, and vegetables (Pakhomov et al., 2018). Results showed that recurrent perseverations on the "animals" test in cognitively normal adults was correlated with a significantly higher propensity for later diagnosis of AD. However, no association was found for perseverations in the "fruit" and "vegetable" categories (Pakhomov et al., 2018). This suggests that reduced fluency in larger categories, like animals, may be a better predictor for early detection of cognitive decline.

Other language-related deficits common in the early stages of AD include word-finding ability and naming ability, which are often associated with word retrieval errors (Chapman et al., 1998; Jourbert et al., 2010; Nebes, 1989). Word-finding difficulty is observed in spontaneous speech when individuals are unable to come up with a desired word for a given definition and may be one of the first noticeable symptoms of AD (Kempler & Goral, 2008; Nebes, 1989; Pistono et al., 2018). These individuals may have trouble describing pictures, recalling names of people or objects, or generating words to fit a certain category (Nebes, 1989; Pakhomov et al., 2018). Kempler and Goral (2008) explain that patients with pathological AD often substitute pro-forms (such as "he" or "it") or use conceptually related words (such as "dog" for "horse") during spontaneous speech. Picture naming tasks have long been used to assess one's word-finding ability. Arnoff et al. (2006) found that AD patients, when compared with "normal old" individuals, had noticeably more errors in picture-naming. In their study, the sample

comprised 64 individuals: 15 individuals (mean age: 83.5) diagnosed with probable AD using the Alzheimer's criteria put forth by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (now known as the Alzheimer's Association) as well as neuropsychological assessment with neurological imaging techniques to rule out other types of dementia; 24 "normal old" individuals (mean age: 78.1); and 25 "young normal" individuals, who were college undergraduate students (mean age: 20.2), all of whom participated in a picture-naming task and a board sorting task. In the picture-naming task, participants named 144 colored pictures that were presented one at a time. Participants were given as much time as necessary to respond to each picture, and responses were transcribed then coded as correct, incorrect, or machine error. Results showed a significant difference in picture naming scores between the "young normal" and AD groups and between the "old normal" and AD groups; the "young normal" and "old normal" groups did not differ.

In another naming study, participants were evaluated on their naming ability of famous people and objects (Jourbert et al., 2010). For each condition a correct response was counted only if a specific name was given (e.g., polar bear vs. bear). The results showed that naming famous faces was more impaired relative to objects (Jourbert et al., 2010). This finding adds to the results of Arnoff and colleagues (2006) and is consistent with Kempler and Goral (2008) who found that AD involves cortical atrophy in the anterior temporal lobe and the inferior prefrontal cortex, key brain regions associated with semantic memory.

Another area of early language decline involves discourse production (Chapman et al., 1998; Pistono et al., 2018). Chapman et al. (1998) used three different tasks to compare AD patients and normal aging controls in their production of extended discourse. The stimuli

included fables, proverbs, and a picture. For the fables, participants were assessed on their ability to retell, summarize the main idea, and give a lesson that may be learned from it. For the proverbs, participants were asked to provide their own spontaneous interpretation of each as well as complete one multiple choice question concerning the meaning of the proverb. For the picture, participants were asked to generate a story based on the picture, give the main idea of their story, and generate a human value depicted in the picture. The results showed that a significant number of AD patients had trouble with generating a dynamic story about the picture, as they instead responded with a picture description. For instance, one AD subject's story generation based on the picture included many unclear references and pronouns, as well as a lack of creativity or informativeness. This conclusion is also consistent with the results from Kempler and Goral (2008) and Venneri et al. (2005) who also found a lack of coherence, clarity, and informativeness in AD subjects' narratives. Nebes (1989) also notes that "the speech of AD patients is often vague, repetitive, and fairly empty of content words" (e.g., consistently using phrases such as "something like that", "that stuff", or "those things")(p. 378).

More recently, Pistono et al. (2018) examined the specific macrolinguistic features of discourse production common to early AD. These features concern the processes relating to establishing cohesion and coherence (Pistono et al., 2018). For coherence, there are two subcategories: global coherence, which refers to the ability to organize conversation around a central theme, and local coherence, which refers to the ability to make conceptual links between connecting utterances. In order to explore which macrolinguistic features tend to decline in the early stages of Alzheimer's Disease, Pistono et al. (2018) studied a group of individuals over the age of 60 who had a memory complaint but no history of a diagnosed neurological or psychiatric disease, as well as a control group comprised of 34 participants matched for age, gender, and

education level. This is important to note because it allowed the researchers to draw conclusions regarding detection and diagnosis of AD in a proactive manner. The task elicited a picture-based narrative that was rated on three levels of macrolinguistic performance: informativeness, local coherence, and global coherence (Pistono et al., 2018). Informativeness was defined as the quantity and quality of the information. The early AD group differed most in informativeness and global coherence as compared to controls. More specifically, for informativeness they provided fewer mandatory elements or ideas crucial to the narrative. They also produced more modalizing discourse (markers indicating confusion or uncertainty, such as “it seems” and “I think”) in the area of global coherence (Pistono et al., 2018). Conversely, it seems local coherence was well-preserved in early AD (Pistono et al., 2018).

While recurrent perseverations in semantic verbal fluency, naming, and macrolinguistic discourse features tend to be impaired in the early stages of Alzheimer's, there is a linguistic limitation that needs to be addressed in order to better generalize these findings. Imamura et al. (1998) indicates that age of symptom onset (early onset AD vs. late onset AD) affects the pattern of language disturbance with different language functions showing greater and more severe deterioration in early-onset versus late-onset patients (Imamura et al., 1998). In their study, Imamura and colleagues (1998) tested a sample size of 150 participants using a comprehensive language battery. They found that word comprehension (at both the word and sentence levels) and sequential commands were heightened in early-onset AD patients, even when controlled for gender, education, disease duration, and severity. Conversely, late-onset patients had lower scores on picture naming tests than early-onset patients (Imamura et al., 1998). This distinction is specifically relevant to the studies discussed above because it only exists at the initial stage of language deficits (Imamura et al., 1998).

Cognitive Reserve

One of the ways in which we may be able to control the onset of AD symptoms is by building cognitive reserve through making specific lifestyle choices. Research has examined the role of cognitive reserve in relation to the expression of neurodegenerative diseases such as AD (Ratovohery et al., 2019; Stern, 2012). Cognitive reserve is described as the individual differences in susceptibility to pathologic changes and age-related changes in the brain (Harvard Health Publishing, 2017). In terms of AD, the overall theory of cognitive reserve posits that certain lifestyle factors and choices can positively influence cognitive processes, acting as a protective mechanism against the onset of AD and other neurodegenerative diseases (Harvard Health Publishing, 2017). According to Stern in his 2012 paper, the concept of cognitive reserve is sometimes separated into two parts: brain reserve and cognitive reserve. Brain reserve is often thought of as quantitative, as in how many neurons and synapses there are in the brain that could potentially be affected by neurodegenerative pathology. A postmortem examination study done by Katzman et al. (1988) found that adults in the upper quintile for functional and cognitive performance in a skilled nursing home for dementia patients, compared to the average AD patient in the facility, had heavier brain weights and a larger quantity of neurons. The results of the examination suggested that these patients “may have had incipient AD but escaped loss of large neurons, or alternatively, started with larger brains and more large neurons and thus might be said to have had a greater reserve.” (Katzman et al., 1988). Cognitive reserve is described as the brain's ability to actively cope with brain changes caused by pathology by either using pre-existing cognitive processes to aid task completion or engaging in compensatory activities (Stern, 2012).

Research suggests that cognitive reserve delays the onset of expression of pathology, and that people with higher levels of cognitive reserve can tolerate age-related changes or pathological changes better than others (Stern, 2012). The assumption by Stern is that the underlying pathology increases many years before expression could possibly be detected with a medical diagnosis and develops independently of cognitive reserve. One cohort review study of 29,000 individuals with AD found a decrease in the risk of developing dementia by 46% in people who had a higher level of cognitive reserve (Valenzuela & Sachdev, 2006). Additionally, it has been found that those with higher levels of cognitive reserve actually decline at a faster rate after diagnosis than those with little cognitive reserve (Stern 2012). The individuals with higher levels of cognitive reserve are more likely to compensate for AD symptoms, which means those symptoms are harder to detect and show up much later in life with a much more rapid progression, as pathology overwhelms the brain's ability to recruit other networks to do the same tasks or engage in compensatory activities (Stern, 2012).

There is significant evidence to suggest that a wide range of life experiences can contribute to an individual's level of cognitive reserve (Stern, 2012; Valenzuela & Sachdev, 2006). Two of the most important life experiences in creating cognitive reserve are educational attainment and occupational attainment, although there are many other factors that seem to do this as well. In one study looking at those with AD pathology, individuals with less than eight years of education had a 2.2 times higher risk for developing dementia compared to those with higher levels of education (Stern et al., 1994). Stern et al. (1994) also reported that those with low occupational attainment over their lifetime (unskilled workers, skilled in craft, clerical workers, office workers) had a 2.25 times higher risk for developing dementia compared to those with high occupational attainment (manager business/government, professional/technical; Stern

et al., 1994). Another important factor relevant to cognitive reserve is engagement in leisure activities, with those who participated in more leisure activities (e.g., walking, dancing, singing, playing board games) throughout their life having a reduced risk to develop dementia (Scarmeas et al., 2001). Although these conclusions most likely will always be correlational, more research is required to conclude the degree to which engaging in these activities contributes to a higher level of cognitive reserve. Similarly, although clinicians may recommend their clients engage in mentally stimulating activities and physical activities to benefit their clients' mental states, it is important that they not present these activities as treatments or fully preventative strategies to protect against dementia.

The complex nature of building cognitive reserve can be partially elucidated through the findings of education, occupational attainment, and leisure activities' effect on the brain. The networks built and reinforced by these activities encompass most of the brain and are highly connected to each other. These complex processing systems have strong relationships with functions like memory, attention, and motor abilities (Besson et al., 2011). Research regarding the underlying neural mechanisms that are reinforced by musical training and bilingualism support the hypothesis that musical training and bilingualism can contribute to cognitive reserve, and thus can be effective at delaying or preventing the onset of AD.

Music in Relation to Cognitive Reserve

Several research findings are beginning to illuminate the nature of musical expertise or training and its correlation with lower rates of dementia, with researchers speculating that musical practice and ability contribute to cognitive reserve (Chaddock-Heyman et al., 2021; Peck et al., 2016; Tsoi et al., 2018). Language and music share many of the same neural networks and processes, including activation in various brain structures like the inferior frontal gyrus, Broca's

area, and brain regions associated with reward; it is not surprising that musical practice and ability contribute to cognitive reserve (Chaddock-Heyman et al., 2021). According to Bugos and colleagues in 2007, active music making involves skill development that directly utilizes memory formation and retrieval, which, based on the conjectured origin of cognitive reserve, makes music practice a perfect activity for building cognitive reserve. One distinction between language and music, however, is that music is highly associated with emotion (Ratovohery et al., 2019). In one study that looked at patients with semantic dementia who were most impaired in the recognition of facial and musical emotions, Hsieh et al. (2012) found that the degree of atrophy in the right temporal pole, the amygdala, and the insula correlated with the ability to label emotions. Chaddock-Heyman et al. (2021) suggest that it may be the case that musical training adds to cognitive reserve, provides musicians with alternative mental strategies to protect against AD pathology, or creates higher functionality and efficiency of common neural networks involved in language, music, and emotion, like the inferior frontal gyrus.

Some studies have demonstrated that musical therapy is effective for improving verbal fluency, while other studies suggest it is ineffective at an older age (Lyu et al., 2018). Music therapy for individuals with mild AD can significantly enhance memory and language ability and can reduce the severe psychiatric and behavioral symptoms like confusion and anxiety in patients with moderate or severe AD (Lyu et al., 2018). The reason for this could be the effect of emotional memory embedded in the songs that the AD patients listened to, and the fact that music knowledge is stored as procedural memory, which remains largely intact through AD progression (Lyu et al., 2018). Additionally, the cognitive benefits of music practice in older adults extend beyond the reduction of abnormal behavior; musical practice is associated with larger brain volume in networks that support cognitive processes such as executive function,

attention, inhibition, memory, cognitive flexibility, spatial ability, and processing speed (Chaddock-Heyman et al., 2021). Although research in this area is promising, more work needs to be done to describe the nature of the activities that will produce the best and longest-lasting changes to aid treatment for neurodegenerative diseases.

In a 2011 study comparing nonmusicians and high activity musicians (older adults who have played instruments for 10+ years), Hanna-Pladdy and MacKay found that participants with 10 or more years of practice performed better in nonverbal memory, naming, and executive processes than nonmusicians. The same study found that the number of years of musical participation was linearly related to cognitive status in advanced age and was the best predictor in the study for ability in nonverbal memory. Unfortunately for patients with diagnosed AD, research has failed to find much evidence that cognitive reserve can be built through musical training in the face of Alzheimer's disease expression. In a study that compared the effects of foreign language training, games, and musical appreciation training in older adults over a 3-month period, music appreciation training did not show any significant differences in cognitive performance from controls, unlike foreign language learning and computer games, which did improve cognitive performance (Wong et al., 2019). Thus, it seems that engaging in high levels of musical training and education throughout the lifespan is the most reliable method for building cognitive reserve through music that can help mitigate symptoms of AD and other dementias in older adulthood (Gooding et al., 2014; Hanna-Pladdy & MacKay, 2011).

Bilingualism in Relation to Cognitive Reserve

Similar to the correlation between long-time music practice and the lower likelihood of being diagnosed with AD, bilingualism appears to serve as a protective factor in the face of AD onset, with some researchers postulating that learning and using multiple languages across the

lifespan contributes heavily to cognitive reserve, particularly in those who are lifelong bilinguals (Bialystok et al., 2007; Gold, 2016; Perani et al., 2017). In a study by Bialystok et al. (2007), the researchers examined the records of 187 individuals who were diagnosed with dementia, of which 51% were lifelong bilinguals, and found that the bilingual sample exhibited dementia symptoms on an average of four years later than non-bilinguals. Additionally, the researchers looked at the participants' results on the Mini-Mental State Examination four years following their diagnosis and found that the scores were similar across participants, suggesting that the later age of onset did not come with higher rates of dementia progression (Bialystok et al., 2007). Similar to these findings, Ossher et al. (2013) looked more specifically at the transitional state between normal aging and the onset of AD, which often is through the diagnosis of amnesic mild cognitive impairment (aMCI), a diagnostic category which describes a deficit in memory that lacks the severity of a dementia diagnosis (Ossher et al., 2013). The researchers looked at two subtypes of aMCI in both monolingual and bilingual individuals, including single-domain aMCI—where only symptoms of memory impairments are exhibited and more likely to lead to a diagnosis of AD—and multiple domain aMCI—where there are additional impairments in other areas such as language and visuospatial abilities and is more likely to lead to a diagnosis of types of dementia other than AD (Ossher et al., 2013). Their results showed that bilinguals with single-domain aMCI were significantly older (four and a half years) than all other groups, to which the researchers suggested that bilingualism may delay the onset of dementia symptoms that are unique to AD (Ossher et al., 2013).

These findings then beg the question of whether or not there are other lifestyle factors, such as diet, exercise, education and more, that may account for the differences in onset of symptoms between individuals who are bilingual and monolingual. To factor out other potential

lifestyle influences, Bialystok et al. (2014) recruited 75 individuals diagnosed with probable AD and 74 individuals diagnosed with mild cognitive impairment (MCI), where half of each group included bilingual individuals who spoke multiple languages actively from early childhood and throughout their lives. Each participant was interviewed to establish symptom onset, as well as to answer a detailed lifestyle questionnaire that asked questions about factors such as diet, exercise, alcohol consumption, smoking and social activity (Bialystok et al., 2014). Participants were also given three tests from the Delis-Kaplan Executive Function System Tests (D-KEFS), which assessed various facets of executive functioning, such as visuospatial, response-timing, and verbal fluency tasks over the course of a year to measure progression of symptoms. Consistent with previous research, this study found that bilingual participants were older than their monolingual counterparts upon both the onset of symptoms, as well as with their first clinic visit in comparison to both the MCI (3.5 years older) and AD group (7.2 years older). Further, they found that these differences could not be attributed to the various other lifestyle factors measured in this study (Bialystok et al., 2014). In addition, Bialystok et al. (2014) found that although both groups experienced a decline in the executive functioning tasks over the course of a year, there were no differences in rates of decline between language groups, suggesting that later diagnosis in bilingual patients is not followed by faster decline. This finding in particular is of unique interest, considering that the theory of cognitive reserve often posits that cognitive reserve protects against the onset of symptoms, but often is followed by faster cognitive decline (Stern 2012). Perhaps these findings imply that bilingualism makes a unique contribution to cognitive reserve that allows the added benefit of normal rates of cognitive decline.

A study by Alladi et al. (2013) looked into other potential confounding factors of bilingualism as a protective factor, such as number of languages spoken, education level,

occupation, rural versus urban dwelling, and literacy. The 648 participants of this study were dementia patients recruited from a specialty memory clinic in Hyderabad, India, where bilingualism is far more prevalent in comparison to the other studies discussed, with over half of the participants identifying as speaking two or more languages (Alladi et al., 2013). Each individual case study was reviewed, and the age at onset of symptoms was assessed for multiple types of dementia, including AD, frontotemporal dementia, vascular dementia, dementia with Lewy bodies, and mixed dementia (Alladi et al., 2013). While incidence of AD between bilingual and monolingual groups occurred at the same rate, the results indicated that, even when accounting for other lifestyle variables, the bilingual participants were found to be 4.5 years older on average at the age at onset of all dementia symptoms when compared to their monolingual counterparts. In regard to AD specifically, bilinguals were an average of 3.2 years older at their age of onset than their monolingual counterparts. Additionally, the results showed that bilingualism offset the age of onset by an average of 6 years in illiterate bilinguals in comparison to illiterate monolinguals. When assessing for the potential additive protective factors of more than two languages, the researchers found no significant benefits (Alladi et al., 2013).

These studies create a picture of lifelong bilingualism as a unique protective factor against the onset and progression of AD symptoms. However, understanding the neural underpinnings that may be responsible for the protective aspects of bilingualism is relevant as well. In a study conducted by Perani et al. (2017), the researchers examined the neurological functions underlying the differences between bilingual and monolingual brains in abnormal aging. This study recruited 85 patients diagnosed with probable AD (45 bilingual, 40 monolingual) who were matched for disease duration, though the bilingual participants were an

average of five years older than their monolingual counterparts, consistent with previous research on cognitive reserve in bilinguals (Bialystok et al., 2007; Bialystok et al., 2014; Osher et al., 2013; Perani et al., 2017). To assess these neural differences, the researchers looked at the cerebral resting-state metabolic activity and connectivity analyses among the participants via an fluorodeoxyglucose PET scan. The results of this study implicated two specific aspects of neural functioning: the first was that bilingual participants showed greater white matter density in executive function regions of the brain, such as in the frontal lobe and the anterior cingulate cortex (Perani et al., 2017). Second, the researchers found that bilingual individuals showed increased levels of metabolic connectivity within the default mode network and executive control networks, suggesting that their brains were better able to cope with neurodegeneration. Taken together, these findings provide further support for the theory that bilingualism can contribute to cognitive reserve (Perani et al., 2017).

Similar to music training in relation to cognitive reserve, it appears that the benefits of bilingualism on cognitive reserve are most impactful when an individual has been engaging in language instruction and use from childhood. Wilson and colleagues (2015) examined the association between foreign language and music instruction with later incidence of an MCI diagnosis and rates of cognitive decline in older age. This study recruited 964 older adults without cognitive impairment at the start of the study who were asked to report the number of years they engaged in either music or foreign language training by the age of 18 (grouped by none, 1-4 years, or more than 4 years). The participants were part of a longitudinal clinical-pathological cohort study, where they were tested annually for cognitive impairments in five domains: orientation, attention, memory, language and perception. Data for this study were collected over the course of six years. Wilson et al. (2015) found that, when adjusted for age,

sex, and education, participants who were trained for more than four years in music, foreign language, and both combined had the lowest risk level for developing both aMCI and nonamnestic MCI. Participants who trained for 1-4 years in foreign language and/or music before the age of 18 also showed a lower risk than those who lacked any early-life training, but were at higher risk when compared to their >4 years cohorts (Wilson et al., 2015). This study suggests that engaging in challenging cognitive activities in early life, such as language and music training, especially for a substantial amount of time, is quite possibly the most effective way to benefit from the protective factors of those activities. This information can be extremely beneficial in informing public policies to allocate more resources and attention towards incorporating bilingualism (and music training) into early public education to contribute to individual cognitive reserve at a young age when it will be most effective.

Although research on bilingualism as a contribution to cognitive reserve is promising, it is important to acknowledge that this topic is still in need of more exploration. One confounding variable in this area of research that has been discussed is in separating the effects of bilingualism from immigration. In response to the work of Bialystok et al. (2007), where approximately 90% of the bilingual participants were also immigrants, a research team from Toronto, Canada (Chertkow et al., 2010) conducted a study looking at the potential effects of immigration on delaying the onset of AD. To do so, the researchers attempted to replicate the findings of the Bialystok et al. (2007) study by not only comparing monolingual and bilingual participants and their age of AD diagnosis and symptom onset, but also comparing those who were nonimmigrant and immigrant bilinguals (Chertkow et al., 2010). The results of this study showed some, but no significant benefits for bilinguals overall in terms of age of AD diagnosis and onset of symptoms. The multilingual immigrant group, however, yielded similar results to

that of the Bialystok et al. (2007) study in that this group showed a nearly 5 year delay of AD diagnosis (Chertkow et al., 2010). However, Chertkow et al. (2010) also found a greater delay in nonimmigrants whose first language was French and not English. Results from this study imply that immigration status may account for the benefits of multilingualism that studies such as Bialystok et al. (2007) found.

It is apparent that there are certain lifestyle factors, such as musical training and bilingualism, that contribute to the development of cognitive reserve that may delay the onset of AD. While this knowledge can be important in influencing public health and policy making, it appears that the benefits of lifestyle factors are most impactful when engaged in at an early age and not as beneficial in older age (Gooding et al., 2014; Hanna-Pladdy & MacKay, 2011; Wilson et al., 2015).

Application of Findings

The research discussed in this paper thus far has practical implications for Alzheimer's disease patients and their caregivers. Caregivers play a crucial role in supporting the well-being of those affected by AD, and this can be challenging. Here, we discuss some interventions that may be used to mitigate or delay symptoms early in the disease progression thereby postponing the extreme caregiver burden and lack of independence associated with later stages of AD. We discuss the role of caregivers in recognizing the onset of AD and using appropriate communication strategies with their loved ones to keep them engaged. Finally, the efficacy of a few cognitive interventions that are prevalent in the current literature is examined and discussed.

Caregiver Role and Communication Strategies

The knowledge of early language deficits can be useful for family members to help them recognize the possible onset of AD and seek out assessment and intervention. According to

Szatloczki et al. (2015), AD may be more sensitively detected with the help of early linguistic analysis than with other cognitive measures. This was concluded by reviewing the current literature of early deficits in the language domain. Specifically, temporal characteristics of spontaneous speech such as longer hesitations, lower speech rate, and utterance length can indicate early stages of AD (Hoffman et al 2010., Pistono et al., 2019). These are changes that might easily be detected by caregivers and prompt the need for an evaluation. Other language abilities that could be tested are semantic verbal fluency, naming tasks, and word finding tasks as described earlier (Joubert et al., 2010; Pakhomov et al., 2018). In terms of language changes in bilingual patients, caregivers should be aware of any language changes to either the patient's dominant or secondary language, as both seem to be affected in the progression of AD (Stilwell et al., 2016). When seeking assessment and care in a clinical setting, caregivers of bilingual individuals should seek clinicians who are fluent in both languages, as well as communicate to them which language is the patient's dominant language in order to best assess and care for them (Stilwell et al., 2016).

Once detected and diagnosed, the communication strategies that caregivers use are crucial. Even early in AD, patients' social lives are impacted due to the many pragmatic difficulties that begin to manifest themselves (Kuca et al., 2015). The main difficulty in this domain is engaging in empty speech or being particularly vague in conversation such as saying "the thing over there" (Kuca et al., 2015). As the disease progresses, patients can begin to talk too much at inappropriate times, speak at too high of an intensity, repeat the same thought many times, or begin to deviate from the topic of conversation (Kuca et al., 2015). With the advancing loss of communication, social exclusion inevitably occurs and quality of life declines, contributing to caregiver burden (Savundranayagam et al., 2005). As a result, a variety of

communication strategies have been developed in order to reduce caregiver burden in the area of language difficulties. The Association of Speech-Language Pathologists established these techniques to maintain patients' language and communication skills for as long as possible. The strategies listed below are a compilation of communication tips for caregivers provided by American Speech-Language-Hearing Association (Eisner, 2016) and the Alzheimer's Association (Alzheimer's Association, n.d.):

- Revising important words or phrases to maintain attention
- Asking close-ended questions for an easier reply, such as by providing answer options within the question
- Asking one question at a time
- Asking questions in multiple choice format
- Giving clear and concise information
- Giving time to respond; not interrupting if help is not requested
- Remaining calm when speaking
- Giving clues to what is trying to be said, such as by pointing at the object
- Offering step by step instructions for a task
- Conversing in a quiet environment
- Maintaining eye contact

Many of these strategies have also been demonstrated as effective by other studies (Ripich et al., 2008; Small et al., 2003; Wilson et al., 2012). For example, fewer breakdowns seemed to occur when eliminating distractions, using simple sentences, and asking closed-ended questions (Small et al., 2003). However, Small et al., (2003) found that reducing speaking rate was ineffective, resulting in more conversation breakdowns. According to Zientz and colleagues

(2007), raising awareness about these techniques can bring about several benefits: better interaction between patient and caregiver, improved quality of life, an increase in caregivers' knowledge of AD, and an understanding of communication breakdown. It is also possible that such strategies may contribute to the maintenance of language abilities and improved behavioral outcomes for the patient, however, more research needs to be done to confirm this (Zientz et al., 2007).

Specific Language and Cognitive Interventions in Early Alzheimer's

There are certain post-diagnosis interventions that may be implemented in early AD that tend to improve or maintain language abilities. One of these is Cognitive Training for Alzheimer's Disease (CTI-AD). Bajpai and colleagues (2018) examined the efficacy of this intervention for early AD patients. Participant inclusion criteria included an AD diagnosis with a score of 1 in clinical dementia to characterize study subjects in the "early AD" category. A control group of "healthy normals" was also included. Different tasks were completed based on the four cognitive abilities manifested early in the disease: episodic memory, semantic memory, language, and attention (Bajpai et al., 2018). Participants were tested once a week for eight weeks in these domains. Although the results for the language category were not as robust as for episodic and semantic memory (Bajpai et al., 2018), for the purpose of this paper, those results are highlighted here. For verbal ability, training targeted word finding difficulty, hesitation of speech, and circumlocution (when many words are used to describe an idea when only a few are necessary) through a verbal learning task that involved naming a selection of images. For the "early AD" group, the median time taken for the tasks was consistent for the first three weeks. From the fourth week to the seventh week it increased and at the eighth week the median dropped and was parallel to the healthy controls. Although results paralleled each other for the

two groups, by the eighth week healthy controls were still completing the task at a faster rate. For memory, tasks targeted delayed recall for episodic memory and object naming, verbal fluency, and semantic categorization for semantic memory. Initially the time taken to complete the tasks were 2.23 times more for the eAD group compared to healthy controls, however, by the last week there were minimal differences in time taken across the two groups (Bajpai et al., 2018).

While this cognitive intervention program is promising, longitudinal evidence would demonstrate if these effects are temporary or long-term. A five-year longitudinal case study investigated the implications of cognitive intervention for a patient initially diagnosed with mild AD (Tsantali & Economidis, 2014). The goal was to improve episodic and semantic memory, naming, and reverse or stabilize coding and recall deficits (Tsantali & Economidis, 2014). The first four months consisted of intensive training, which involved tasks to improve deficits in episodic and semantic memory, naming, and comprehension (Tsantali & Economidis, 2014). The case study participant, P. N., had sessions five times a week for 90 minutes at a time. Three of these sessions were under the training of an expert cognitive neuropsychologist; for the other two, P. N. would complete the tasks at home. For approximately the next four years, P. N. was restricted only to feedback with no guidelines provided (Tsantali & Economidis, 2014). The first follow up, 11 months from baseline, showed improvements on categorical verbal fluency, comprehension and written narrative abilities. After 5 years, the areas that started to improve initially continued improving (Tsantali & Economidis, 2014). Naming ability did not improve, however, it did remain at baseline. In fact, there was no test that scored lower than baseline after five years (Tsantali & Economidis, 2014). This suggests that there was no symptom progression for five years, which is extremely unusual for a degenerative disease. Importantly, the training

led to improvements in untrained functions as well, namely behavior and functional ability (Tsantali & Economidis, 2014). This demonstrates that extended cognitive programs can potentially better the symptoms of mAD, though the case study nature of the study limits its generalizability.

As a more targeted intervention, lexical-semantic intervention has been explored. The rationale behind such an intervention in early AD relies on brain plasticity and how different functional mechanisms are systematically organized, but also overlapping (Agnati et al., 2007). As a result, stimulating lexical-semantic abilities and fortifying semantic representations may produce improvements in verbal communication and semantic memory, to, in effect stimulate and reshape other verbal-related cognitive networks also impaired in early AD (Jelcic et al., 2012). Jelcic and colleagues (2012), tested the effectiveness of lexical-semantic stimulation (LSS) with patients who presented a diagnosis of probable AD. This intervention focused on lexical-semantic rehabilitation exercises to improve semantic verbal processing. The emphasis was placed on the interpretation of written words, sentences, and stories. While one treatment group received LSS, the second group served as a control group and received unstructured cognitive stimulation (UCS; Jelcic et al., 2012). The UCS tasks had no overlap with LSS tasks and included creative work such as practicing manual skills, creating external memory aids, stimulating imagination, etc. The LSS group's exercises highlighted interpretation of written words, sentences, and stories. At the end of a 3-month treatment, the LSS group improved in global cognitive performance, lexical-semantic abilities, and verbal episodic memory (Jelcic et al., 2012). However, there were no significant improvements for attention and executive functioning. The UCS group demonstrated impairments or no changes of the targeted cognitive domains. At a 6-month follow up, the LSS group's global cognitive performance remained

substantially higher than at baseline, however, improvements of specific cognitive functions were not retained (Jelicic et al., 2012). This suggests that focused cognitive stimulation with the purpose of improving lexical-semantic abilities in early AD may spread its effects to other affected abilities not targeted in intervention, involving memory and other cognitive capacities. Additionally, while LSS treatment improved the efficiency of the corresponding semantically related domains (i.e., naming, immediate story recall, delayed story recall) only in the short term, the effects on global cognitive functions, assessed by the Mini-Mental State Examination, continued into the longer term (Jelicic et al., 2012). With more expansive research in this area, LSS may prove to be an effective way to counteract the progressive decline common to AD.

These studies suggest that while certain language interventions may be effective early in AD, there is much more research to be done in this area in order to replicate these studies with larger, more diverse samples. Other, more niche areas where interventions may benefit AD patients are for those that may be musically inclined or speak multiple languages.

Music as Therapy in Alzheimer's Disease

There is much discussion as to whether receptive music therapy, or just listening to music, has better or different effects on the individual with AD than interactive music therapy, which includes participation in the process of music creation. Interestingly enough, it appears that receptive music therapy alone can have significant effects on patients' memories, behavioral and psychiatric symptoms, as well as enhance encoding efforts. In contrast, interactive music therapy can help facilitate communication in severely symptomatic individuals that are non-communicative (Clare et al., 2019).

According to El Haj et al. (2012), listening to music in the background has been shown to improve autobiographical recall. El Haj et al. (2012) suggests that the memories evoked by

music are functionally equivalent to involuntary memories, suggesting that music can be used as a cue to evoke involuntary autobiographical memories. Additionally, Simmons-Sterns et al. (2012) found that music listening could enhance verbal encoding of information. It is postulated that music can induce arousal and positive emotional responses that activate the parasympathetic or sympathetic nervous system depending on the rhythm, tempo, and other characteristics of the music. These different fluctuations in the dopaminergic system, autonomic nervous system, and default mode network are likely the reasons for music's ability to alleviate neuropsychological symptoms and enhance memory functions in patients with dementia (Peck et al., 2016). The Alzheimer's Association (2012) recommends music listening for affected individuals to better manage their symptoms, as well as for their caregivers, as mitigating the neuropsychological symptoms of AD can help prevent caregiver burnout. The Alzheimer's Association (2012) also recommends that one should pick the music carefully, based on the type of music played, as music can evoke happy and sad memories. Choosing songs with a livelier rhythm and beat will likely affect the AD patient's listening by arousing their nervous system and brain more than, for example, a slow piano composition would (Alzheimer's Association, 2012; Peck et al., 2016;).

Interactive music therapy also offers insights into proper methods to facilitate communication in AD patients who suffer from severe language deficits and are sometimes labelled as non-communicative. A longitudinal study by Clare et al. in 2019 analyzed the effects of Music for Life, a multisensory, collaborative music therapy approach, on eight non-communicative people with late-stage AD. The patients participated in an one-hour long weekly music session for 8 weeks, managed by 3 music therapists trained to respond to minute communicative actions. The goal of this study was to develop a grounded theory for the important factors that play into developing communication and social connection in late-stage

AD patients through the multisensory interactive music approach. Several aspects of the Music for Life approach give support to the idea that even severe AD patients can improve their ability to communicate, including nonverbally, and their ability to freely choose their own desired activity, which is referred to as “agency” (Clare et al., 2019).

The first aspect of importance in the Music for Life approach is creating a multisensory communication environment. The diversity of the AD patients' experiences during therapy, which includes listening to music, playing instruments, clapping, singing, or choosing to participate in the creative music process in other ways is what defines the multisensory communicative environment and is hypothesized to contribute to a large variety of different complex, cognitive activities. Second, the careful noticing and responding to the multiple types of communicative actions participants made during the therapy sessions, such as facial movements, looking, pointing, singing, laughing, etc., by therapists, can create the foundation for social interactional components of communication, like turn-taking, mirroring, and humor, as well as agency. During the interactive sessions, it was essential that the music therapists responded to both verbal and nonverbal communication by the participants as they were playing musical instruments. Their responding allowed a nonverbal conversation to follow, which relied on turn-taking and mirroring, techniques that kept the participant engaged and focused on communicating. Responding to these communicative actions provided the participants an opportunity to have a one-to-one interaction with a music therapist. This allowed the participant to choose how to participate in the conversation or creation of music, offering agency to a group of individuals that struggle with the freedom of thought and action. The effects of turn-taking and mirroring on the participants were shown to result in an increase in the participant's nonverbal communication repertoire, an improvement to quality of life, and the allowance of a

connection to be drawn between the therapist and the participant. Additionally, responding to individual communicative actions helps foster the formation of caregiver-resident relationships, which may help reduce social isolation in this population and encourage positive interactions among staff, residents, and music therapists.

In the same study, a session involving the same participants but using only receptive music therapy (just listening to music) showed there to be fewer communicative actions done by the participants overall, except for talking, which increased as a result. There were also fewer observations of mirroring, turn-taking, and humor. The data collection and analysis remained the same after transitioning to the negative case, as researchers scanned the video recordings of the sessions and counted the number and types of communicative (usually nonverbal) actions made by the participants. Although more research is required to replicate these same results with a larger number of participants with a broader demographic profile, including socioeconomic status and ethnicity, this example shows the vast difference in communicative facilitation in severe AD patients between receptive and interactive music therapy.

An Intervention for Bilingual Individuals with Alzheimer's Disease

The research surrounding interventions that are specific to improving communication in bilinguals with AD appears to be very sparse and little is understood with regard to the progression of language and communication impairments that occur post diagnosis for bilingual speakers (Kokorelias et al., 2017). However, Kokorelias et al. (2017) provide promising case study evidence for the improvement of meaningful conversation for bilingual long-term care residents with a diagnosis of dementia. Their study used language activities from the DementiAbility: Montessori Methods, a collection of activities created specifically for those with dementia to help increase grammar and vocabulary, along with conversational engagement in

English to increase English communication in five Greek-Canadian participants with dementia who showed signs of regression to their mother tongue, Greek (Kokorelias et al., 2017). The study was conducted at two separate long-term care facilities, one of which was mono-cultural, where both staff and patients spoke Greek primarily, and the other of which was multicultural, where the staff spoke English and the patients spoke Greek with each other (Kokorelias et al., 2017). Baseline data were collected over a three month period via observations of participants in natural settings to observe the participants' personal language choice and use in their daily routines (Kokorelias et al., 2017). After the baseline data were assessed, each participant engaged in the DementiAbility Methods English-language exercises over the course of two months in a one-on-one setting with a researcher accompanied by a service worker who was able to translate Greek to English (Kokorelias et al., 2017). The observational data from field observations and activity sessions were collected and interpreted through a multiple-coding process and compared to baseline data (Kokorelias et al., 2017). The results from this study showed no significant improvements in the DementiAbility activities specifically, but four out of the five participants showed increased conversing in English and initiating conversations in English that Kokorelias and colleagues (2017) postulate was due to the consistent conversational stimulation of English and the Montessori approach, which emphasized adjusting the learning process to the specific interests of the participants. For example, one participant, highlighted by Kokorelias et al. (2017), was able to recall memories in the language that they were initially encoded in, which may suggest that the intervention made this information accessible and further suggests a particular strategy to bridging communication gaps within this population.

This study also suggests styles of communication that may engage bilingual individuals with dementia. For example, taking the time to consistently engage a bilingual individual in

conversations in the language to which that are *not* regressing may be able to help in slowing the regression to the favored language. Additionally, by using a personalized approach to engage bilingual individuals, such as the Montessori approach, facility staff members, caregivers, and loved ones can form and/or maintain relationships with them and subsequently affirm their personhood and individuality. It is also important for long-term care facility staff to not limit their engagement with their bilingual patients to one language, as engagement in both languages appears to be a necessary component to using AD patients' bilingual abilities (Kokorelias et al., 2017). Although the results of this study appear promising, much more research will be needed to develop and identify effective interventions.

Conclusions and Recommendations

As the older adult population grows both nationally and globally, it is of great necessity that we continue to prioritize research that emphasizes treatment, preventative measures, and symptom management for age-related diseases, particularly in AD (Alzheimer's Association, 2021). Considering that there is currently no cure available for AD, our research focused on aspects of AD, including the neurological mechanisms associated with early stages of the disease, the language deficits and capacities associated with early detection of the disease, and the exploration of lifestyle factors that contribute to cognitive reserve as a protective factor against the onset of AD symptoms. As a result, we discovered that cognitive reserve is likely to be built over the entirety of the lifespan, and that engaging in cognitively stimulating activities such as higher education, a demanding occupation, musical practice, and even leisure activities from an early age can help to delay the onset of AD in later life. Additionally, we explored strategies associated with improving communication between caregivers and individuals with

AD, including the use of music therapy, which has also been shown to relieve psychiatric and behavior problems to improve communication with this population.

Communicating effectively is a unique factor in identity and personhood that can be compromised in the course of Alzheimer's Disease. We believe the information presented here can be beneficial to caregivers and families of those diagnosed with AD who seek to effectively communicate with their loved ones. The information can benefit young adults as well by providing them education on certain lifestyle factors that they can engage in at an earlier age to help delay and maybe even prevent the onset of AD in their later life. Policy makers at the political and social level should extensively utilize knowledge such as this by providing funding for interventions and for reinforcing cognitive support at every stage of life to give the population the best chance at deterring the progression and expression of AD.

Need to Address Demographic Gaps

Future research is needed regarding the demographic gaps in dementia studies in order for findings to be applicable to a variety of populations. Pertaining to race, the collection of literature on this topic finds that African Americans and Latinos have a higher prevalence of AD than white individuals (Manly & Mayeux, 2004). However, the participants in dementia research are overwhelmingly white (Brewster et al., 2018). In addition, the most widely used criteria for probable AD includes cognitive ability measures that have not been properly validated for use among ethnic and racial minorities (Brewster et al., 2018; Manly & Mayeux, 2004). As a result, they are more likely to be diagnosed than whites although these diagnoses may be erroneous (Manly & Mayeux, 2004). Issues arise as well when we turn our attention to sex and gender differences. It is well known that women are at greater risk, however, the integration of sex and gender has not been adequately included in the approaches to advance our understanding of the

development and progression of AD (Mielke, 2018). Many studies “adjust” for sex, but do not determine if there are salient sex differences. However, sex differences do exist in the areas of risk factors as well as psychiatric symptoms (Mielke, 2018).

Brewster and colleagues (2018) offer several directions for future research in respect to race and ethnicity. The primary focus is to change the emphasis from a descriptive approach to diving deeper into the mechanisms that underlie racial and ethnic differences and the pathways involved. One way to achieve this is to improve the underrepresentation of minorities in clinical trials as well as developing new diagnostic measures for AD that consider ethnic/racial minority factors (Brewster et al., 2018). For example, education level is said to be a reliable predictor of cognitive measures, is associated with reduced dementia risk in old age, and is considered a potential contributing factor to cognitive reserve (Stern, 2012). However, these associations are reduced in African Americans and Latinos due to lack of access to quality education (Brewster et al., 2018). As a more appropriate measure of quality of education for racial/ethnic minorities without access to quality education, other cognitive measures should be considered, such as single word reading ability (Brewster et al., 2018, Manly et al., 2002) or tests that are specifically related to executive functioning that better measure AD-related cognitive impairment (Bialystok et al., 2014). As far as including more research participants from underrepresented groups, this is of particular importance when considering aspects such as bilingualism as a protective factor. Increasing the number of non-native English speakers would likely provide an array of new perspectives into the protective aspects of bilingualism.

In addition, while there is greater awareness of the importance of including underrepresented groups in research samples, little action has been taken. For example, amyloid imaging has regulatory approval as a diagnostic marker for AD. It is used diagnostically and for

screening, yet its efficacy has not been sufficiently demonstrated in racial/ethnic minority samples (Brewster et al., 2018). Racial/ethnic minorities need to be included early in the validation process. As a plausible solution to this limitation, Brewster and colleagues (2018) suggest a system-level framework for future research where all levels of analysis (environmental, sociocultural, neuropathological, etc.) are examined together to identify the mechanisms that influence disparities.

Ferretti and colleagues (2018) are critical of the current research available on sex and gender in relation to AD and propose future directions for research. Their recommendations are based on the finding that sex is an important factor for phenotypic variability in AD and should be used more than to just adjust covariates (Ferretti et al., 2018). Data have shown that women show faster decline after diagnosis of MCI and AD and that in MCI brain atrophy is also more rapid. In addition, the prevalence of cerebrovascular, metabolic, and socio-economic risk factors for AD are different between males and females (Ferretti et al., 2018). The faster progression seen in women makes risk factors and early detection that much more important to address. Therefore, they suggest increasing the quantity and quality of studies on this topic in both clinical and preclinical studies (Ferretti et al., 2018). In addition, a large-scale, population-based screening that includes evaluation of risk, biomarkers, and genetic stratification should be implemented. This would allow disease models to be based on large samples that help account for individual variability (Ferretti et al., 2018). Lastly, they suggest a precision medicine approach that emphasizes the need to consider the individual's specific biological makeup. This can be done by systematically studying and reporting sex differences relating to symptomology, biomarkers, progression, risk factors, and treatments (Ferretti et al., 2018).

Final Comments

Overall, researching and honing our understanding of a topic as vast as AD proved to be interesting but difficult, particularly in bridging all of our individual interests into one cohesive literature review. We believe that we could have spent far more time on this subject and its various aspects, and still would not have a complete grasp of the full picture. However, we continued to work hard to successfully incorporate a unique set of interests and background knowledge into a topic that was inclusive of a variety of angles in relation to communication and AD. One rewarding aspect of this research was delving into topics and understanding the impact of a disease that is not seemingly an immediate threat to younger individuals our age. It was surprising to grasp how devastating this disease is, but also exciting to realize that there are ways in which we take action in the present to prepare for a more successful future.

The research on cognitive reserve has special importance for college students, including ourselves, as both future caregivers and potential AD patients. The information reviewed here could be used to construct a campus-wide awareness campaign for college students to get them thinking about how engaging in lifestyle factors now, such as musical training and foreign language training, can benefit them and their futures as they continue to age. We also believe this review can be beneficial to caregivers and family members of individuals diagnosed with AD. Another prospective future direction in this research could involve a community-based awareness campaign on how to successfully communicate with those diagnosed with AD.

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