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ABSTRACT

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Adult Monolinguals

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Second language acquisition has proven to impact the brain in many ways. Studies have shown a distinct difference between the monolingual and the bilingual brain. These structural differences have included an observable increase in cortical thickness in bilingual individuals when compared to monolinguals. This is a significant observation since many neurological diseases and impairments have been connected to a decrease in cortical thickness. However, previous studies have focused solely on bilinguals who had acquired their second language early on in life. These studies have failed to focus on the potential impact that could be observed on the cortical thickness of individuals who acquire a language after the age of 40. This study focused on monolingual students 40 years and older, who participated in an entry level university level Spanish course and examined how their brains structurally changed after a three-month course. These results were compared to a group of adults not participating in a language course who acted as a control group. This was achieved through MRI imaging of all the participants' brains and measuring any changes in their cortical thickness. Upon completing the second round of MRI imaging, the comparison of the pre and post MRI scans yielded an observable difference between the experimental group who had participated in the Spanish course and the control group. However, these differences did not prove to be significant and should be viewed as exploratory. Future research opportunities should entail studies with a longer duration combined with a curriculum better suited to this age group.

Keywords: cortical thickness, geriatric learning, monolinguals, second language acquisition, bilingualism

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Introduction

It is widely assumed that acquiring a second language opens one's mind to the richness of other cultures and broadens one's world perspective, but are there any biological and cognitive advantages? Cognitive advantages would be of interest to most since age brings with it countless threats to one's mental health, with one severe threat being the deterioration of one's cognitive abilities. This is demonstrated by cases of dementia and Alzheimer's that cause a severe reduction in grey matter and lead to a variety of cognitive problems (Alladi et al., 2014). These issues drastically reduce the quality of life of individuals who often spend their remaining years in search of medical solutions that might grant reprieve.

Striving to address these threats, researchers have dedicated years' worth of studies to examine how to aid the geriatric community in addressing these issues (Bak et al., 2014). Some have focused specifically on the impact second language acquisition has on the brain to examine any potential cognitive benefits. Several studies have produced results that would suggest that learning a second language not only impacts the neuroplasticity of the brain but can also cause positive anatomical changes (Mårtensson et al., 2012). This is extremely significant in of itself, as other studies have hypothesized that an increase in cortical thickness offers cognitive benefits that could last into one's golden years (Klein et al., 2014).

However, as one reviews the previous research, it is apparent that many studies, such a Alladi et al. (2014), dealt with a majority of participants who were below the age of 30 producing results representative of only a younger demographic, whose fear of mental decay lies in the far distant future. The few studies that have included older participants, such as Klein et al. (2014), dealt with participants that were bilingual and had already learned a second language in their youth. How would learning a second language impact those monolingual individuals found in an older demographic, a demographic faced with the more immediate consequences of age? For this reason, this study was proposed to examine the impact of second language acquisition on a group of older participants who had no previous experience learning a foreign language. The results produced in this study are of great value to those of an older demographic since significant atrophy of the brain occurs around the age of 30 in most adults and continues during the aging process (Alladi et al., 2014). Additionally, few studies have examined participants in their 40s and older. If learning a second language as an adult produces structural changes linked to cognitive benefits, then researchers have only skimmed the surface in how learning a second language can improve cognitive health and potentially combat neurological disease. The methods detailed in this study can serve as a template for future research by focusing on the gaps in previous studies and seeing the possibilities of future research prompted by the results and conclusions found within the present study.

Research Question and Hypothesis

To aid in this pursuit, this study focused on the following question:

- What is the effect of a three-month-long language course on the cortical thickness in the cerebral cortex of the brain on students over the age of 40?

Additionally, the following hypothesis was considered:

- The comparison of pre and post MRI scans will reveal an increase in cortical thickness of monolingual students above the age of 40 enrolled in a three-month language course when compared to a control group who is not studying a language.

Review of Literature

The impact second language acquisition has on the human brain has been a subject of interest for several decades. Klein et al. (2014), Stein et al. (2014), Pliatsikas et al. (2013) and Yang et al. (2015) have produced results that would suggest that learning a second language not only impacts the neuroplasticity of the brain but can also cause anatomical changes. These deductions have been made from comparing the monolingual brain to the bilingual brain. While some studies concentrated on the distinctions in neural activity, others focused on the structural dissimilarities between monolinguals and bilinguals (Burgaleta et al., 2016). Differences were not only observed in isolated coordinates of the brain but were also seen in locations in the cerebral cortex.

The significance of this research lies in the assumption that an increase in cortical thickness offers cognitive benefits. This is relative to those of an older demographic who experience a decrease in cerebral matter as they age, including the more extreme examples of this that can be seen with those who experience dementia. Examining how second language acquisition can combat the atrophy of cerebral matter could provide additional research opportunities to examine how learning a second language can preserve cognitive health. However, before examining how second language acquisition increases grey matter, the value of these anatomical changes must be established.

Cerebral Matter Volume and Cognitive Health

A decrease in the volume of cerebral matter and the negative impact it has on one's cognitive health has been established by several studies examining memory performance, motor skills, and depression. Allen et al. (2004) found a strong correlation between the amount of hippocampal, cerebrum, and major lobe volume with memory performance in their participants.

They set out to investigate the quantitative relationship between regional brain volume and the memory tests in 13 anoxic participants who had suffered brain injury due to a lack of oxygen. A control group comprised of 87 healthy individuals was included in the study and both groups were administered memory tests accompanied by MRI scans. They found that the anoxic participants with severe amnesia had a hippocampal volume that was 36% smaller than normal, whereas anoxic patients with mild or no amnesia had normal hippocampal volumes. In addition, regional grey matter volumes of participants with sever amnesia were substantially small than expected. The memory test scores were significantly correlated with hippocampal and regional grey matter volume.

Another study (Hellewell et al., 2019) examined MRI scans of 233 participants with a confirmed diagnosis of Major Depressive Disorder (MDD) and compared them to the MRI scans of 66 healthy individuals who acted as a control group. Their goal was to replicate and extend their previous findings of profound and widespread grey matter loss in individuals with MDD. Using 3T MRI T1-weighted volumes, GM volume differences were evaluated using voxel-based morphometry. Sensitivity, specificity, and area under the receiver operating characteristic curve were used to evaluate an MDD diagnostic biomarker based on a precise spatial pattern of GM loss constructed using principal component analysis. According to Hellewell et al., a profound interconnected anatomical pattern of reduced grey matter volume was associated with those diagnosed with MDD.

Shad et al. (2012) also examined the idea that those with depression experienced a decrease in grey matter volume. Their study produced results that suggested that depressed adolescents when compared to controls, had smaller grey matter volume in the right superior and temporal gyri, the caudate nucleus bilaterally and in the frontal lobe. They concluded that these results were consistent with previous findings showing a positive correlation between depression and lower grey matter volume.

Ansell et al. (2012) produced another study that examined how stress can negatively impact brain volume. This study focused on how cumulative adversity and stress were associated with differences in grey matter volume. They examined 103 healthy community participants aged 18 to 48. They completed an interview assessing the level of stress they were currently experiencing combined with an MRI scan. These scans were conducted on all participants using a whole-brain voxel-based-morphometry analysis. When comparing the level of stress experienced by the participants and their brain volume, researchers observed that the higher the stress experienced by the participants, the smaller their grey matter volume.

There have been other studies produced that demonstrate a decrease in grey matter volume and a decline in cognitive performance that accompanies those who age. Ramanoël et al. (2018) yielded results that suggested a decrease in grey matter was observed in several regions of the brains of older participants when compared to middle-aged participants. There was a positive correlation between the grey matter volume of the participants and their cognitive scores from assessments that focused on domain general and specific processes. The older the participant, the lower their grey matter volume and the lower their cognitive test score.

This idea is of great interest to researchers that have studied how age affects the brains of the elderly. Scahill et al. (2003) studied how age affects the volume of the brain and the rate at which it atrophies. In total, 39 participants had MRI scans of their brains. Participants had varying ages ranging from 31-84. The MRI scans focused on the brain as a whole and then focused specifically on the temporal lobe, the ventricular volumes, and the hippocampus. The researchers found as age increased among the participants, a significant decrease in volume was seen in the temporal and hippocampal lobes of the brain.

Zasshi (2004) explored this area further and noted that, although atrophy was seen universally in the aging participants, the specific areas that had atrophied were not universal. He examined 61 participants whose ages ranged from 61-91. None of the participants had a history of mental illness or of any type of neurological disorder and had MRI scans which revealed normal changes in regards to volume. The grey matter and the prefrontal cortex were within the normal range of where it was expected that it would be. However, the researchers noticed that the entorhinal cortex had a severe reduction in volume when compared to the other areas of the brain.

These studies help establish the idea that a decrease in grey matter volume is associated with a variety of negative characteristics whether it be memory loss, depression, or aging. While a decrease in grey matter volume can be an indicator of cognitive decline, it would make sense to say that the opposite would be of cognitive benefit or at least, the maintenance of cognitive capacity. Indeed, much research has shown strong correlations between amount of cerebral matter and cognitive benefits.

Benefits of Increased Cerebral Matter

Yang et al. (2016) examined students learning Chinese to see how their brain volume correlated with academic success. The participants consisted of 39 individuals with no prior exposure to Chinese or any other tonal language. The participants were separated into a learner group and a control, or non-learner, group. The learner group had 23 participants and the non-learner had 16 participants. The experimental group was taught a novel tonal vocabulary in a 6-week training program. The learner group started learning Chinese and each training session had a study phase and a test phase. During the test phase, the researchers would test the retention of the learners regarding the material they had learned. Behavior performances and MRI scans were carried out on all participants before and after the training program. By the end of the program, the learner group averaged 85% accuracy on the test and showed a significant increase in grey matter when compared to their non-learner friends. There was also a positive correlation between success on the exam and increases in grey matter volume. These findings help solidify the importance of observing cerebral volume and cortical thickness in connection to second language acquisition since the cerebral cortex where cortical thickness is measured, comprised a large percentage of grey matter found in the brain.

It must be recognized that while these findings are significant and differences have been noticed between the cerebral cortex and the subcortical levels of monolingual and bilingual participants, can these differences be observed in participants in an older age group? The study in the previous paragraph focused on a young group of adults with an average age of 20.61 years with the oldest participant being 23 in the experimental group. Of the control group the mean age was 20.8 years with the oldest participant being 25, making the question regarding the reproducibility of these results in an older population very relevant. These questions are critical due to the dramatic changes in cerebral matter that one experiences through life as aging brings with it additional threats to one's cognitive wellbeing.

Second Language Acquisition and the Aging Brain

While aging is accompanied by cortical thickness and cognitive decline, research has been conducted that has unveiled the mitigating influence of second language acquisition. Klein et al. (2014) noted that the bilinguals that had learned two languages simultaneously from their infancy to the age of 4 had no observable differences in their grey matter volume when compared to a monolingual group. This study examined the cortical thickness that was measured in the MRI scans of 22 monolinguals and 66 bilinguals. Of the bilinguals, twelve had learned both languages simultaneously from birth and were defined as simultaneous bilinguals. Another 25 of the bilingual participants were described as early sequential bilinguals since they had first learned a primary language and then began learning a second language between the ages of 4 and 7. The remaining bilingual participants were deemed late sequential bilinguals since they began learning their second language between the ages of 8 and 13. Upon analyzing the cortical thickness between the groups, the monolinguals and simultaneous bilinguals did not exhibit any differences in cortical thickness in any region of the brain. The opposite was seen when comparing the cortical thickness of the monolingual group to those in the early and late sequential groups with the bilinguals having greater cortical thickness in certain areas of the brain. This led the researchers to theorize that the impact of second language acquisition on the brain in changing the grey matter volume and cortical thickness only occurs after a certain age. In other words, the more one waits to learn a language the more likely it will impact their cerebral structure. This is a complex realization that might cause one to question the value of learning a second language when young as opposed to when one is older. It also raises the question of how learning a third or fourth language could increase cortical thickness of a simultaneous bilingual.

However, while there can exist social benefits to learning early on, Klein et al. (2014) suggest that learning a second language after the critical period is when individuals might experience cerebral structural changes. This could potentially be the case with any language acquired beyond the critical period when the brain is naturally programmed to accept language acquisition. Beyond this period, it requires a more strenuous labor-intensive process almost as though one were exercising the brain.

Other researchers (Bak et al., 2016) explored the effect of bilingualism on the cognitive health of adults later on in life. A total of 853 participants were first tested in 1947 when they were 11 years old and then were tested again when they were 70 years old. Testing involved a series of assessments that included an intelligence test, and the test scores were compared from when the participants were 11 to when they were 70. The researcher observed that the bilingual participants as well as those who acquired a second language later on in life performed significantly better than predicted from their baseline cognitive abilities. The strongest difference was observed in general intelligence scores.

Kousaie and Phillips (2017) investigated the benefits of bilingualism among healthy older bilinguals and monolinguals using behavioral and electrophysiological measures where they recorded the spontaneous bioelectric activity generated by the brain. Their participants numbered 43 in total, ranging from 60-83 years old. All of the participants performed three cognitive tasks while their electrophysiological measurements were taken. They found electrophysiological evidence was produced indicating that the bilingual group demonstrated greater cognitive performance for all tasks when compared to the monolingual group. They concluded that older bilinguals execute enhanced cognitive processing when compared with older monolingual individuals.

While all the before mentioned studies offer promising results for the aging brain, some individuals might be hesitant to learn another language because it would be too hard. Ristin-Kaufmann and Gulberg (2014) found that older participants are equally good or even better than younger participants when they derived new phonotactic knowledge from auditory L2 input.

Their research examined how quickly can adults learn to distinguish sound regularities in natural language input. They also examined if adults can extract abstract phonotactic knowledge and if this ability changes across the lifespan. The researchers tested 152 participants, 84 females and 68 males, between the ages of 19 and 86. They separated participants into 9 specific age groups. These groups were categorized according to the ages of 10-12, 15-16, 20-29, 30-39, 40-49, 50-59, 60-69 and 70-79 (there were no participants between the ages of 17-19). All participants were exposed to two sets of stimuli. One was an audio-visual sample of a seven-minute weather report in Mandarin Chinese. The second was a lexical task that consisted of 256 Chinese monosyllables half of which were real Chinese words and half were Chinese nonwords containing phonotactic violations. After listening to the weather report, the participants were tasked with identifying the nonwords in the lexical task. They found that participants were able to generalize newly acquired phonotactic knowledge in order to correctly reject non-words in the unknown language after only seven minutes of input. They also found that this capacity improves or at least remains stable across the life span and that there is no evidence for a declining capacity to learn and generalize L2 phonotactics across the age span.

Engvig et al. (2010) examined the short-term impact of a memory training program on brain structure of middle-aged and elderly participants. In total, there were 42 participants with 22 being assigned to the experimental group and 20 in the control group. The average age of the experimental group was 61 whereas the control had a group average of 60. The experimental group completed an 8-week training program that was designed to improve verbal memory while control participants did not participate in a program. Both the experimental and control group underwent MRI scanning and memory testing before and after the 8-week period. The comparison of scans revealed that the memory training improved source memory performance and that the experimental group showed regional increases in cortical thickness when compared with controls. These results are very promising because they show the potential that older students have to learn and to memorize material; memorization that could positively impact their cortical thickness. This information is relevant for adults as learning a language could potentially help them retain cognitive health later in life; cognitive health that is threatened by diseases, such as dementia, that accompany old age.

Dementia

Alladi et al. (2014) examined the relationship between age at onset of dementia and related mental illnesses and bilingualism. The study was composed of 648 participants who had dementia and of the 648, 391 of the patients were bilingual. During this study, the age when symptoms of dementia of the bilingual group first started to appear was compared to the monolingual group and when their symptoms started to appear. Other important factors were acknowledged in the study such as education, other languages spoken, and occupation. After comparing the two groups, it was revealed that on average, the bilingual participants had developed dementia 4.5 years later than the participants who were monolingual. It could be concluded from the results of this study that although bilingual individuals might develop symptoms of dementia later in life, monolinguals are more likely to develop symptoms sooner.

Other studies have supported these results suggesting that bilingualism has the potential to delay dementia. Zasshi (2004) supported this idea previous to Alladi et al. (2014) and produced very similar results and observed that on average the monolingual participants developed dementia 4.5 years earlier than the bilinguals. Bialystok et al. (2007) also examined this same idea to see if being bilingual had any effect on retaining cognitive functioning and hindering the development of symptoms of dementia in old age. They accessed the records of

228 patients who suffered from memory issues of whom 184 were diagnosed with dementia. Out of the 184 patients, 51% were bilingual. The records of the bilingual and monolingual patients were compared to see at what age they developed the initial symptoms of dementia. Upon comparing the records of the monolingual and bilingual group, it was shown that the monolingual group on average developed symptoms of dementia 4 years earlier than the patients that had learned a second language. While these results seem to be promising, they have been challenged by other researchers attacking their validity.

De Bruin et al. (2014) directly challenges the Bialystok et al. (2007) study as well as other similar studies and labeled their findings as an example of publication bias and called into question the research methods utilized to produce their findings. De Bruin et al. also fairly indicate that a significant number of studies were never published; studies that produced results suggesting bilingualism did not delay dementia. Paap et al. (2015) argued that many of the claims of bilingual advantages do not exist or are restricted to a very specific and undetermined circumstance. They claimed that more than 80% of the tests of bilingual advantages conducted after 2011 yield null results and those resulting in significant bilingual advantages tended to have small sample sizes. They further claimed that the positive results were likely to have been produced by failures to match on demographic factors and others have yielded significant differences only with a questionable use of the analysis-of-covariance to act as a control for these factors. Studies with MRI scans were also addressed and Paap et al. (2015) stated that these studies have only made a modest contribution to evaluating the bilingual-advantage hypothesis, principally because the neural differences do not align with the behavioral differences, besides the fact that the neural measures are often ambiguous with respect to whether greater magnitudes should cause increases or decreases in performance.

While Paap et al. (2015) and De Bruin et al. (2014) express valid concerns, other studies have examined Bialystok's claims producing less severe conclusions. Ware et al. (2020) conducted a meta-analysis of studies supporting the idea of bilingual advantage, several with Bialystok participating as a researcher. This analysis synthesized the results of 170 studies to test whether the bilingual advantage is dependent on the task used to assess executive functioning and the age of the participants. The results indicated that the bilingual advantage was both task and age specific. When compared to their bilingual counterparts, the monolinguals were significantly slower and less accurate when compared. Additionally, Ware et al. also examined the idea of publication bias connected to the bilingual advantage. They researched concluded that publication bias was not uniformly detected after subjecting the before mentioned studies to a series of tests, one being Egger's Test of Asymmetry. This weakens the argument that second language acquisition does not offer cognitive advantages. Other studies have delved even further into how learning a language can increase thickness at the subcortical level but unfortunately, most of these studies only examined a young population. However, their results are still valuable and can help create additional studies.

Learning and Subcortical Levels

Structural differences have also been seen at the subcortical level. One study in Spain primarily focused on the effects that could be seen at the subcortical level (Burgaleta et al., 2016). As seen in previous studies, the focus was to analyze if any observable differences could be made between a group of monolingual and bilingual participants regarding the structure of the brain. The subcortical areas of interest that were examined were the bilateral putamen, thalamus, the left globus pallidus and the right caudate nucleus. There was a total of 88 participants who were students at the University Jaume I of Castellón de la Plana in Spain. Of the 88 participants, 46 were Spanish monolinguals and 42 were bilingual who spoke Spanish and Catalan. Bilingual participants had used both Spanish and Catalan since birth on a daily basis and had attended a bilingual school from the age of 5. Participants were also identified as bilingual participants with the administration of a self-rating survey where participants rated their proficiency in comprehension, fluency, writing and reading on a scale of 1-4. It is concerning that they did not specify the guidelines used to determine their level of proficiency which again complicates the replication of this study.

A 1.5T scanner was used to provide MRI imaging from which an image of the entire brain was first taken of each participant and then a second image was taken only of the subcortical structures. Several differences were observed between the monolingual and bilingual participants at the subcortical level. Bilinguals displayed more bilateral expansion of the thalamus and the putamen when compared to monolinguals. This was also seen when comparing the right caudate and the left globus pallidus of the bilingual participants to the monolingual participants. The volume of the bilateral putamen, the bilateral thalamus and the right caudate nucleus was greater in bilingual participants than it was in monolingual participants (Burgaleta et al., 2016).

Ehling et al. (2019) produced results that also demonstrated how language learning can impact subcortical levels. The researchers recruited participants in both the experimental and control groups that had been diagnosed with multiple sclerosis (MS). According to Ehling et al. (2019) one of the main characteristics of the disease is the severe atrophy of cerebral tissues. The goal of this study was to see how language learning could potentially counteract the atrophy caused by MS. The experimental group contained 11 individuals with relapsing-remitting MS whereas the control group contained 12 healthy individuals that matched the demographics of the experimental group in sex and age matched controls. All had an MRI scan previous to the commencement of the language course.

The participants participated in an eight-week English language training which was taught three hours per week in what was described as a typical classroom setting. The class was structured around six topics that were considered relevant for everyday life and travel (e.g., directions, shopping) and focused on listening, vocabulary and speaking. The instructor followed a communicative approach to teaching the language and utilized accuracy drills to focus on meaning and use of the language in comprehension and production. Interactive classroom activities were also used that had vocabulary items embedded within so that vocabulary training happened at a sentence and discourse level context. The healthy controls and the experimental participants were mixed together in the class and the teacher was not aware of the group differences. After the completion of the class there was a secondary round of MRI scans for all participants. Upon comparing the MRI scans, the healthy individuals and the participants with MS exhibited an increase in grey matter volume at the subcortical level, specifically in the right hippocampus. The MS group also experienced an increase in the right parahippocampus and the right anterior putamen. The researcher found these results very promising in demonstrating that even those dealing with severe atrophy of the brain could receive positive benefits from learning a language, benefits that had already been demonstrated by healthy participants.

Language Learning and the Cerebral Cortex

Mårtensson et al. (2012) specifically examined the notable differences in cortical thickness between students learning a foreign language and students studying other core subjects at the Interpreter Academy of the Swedish Military. In this study, there were 14 students who had enrolled in a foreign language class at the academy that were asked to participate in the research to serve as an experimental group. There was another group of 17 students enrolled at the academy that participated who were not studying a foreign language but were enrolled in other classes. MRIs were acquired from each participant before and after the first three months of the language program.

When comparing the MRI scans, it was revealed that there were several observable changes in the brains of the students that had been learning a foreign language. These changes consisted of an increase in the thickness of the cerebral cortex with some additional areas of the brain showing a significant amount of change, including the dorsal middle frontal gyrus, the inferior frontal gyrus, and the superior temporal gyrus. The participants that were learning a language showed large increases in cortical thickness in these three areas, whereas no such changes were observed in the group of 17 students who only studied core material that did not include a foreign language. The researchers concluded from these findings that language learning affects the volume of certain areas of the brain. It specifically seems to affect the hippocampal areas along with the superior temporal gyrus, the middle frontal gyrus, and the inferior frontal gyrus. This study is significant because it could imply that language learning causes a far more drastic structural change in cerebral tissue when compared to other types of learning. However, it was not clear in this study that the students that were learning a second language were not also learning other material. If they were, it could be claimed that the structural changes seen in their brains were not solely due to their language acquisition.

Mårtensson et al. (2012) is not the only study that has shown that second language acquisition affects the structure in the cerebral cortex. Another study also observed differences in the cortical thickness of participants (Klein et al., 2014). While Mårtensson focused solely on the comparison of students learning a foreign language to those who were not, Klein et al. focused on comparing monolinguals to other participants who were bilingual. Klein et al. also had a greater number of participants, 88 compared to Mårtensson who had 31. Klein et al. studied 88 participants with 22 being monolingual and 66 being bilingual. All participants that were bilingual had undergone an assessment to assure they could be considered bilingual. The assessment consisted of providing the participants with an in-house questionnaire which ranked on a scale of 1–7 their comfort in their second language on reading, speaking, writing, and comprehension, as well as detailed information about their family linguistic background and language-acquisition history. If they achieved a certain proficiency score based on their answers, they were considered bilingual and were allowed into the study.

MRI scans were taken of each participant scanning over 80,000 points of the brain to provide multiple measurements of the cortical thickness. Upon examining these images, it could be seen that there were significant differences in the cortical thickness between the monolingual and bilingual participants who learned their second language later in life. There were two main areas of the brain that showed these differences in cortical thickness. In the left inferior frontal gyrus, observations were made that the bilingual group showed greater thickness when compared to the monolingual group. This was also seen in the area of the right hemisphere of the brain (Klein et al., 2014). While these findings were interesting, they failed to include participants above the age of 40 who would have benefited even more from an increase in cortical thickness.

Another study in Switzerland examined if language immersion programs could produce any observable structural changes in the brains of student participants in said programs (Stein et al., 2014). With the reported benefits from immersion programs, it was hypothesized that the results would indicate that positive effects would be able to be seen in the brains of the participants. The study was conducted in Switzerland on a group of native English-speaking students that were learning German and were participating in a program where the participants first attended an intense German language course for 3 weeks and then continued to attend their standard curriculum high school class in German that lasted 5 months. The students took a variety of language proficiency tests at the beginning and end of the program. Before the five-month course, each student had MRI scans as well as a scan at the conclusion of the course. The pre and post scans were analyzed to determine any changes that occurred in certain parts of the brain with a specific focus on whether there was an increase in the grey matter in the left inferior frontal gyrus. Notable increases were detected in the grey matter in this area of the brain as well as an observable increase in cortical thickness located in the left anterior temporal lobe (Stein et al., 2014). While the results of this study were interesting, it failed to compare these results to students who were not studying in an immersion program, thus making it very difficult to attribute the cerebral changes solely to their language acquisition. In addition, it only focused on younger students.

One study conducted in the United Kingdom searched for any general changes in cerebral matter that could be observed between participants learning a foreign language and others who were not learning a foreign language (Pliatsikas et al., 2013). There were 17 native Greek speakers who were learning English. They all had started learning English after the age of 6. The second group was the monolingual group with 22 native speakers of English. Both groups were taken through a series of tests examining their ability to deal with certain tenses and grammar structures in English. In addition to the proficiency test, all participants were taken to a facility for an MRI scan, which revealed that the participants who had learned a second language had a greater volume of grey matter when compared with the monolinguals. While this study was useful in demonstrating a general change in cerebral structure, it could have been more detailed regarding the specific areas impacted. Also, it focused on participants who had already learned a language and not those who were in the process of learning a language.

There are many opportunities for further studies in this field. A specific example would be to focus on the impact that second language acquisition would have with elderly monolingual students who begin to learn a second language. As stated within this review, there are studies that have researched the difference between the brains of monolinguals and bilinguals but most of the participants were below the age of 40. There have also been studies examining bilinguals in their later years, but all these participants had learned their second language in their youth. Few studies have been done to examine effects on the cortical thickness of learning a second language on participants who are older and who had begun their acquisition while being elderly. However, these studies focused on individuals with multiple sclerosis. Would the same results be seen in this age group consisting of healthy participants? Would the same increase in cortical thickness be observed? These are the types of questions that could be answered with further research.

Methods

Participants

This study consisted of a total of 53 participants, with 30 participants in the experimental group and 23 participants as part of the control group. There was an age range of 43-80 amongst the participants who qualified and were able to participate in the study. The details regarding how participants were recruited, the exclusionary criteria key to participant selection, participant characteristics, and compensation will be detailed in the following sections.

Recruitment

The recruitment of participants was achieved through three methods: fliers, emails, and the snowball method. The flier contained a brief description of the study and the need for participants who would be willing to attend a three-month-long Spanish course (see Appendix A). The contact information for the researcher charged with recruitment was provided. Since the focus of this study was to examine adults 40 years and older, the fliers were placed in communal areas that traditionally entertained large groups of adults and senior citizens. They were also placed in areas to attract the attention of younger individuals who would have older relatives that might be interested. Such areas included the senior activities center in the Provo City Recreation Center, the Orem Senior Friendship Center, the main office of the Department of Spanish and Portuguese at Brigham Young University (BYU) and other bulletin boards located on the campus of BYU. Additionally, a standardized email was created to be sent to the researcher's acquaintances verifying if they would be willing to be part of the control or experimental group. This email also contained a brief description of the study and the need for adult participants (see Appendix B).

In the control group, 15 participants were recruited through snowballing and the majority of the control group was recruited by individuals who had originally stated that they were interested in the Spanish class but realized their schedule would not allow them to attend. They were then asked if they would be willing to be a part of the control group, a request that all 15 accepted. The remaining participants were recruited by the direct request of the researcher. Several of the initial interested individuals took the initiative to contact their friends and family to increase awareness of the study. Upon notifying their contacts, they also provided them with either the flier produced by the researcher or a forwarded email from the researcher detailing the study. These combined efforts produced a total of 120 individual responses. After collecting the necessary contact information, two introductory meetings were scheduled for all the interested parties to come and receive more details regarding the study itself. The goal of this meeting was to assure that participants met the necessary criteria in order to participate in this study.

Exclusionary Criteria and Subject Selection

The orientation meetings were held on August 20, 2019 and August 22, 2019. Combined, over 80 individuals attended these meetings. Besides providing these potential participants with the details of the study, two additional motives for the meeting were addressed. First, it was necessary to deduce if the participants met the criteria to be classified as monolinguals. Second, it was critical to ascertain that they met the psychological and safety requirements in order to have an MRI scan of their brain.

Previous to the recruitment process, the researcher had deemed it necessary to define a "monolingual participant" as an individual who had had limited exposure in learning a second language. In order to define "limited exposure" with more precise criteria, the proficiency levels created by the American Council on the Teaching of Foreign Languages were used. ACTFL's proficiency standards were chosen due to their in-depth analysis of oral and written proficiency and specific guidelines used to categorize different levels of proficiency. While an official Oral Proficiency Interview (OPI) was not administered, the descriptors from ACTFL served as guidelines to determine the proficiency of potential participants. It was determined that only those who demonstrated proficiency within the Novice level would qualify for the study. Those who demonstrated proficiency in a second language above the Novice proficiency level would be excluded from the study.

During the orientation meeting, potential participants completed a participant screening questionnaire to assess if they were monolingual and to assure that they met the safety demands for an MRI scan (see Appendix C). Individuals 39 years old or younger were not allowed into the study. Individuals were also asked to identify all languages that they spoke or had started learning during their lives. If they had learned a second language, they were asked to rate their level of proficiency. Seven individuals spoke second languages with a proficiency that would have been rated above Novice High and were excluded from the study based on their answers provided in this section of the questionnaire. This conclusion was made after brief conversations between the researcher and the participants in addition to the questionnaire. All seven that had been excluded had lived abroad for two years and had extensive experience learning and using a second language. For the rest of the individuals not excluded at this point, more in-depth questions were asked that focused on their oral proficiency and were designed to test their proficiency at the Advanced, Intermediate, and Novice levels. These questions reflected the different aspects of each level in regard to Global Tasks and Function, Context/Content, Accuracy, and Test Type.

The participants allowed to participate in the experimental group demonstrated that they could communicate minimally using rote utterances, simple phrases, and lists. One question on the questionnaire specifically asked that they list as many Spanish words as possible. Their written responses to this question were at most short and rudimentary with the vast majority not being able to write anything. Other questions were designed to test their ability to discuss common informal settings as well as common aspects of daily life. Again, these questions produced very elementary answers if any at all. Most wrote in English such answers as, “I have no idea.” or “Sorry, no hablas Spanish.”

Text type was also an extremely important factor in deducing their proficiency level. Because an Intermediate level individual would produce a string of sentences when responding to a question, the researcher created simple questions that would allow the individual to narrate at length. These questions were also mostly left blank with a few who answered with written responses that consisted of individual words and short phrases characteristic of a novice learner.

In addition to analyzing the participants' level of proficiency, the researchers included sections in the questionnaire to survey the individuals regarding their safety in having an MRI scan and an additional more in-depth screening form was used at the MRI facility (see Appendix D). This screening was of paramount importance to eliminate the possibilities of any accident or psychological adverse reaction while having an MRI scan. Therefore, anyone who had non-MRI compatible metal in their body, with examples being pacemakers or metallic particles from welding or injuries, were disqualified from participating in the study. This was due to the powerful magnetic field found in the bore and surrounding area of the MRI scanner; any ferromagnetic substance would have caused severe harm to the participant. Additional safety measures were taken to exclude individuals with permanent makeup or tattoos. Dependent on the reputable sources of inks used, individuals with tattoos could potentially have had significant amounts of ferromagnetic particles in their skin with the potential to cause bodily harm in severe cases or feelings of discomfort in minor cases. All participants with tattoos verified that they had been done at a reputable source and no one was excluded based on these criteria.

Individuals with neurological disease were also not considered as well as individuals who were left-handed, with past brain trauma, who had a diagnosed neurological condition, mood, or psychiatric disorder or who were claustrophobic. It was necessary to include these factors for the mental safety of the participants and due to the inability to accurately process the MRI scan of such individuals. A total of 8 individuals were excluded from the study based on these criteria.

Other exclusionary criteria were considered and individuals were disqualified if they were pregnant or weighed 300 pounds or more. The table carrying the participants inside the

MRI scanner itself was not capable of supporting weight exceeding 300 pounds. Additionally, individuals weighing 300 pounds or more likely would have had a bodily circumference impeding them from entering the cylindrical entrance of the scanner itself. It was also critical to assure that participants could consistently attend class and therefore attendance was taken at the start of every class. Students who missed over 10 days of class were disqualified from participating in the study. This was done based on the idea that only participants who had been exposed to the experimental stimulus could aid in accurately testing the hypothesis of this study. In total 4 participants left the study due to the aforementioned criteria, specifically due to absences.

Participant Characteristics

During the orientation meeting, when participants came to the MRI facility or in response to a Qualtrics survey, demographic information was collected in order to specify the participants' gender, age, and educational background (see Table 2). The whole group of participants, with the control and experimental groups combined, consisted of 39 women and 14 men. This contrast was more severe when only observing the experimental group where only 3 of the participants were male and 27 of the participants were female. The control group demonstrated a more equal distribution of the sexes with 12 being female and 11 being male. The age range was also significant with the youngest participant being 43 years old and the oldest participant being 80 years old. When examining the groups individually, the experimental group had an average age of 58 while the control group had one of 56. The age range for the experimental group was 43 years old to 80 years old and the range of the control group was 45 to 76. While all of the participants in the experimental group were classified as Novice level speakers, there were four participants in the control group who were bilingual even though none of them were enrolled in a language course during the time of the study. More differences could be seen in the educational background of the participants. Overall, almost half (42%) of the participants in both the control and experimental groups had completed a 4-year degree. In addition, 30% of the participants had completed a professional degree with another 19% having completed some college and 9% having completed a 2-year degree.

In the control group, 39% of the participants had completed a professional degree whereas only 22% of the participants in the experimental group had. Additionally, 43% had completed a 4-year degree in the control group and 40% had in the experimental group. The control group also had 9% who had completed a 2-year degree while 10% had in the experimental group. The remaining category showed only 9% in the control group had only some college while 28% had in the experimental group.

Table 1

Demographic Findings

	Whole Group	**Experimental**	**Control**
N =	53	30	23
Gender	• Male: 14 (26%) • Female: 39 (74%)	• Male: 3 (10%) • Female: 27 (90%)	• Male: 11 (48%) • Female: 12 (52%)
Age	• Range: 43-80 • Mean: 58 • Mode: 60	• Range: 43-80 • Mean: 58 • Mode: 58	• Range: 45-76 • Mean: 56 • Mode: 56
Education	• Some college: 10 (19%) • 2-year degree: 5 (9%) • 4-year degree: 22 (42%) • Professional degree: 16 (30%)	• Some college: 8 (28%) • 2-year degree: 3 (10%) • 4-year degree: 12 (40%) • Professional: 7 degree (22%)	• Some college: 2 (9%) • 2-year degree: 2 (9%) • 4-year degree: 10 (43%) • Professional degree: 9 (39%)

Participant Compensation

Both the participants in the experimental group and the control group had the option to receive $20 should they wish. In addition to attending a Spanish course free of charge, participants in the experimental group were also granted permanent access to all materials utilized in class for future reference.

Instruments

Screening Questionnaire

As previously stated, the sources for the questions in this form were from the standard MRI facility screening form as well as the proficiency standards set forth by ACTFL (see Appendix D). This was to ensure that participants could safely participate in an MRI scan and would be considered monolingual according to the before mentioned criteria. The most critical questions from the MRI screening form were inserted into this questionnaire to immediately detect disqualifying neurological factors or major concerns regarding the safety of the participants having an MRI scan. Regarding the questions connected to determining the students' monolingual state, they were formed in close connection with the ACTFL's proficiency standards (see Figure 1).

ACTFL characterizes a Novice level of proficiency in a second language when the individual communicates minimally with formulaic and rote utterances and uses lists and simple phrases. The context in which they can maneuver with the target language deals with the most common aspects of daily life and, when it comes to text type, they can only produce individual words and phrases. The questions focusing on proficiency on this form, therefore, were carefully chosen to allow potential participants the opportunity to demonstrate proficiency at this level and beyond. The questions granted individuals the chance to exhibit proficiency at the Intermediate level by creating text types with discrete sentences and focusing on content revolving around predictable and familiar topics related to daily activities.

Figure 1

ACTFL's four levels of proficiency (ACTFL 2012)

Proficiency Level	Global Tasks and Functions	Context/Content	Accuracy	Text Type
Superior	Support opinions, hypothesize and deal with topics abstractly.	Most formal and informal settings.	Errors virtually never interfere with communication or distract the native speaker from the message	Extended discourse
Advanced	Narrate and describe in major time frames and deal effectively with an unanticipated complication.	Most informal and some formal settings.	Understood without difficulty by speakers unaccustomed to dealing with non-native speakers.	Paragraphs
Intermediate	Create with language, initiate maintain, and bring, and bring to a close simple conversation by asking and responding to simple questions.	Some informal settings and a limited number of transactional situations.	Understood with some repetitions by speakers accustomed to dealing with non-native speakers.	Sentences
Novice	Communicate minimally with formulaic and rote utterances, lists and phrases.	Most common informal settings.	May be difficult to understand, even for speakers accustomed to dealing with non-native speakers.	Individual words and phrases

MRI Scanning

A 3T Siemens TIM Trio MRI scanner (Erlangen, Germany) with a 32-channel head coil at the BYU MRI Research Facility was used to produce a structural MRI scan of the brain of each participant. Structural scans used a T1-weighted MP-RAGE sequence with the following parameters: TR=1900ms; TE=2.26ms; acquisition matrix: 215 × 256; field of view=218 × 250mm; slice thickness=1.0mm; voxel size=.977 × .977 × 1.0mm; flip angle=9°; and number of slices=176; GRAPPA factor=2. All MRI scans were imported from DICOM to NIfTI file format using program dcm2nii (v. 1JUNE2015). As part of the file conversion process, structural scans were reoriented to the nearest orthogonal using rigid-body transformation and extraneous field of view was cropped. Structural scans were further processed using the FreeSurfer. This brain imaging software produced a cortical reconstruction as well as volumetric segmentation. Additionally, the software was able to remove the imaging of non-brain tissue through the utilization of a hybrid watershed/surface deformation procedure (Segonne et al., 2004), automated Talairach transformation, segmentation of the subcortical white matter and deep grey matter volumetric structures (including hippocampus, amygdala, caudate, putamen, ventricles) (Fischl et al., 2002) intensity normalization (Sled et al., 1998), tessellation of the grey matter white matter boundary, automated topology correction (Fischl et al., 2001; Segonne et al., 2007), and surface deformation following intensity gradients to optimally place the grey/white and grey/cerebrospinal fluid borders at the location where the greatest shift in intensity defines the transition to the other tissue class (Dale et al., 1999; Fischl & Dale, 2000).

Upon the reconstruction of these images, additional procedures could be executed for further analysis such as surface inflation registration to a spherical atlas which is based on individual cortical folding patterns to match cortical geometry across subjects, parcellation of the cerebral cortex into units with respect to gyral and sulcal structure (Desikan et al., 2006) as well as creating a myriad of surface-based data which included sulcal depth and maps of curvature. This process entailed using the continuity information and intensity from the three-dimensional MR volume in segmentation and deformation procedures in order to create representations of cortical thickness. This was achieved through calculating the closest distance from the grey/white boundary to the grey/CSF boundary at each vertex on the tessellated surface (Fischl & Dale, 2000). The maps were created by using spatial intensity gradients across tissue classes and are therefore not simply reliant on absolute signal intensity. The maps produced are not restricted to the voxel resolution of the original data and thus are capable of detecting submillimeter differences between groups. Procedures for the measurement of cortical thickness were validated against histological analysis (Rosas et al., 2002) and manual measurements (Kuperberg et al., 2003; Salat et al., 2004). Freesurfer morphometric procedures have been demonstrated to show good test-retest reliability across scanner manufacturers and across field strengths (Han et al., 2006).

Language Course

The experimental group attended two different 3-month long Spanish classes which were taught on the campus of Brigham Young University. Due to the large number of students and their complicated schedules, two sections of the class were created with one class being taught at 10:00am and an evening class being taught at 5:00pm. The class met on Monday, Tuesday, Wednesday, and Thursday with each class period lasting for 50 minutes. The instructor made every effort to speak Spanish for the entire duration of the class but would resort to English in the case that students requested that he clarify certain points. The daily routine consisted of a brief welcome to the class, a warm-up activity, addressing new material, which was then followed by presentational, interpersonal, and interpretive based activities lasting the rest of the class period (ACTFL 2012).

The welcome phase of class would begin with the instructor welcoming the students to class and then a brief inspirational thought would be shared by one of the students in the target language. The welcome and inspirational thought would last for 5 minutes. The instructor would then assign the students to speak in pairs with a speaking prompt that reflected the material covered the previous day. These warm-up activities would usually last 5 minutes. Next the instructor would spend 10 minutes discussing new grammar principles or would focus on the culture found in different Spanish-speaking countries. The textbook, *Unidos* second edition, published by Pearson, was used as a reference for the grammatical and cultural instruction of the class. Appendix E contains the course expectations including topics covered, classroom locations as well as links to class materials.

After new material had been covered in class, the remaining 35-40 minutes were utilized to implement the use of said material through presentational, interpersonal, and interpretive based activities. There was a strict 'No English rule' enforced in class and students were not allowed to speak English unless they had been given permission by the instructor. Exceptions to this rule included students asking how to say specific words in Spanish. Students could raise their hand at any time and ask, "¿Cómo se dice________en español?" The instructor would then provide the student with the word in the target language. During the first week of class, students struggled to remain in Spanish and obey the 'No English' rule, but by the second week complied without issue.

Before the conclusion of each class, students would be given an assignment to take home. All assignments and Power Points used in class were also shared with students via Google Drive so that they could access the material for review at any time. They were also able to access the Power Points for future lessons so that they could prepare for the lesson.

Data Analysis

Thickness measurements of the entire brain was derived with FreeSurfer were resampled into three-dimensional NIfTI volumes using FreeSurfer program 'mri_surf2vol'. The original structural scans and thickness measurements were then normalized to the MNI152 template using the following Analysis of Functional NeuroImages (AFNI) programs: '@SSwarper' to skull strip the structural scan and calculate a warp from original subject space to template space and ‘3dNwarpApply’ to apply the warp to template space to the thickness measurements. A mask of the cortical surface was created by averaging together the cortical thickness maps across all subjects and then thresholding at 85% overlap. Smoothness of the maps was estimated using program ‘3dFWHMx’ and smoothness parameters were entered into program ‘3dClustSim’ to perform Monte Carlo simulations for multiple comparisons correction, which indicated a voxel-wise threshold of $p<.001$ and a spatial extent threshold of $k=59$ contiguous voxels (nearest neighbors’ level 2) for an overall group-wise $p<.05$. Group analyses were performed with program ‘3dMVM’ which performed a repeated measures ANOVA with timepoint (pre, post) as a within-subjects factor and group (control, experimental) as a between-subjects factor.

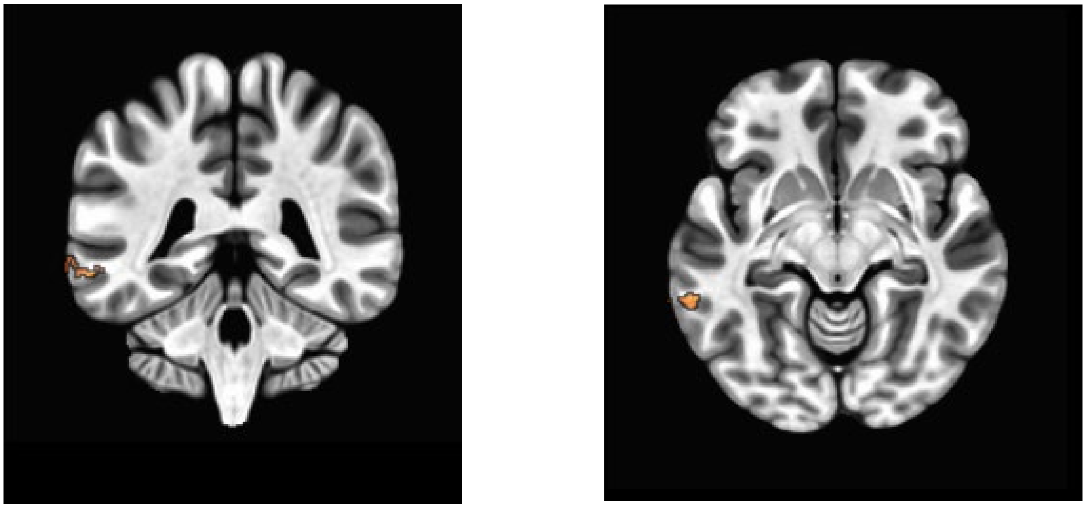
Results

MRI Results

The analysis examined every area of the brain attempting to locate any region that exhibited changes in cortical thickness. Using the multiple comparison thresholds determined in the Monte Carlo simulation, no significant clusters were found. Doing an exploratory analysis with a more liberal threshold combination (voxel-wise threshold of $p<.05$ and spatial extent threshold $k=150$) revealed a small cluster in the left middle temporal gyrus (see Figure 2).

Figure 2

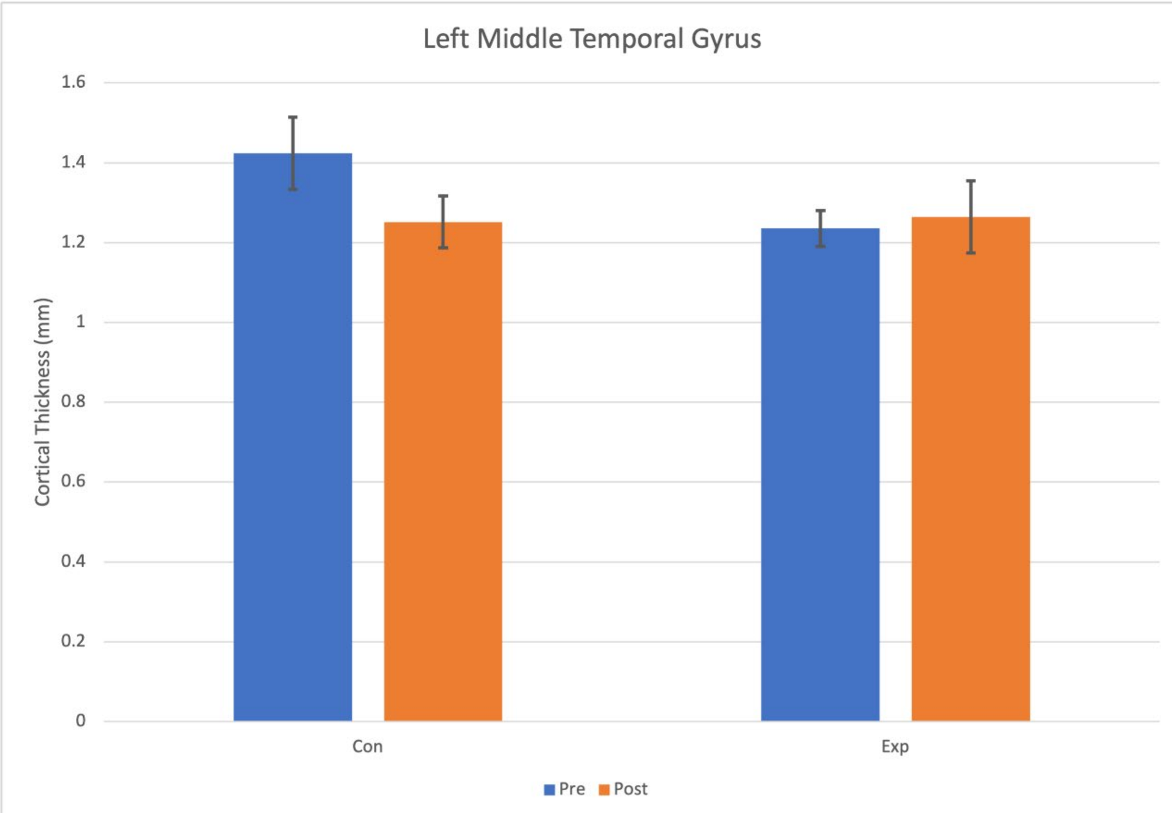
Observable clusters found in the left middle temporal gyrus.



In Figure 2, the orange irregular shaped areas represent the cluster that demonstrated the changes in cortical thickness. This cluster is comprised of several voxels which are 3-dimensional units that embed the signals in the brain's scans, focusing on each dimension of the brain millimeter by millimeter rendered into visual form. Each voxel itself has the potential to represent around a million brain cells. When comparing the results of this cluster between groups, the control group experienced a decrease in cortical thickness while the experimental group experienced an increase in cortical thickness (see Figure 3).

Figure 3

Cortical thickness measurements of left middle temporal gyrus



At the commencement of the study, the control group had a cortical thickness average of 1.42, measured in millimeters. After the 3-month period and conclusion of the class, the control group's second series of MRI scans produced a group average of 1.25 mm. This indicates that the control group experienced an 0.17 mm reduction in cortical thickness in the Left Middle Temporal Gyrus. While the control group experienced a decrease in cortical thickness in this region, the experimental group displayed an increase in thickness. This group produced a cortical thickness average of 1.24 mm from the scans collected before the study. Upon completing their scans after the end of the Spanish class the group average had changed to 1.26 mm indicating an average 0.02 mm increase (see Figure 3). Again, these changes were only observed upon the utilization of a more liberal threshold and should be viewed as exploratory.

Discussion

The purpose of this study was to examine the effect of a three-month-long language course on the cortical thickness in the cerebral cortex of the brain of students over the age of 40. It was hypothesized that the comparison of pre and post MRI scans would reveal an increase in cortical thickness in the monolingual students when compared to the control group who did not study a language. Initially, a small cluster was observed in the Left Middle Temporal Gyrus that did indeed show an increase in cortical thickness of the experimental group and a decrease in cortical thickness of the control group. While it could not be disproven that this cluster was produced by random chance alone, these results are still important and can serve as a basis for future longitudinal studies.

Implications of Stress and Second Language Acquisition

The small size of the cluster observed in the experimental could be attributed to several variables. It should be considered how the effect of stress could potentially have impacted the results. Several students in the experimental group at the beginning of the study shared that they were very stressed with the pace of the course and were also feeling anxious. Some mentioned that the beginning of the course caused them to feel anxiety that they had not felt since they had been enrolled in courses during their time at college. In total, three students left the study citing this stress as their reason for leaving. This is significant since stress has been known to negatively affect learning. Schwabe and Wolfe (2010) found profound memory impairment in participants that were stressed during learning. They focused on 48 healthy young men and women; 24 were part of the experimental group that were placed in a stressful environment while the other 24 acted as a control and were placed in an environment without the stressful conditions imposed upon the experimental group. Both groups were given 32 words to memorize. The control group outperformed the experimental group and the researchers concluded that learning under stress reduced both free recall and recognition performance by more than 30%.

The cited stress experienced by students in this study caused the researcher to change and reduce the workload to avoid impacting their learning experience. The researcher eliminated several assignments and slowed the pace of the class. Consequently, only 75% of what the researcher initially intended to cover in the course was taught. While complaints of stress were mitigated, students still continued to express being stressed occasionally from participating in the course. It is a reasonable concern that the stress and anxiety experienced in the class could have negatively impacted the results. This is especially the case if one considers the findings of Ansell et al. (2012) demonstrating how stress can negatively impact brain volume. A more stress-free structure combined with a longitudinal study would perhaps produce more accurate data. The class could utilize activities and assessments designed to avoid eliciting stressful memories from students' past academic experiences.

Implications for Language Acquisition and Cognitive Benefits

The results of this study seem to support the ideas expressed by De Bruin et al. (2014) and Paap et al. (2015) that MRI studies have only made a modest contribution to evaluating the advantages of second language learning. While an initial cluster had been observed in the scans of the experimental group that had learned Spanish for 3 months, it could not be proven that this cluster was not a result of random chance.

This study also does not support nor negate Bialystok's et al. (2007) idea that language learning has the potential of combating neurological disease such as dementia. Some evidence was produced that learning a language later in life appears to have a positive impact on cortical thickness. Although these results are not definitive, they do suggest that a longitudinal study might show significant results. The distinction should also be made that this study dealt with the comparison of monolinguals learning a second language that lasted only 3 months. Bialystok dealt with participants who were defined as bilingual and proficient in both languages. In order for this study to fairly counteract or support Bialystok's claims, the participants would need to participate in a more longitudinal study, lasting the space of years in order to reach the level of proficiency necessary to be considered bilingual. This type of study might produce results in favor of Bialystok's claims for bilingual advantages.

Additional research could add much needed clarity to this field. Previous researchers like Bialystok et al. (2007), De Bruin et al. (2014) and Paap et al. (2015) all failed to examine individuals who had become bilingual past the age of 40. This study serves as a start to combatting these limitations as it dealt with participants above the age of 40. However, in order to add to this field, additional studies should be conducted with participants above the age of 40 who start learning a second language and carry on for an extended period of time. Their results could then be compared to those observed in Bialystok's studies to see if they experience the same supposed benefits.

Implications for Practice

In order to produce more reliable future studies and to make classes that are more conducive for those learning above the age of 40, the following several items should be considered. The curriculum should revolve around different teaching methodologies to ensure long term memory retention of the material. The material itself should be themed towards students in this older demographic reflecting their interests and motivations for learning. The pace at which the material is taught should also be reassessed and a more detailed approach focusing on creating a better learning environment for this age group should be addressed. This would produce a more reliable class structure to teach older students and thereby measure how second language acquisition impacts the adult brain.

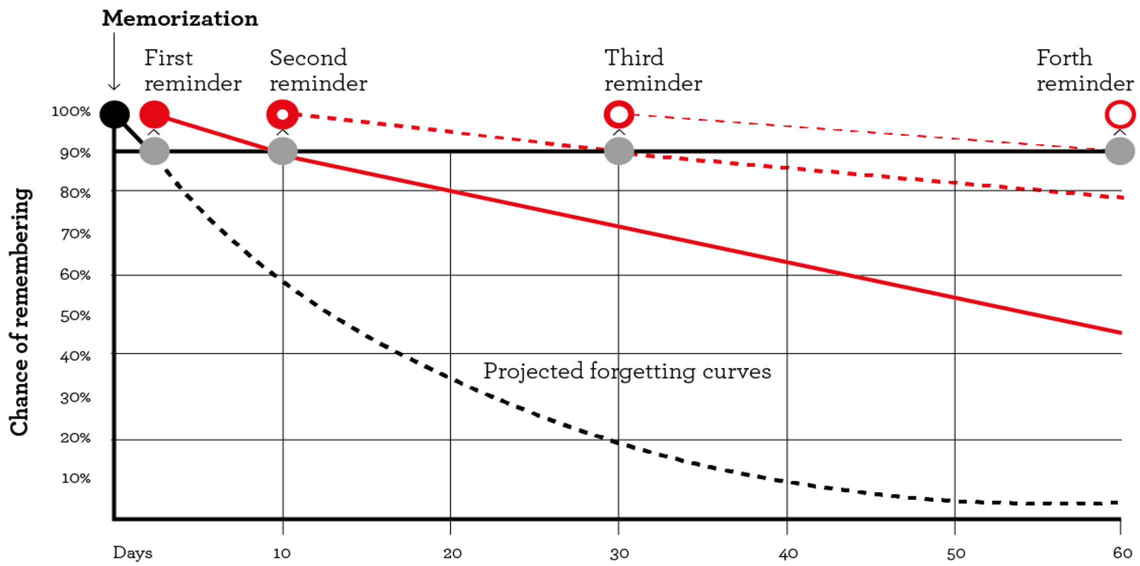
Curriculum and Spacing Effect Integration

One of the biggest concerns that the participants in the experimental group had was that they would forget what they had learned during the previous week. Often the researcher had to postpone the presentation of new material because it was evident that the students required additional time to fully understand what they had learned from previous weeks. It became obvious that the researcher would not be able to present topics one week in class and expect his students to remember the material unless there was some system of review. It would be of great benefit to integrate a system of review throughout the curriculum to help students in this age demographic internalize the material into their long-term memory instead of momentarily helping them understand small units of information temporarily only to be forgotten the following week.

One method to increase retention that could be used in teaching a second language is the Spacing Effect method. The American Psychological Association (APA) defines this approach as a cognitive phenomenon in which disturbing to-be-learned information across time in short, interrupted study sessions leads to better long-term retention than continuous massed sessions (see Figure 4).

Figure 4

Spacing Effect Model



These study sessions usually involve reviewing information after an hour, then a day, then every other day, then weekly, then monthly, then every six months and then yearly. This system of review could be fully automated via technology to eliminate an excessive amount of time that would otherwise be needed to plan and distribute the necessary review sessions amongst the curriculum. For future studies focusing on how learning a second language impacts the brain of adults, a curriculum could be created using this type of review to increase the validity of the study. If students are not retaining what they have studied, it could be argued that they are not truly learning.

Bahrick et al. (1993) conducted a study that showed just how effective the Spacing Effect model can be. They conducted a longitudinal study that lasted nine years that focused on four participants who were taught using this method. These individuals learned and relearned 300 English-foreign language word pairs. According to Bahrick et al., the results rendered by this study showed that extended retrieval practice of foreign language vocabulary yields large retention benefits over a five-year period following the termination of practice and that these benefits are greatest when the intervals between retrieval sessions are 2 months or longer. While these results are very promising, there are some concerns that should be addressed. The researchers state that it would be important to establish whether these benefits extend beyond the five-year period under observation and whether they also apply to content knowledge that is more complex and integrative than individual word pairs. This is a valid statement since learning a language is far more complex than simply memorizing vocabulary. It would be fascinating to examine the introduction of grammatical concepts and how their utilization was retained by conducting extended retrieval practice of these concepts where students have to produce spontaneously in the target language. In developing a course specifically for older adults learning a second language, researchers could create a curriculum that reviewed more than just vocabulary and included review for certain cultural and grammatical themes.

Another limitation that Bahrick et al. (1993) readily admits is that memory experiments require control of the conditions of acquisition and such controls are manageable in laboratory sessions lasting up to a few hours. However, they did not view this as possible when examining acquisition and retention extended over several years and that to investigate the maintenance of knowledge over long time periods, it is necessary to accept diminished control over some conditions.

One strength of Bahrick et al. (1993) research that is relevant to this study is that two of the participants were older adults with two being age 57 at the beginning of the study. This might suggest that similar results could be observed in the participants that participated in this study had they been given a curriculum structured with the Spacing Effect. This idea would be of benefit to other researchers or instructors looking to design curriculum for students above the age of 40. It might also be of interest to instructors with younger students. Bahrick et al. also made a critical point in their study when they stated that present curricula make few provisions for periodic retrieval practice of previously acquired knowledge. Most textbooks present information sequentially and do not offer opportunities for periodic review. This is also reflected in the classroom with teachers that follow the format of the textbook. This is understandable due to the fact that developing a curriculum with the integration of the Spacing Effect is far more complicated and time consuming than developing one that is simple and sequential in nature. However, based on the finding from Bahrick et al., it would be far more beneficial for students.

One final point that should be made regarding the Spacing Effect, is its relevance to this study. Implementing this type of approach in further studies examining how second language acquisition impacts cerebral matter could increase the validity of said study. The Spacing Effect might assist in students actually remembering what they learn as opposed to understanding a concept one week and forgetting it the next. This could also impact the MRI results of such a study since memorization and retention has been found to impact cortical thickness (Engyig et al., 2010).

Motivation and the language learning environment

Another item that should be addressed is the motivation demonstrated by students in this study. The researcher noted that they exhibited a great motivation to learn. This was a valuable observation and if this type of motivation were nurtured, it could help increase the quality of learning of older students and increase the validity of future studies focusing on second language acquisitions in older students.

In the book entitled *Teacher's handbook: Contextualized language instruction*, Shrum and Glisan (2016) state that second language acquisition can only occur in the presence of certain affective conditions, such as when the learner is motivated, self-confident, and has a low level of anxiety. Csizer and Dörnyei (2005) support the importance of nurturing motivation but also add that motivation and attitudes are often connected with anxiety and fear of language learning experience. While motivation is an important component in successfully acquiring a second language, managing the anxiety and fear of students is also of paramount importance. While instructors should try to attempt this with all students, one is faced with a unique set of variables when trying to accomplish this with a class comprised of students above the age of 40. The researcher in this study found this to be the case and made several observations that might help in developing classes specifically for older students.

In general, motivation is very important when it comes to learning a second language. Dörnyei and Skehan (2003) state that motivation is the most influential factor in successfully learning a new language. Other researchers such as Gardner and Lambert (1972) have identified two main ways to categorize students' motivation for learning a second language. One category is instrumental motivation, which entails learning a second language because it is a requirement or encouraged in an academic or professional environment. The other category is integrative motivation that represents learners who wish to learn the language for human connection. They want to know the people who speak the language and create bonds with them. Gardner and Lambert suggest that language learners who are integratively motivated are more successful than those who are instrumentally motivated. This offers very promising possibilities in a class for adults over the age of 40. In this study, many participants in the experimental group informed the researcher in conversation of their integrative motives for learning a language. Students with this type of motivation could be very successful with the language should their motivation be nurtured correctly.

Dörnyei and Skehan (2003) also advocate the use of certain strategies for decreasing anxiety such as integrating pair and small groups, providing opportunities to plan responses and rehearse before performing, personalizing language tasks, using personal meaningful tasks and materials to appeal to students interests and providing a non-threatening environment. These recommendations seemed even more important to the instructor when teaching students of an older demographic. The students functioned very well when placed in pairs or in small groups. When students were challenged to work together as a whole class, very little participation was observed. The instructor also observed that when students were randomly called upon to answer questions, students appeared nervous and would often not respond. The instructor concluded that students in their class should not be called upon at random at any point. If questions were presented to the whole class, the instructor would ask for a volunteer.

Students greatly appreciated the opportunity to plan their response and rehearse before performing. One idea for future classes would be to schedule speaking appointments for students outside of class with classmates. Prompts could be provided to guide the students' conversation while still allowing for spontaneous production. This would allow students to prepare their responses beforehand and to rehearse before performing. Another idea would be to provide students with the Power Points before class so that they could view the type of speaking activities that would be conducted in class so that they could prepare beforehand. This would potentially lower stress through increased preparation and could theoretically increase the cortical thickness at an accelerated rate.

In addition to providing students with opportunities to plan responses and rehearse before performing, the instructor should personalize language tasks, using personally meaningful tasks and materials to appeal to students' interests in this age demographic. One way to do this would be to give students assignments that focus on establishing human connections, thus supporting integrative motivation. An example of this would be to assign students ethnographic interviews where they could meet with a native speaker of the target language and ask them questions connected to one specific cultural theme. To continue to engage in these types of interpersonal activities, students could also meet with a native Spanish speaker and learn to cook an authentic meal. Additionally, any assessment utilized in class could be connected to authentic materials from the target language's culture and related to these themes to further engage students.

Another way to nurture the motivation of these students would be to adjust the type of textbook utilized in class. One observation that the instructor made when teaching the course was the disconnect between the students and some of the references from the textbook. Some of these pop culture references reflected the interests that would have been more typical of university students in a younger demographic. A classroom created for students in an older demographic should contain themes connected to their interests. Harackiewicz et al. (2016) discuss the importance of eliciting students' interest in the class. They stated that interest is a powerful motivational process that energizes learning, guides academic and career trajectories and is essential to academic success. They promote attention-getting settings, contexts evoking prior individual interest, problem-based learning and enhancing utility value. They claim that promoting interest can contribute to a more engaged and motivating learning experience for students. To promote this type of learning experience, future curriculum could be created with themes that would be of interest to students in this targeted age demographic. A series of surveys could be utilized to ascertain the most common themes of interests. These themes could then become the focus of specific units used in teaching the material. The instructor could try to find a textbook with these types of interests. If unsuccessful, then perhaps the development of a textbook with these themes, combined with the utilization of the Spacing Effect, would be needed to support students' interests.

While the before mentioned ideas will aid in developing a better suited class for older adults, perhaps the most important observation that the instructor made was guaranteeing a non-threatening environment for their students. It would be wise for future classes to focus on the input hypothesis developed by Krashen (1987). This hypothesis suggests that acquisition occurs only when learners receive an optimal quantity of comprehensible input that is interesting, a little beyond their current level of competence and not grammatically sequenced but understandable using background knowledge, context and other extralinguistic cues such as gestures and intonation. This hypothesis is usually represented as *i*+1, where the *i* refers to the current competence of the learner while +1 refers to the next stage in the student's acquisition. Determining input that would be ''a little beyond the student's current level'' was very difficult and the instructor had to take extreme care not to present the students with material at a level that was too far above their current knowledge and language abilities. Doing so caused students to be anxious and intimidated by what they were learning. New principles had to be introduced more gradually when compared to the instructor's university classes with younger students. As opposed to focusing one week on certain concepts, three of the concepts (present tense conjugations, direct and indirect object pronouns) required an extra week for additional instruction. Learning about present tense conjugation initially demanded more time than anticipated and presented the learners with several gaps in their knowledge; gaps that initially made them extremely uncomfortable. The inclusion of an extra week to focus on the topic eliminated the students' frustration. Although the instructor had taken several measures to assure proper scaffolding in preparation for this topic, further, and more in-depth, scaffolding would have been beneficial. This could have been achieved by focusing on the structural differences students had observed between the conjugations of the verbs *ser* and *estar* and then drawing connections to other verbs before identifying the conjugation partners observed with -*AR*, -*ER* and -*IR* verbs.

The instructor also identified certain activities that caused students to feel vulnerable, anxious, and frustrated. Traditional assessments consisting of multiple-choice questions had to be eliminated altogether. In total, eight students confessed that such tests triggered memories of the stress students experienced in high school or college and distracted students to the point where they could not focus. It also caused them to be worried when learning new material since they focused more on how they would be tested on the concept instead of how they would be able to converse with the topic. It would be more beneficial for this age group to be assessed using Integrated Performance Assessments (IPA). This IPA format would allow students to still be assessed in their interpretive, interpersonal and presentation capabilities in the target language, while avoiding the stress they experience in a traditional exam. These assessments also have the potential of being administered without the students realizing they are being assessed.

All of these recommendation and implications of practice could greatly serve to increase the quality of future classes designed for learners above the age of 40. This would be important in order to provide a positive learning environment for students. Without an environment conducive to the learning of an older demographic, a limited amount of learning would take place. If the learning of a second language is not taking place, then how could future studies examine the impact second language acquisition on the adult brain?

Limitations

One limitation of this study that should be addressed was the intensity of the course. A more intensive course might have yielded more observable results with the scans of the participants. It was the goal of the instructor to conduct the class with the same degree of intensity as displayed in his other sections of the same university level class. This would have entailed more daily assignments, weekly speaking appointments between students outside of class, and group projects. After the completion of the preliminary week of class, eight students told the instructor they were considering leaving the class due to the workload and because of the pace at which the class was taught. These factors proved to be very intimidating to these eight participants and their motivation to participate in the study was negatively impacted. It had originally been the goal of the instructor to teach this class in complete synchronization with his two Spanish 101 classes that were taught at Brigham Young University with the same assignments and at the same speed. It was soon apparent this this would not be possible. Concepts in the experimental class were not understood at the same speed and students stated that they were struggling with the amount of material being covered as well as keeping up with all the assignments. To reduce potential attrition, the instructor decreased the amount of homework, eliminated several assignments, and slowed the pace at which the course was taught. No attrition occurred following these changes. While this resolved the issue of attrition, it potentially could have impacted the results of the MRI scans. The researcher was concerned that the reduction of intensity could have directly impacted the observable structural changes seen in the MRI scans. Engvig et al. (2010) suggest that a certain amount of mental stimulation must take place for neural pathways to be formed that eventually will cause an increase in cortical thickness. For this reason, participants in that study had undergone an intensive memory program that helped yield results in the short period of eight weeks. It is possible that the class connected to this study did not provide the necessary mental stimulation or demand to illicit significant changes. It would have been wise to create a completely new curriculum for this class instead of the instructor using the curriculum that had been previously used for their young students enrolled at BYU. In addition, a different curriculum could have reflected the interests and learning styles of these older participants.

Another limitation was the limited duration of the study. The experimental group participated in their Spanish class for a period of three months. While other studies such as Klein et al. (2014) and Engvig et al. (2010) produced results in three months and in eight weeks, it might have been beneficial to focus on creating a longitudinal study consisting of a year that could potentially have increased the likelihood of obtaining significant data.

Another limitation in this study is that both the experimental group and the control group were extremely heterogenous in the participants' gender, ethnicity, socioeconomic status, and age. Originally the study intended to focus solely on students above the age of 70 in an attempt to examine the impact of second language acquisition on the elderly. This age threshold soon became problematic as it drastically reduced the number of interested participants. Had the original age threshold remained in effect there would have been a total of four participants with two individuals in the experimental group and two in the control group. The minimum age range was modified and lowered to 40 years of age. The age change still functioned with the focus of the study since continual atrophy of the brain is experienced from the age of 30. The change also caused a heterogenous effect in the genders of the participants. When the age requirement was lowered, many female participants joined the study. Many of the participants who self-identified as homemakers were able to attend the class because it did not conflict with their schedules. In total, 15 men were not able to take the class because it conflicted with their work schedule when they otherwise would have qualified. It was not an option to create a class at a later time in the evening to accommodate more participants due to the instructor's schedule. Due to these complications, the majority of participants in the experimental group were female while there was a significantly greater percentage of men that participated in the control group. The 15 men who were not able to attend the class due to their work schedule agreed to participate in the control group and completed their MRI scans on a Saturday. Future studies might have a class taught in the late evening in order to avoid a female dominant experimental group and a male dominant control group.

One last limitation that is a concern is that of the language background of individuals participating in the control group. There were 4 individuals in the control group that were bilingual or who had extensively studied a foreign language. It would have been beneficial to have a control group that was entirely monolingual in order to compare a monolingual control group to a monolingual experimental group. Instead, the control group's main identifying factor was that they did not participate in a language course whereas the experimental group did.

Recommendations for Future Research

There are several opportunities for future research connected with this study. As mentioned previously, several individuals were excluded from this study due to neurological disease. One such disease was multiple sclerosis. MS results in severe reduction in cortical thickness and grey matter volume in general. If language acquisition can counteract this reduction, it would be beneficial to focus entirely on a group of participants suffering from MS to observe how learning a second language might potentially assist in combating the severe atrophy they experience.

In connection to the previously mentioned limitations to the study, it could be beneficial to conduct a longitudinal study spanning over the course of one year to see if the increase in time dedicated to acquiring a second language would have more of an impact on increases in cortical thickness. The curriculum for the course could be redesigned to be better suited for older students, designed around their interests and motivations. Multiple MRI scans would be conducted with one at the beginning of the study, a second in the middle and a third at the end.

Another recommendation would be to focus specifically on rating the proficiency of the students at the beginning of the class as well as at the end. While this study focused on any potential change in cortical thickness, it did not access the students' proficiency at the end of the class to see how students had improved. It would be beneficial to conduct an Oral Proficiency Interview (OPI) to see what correlations could be seen with increases in oral proficiency and cortical thickness.

One area that might provide immediate benefit would be to conduct a vertex-wise analysis with the MRI scans produced from this study. This might have provided greater sensitivity in order to detect changes between the pre and post MRI scans.

One last recommendation would be to conduct studies with a more homogenous population dealing with participants with an older age average as well as a tighter age range. Since the goals of these types of studies is to examine an older population it would also be beneficial to set the age threshold of 60 or higher.

Conclusion

This study showed that second language acquisition has the potential to increase cortical thickness. An observable cluster was observed that showed the control group experienced a decrease and the experimental group an increase in cortical thickness. While the increase in this cluster did not reach significance after a test for multiple comparisons, the results and methodology of this study can serve as a guide for further exploration of how second language acquisition can impact the adult brain.

Future studies targeting this same area will still be of great worth. With all the studies that contradict each other regarding the potential cognitive benefits experienced by those learning a second language (Bialystok et al., 2007; De Bruin et al., 2014; Ware et a., 2020), future research will be necessary to solidify conclusive evidence that disproves or supports this idea. Additional longitudinal studies would be necessary combined with a more well-balanced curriculum that reflects students' interests and assists them to retain what they learn long-term. While the integration of the Spacing Effect into this curriculum would be labor intensive, it could benefit future students and add emphasis in the field of education on students' learning and retaining what they learn. Curricula designed towards these older learners will also help the world of academia focus on these students, a population of students who are consistently overlooked.

Future research should also make sure to focus on older participants and those in the geriatric community. Potential cognitive benefits would be relevant to this demographic that deals with constant atrophic conditions of the cerebral tissue resulting in cognitive decay as time progresses. This is demonstrated by cases of dementia and Alzheimer's that cause a severe reduction in grey matter and lead to a variety of cognitive problems. These issues drastically reduce the quality of life experienced by those suffering from the disease who often spend their remaining years in search for medical solutions that might grant reprieve. As a result, if learning a second language still has the possibility to produce structural changes linked to cognitive benefits in adult students, then researchers have only skimmed the surface and must continue to explore this frontier.

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Appendix A

Recruitment Flyer

Research Participants Needed to Learn Spanish!

Where: **BYU Campus**
When: **Monday-Thursday**

Cost: **FREE!**
Duration: **Sept-Nov**

The Research

Studies suggest that learning a foreign language offers cognitive benefits. This study focuses on the impact learning a second language has on the adult brain. All students would receive an MRI scan should they choose to participate after having completed a complementary Spanish course.

The Spanish Course

Participants would attend a free introductory Spanish class designed specifically for adults that would be held in conjunction with this research currently being conducted at Brigham Young University. No official credit would be received upon completion.

If interested contact

Ben Jorgensen at
jorgensenbyu206@gmail.com or
509-760-3346
for additional information.

Appendix B

Recruitment Email

Dear______,

I am organizing a study that focuses on the impact learning a second language has on the adult brain. I am looking for participants who would attend a 3-month long Spanish course for free. Class would be held at least three times a week in the evening on BYU campus. During the study you would have two MRI scans of your brain to see if any physical changes could be observed upon completion of the course. Would you be interested in participating in this study? Please feel free to reach out to me for more information.

Sincerely,

Ben Jorgensen

Appendix C

Screening Questionnaire

Screening Questionnaire

1. What is your Last name?

2. What is your First name?

3. What is your date of birth?

4. What is your email?

5. What is your phone number?

6. What is your gender?

7. Do you speak any foreign language?

8. Have you ever taken a foreign language class, if so for how long did it last and in what year did you take the class?

9. Would you rate yourself as a novice, intermediate or advanced speaker of Spanish and why?

10. For the duration of 1 minute; write as many Spanish words as you can.

11. Please answer the following questions in Spanish to the best of your ability in complete sentence. Please do not use a Spanish dictionary or any other translation tools or resources. If you do not understand the question you may leave it blank.

¿Cuál es tu nombre?

¿De dónde eres?

¿Cómo eres?

¿Cómo es tu familia?

¿Cómo es tu rutina diaria?

¿Qué hiciste ayer?

¿Qué vas a hacer mañana?

12. In the space provided please describe and recount a memory from your childhood all in Spanish to the best of your ability. Please only write using Spanish.

13. Are you right or left handed?

14. Have you had a traumatic brain injury where you lost consciousness?

15. Have you been diagnosed with a neurological condition?

16. Do you have a permanent retainer or braces?

17. Have you ever been injured by a metal object or foreign body (e.g., bullet, BB, shrapnel)?

18. Have you ever worked with metal (e.g., welder, grinder, fabricator) or ever had an injury to the eye involving a metallic object (e.g., metallic slivers, shavings, foreign body)?

19. Is there anything in your body that you were not born with? (e.g., pacemaker, metallic implants, IUD, etc.)

20. Would you take the morning or evening class?

Appendix D

MRI Screening Form

BYU MRIRF Screening Form

All information is held in confidence and will not be part of any aspect of the study for which you are participating.

Brigham Young University
Magnetic Resonance Imaging Research Facility
Tel: (801) 422-9420

Name (first, middle, last): ____

Today's Date: ___ / ___ / ____ (mm/dd/yyyy)   Time: ____:_____ (am) (pm)

Date of Birth: ___ / ___ / ____   Height (ft. in.): ________

Sex (circle one): Male Female   Weight (lbs.): ________

Are you fluent in English? ☐Yes ☐No

Can you lie still for an hour? ☐Yes ☐No

Are you pregnant or could you be pregnant? ☐Yes ☐No ☐N/A

Are you currently breastfeeding? ☐Yes ☐No ☐N/A

Have you ever had an MRI examination or participated in an MRI study? ☐Yes ☐No

If so, did you have complications? ☐Yes ☐No

If yes, please explain: ____

____

Have you ever been injured by a metal object or foreign body (e.g., bullet, BB, shrapnel)? ☐Yes ☐No

If yes, what was the object: ____

Is any of it still present in your body? ____

Have you ever worked with metal (e.g., welder, grinder, fabricator)? ☐Yes ☐No

If yes, did you always wear proper eye protection: ______________________________

Describe what you did and the environment in which you worked: ______________________

____

Have you ever had an eye injury involving a metallic object (e.g., metallic slivers, shavings)? ☐Yes ☐No

If yes, what was the object: ____

Is any of it still in your eye? ____

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Check if you have **ANY** of the following:

Please be honest: It is for your safety. All of your responses are confidential.

****IMPORTANT INSTRUCTIONS****

1) The objects below can be hazardous or interfere with the MRI exam. Please go through the list carefully and check any that apply to you.

2) Before entering the scan room, remove any and all metallic objects and the following: hearing aids, dentures, false teeth, partial plates, keys, beepers, cell phones, pagers, eyeglasses, hair/bobby pins, barrettes/hair clips, jewelry, body piercing jewelry, watches, safety pins, paperclips, money clips, credits cards, bank cards, any magnetic strip cards, coins, pens, pocket knives, nail clippers, tools, clothing with metal fasteners and/ or zippers, and clothing with metallic threads.

__ Yes __ No Heart Pacemaker
__ Yes __ No Implanted Cardiac Defibrillator (ICD)
__ Yes __ No Aneurysm Clip
__ Yes __ No ANY Electronic, Mechanical, and/or Magnetic Implant and/or Biostimulator or Neurostimulator. Type: ______________
__ Yes __ No Any Type of Ear Implant (e.g., cochlear, stapes, etc.)
__ Yes __ No Spinal Cord Stimulator
__ Yes __ No Internal Electrodes or Wires
__ Yes __ No Aortic or Carotid Artery Clips
__ Yes __ No Hearing Aid (*Remove before MRI scan room entry*)
__ Yes __ No Insulin or Other Implanted Infusion Pump
__ Yes __ No Swan-Gantz or Thermodilution Catheter
__ Yes __ No Antimicrobial Athletic Clothing
__ Yes __ No Heart Valve or Stent
__ Yes __ No Shunt (intraventricular or spinal)
__ Yes __ No Vascular Coil, Umbrella (filter for clots), or Stent
__ Yes __ No Vascular Access Port and/or Catheter
__ Yes __ No Prosthesis (limbs, joints, or eye)
__ Yes __ No Joint Replacement (hip, knee, etc.)
__ Yes __ No Metal (circle) Rods / Plates / Screws / Nails / Pins / Clips / Other: ______________
__ Yes __ No Surgical Staples, Clips, or Wire Sutures
__ Yes __ No IUD, Diaphragm, Penile Implant Which brand? ______________
__ Yes __ No Shrapnel (metal fragments) / Gunshot Injury. Location: ______________
__ Yes __ No Metal Fragments in Eye (history as a grinder or welder)
__ Yes __ No Implanted Drug Infusion Device
__ Yes __ No Eyelid Spring or Wire
__ Yes __ No Medication Patch (nicotine, nitroglycerine, Other: ______________)
__ Yes __ No Wire Mesh Implant
__ Yes __ No Removable (circle) Dentures / Retainers / Other: ______________
__ Yes __ No Permanent Retainers or Metal Braces
__ Yes __ No Dental Bridge
__ Yes __ No Bronzing / Tanning Lotions
__ Yes __ No Body Piercing that Cannot Be Removed (*Removables must be removed before entry into MRI scan room*)
__ Yes __ No Hair Pins or Hair Piece / Wig / "Weave" (*if there are ferromagnetic items involved, you will have to remove item before MRI scan room entry*)
__ Yes __ No Breast Expander / Markers / Implants / Other: ______________
__ Yes __ No Acticoat Silver Wound Dressing
__ Yes __ No Any Other Implants (e.g., pill camera, etc.) Type: ______________
__ Yes __ No Any Other Type of Internal Coil, Filter, or Stent
__ Yes __ No Halo Vest
__ Yes __ No Spinal Fixation Device
__ Yes __ No Spinal Fusion Procedure
__ Yes __ No Any Type of Implant Held in Place by a Magnet; Type: ______________
__ Yes __ No Any IV Access Port (e.g., broviac, hickman, port-a-cath, picc line, etc.)
__ Yes __ No Radiation Seeds (e.g., cancer treatment)
__ Yes __ No Colored Contact Lenses
__ Yes __ No Claustrophobia
__ Yes __ No Tattoo and/or Permanent Make-up (e.g., lips, eyeliner, etc.)

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__ Yes __ No Have you had any previous surgeries?

If so, list all prior surgery dates and details:

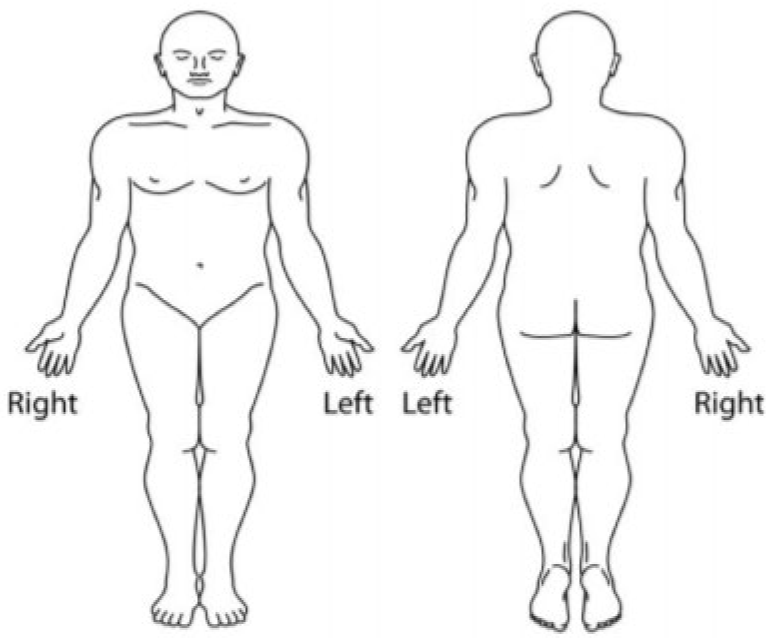
____

____

____

____

If you have had any implants or surgeries done, please indicate where on the body forms:



MRI Personnel Only

I, a certified Level 3 MRI Operator, have screened for hazardous materials and approved the subject for participation in this MRI research study.

This is valid *only* on the day it is completed. Returning subjects must fill out a new form.

Subject ID: __________________

Name of MRI operator completing form (print)	Signature	___/___/___ Date

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Appendix E

Class Syllabus

Adult Spanish Class Syllabus

Instructor: Benjamin Jorgensen

Email: jorgensenbyu206@gmail.com

Phone# (509)760-3346

Office Hours: By Appointment Only

Welcome to the class!

I'm excited to work with you! I know from personal experience that learning a foreign language can be very intimidating. It does not have to be this way. As your instructor it is my responsibility to push you so that you can progress as fast as possible but not at the expense at making you feel inadequate or uncapable of mastering the Spanish language. You will find that I encourage questions even if you have to ask them multiple times. Even if you feel you do not have a natural gift for learning language I encourage you try your hardest and you will be surprised to see what you can accomplish. **Have fun** and **learn from mistakes during these lessons**! Knowing Spanish and being able to talk to people from another culture in their language is awesome! But you're going to make lots and lots of mistakes along the way. DON'T WORRY ABOUT MISTAKES, especially when speaking. It just means you are learning. Pat yourself on the back regularly for trying and enjoy the fact that you can communicate lots more now than when you started.

English Rule

In class we will only speak Spanish. If you wish to ask a question, you will need to ask me directly for permission to speak in English. You can simply say "¿Puedo hablar en inglés?" I will then give you permission to speak in English. The same goes for me. If at any time I wish to speak to the you or the entire class in English, I will also have to ask for permission.

Class Materials

All the power-points that I use in class will be posted in our shared folder that we will use for our class. You can click here to access class power-points and supplemental materials. The day before class I will post the power-point we will use for our class as well as any assignments.

Schedule

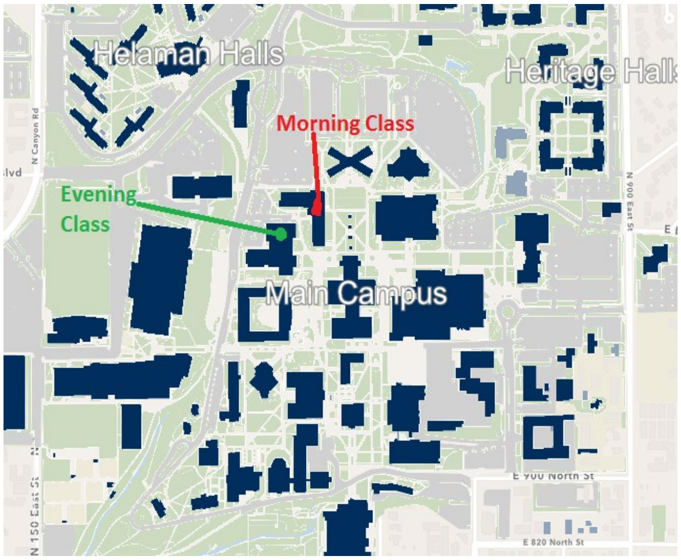
Class will be held Monday-Thursday. Please reference the charts below to the where class will be held for the Morning and Evening classes. Please remember that you are allotted only a certain amount of absences before you will be disqualified from the study and ergo will not be allowed to attend the class.

Morning

Day	Time	Classroom
Monday	12:00pm-1:00pm	2111 JKB (Jesse Knight Building)
Tuesday	12:00pm-1:00pm	2104 JKB (Jesse Knight Building)
Wednesday	12:00pm-1:00pm	2105 JKB (Jesse Knight Building)
Thursday	12:00pm-1:00pm	2104 JKB (Jesse Knight Building)

Evening

Day	Time	Classroom
Monday	4:00pm-5:00pm	120 TMCB (Talmage Building)
Tuesday	5:00pm-6:00pm	120 TMCB (Talmage Building)
Wednesday	4:00pm-5:00pm	120 TMCB (Talmage Building)
Thursday	5:00pm-6:00pm	120 TMCB (Talmage Building)



During this semester we will cover:

- Standard Greetings
- Alphabet and Pronunciation
- Use of Articles, Nouns and Adjectives
- Present Tense Conjugations of AR, ER and IR verbs
- Use of SER vs ESTAR
- Irregular Verbs: Poner, Hacer, Traer & Salir
- Saber vs Conocer
- Por vs Para
- Reflexive Verbs
- Direct and Indirect Objects and Pronouns
- Preterit

Additionally, the following themes were covered:

- Daily occurrences
- Weather and the Seasons
- Expressing opinions, plans
- Daily routines
- The Home and Household Appliances
- Hispanic Cuisine

If you have any questions or concerns, please do not hesitate to reach out to me and I will be happy to answer them for you.