Attrition and Language Reversion in Dutch-English Migrants in Australia:

Working Memory Capacity and Inhibitory Functioning across Languages and Age Groups

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Abstract

Language changes across a lifetime, in particular among bilingual migrants, who can experience both language attrition and reversion. The question is if cognition skills affect or are affected by attrition and reversion as people age. For this reason, 64 Dutch-Australian migrants and 44 Dutch controls were tested. There were three different age groups: 40-45, 60-65, and 75+. They were given three cognitive tasks and three language tasks. The cognitive tasks tested their working memory (linguistic and non-linguistic) and executive control, while the language tasks examined their vocabulary, grammar, and overall language proficiency. The results showed that language development in migrants (in particular the L2) was determined in part on how well the cognitive skills were developed and how little cognitive decline there was due to aging. There was less chance of language reversion from the L2 to the L1 if people had good executive control.

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Introduction

Moving to another country can have a big impact to what happens to the native or first language (L1). People who migrate are suddenly required to speak in a foreign language most or sometimes all of the time. This can cause attrition or language loss to occur in the L1 when the L1 is no longer spoken, but the first language does not appear to be lost entirely during this process. Even after decades, people under the influence of attrition can still remember their L1 (Köpke 2004), but the L1 is often not in the same state it was before migrating. The vocabulary is often affected, making it harder to access lexemes and in cases that are more progressive the grammar is affected as well. However, the language is typically not entirely gone. In fact, after a period of attrition there can be language reversion in which the speaker reverts to speaking the L1 once again (Schmid & Keijzer 2009).

During this process of attrition and language reversion, cognitive capabilities may change as people are aging (Brèbion, 2004; Fisk & Warr, 1996). In general, cognitive abilities, such as working memory and inhibition, decline with age, which means that the elderly have fewer cognitive resources available while performing a task. Working memory has two main functions: storage and processing of (linguistic) information (Baddeley & Hitch, 1974). Aging effects the amount of resources people have for working memory and the consequence is that people develop a trade-off as they age (Brèbion, 2004). They store limited chunks of information to be able to maintain processing. A similar development takes place with inhibition. This is also negatively affected by decline of attentional resources (Robert et al 2009). The reduction in resources makes it more difficult to inhibit all irrelevant items. The working memory can be storing some items that are not needed but inhibition was unable to suppress. This means that working memory cannot be optimally used if inhibition is failing.

In elderly migrants, this decline in cognitive skills can have interesting consequences. The lack of proper inhibition can mean that some of the 'non-relevant' information are items from their L1, the language they are (almost) constantly trying to inhibit, meaning that the L1 is not successfully inhibited all the time. This can cause lexemes in the wrong language to be activated. Consequently, this lack of inhibition could provide the first step to language reversion. To go back to the L1 also requires motivation and a change of environmental circumstances, such as retirement, which makes it less necessary to keep speaking the second language (L2) (de Bot & Clyne, 1989; Schmid & Keijzer, 2009). It is a combination of internal and external factors that can create a situation in which language reversion may be possible and people start using their L1 again.

Working memory decreases with age, but it could change under the influence of attrition as well. There is evidence that L2 learners are able to make better use of working memory as they get more proficient (e.g. Gass and Lee, 2011). Conversely in work done by Daller and Grotjahn (1999), they show that (certain aspects of) language proficiency can decrease when there is attrition and the decrease gets stronger the longer a person lives in a foreign language environment. The longer a language is barely or not used, the harder it can become to process and store items in that language. This difficulty in turn should reduce how optimally working memory can be used. The stronger the attrition is, the less linguistic information can be stored and processed, but the efficiency can increase when there is language reversion and the language once again gets used more. In short, the difference in efficiency of the working memory between the L1 and L2 can say something about attrition or language reversion depending on where people are on this continuum.

To examine this interaction between attrition and language reversion, inhibition, and working memory, people from several age categories were examined in this study, namely: 40-45, 60-65, and 75+. The people that were tested were Dutch-English migrants living in

Australia and a Dutch control group residing in the Netherlands. They participated in several tests that examined their working memory (both linguistic and non-linguistic), language proficiency, and executive control[1]. The main function of the control group was to see how age affects cognitive decline, since there were multiple factors that could influence working memory in various age groups for the migrants. Furthermore, the control group did not experience any confounding effects due to bilingualism, which the migrants might have experienced.

The following chapters present how working memory and inhibition changes in migrants of various ages under the influence of attrition and language reversion. Chapter one provides background information about aging and cognitive decline (of working memory and inhibition), language attrition, and language reversion in more detail. In chapter two, the method is outlined and it provides information about the background of the participants, the various tasks, and how the tasks were administered. Chapters three and four show the results and discuss the implications of the results before ending with a conclusion.

Notes

[1] These are conducted as part of Merel Keijzer's Veni project (2012), which examines first language reversion of Dutch migrants in Australia.

Chapter 1: Background information

Language attrition and reversion are processes that take time. People, after migrating, start speaking an L2, and the L1 typically gets used less. In time, the L1 can become eroded (referred to as language attrition), reflected in difficulty accessing lexical items and in more progressive cases syntax can be affected as well (Köpke, 2004). At the same time, people go through the normal cycli of aging after being away for longer, which means that their cognitive functions slowly decrease. Consequently, when looking at attrition and reversion, it becomes necessary to separate cognitive decline due to aging and the effects of attrition. Attrition does not cause cognitive decline, but attrition might influence processing and storage capacity of working memory in the L1 compared to L2. Furthermore, the inhibitory function decreases as a part of aging. This can influence working memory since irrelevant items might not be properly inhibited, such as lexical items from the L1 that are phonemically or semantically similar as the L2 target item. At the same time, this lack of inhibition can be a factor that helps the L1 to resurface.

The cause of attrition is usually a change of environmental circumstances, when people move to another country. The social contacts of people have can have a strong impact on whether people want to use their L2 as their dominant language (Köpke, 2004). This social aspect is one of the elements that influences whether attrition occurs and how quickly after the language switch. However, some people who undergo attrition of their L1 can revert back to their L1 in due course. Reversion depends for a large part on environmental changes and personal motivation (e.g. De Bot & Clyne, 1989; Schmid & Keijzer 2009), but there might be reasons to believe that cognitive decline due to aging is a factor as well. Aging can cause a decrease in inhibition, which can cause the L1 to become more accessible and even interfere with L2 production in some cases. This chapter discusses aging and cognitive decline, language attrition, and language reversion before discussing the hypotheses for the present research.

1.1 Age and cognition

As people age, their cognitive functions start to decline (Fisk & Warr, 1996; Brèbion, 2004). For example, in Brèbion (2004), the overall working memory capacity of young adults compared to old adults was larger when they were tested in a reading span task (see method). Salthouse (1994) compared previous research that used various working memory tasks in elderly people and the results showed that cognitive processes slowed down with aging, since older adults needed more time to process and encode information. This slowing down did not result in decreased accuracy, but could partially explain why elderly had more trouble in timed tasks. This slowing in processing might present problems with parsing and understanding spoken sentences as well. The sentence was often produced too quickly for subjects to completely process and this caused a situation where not all operations could be executed. This causes sentence to not be properly parsed and analyzed, and this could impair understanding (Salthouse, 1996). Additionally, older adults often have impaired vision and hearing (Burke & Shafto, 2008). This is another factor that could make processing incoming information more difficult. This might cause a degraded signal that may make it harder for items to be activated in the lexicon. However, not everything decreased with age and the semantic processes of the elderly are at least as good as or better than younger adults (Burke & Shafto, 2008). Elderly people are better in semantic meaning since they have more experience across their lifetime. This gives them better recognition of both high and low frequency words compared to young adults. Elderly have trouble processing words without context, but given sufficient context, they can perform well (Schneider et al., 2005).

Some older adults, however, seem to be more affected by aging than others are. Research done by Rabbitt el al. (2008) provided a possible explanation for these differences in cognitive decrease of the elderly. They examined the cognitive changes of 5.8 thousand people over a 20-year period. Of this group, 2.3 thousand people died and 3.2 thousand dropped out. The remaining people showed cognitive decline but this was insignificant compared to those subjects who died of natural causes. In their results, they concluded that people who are within 8 years of their natural death start to experience a stronger decline of their cognitive skills. This means that people who were physically more robust and live longer are less likely to experience the same type of cognitive decline as their less robust counterparts at the same age. There can thus be great individual variation in how strong the decline is in people.

1.1.1 Working memory and cognitive decline

Working memory is a limited storage space that, according to Baddeley and Hitch (1974), has two main functions: to store and process items. The functions of working memory are further elaborated in Baddeley (2003) in an attempt to explain everything working memory can do. Working memory has been modeled as containing a phonological loop, a visuospatial sketchpad, and an episodic buffer. The first two temporarily store various types of information, which can be linguistic and non-linguistic, e.g. visual, auditory, and spatial information. The episodic buffer chunks the information or stores it in episodes, so more can be stored and the limited space of the working memory can be used more effectively. This process is controlled by the executive control, which overlooks all the three previously mentioned processes. The executive control is an attentional process which controls what information should be stored, processed, and assigns different levels of priority to the incoming information. Ellis and Sinclair (1996) say there is a relationship between what can be stored in the short-term memory and the long-term memory. An item with a stronger memory trace is easier to remember than an item that is weaker. This can be based partially on the frequency of the item, but also on semantic relations. It is easier to remember a flower name when talking about gardening, than warfare for example. This means the memory load can vary based on many factors.

Working memory changes with age. The basic functions remain the same, but the way they are executed changes. In Brèbion (2004), the working memory of different age groups was tested. Young adults whose memory was in peak condition were able to simultaneously store and process information. However, with the elderly there was a trade-off in most cases in which they gave priority to either processing or storage when the resources of working memory were put to the limit. The elderly often showed a pattern in which they maintained a limited amount of information. They stored only a few items instead of trying to remember more. They seemed to deliberately stop themselves from memorizing more than three or four words in a working memory task, while the young adults did their best to store and processing all incoming information, even when it was too much. This caused the young adults to be unable to store and process all items, and this affected their accuracy during recall. It might seem that elderly share a particular strategy in working memory when it comes to storing items and that it is a deliberate or conscious process. During a different reading span task by Brèbion (2004), participants were tested between the trade-off of reading speed and storage. The participants were given different instructions during each of the three blocks. For the first block, they were told to read each sentence quickly while trying to remember each word at the end of the sentence as accurately as possible, like a regular reading span task. For the other two blocks, they were asked to read the sentences as fast as they could to the detriment of accuracy and the opposite applied in the last block. Every participant completed all three conditions. The elderly were not able to reduce their response times when specifically asked to do so, unlike the younger participants. Brèbion says that this inability of the elderly to speed up at the cost of accuracy might not be voluntary, but part of their general cognitive slowing, which was their main limiting factor or alternatively they might be unable to step away from their slower and more cautious approach.

While Brèbion (2004), said that the change in working memory is due to the decrease of resources at an older age, Robert et al. (2009) gave an additional argument for the change in working memory. They said there was also a lack of attentional resources in the elderly to inhibit irrelevant information and activate relevant information, which impairs the functioning of inhibition.

1.1.2 Inhibition and cognitive decline

Inhibition is a function that is closely related to working memory. Baddely and Hitch (1974) in their model for working memory say that there is a close relationship between the storage and processing capabilities of working memory and executive control. The executive control is further elaborated in Baddeley (2002) and it is a top-down process that watches and controls the processes. It decides how the various resources of working memory should be used and tries to inhibit irrelevant information to allow the storage and processing functions of working memory work optimally. This helps to keep the working memory operating as efficiently as possible. For bilinguals there is an additional problem compared to monolinguals. Inhibition mechanisms are needed to suppress the language that is not in use. In a simple example, when bilingual person looks at a tree, the word in both of his languages can be activated. If that person wishes to talk about the tree to someone else, it should be done in only one language and therefore the other language needs to be inhibited. This process makes use of attentional resources (Robert et al., 2009). While it initially may seem that inhibition in older age presents a bigger problem for bilingual people in contrast to monolinguals since there is more to inhibit, they are more practiced in using inhibition and executive control compared to monolinguals. This cognitive advantage has mainly been found in early bilinguals (e.g. Bialystok & Martin, 2004; Carlson & Meltzoff, 2008), however it may apply to all bilinguals and not only early bilinguals (Bialystok et al., 2004, Bialystok, Craik & Ryan, 2006; Bialystok, 2009). .

Green's inhibitory control model (1998) provides a more detailed account of the functioning of inhibition. Inhibition mechanisms are not only used to suppress items that were not relevant but also to promote relevant items. The model consists of three elements:

- The functional control circuits help determine which cue to follow during competition. For example, it could be competing lexical items from both the L1 and L2.
- A means to select the correct items that can be used. Every lexeme has tags much like those proposed in Levelt's model (1999) and these include a language tag. This tag is part of conceptualization and the learner wants to create and formulate this strictly in one language.
- A selection mechanism that promotes the concept with the corresponding lemma and inhibits lemmas with incorrect tags, such as the foreign language counterparts of the concept.

During old age, this mechanism of inhibition works less effectively and this means that false competitors such as foreign language counterparts are not inhibited as well as they should be. This makes it harder to distinguish items in one language from the other. The speaker is well aware of which lexeme belongs to which language, but the lack of proper inhibition can cause interference and may give the L1 a chance to resurface. The lack of inhibition can cause interference and the L1 might be used in L2 production (and vice versa).

The interference is more likely to occur when the L1 is more dominant, despite its limited use, or the proficiency of the L2 is not high in comparison to the L1 (de Bot & Clyne, 1989). This can cause the L1 to interfere in the L2, though this does not exclude the L2 from interfering in the L1 (but it is likelier to occur less frequently than in the L2). Over time, more of the L1 is able to resurface, because the inhibition is insufficient and the speaker has personal motives to start using this language again. The slow deterioration of the cognitive systems in addition, can allow language reversion to take place, but it will only happen under the right circumstances. Keijzer and Schmid (2009) say that language reversion can happen among people who have retired, no longer have children at home, and experience a general feeling of nostalgia. A combination of factors, both internal and external, makes language reversion possible.

Robert et al. (2009) looked at the how inhibition and working memory changed in people of three different age groups and say how they also used a RST. The age ranges were: 10-12, 19-24, and 60-69. The young adults performed best during the reading span task. The old adults and children had fewer attentional resources available than the young adults and this caused more errors during the reading span tasks. Overall, the young adults were able to recall more items than any other group and were showing fewer signs of interference. The older adults showed more signs of intrusion errors and this means they had trouble disregarding information that was previously activated. For example, this could mean that words that needed to be remembered from a previous block were still active instead of being inhibited and disregarded since it was no longer relevant. The intrusion errors were greatly reduced in all age groups when a reading span task was presented that took into account the limitations people had in their memory load. It showed that in cases where people did not have enough attentional resources, because of the demands of the tasks, errors started to occur. The older adults had more difficulty disregarding previously relevant information, more so than any other age group and the reduction of resources due to aging. This made the older participants more likely to fail to inhibit compared to younger counterparts since old information remained active. Borella et al. (2007) found similar results that once an item is active it becomes harder for older adults to inhibit it when it is no longer needed.

The previously mentioned examples (e.g. Brèbion, 2004; Robert et al, 2009), show that inhibition and working memory decrease with age. The main argument is that there is a decrease in resources in both inhibition and working memory. For this reason, it is assumed that inhibition is part of working memory or at least make use of the same pool of cognitive resources. However, the bilingual participants in the present study not only experience aging, but language attrition as well, and this can potentially cause a confounding effect on working memory processes in the non-dominant language.

1.2 Attrition

As Köpke (2001) explains, "[a]ttrition can be defined as the non-pathological loss of a language in, usually, bilingual subjects. Attrition is non-pathological and therefore distinct from other language loss phenomena, such as aphasia" (p. 3). The problem with this definition is that it suggests that a language is irrevocably lost, but this is not typically the case, especially in adults. Attrition research usually focuses on the loss of the L1 and mainly in two groups of people: bilingual adults and children. The reason these two groups are interesting is because the effects of attrition can be quite different in both populations, which can be one of the underlying reasons why it is difficult to define attrition. In some cases, it seems that in young children the attrition can be manifested so strongly that in some cases it appears that the language is forgotten altogether, (Ammerlaan, 1996; Ventureyra et al, 2004) but with adults it is typically not that severe (Köpke, 2001). Attrition in adults often means that the subjects have more trouble accessing lexical items and in cases that are more progressive the syntax can be affected as well, but they still have access to the language even though it requires more effort to speak in this language (Köpke, 2004). According to Bahrick (1984), most attrition takes place in the first five years of moving. After these five years, relatively little more language is lost for the next 25 years. The items that are lost are usually items that are the least integrated in the language system, and these are often infrequently used vocabulary items and can be forgotten in the first five years.

As previously mentioned, attrition in children is typically more severe than in adults. There had been cases reported such as in Ventureyra et al. (2004), in which Korean-born adults, who were adopted by French families between the ages of three and nine, were tested to see if they were able to distinguish various contrastive phonemes in Korean. The participants were unable to do so, which would initially suggest that a language can be completely forgotten, but results did not take into account the possible trauma the children endured. This means the loss of language could be caused by more than solely migrating to another country.

In his dissertation, Ammerlaan (1996) examined the lexical access in people who migrated at the age of 6 and older. While the participants who moved, especially those at a young age, had trouble recalling words, the language was not completely forgotten. In general, it thus seems that there is a general trend that attrition is more severe if people are younger when they migrate.

The severity of attrition in adults can be divided in two categories, in which in the first group only the lexicon is affected and in the second group the attrition is more extensive and the grammar is affected as well (Köpke 2004). In the first group the lexicon is affected which means that they have trouble accessing words from memory for production. In the second group, the grammar is affected as well, and it is quite possible that structures that are grammatical in the L2, but not in the L1, can be perceived to be grammatical by people in this group. This is shown in the following examples (1+2). Main clauses in both English and Dutch both have a Subject-Verb-Object (SVO) word order, but in Dutch - as opposed to English - the verb must be in second position (V2). In English, it is possible for any number of adverbials to precede the subject and verb, which is not possible in Dutch without moving the subject to a position after the verb. The following examples (1+2) demonstrate these differences:

1) *Gisteren liep ik naar school.*

   Yesterday walked I to school.

   `Yesterday I walked to school.´

2) **Gisteren ik liep naar school.*

   Yesterday I walked to school.

For people who are suffering from attrition, it is possible that they will find both examples 1 and 2 acceptable if their grammar is affected as well and they no longer consistently apply the V2 property that exists in Dutch.

Another important issue in attrition research is the question what can cause the switch from using the L1 to the L2 (Köpke 2004). Such drastic changes from the L1 to the L2 typically involve migration or a move that causes people to live in a different language environment. After this move, some people remain in contact with L1 speakers from their home environment and others have no one in their close environment that speaks the L1. The amount of contact, the quality of contact, and the domains in which either the L1 or L2 is used, determine whether there is a shift in language dominance and how dominant the L2 likely is to become over the L1. If someone is alone in an L2 environment, in the sense that there are no other L1 speakers, which causes them to use the L2 in everyday life, work, and private domains, there will likely be a shift in dominance from the L1 to the L2. However, someone who still has contact with their family and may have some friends that speak the L1 in the L2 environment, there might not be a shift to the L2 or the L2 might not be as dominant as someone with no or little contact with L1 speakers. Köpke (2004) says that both the quality and quantity of contact in the L1 can play an important role in attrition. This contact helps to maintain strong memory traces in the L1 if the quality and quantity is sufficient and this can prevent attrition. If the L1 is not used frequently then the memory traces will slowly weaken and it becomes harder to retrieve the L1.

1.2.1 Working memory and attrition

The efficiency of the working memory, making optimal use of its resources, should be different for people who are and who are not under the influence of attrition. The Activation Threshold Hypothesis by Paradis (2000) says that an item needs a certain amount of impulses to reach the threshold and be activated. The more often an item is activated, the fewer impulses are needed to reach the threshold and it becomes easier to activate that item. Therefore, the opposite should also be true and an item may become more difficult to activate when it has not been used for a long time, which is the case for people under the influence under attrition. The opposite of the Threshold Hypothesis would be that the more impulses that are needed, the harder it becomes to retrieve words and this should be reflected in the number of attentional resources needed in working memory. The total number of resources for working memory should be the same in the L1 and L2, but how well these resources are used depends on how little attrition there is. Consequently, if there is language reversion then the efficiency of working memory should in time increase once again, allowing more information to be stored and processed. A possible example to highlight the differences in use in resources comes from language acquisition research. Gass and Lee (2011) tested two groups of English students learning Spanish with reading span tasks in their L1 and L2. One group was highly proficient in their L2, while the other group were beginners. Both groups performed similarly in reading span tasks in both the L1 and L2 in their native language, but there were differences in the scores for L2 in which the highly proficient group performed significantly better. One possible explanation why the highly proficient group performed better in the L2 was that the language (and lexicon) was more frequently used and therefore it required fewer activation costs, which made it easier to store items working memory. Additionally, the difference in proficiency may also affect reading and other abilities in the L2, so less attentional resources could be dedicated to storage and processing.

1.3 Language reversion

As mentioned before, some of the people who may initially have been labeled as attriters might at some point in their lives revert to a previously acquired language, typically their L1. The underlying cause of this is complex since it is dependent on many factors. Previous literature has mainly focused on the social and motivational aspects of language attrition in which personal motivation, a change in environmental circumstances, and a person's lifestyle paid an important role (e.g. De Bot & Clyne, 1989; Schmid & Keijzer 2009). However, language reversion might not be solely based on this. It could also partially be caused by a decline of cognitive skills and in particular inhibition. If someone is no longer able to fully inhibit the L1, it can give rise to the L1 to slowly resurface after having been inhibited for a long time.

1.3.1 Language reversion and socialization

De Bot and Clyne (1989) examined the results of a longitudinal study into Dutch migrants living in Australia. The participants completed interviews, language tests, and described pictures portraying a quintessential Dutch scene as well as an Australian one. From the results, the authors concluded that the social circumstances promote language reversion in old age in healthy adults, but this mainly applies to adults who had low proficiency in their L2 English to start with. The reversion then takes place when the migrants no longer need to use their L2 in their daily lives. This can be due to many reasons, such as retirement and children moving out of the family home. The L2 is slowly forgotten and this causes the L1 to become more dominant again. De Bot and Clyne based their assumption on Neisser's (1984) critical threshold theory. The participants that were susceptible to language reversion did not have what Neisser called 'an extensive and redundant cognitive structure'. A complex structure with relations between various items is harder to forget than individual items, and therefore people with a low competence in their L2 and who can thus only use their L2 in a limited number of social settings, such as buying food in a store and asking for directions, are more susceptible to language reversion.

Schmid and Keijzer (2009) not only looked at social circumstances, but emotional or motivational ones as well and describe a set of possible internal and external factors that can contribute to language reversion. The migrant needs to have personal motivation such as experiencing (self-reported) nostalgia, a longing for the 'old' country. Furthermore, external factors are present as well. The L2 needs to become less relevant in daily life and this occurs when the migrants retires and the children leave home, so there are fewer people who continually need to be spoken to in the L2. De Bot (2010) says that not only sociolinguistic factors, but sociopsychological influence language processing in play a role in language processing as well. For language attrition and reversion, this would imply that the individual differences and the different circumstances people live in matters. This in consequence can imply that the environment plays a role how well the cognitive processes remain preserved during aging and if circumstances will allow someone to start using their L1 once again. This requires a better understanding of how the brain changes as a part of aging, which is discussed in the following section.

1.3.2 Language reversion and inhibition

With aging, the cognitive skills of people decrease and this includes inhibition mechanisms (Brèbion, 2004; Robert et al., 2009). Fewer non-relevant items can be properly inhibited and this can cause false competitors from the inhibited language to pop up in the mind of migrants. This lack of complete inhibition can help start the process of language reversion if the right sets of circumstances are present. The study of de Bot and Clyne (1989), pointed out that L2 competence and social circumstances were important for language reversion, but they also had noted that many older participants were inclined to code switch involuntary more often in their advanced old age. They said the code switching was caused by either a decrease in attentional resources or memory failures in which elderly bilinguals have trouble remembering the task at hand. The aging process might help to promote the L1 to once again be used by migrants.

A possible explanation of how the brain changes with aging and how this affects language processing is provided in a review done by Wingfield and Grossmann (2006). The brain volume decreases with age and this affects the language functioning in older people. Some of these changes in the brain are demonstrated in an fMRI study (Grossmann et al., 2002), in which younger and older people participate in a sentence comprehension task. The participants are given sentences such as the following, “The man insulted the woman and hired a lawyer.” The participants are asked yes and no questions about who performed the actions. The results show that the older group has a diffuse activation in the brain when analyzing the sentences compared the young adult whose activation is focal. The older group shows greater variability in the results and this is in part attributed to the reduction of brain volume due to aging. The older adults compensate for their comprehension by activating other parts of the brain as well. Activation of the young adults is mainly in the posterolateral temporal-parietal cortex, which is thought to be an auditory-phonological buffer that can retain information for processing (Chein and Fiez 2001; Jonides et al. 1998). The older adults show increased activation in the dorsal portion of left inferior frontal cortex (used for maintaining and rehearsing verbal information. Furthermore, the older adults showed more activation in the right posterolateral temporal-parietal region. Young adults showed activation in this area as well but only when a sentence was demanding for working memory. The cognitive demands of processing sentences require a certain amount of resources, which is more easily to accomplish for the young, but the older have less cognitive resources due to the decline of brain volume. Consequently, it is harder for the elder to accomplish the same focused activation as the young and use compensating strategies, by activating additional regions in the brain to process sentence or task at hand. This therefore can have consequences for inhibition, since this diffusion and reduced activation seem to take place in the entire brain. This could mean that inhibition is not as strongly activated in older people as in young people or that the overall increase in activation in more areas of the brain require more of the inhibitory function than it can handle. For bilinguals, a diffuse activation in areas of the brain makes is more plausible that items in the non-dominant are activated as well in older people, since it can mean that items in the non-dominant language can be activated and inhibition might not be able to counteract this activation effectively. This is turn can provide an explanation why the non-dominant might start to be used after decades of non-use.

1.4 Hypotheses

This present study examines language attrition and reversion, and how working memory and inhibition influence or are influenced by the state of the language in several age groups. The focus lies on bilingual Dutch-English migrants, but there is also a monolingual Dutch control group. Aging should reduce the availability of resources that working memory has and is therefore mainly a quantitative decline, which should affect both the monolingual and bilingual group. This reduction in resources could affect language. Attrition should affect the resources needed to store and process items and therefore is a qualitative measure. This research aims to look at the influence attrition has on working memory, taking into account that cognitive skills decrease as people age. A second aim, which might apply to the oldest old participants who are 75+, is whether the cognitive decline that can cause problems for inhibition might help promote language reversion. For this reason, the results of six tasks are examined of which three are language tasks and three working memory and executive functioning tasks. The language tasks are: C-test, Peabody picture vocabulary task, and grammaticality judgment task (see method for more details). They were administered in both the L1 and L2 and gave an indication of the participants' general language proficiency as well as measured their vocabulary and grammar. The cognitive tasks used were: reading span task, backwards digit span task, and Simon task. These tasks provided both linguistic and non-linguistic measures for working memory, as well as a measure for executive functioning.

- Age and cognition

The effects of aging, language attrition, and reversion need to be separated to determine if there is a qualitative change in working memory due to attrition. For this reason, a group of monolingual speakers of Dutch was added as a control group. They should not show any signs of attrition of Dutch and therefore can show the isolated effects of aging in both working memory and language tests. Expected is:

  - A decrease in results for all cognitive tasks as the subjects' age increases. The youngest group overall should have the best scores for the backward digit span task and Simon task compared to the two older age groups. This should happen in the cause of the bilingual group as well, but the attrition or reversion can have a confounding effect in the reading span task. This means that the bilingual participants should show a difference in performance between tasks in the dominant and non-dominant language in favor of the former. This should show most clearly in the reading span task since this is timed and stressed working memory strongest. The trade-off in performance should be stronger when there is more attrition or is more extensive and decreases with language reversion. Alternatively, the youngest bilingual age group might not be as proficient in English as their older counterparts (given their shorter LoR), and there might not be a trade-off in the youngest group, since their proficiency might significantly lower.

- Attrition

The effects of attrition are measured through not only language tasks, but cognitive tasks as well. The language tasks show what is left of the language system and the severity of attrition. The C-test, grammaticality judgment task, and the Peabody picture vocabulary task can show the language competence of the participants for lexicon, grammar, and their overall language proficiency in both their L1 Dutch and L2 English. Furthermore, language attrition should affect the manner in which the attentional or cognitive resources are used, in which more resources are used to perform the same task in comparison to someone who does not experience attrition. For this reason it is to be expected that the stronger the attrition is, the poorer the results are for tests that require both working memory and language skills simultaneously, such as the reading span task, since the attrition could require more resources to perform the same task compared to a language that is not undergoing attrition.

- The results of the Dutch language tasks and reading span task should be worse compared to the control group and to the L2 counterparts of the task as well. The non-linguistic working memory tasks should not be affected by attrition, but it should not be similar to the control group due to a bilingual cognitive advantage, which means the bilingual participants overall should score better (e.g. Bialystok & Martin, 2004; Carlson & Meltzoff, 2008). Furthermore, the language tasks are not likely to be affected by constraints of working memory due to attrition. Simply put, there could be differences in results between the reading span task in both languages and between the bilinguals and the controls. The results of the C-test, grammaticality judgment task, and Peabody picture vocabulary task should not be constrained by working memory, but indicate their overall language proficiency. If the attrition is strong then there could be differences in the performance between the L1 and L2. The results in the C-test should differ between groups and favor the control group. The difference in results should increase between control and bilingual as the attrition get stronger. The results of the Peabody vocabulary task Dutch should show differences mainly in the older bilingual participants in which the development of Dutch vocabulary is obstructed by the English one. The grammaticality judgment task should be the least affected, since only the severest cases of attrition show a difference in results. A greater standard deviation in the results of the bilinguals compared to that of the controls would suggest that some show signs of stronger attrition.

- Language reversion

For the present study, it is hypothesized that language reversion is caused or partly caused by social, motivational, and cognitive factors. The age group that is most prone to experience language reversion is the oldest group of 75+ and possibly the 60-65 as well, since they are most likely to experience the strongest effects of cognitive decline and most likely live in the right social circumstances. However, not all of them will experience language reversion. There should be some differences based on individual differences among the participants (de Bot, 2010). In part, this should be due to social factors, but some cognitive factors, such as a deterioration of inhibition, could make participants more prone to language reversion.

People who experience language reversion should show reduced inhibitory functioning due to a lack of attentional resources. While the participants are highly fluent in their L2, it should require more attentional resources to speak in this language in comparison to their L1, even though it has not been used much for a long time. The cognitive decline, which in part results in a decline for inhibition should allow the L1 to resurface in part since it should require less cognitive resources to use. Participants in this group should have overall lower results in the Simon task to indicate reduced inhibition. This should reflect on their ability to perform language tasks. The group that has a high performance in the Simon task should show good results in both the L1 and L2 and most likely, they will perform better in the L2. The low performing group however should show relatively poor results in the L2, but high in the L1. Their results in the L1 will likely not be as high as the controls, but should be significantly better than the high performers. The difference between in performance should be reflected in the Peabody picture vocabulary task and the reading span task since these are done in the L1 and L2. The C-test Dutch should show a difference in results between the high and low performers of Simon task in favor of those who had a low score in the Simon task. The difference in results of the grammaticality judgment task Dutch is likely to be non-significant unless some people in the high performance group experiences strong effects of attrition.

Reversion most likely affects people who have little need for their L2 in daily life even though they still live in a foreign country. The social aspect can affect people in two different ways. First is the reason or motivation to speak in the L2 and second is in determining what influence their lifestyle has on their cognitive function. People with more active social lives may have more reason to speak their L2, if some of their contacts do not speak the L1. This does not apply when most people they interact with speak the L1, so when they are active a Dutch club for example. Furthermore, activities that keep the mind and/or body active might reduce the rate of cognitive decline.

- This might apply to some participants of the 60-65 and 75+ group. The oldest participants are divided based on their active lifestyle or lack thereof to see if there are differences in results for both the language and working memory tasks. There should be differences in the non-active and active groups concerning performance in language and working memory tasks. Alternatively, if language reversion is not dependent on cognitive changes then the group should be divided based on the results of the language tasks and then seen if there are differences in the working memory tasks between groups and in particular the Simon task to see if cognitive decline is related to language reversion.

Chapter 2: Method

2.1 Participants

Two groups of participants were included in this study: Dutch-English bilinguals living in Australia and a comparable Dutch monolingual control group. All participants were divided into three age groups of 40-45, 60-65, and 75+. Prior to testing, all participants were screened to exclude people who were deaf, (color)blind, or had any other cognitive impairment or diseases that could affect the results. On the day of testing, the participants also underwent a mini mental state examination for screening purposes[1]. There were 64 Dutch-English migrants and 44 Dutch controls. The following table shows the number of participants per age category, their mean age, gender, and years of education, for both the Dutch-English migrants and the Dutch control group.

Table 1. Number, age, gender, and education of the Dutch-English bilinguals and Dutch controls

	Dutch-English bilinguals			**Dutch control group**		
Age category	*40-45*	*60-65*	*75+*	*40-45*	*60-65*	*75+*
N	18	21	25	12	19	13
Age Mean	44.83	64.48	78.92	46.00	63.42	76.38
Age SD	5.12	7.22	4.34	5.48	2.95	5.24
Gender (M/F)	6 – 12	7 – 14	14 - 11	5 - 7	9 - 10	5 – 8
YoE mean	19.13	15.38	14.17	17.36	15.47	11.46
YoE SD	2.00	7.71	5.25	2.25	4.29	4.14

It is clear that there were fewer controls than there are participants and in particular for the oldest age group. There were nearly twice as many migrants as there are monolingual controls in this group. Furthermore, there was a difference in education between the various age groups, but the decrease in years of education between the youngest and oldest groups is similar for the migrants as it is for the controls.

As part of the pretesting, the participants provided information about their age of arrival (AoA), the length of residence (LoR), their self-assessment of their language skills in past and present, and previous language education, hobbies, and their social life. As it was to be expected, the older the age group, the longer they generally indicated to have lived in a foreign country. The youngest group included people that had lived in Australia as little as one year and of this group eight had lived in Australia for less than five years, which meant that some of them might not have experienced much or even any attrition yet. While the older group consisted only of people who wanted to build a life in Australia, the youngest group included people who lived in Australia for a short time or who lived in that country temporarily. They therefore may not have been as committed to make the L2 a dominant language as people who had migrated permanently. This became clear after close inspection of the sociolinguistic questionnaire, and therefore some of these participants could have been less motivated or committed to speak their L2. They saw themselves not as migrants but more often they called themselves expats. The following table shows the AoA and LoR or the Dutch-English migrants.

Table 2. Age of arrival and length of residence of the Dutch-Australian immigrants

Age category	AoA Mean	AoA Range	SD	LoR mean	LoR range	SD
40-45	34.24	14 – 43	8.55	10.18	1 - 31	10.22
60-65	25.29	14 – 43	7.71	38.76	13 - 56	11.14
75+	23.86	13 – 61	10.07	55.52	25 - 61	7.81

The participants also provided a self-assessment about how good their Dutch and English was when they arrived in Australia and how good it was when they were tested. They did this on a five-point scale in which one was very bad and five was very good. Table 3 shows the mean of this self-assessment per group. As can be seen, all participants felt that their English had improved over time, but the same did not apply to Dutch. Subjects generally felt that it was less good than it once was.

Table 3. The self-assessment of the migrants' Dutch and English proficiency

	English		Dutch	
Age category	Upon arrival	Current	Upon arrival	Current
40-45	3.87	4.73	4.93	4.33
60-65	3.20	4.62	4.83	4.11
75+	3.04	4.70	4.68	4.00

As people age, their cognitive functions slowly decrease, but the rate at which this occurs can vary. For this reason, it can be important how active people are in their daily lives and how much contacts they have outside the home. Both the quality and the quantity of contact people have can help determine whether language reversion can occur. Furthermore, a lack of physical and/or mental activities might cause cognitive decline to occur at a quicker pace compared to those who are active. The following table indicates how active the participants are in their daily lives.

Table 4. Bilinguals and their social and physical activities

	Dutch-English bilinguals			**Dutch control group**		
Age category	*40-45*	*60-65*	*75+*	*40-45*	*60-65*	*75+*
N	18	21	25	12	19	13
Little social activities	3	1	1	2	1	3
Lots of social activities	2	10	10	7	10	5
Social and physical activities	13	4	10	3	7	5
Unknown	0	6	4	0	1	0

For oldest two age groups, there was little difference with their age-matched counterparts in social in physical activities. There was a similar division in activities between the bilinguals and the Dutch controls. Overall, at least half of the people who had indicated what their activities were had indicated that they had many social activities. However, among the bilingual participants there were ten of which it was unknown what their activities were compared to one in the Dutch controls. The biggest difference in data was between the bilinguals and Dutch controls in the youngest age group. The bilinguals had more significantly more people that had both physical and social activities, while the Dutch controls had more people who had only social activities. While the youngest age group had the most difference between bilinguals and Dutch controls, at the same time this age groups should be the least affected by cognitive decline due to aging.

2.2 Tasks

In the present research, the results of six tests[3] were used to examine how working memory and inhibition changes during attrition and language reversion, taking into account that the subjects' cognitive capabilities may decrease with age. The tasks used to examine working memory and the current state of their language in both the L1 and L2 are: the reading span task (RST), the backward digit span task (BDST), Simon task, Peabody picture vocabulary task (PPVT), C-test, and grammaticality judgment task (GJT). These tests were chosen since they examine working memory, executive functioning, and the current state of the participants' language. The BDST focuses solely on working memory, while the RST examines the working memory in relation to the language proficiency. The Simon task focused on executive functioning and inhibition capacities in particular. The C-test gives an indication of overall language proficiency and the PPVT examines receptive vocabulary.

Finally, the GJT examines whether the participants still have a native judgment of their L1 and how acceptable each item is and how this related to their L2 grammaticality intuitions.

2.2.1 Backward Digit Span Task

The backward digit span task, like the reading span task tests the storage capacity of working memory, but it does not have a strong language element and it is overall simpler in its design. The participants see a series of numbers that they have to recall them and the digits keep increasing in number until the participant is unable to recall them correctly. The complication that the backward digit span task presents is that the recall has to take place in a backward order. Previous research has shown that elderly participants in particular have trouble with this task (Kemtes and Daniel, 2008). They attribute this to two possible causes, a hearing deficit and/or an attention or memory deficit. For this reason, a visual version of this task is used in the present study to eliminate a possible hearing deficit as a factor.

2.2.2 Reading Span Task

The reading span task was originally created by Daneman and Carpenter (1980) to explain the differences in reading abilities in 20 students. This task tests both the storage and processing capabilities of working memory. In the original format, participants are required to read aloud a series of sentences. The sets can vary in length from two up to six sentences. Apart from reading, the participants must do two other things; remember the last word of the sentence and the semantic content of the sentence. After each set, they are required to recall the final words in any order. Furthermore, they are asked to answer questions about the content of what they have read. The assumption is that participants with a poorer reading ability will have less effective working memory resources than the participants with better reading ability. The latter group should be able to more effectively make use of working memory. In other words, the storage capability is similar in all participants, but the processing abilities vary based on proficiency. Working memory is a limited resource, which means that there is only so much people can store and process. Once people start to reach this limit there is a trade-off in which people must prioritize and choose between these two functions of storage and processing in order to maintain accuracy in working memory. This means that the participants might decide to remember only a certain number of words, like the elderly people in Brébion (2004). If people go beyond of what they are capable of, then they will have more trouble reading and processing the sentences for the task, while remembering the words that they need to remember. This can result in slower reading, if they are trying too hard to remember every word or they forget some of the words of the semantic content of the sentence.

Originally, the reading span task is designed to test the reading ability of a learner. In the course of time, the test has been applied to foreign language acquisition. An example of this can be found in the work done by Gass and Lee (2011), in which high and low proficiency learners were tested in relation of their working memory and inhibition capacities. Their L1 was American-English and their L2 was Spanish. All participants performed similarly for the reading span task in the L1, but not the L2. In the high proficiency group, there was a correlation between the L1 and L2, but not in the low proficiency group. In the latter group, the participants performed significantly worse in their L2. They had a lower working memory score. This showed the difference in the efficiency of resources that were required based on the proficiency of the learner.

The format used in the present study to examine working memory of Dutch-English elderly migrants for the present study is that of Van den Noort et al. (2008). These participants can be highly proficient in both the L1 and L2, although they might not have spoken Dutch for a long time, so the differences in efficiency of working memory should be visible between the various age groups if the L1 is affected by attrition. The participants are examined in both languages, and there have been many versions of the reading span task in the past, but Van den Noort et al. have designed a standardized version in four languages, which include both English and Dutch. They have improved upon Daneman and Carpenter's (1980) design by taking various elements into account, which had not been taken into account in the original design. These include: the length of the sentences, length of the final words, frequency of the final words, and method of administration. This means that the tests between the four languages are more comparable with regard to the sentences and the final words that are to be remembered. The method of administration changed and the test is no longer self-paced, since the computer is used instead of index cards and there is a six-second time limit to how long the participants can examine a sentence. This means that they have less time to use methods to recall the final items better.

2.2.3 Simon task

The Simon task was originally created by Simon and Wolf in 1963 to test participants' executive functioning and in particular inhibition. The participants were presented with bi-colored stimuli. The color was linked to a response key, so for example the color red might be the right response button and blue could be the left one. In some trial (congruent trials), the colors were presented on the same side in which the button needed to be pressed, i.e. blue was presented on the left side. In the incongruent trials, the opposite happened and the color was presented on the opposite side, i.e. the blue color appeared on the right side. The task was to prove that if the stimulus and response button were on different sides, the response time was slower than on the congruent trials and this should be due to inhibition costs. This slower time response was known as the Simon effect and the difference in response time between congruent and incongruent time was typically between 20 and 30 ms.

Subsequent research using the Simon task and following from Simon and Wolf (1963) has shown that inhibition reduces with age (Hasher & Zack, 1988). It has also commonly been used in bilingualism research to examine whether there is a difference in cognitive development in monolinguals and bilinguals, and whether bilinguals show an advantage in older age with their cognitive control (Bialystok et al., 2004, Bialystok, Craik & Ryan, 2006; Bialystok, 2009).

In the present research, the task is used to determine if a reduced inhibitory control mechanism has any influence on language reversion. The format was run under Linux Ubuntu and used four different colors, two on each side, to make the task more demanding (in line most demanding condition Bialystok et al. 2004). Subjects were presented with a fixation point for 800 ms that was projected on the screen and then a blank screen for 250 ms before a stimulus was presented on either side in either congruent or incongruent conditions for which they had 1000 ms to respond. The participants were instructed that the left button was for green and pink while the red and yellow has the right button. The participants all did a pretest in which 5 out of 8 responses had to be correct to continue. The test consisted of 24 items. There were six items per color, of which three were congruent and three incongruent. All items were presented in a random order. The results included the mean response times for congruent and incongruent trial, accuracy scores, and Simon effect (which is the increment between the mean congruent and incongruent trials).

2.2.4 Peabody picture vocabulary task

Picture naming tasks, such as the Peabody picture vocabulary task (PPVT), have been used to assess a participant's receptive vocabulary. The task requires the participants to indicate which of the four pictures matches the word they hear. The test can be used from age 2;3 up to 90 years old and does not require the participants to be literate, since there is no reading or writing involved in the task. Since the age range is large, it is possible to compare various age groups. The first standardized PPVT was created in 1959 by Dunn (Dunn & Dunn, 1959). Since that time several more versions have been created and the latest one in English is the PPVT-4 (Dunn & Dunn, 2007), which is the version used in the current study. The PPVT has been standardized in several languages including Dutch and English. In the past, this task was used to assess lexical access and mental abilities for both children and adults (Pankratz et al. 2004, McWilliams 1974). Furthermore, it was used as an alternative standard proficiency test, and as an independent measure of verbal intelligence in both L1 and L2 research (Unsworth & Blom, 2010).

For the present study, two picture tasks were used to test both the L1 and L2 in the bilingual migrants. The PPVT-4 was used to test English vocabulary (Dunn & Dunn, 2007), and the PPVT-III-NL to test Dutch (Dunn et al., 2005). The participants started at set 14, which is the set intended for 19 years and older. If the participants had answered four or less items of a set incorrectly they could move on to a higher set; if they made more errors they were required to complete a lower set until they had at most four errors to establish a base level. From this low point or basal set, the participants continually completed sets that are more difficult until they had eight errors or more, or they finished the final set with less than eight errors to establish a ceiling set. The examiner recorded the answers using a scoring form with the numbers 1-4 or writes down "dk" if the participants could not give an answer.

2.2.5 C-test

The C-test, which is a variation of the cloze procedure, requires participants to fill in gaps in texts. The participants are given a text in which parts of words are deleted and this need to be filled in. The test gives an indication of overall language proficiency with regard to vocabulary, grammar, and use of idioms (Orcarson, 1991). By leaving out words in a text there is reduced redundancy in a text and the text becomes less clear. However, native speakers presented with this test have expectations of what needs to be filled into these gaps and this is known as internalized pragmatic expectancy grammar (Oller & Streif, 1975). These expectations can be about what type of word needs to be filled into a gap and this could be a noun for example. The next step is trying to use the context to determine which noun is the mostly likely to be the answer. For non-native speakers, unlike for native speakers, there should be greater processing difficulties, since the internal grammar is likely not as developed as that of native speakers (Gradman & Spolsky, 1975). The test has been used in both language acquisition (e.g. Grotjahn, 1987; Daller & Grotjahn, 1999) and language attrition research (e.g. Murtagh, 2003; Keijzer, 2007) to test the current level of the participants' proficiency in either their L1, L2, or both.

The C-test consists of several short texts, which on average are 60-70 words long. The first sentence of the text remains intact to provide sufficient context while in other sentences gaps are created. The words that are gapped are either content or function words and only half of the word is removed. In the case of uneven number of letters in a word there is one more letter removed, i.e. in a five letter word only two letters remain and not three.

For the present research, the participants were presented with five short texts and each text had twenty gaps. The Dutch texts had a mean length of 74 words and the English texts 81.2. The balance of content and function words were similar in both languages: 14.4 content and 5.6 function words on average in Dutch texts, and 14.6 content and 5.4 function words in

English texts. All text were pretested by native speakers of either English or Dutch[3] to make sure the topics were appropriate, well written, free of direct speech, and did not have a specialized vocabulary. The gapping started at the second word of the second sentence and when possible every second word was deleted. Exceptions were made with compound words, reoccurring words, proper names, place names, or when too many function words would be deleted. In these cases, the following word would be gapped.

The participants received the test before the day of testing. They did the task at home in which they filled in the gaps as well as they could and brought the results with them at the day of testing. The instructions indicated that the participants had 5 minutes per text.

2.2.6 Grammaticality Judgment Task

The grammaticality judgment task was used to examine what the participants perceived as being grammatical or ungrammatical. In progressive cases of attrition in adult speakers, the grammar could be affected (Köpke, 2001). The participants were tested about their intuitions in both English and Dutch. For some participants, it was possible that they could accept structures that were grammatical in English, but ungrammatical in Dutch, to be grammatical in Dutch as well. While there is overlap between what is grammatical in English and Dutch, there are distinct points where the two languages differ. The focus was on determining if the participants still recognize the difference in Dutch and English structures, and these include: the verb second properties of Dutch, negation, embedded clauses, passives, and reflexives.

The participants performed this task by themselves at home beforehand. They brought the GJT task with their answers on the day of testing. The participants indicated how grammatical an item is on a five-point scale, marked which part of the sentence was ungrammatical, and corrected the sentences. The sentences for Dutch and English were tested separately from each other.

2.3 Procedure

All the test results used in the current research are part of Merel Keijzer's Veni project (2012). Some of the tasks the participants did at home and these included the Grammaticality judgment and C-test. The participants received written instructions on how to do the task. The grammaticality judgment task was self-paced, and subjects were asked to indicate how grammatical they thought a sentence was on a five-point scale. Additionally, they were asked to indicate which part seemed to be ungrammatical, in sentences where they indicated that the sentence was ungrammatical and corrected them. For the C-test, they were given five short texts and each text had twenty gaps. The first sentence remained intact to provide context and the following sentences parts of words were deleted. The written instructions told the participants to spend no more than five minutes per text.

The other tasks were done either at a university or at the participant's home, while a researcher was present. They made use of a laptop on which Linux Ubuntu was installed. The audio recordings were done under Audacity. The participants signed a consent form, before moving on to the socio-linguistic questionnaire, mini-mental state exam, and the various language and cognitive tasks. The participants were given the instructions orally and if the task required a laptop, the tasks were repeated in written form as well on the screen. For the bilingual participants the tasks were divided, which meant that the tasks for the first half were tasks in the L1 and for the second part in L2. The switching between languages was thereby kept to a minimum. Due to the length of the test battery, the participants were able to have a break every half hour. The instructions for tasks such as the Simon task, which were not language based, were given in the dominant language of the participant and for the bilinguals it was assumed to be Dutch. The participants were given 20 euros if they were part of the control group and 30 euros if they were bilingual or its equivalent in Australian dollars.

Notes

[1] The mini mental state exam was conducted as part of the test battery in Merel Keijzer's Veni project (2012).

[2] These were a subset of the test battery from Merel Keijzer's Veni project (2012).

[3] The Dutch texts used were from Keijzer's (2007) research of attrition in Dutch-English migrants in Canada and the topics were considered generic in their topic matter by Dutch students from the Vrije Universiteit in Amsterdam. The English texts came from Keijzer's research as well but some were replaced for the current research, since the topics in some texts were related to Canada. The new texts were pretested by Australian students from Monash University in Melbourne.

Chapter 3: Results

The results are given per test[1], before examining relations between tasks. Finally results are presented that might show how working memory and inhibition are affected by age, and if they affect attrition and language reversion.

3.1 Monolinguals and bilinguals per test

3.1.1 Backwards digit span task

The test required the participants to recall up to 10 items, which some people were able to achieve. Overall, the bilingual group had a mean score of 6.94 with a standard deviation of 1.99, while the monolingual group had a score of 6.07 and a standard deviation of 2.21. The bilinguals performed overall better than the control group. Table 5 and Figure 1 show the results of the bilinguals and Dutch controls for each age group:

Table 5. Results of the backwards digit span task: mean and standard deviation

		Dutch-English bilinguals			**Dutch control group**		
	Age category	*40-45*	*60-65*	*75+*	*40-45*	*60-65*	*75+*
BDST	*Mean*	8.29	6.40	6.46	7.70	5.95	4.69
	St. dev.	1.99	1.501	1.96	2.00	2.12	1.49

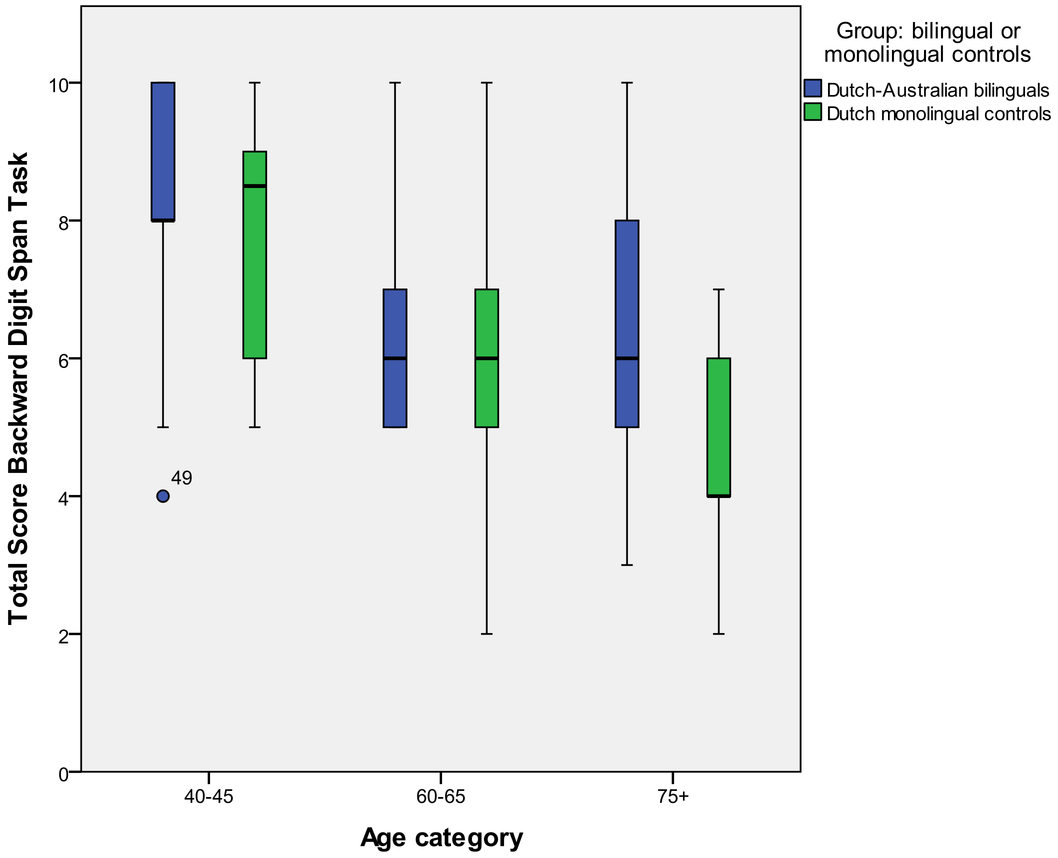

Figure 1. Results of the backwards digit span task

The total score of the BDST for bilinguals, D(63) = 0.14, p < .05, and Dutch controls, D(42) = 0.14, p < .05, were both non-normally distributed. The results for the three age groups were significantly non-normally distributed as well with the following results for the 40-45 (D(27) = 0.21, p < .05), the 60-65 (D(39) = 0.16, p < .05), and the 75+ age group (D(39) = 0.16, p < .05). The variances were equal between language groups, F(1, 103) = 0.001, *ns*, and the same applied to age groups, F(2, 102) = 0.573, *ns*.

The results of the correlations of the BDST showed that there was a significant difference between the task and the two language groups, r = -.20, p < .05, but there was no significant correlation with lifestyle. The results showed that the bilinguals overall scored significantly better in comparison to the control group, showing signs of a bilingual advantage. Furthermore, there was a significant correlation between the task and the age of the participants at testing, $r_s = -.37$, $p < .01$, which means that older participants overall had poorer results compared to young ones. There was a significant correlation between the BDST and the length of residence of the bilinguals ($r_s = -.34$, $p < .01$), but this was most likely because the people who lived the longest in Australia were often the oldest as well. The BDST showed a significant relationship with both reading span tasks. The relationship applied to all participants between the BDST and RST Dutch, $r_s = -.39$, $p < .01$, and for the bilinguals in the RST English, $r_s = -.41$, $p < .01$. The BDST and RST both tested working memory. Finally, there was significant correlation between the BDST and Simon task (acc), $r_s = -.34$, $p < .01$, for all participants. This showed that all other cognitive tasks were related to the BDST.

3.1.2 Reading span task

For the RST, the participants did three blocks of twenty sentences and answered six questions. Each sentence and answer gave one point. For the RST Dutch, the bilingual group had a mean score of 35.56 with a standard deviation of 7.18, while the monolingual group had a score of 36.86 and a standard deviation of 6.16. The control group performed slightly better and showed a smaller standard deviation in comparison to the bilinguals. The reading span English had a mean of 34.56 and a standard deviation of 7.24. These results were similar to the bilinguals' performance in the Dutch version of this task. The following table and figures show the total score of the RST for both English and Dutch for the bilinguals and the results for the Dutch RST for the controls.

Table 6. Results of the reading span task: mean and standard deviation

		Dutch-English bilinguals			**Dutch control group**		
	Age category	*40-45*	*60-65*	*75+*	*40-45*	*60-65*	*75+*
RST Dutch	*Mean*	40.71	35.57	32.23	41.10	36.63	32.62
	St. dev.	4.30	6.93	7.69	5.53	6.47	1.69
RST English	*Mean*	39.35	35.10	31.00	--	--	--
	St. dev.	5.88	6.60	6.79	--	--	--

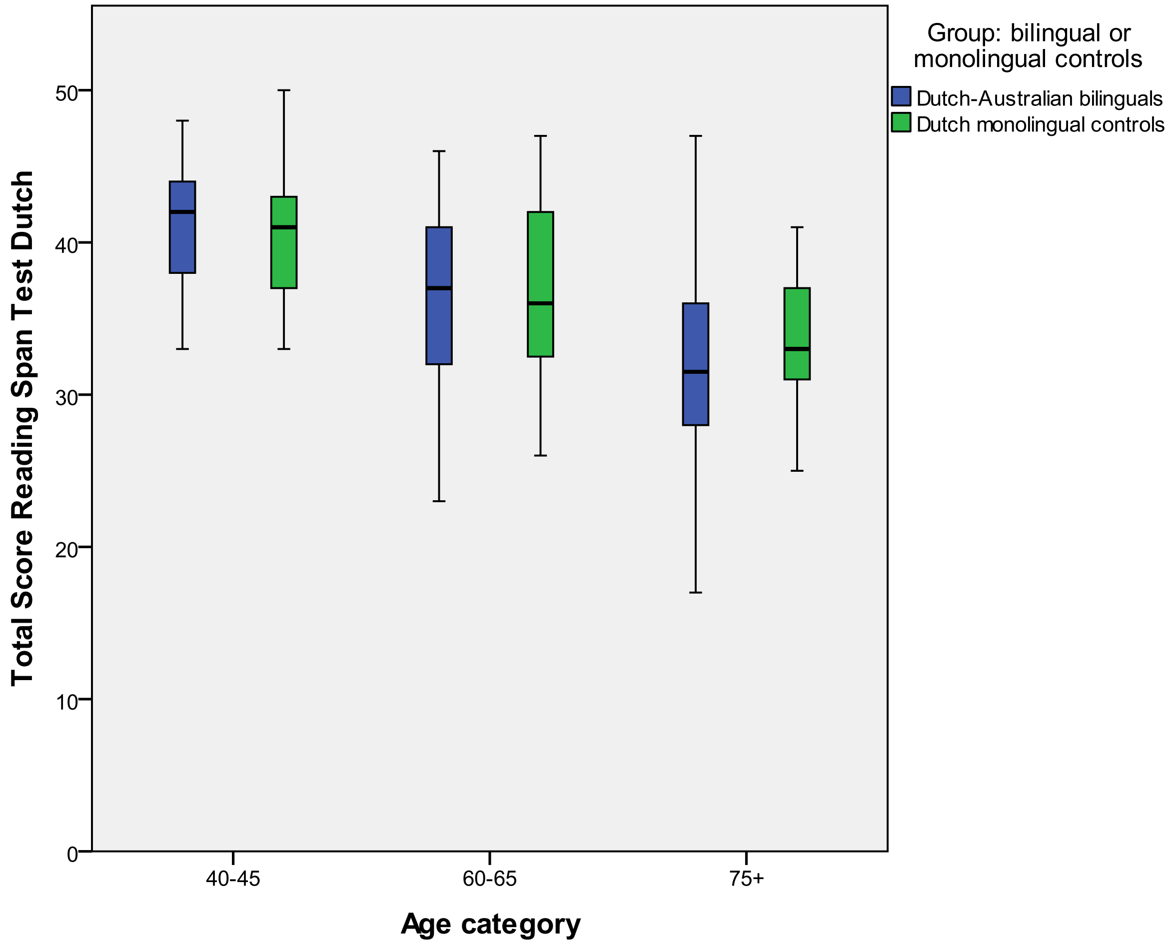

Figure 2. Results of reading span task Dutch

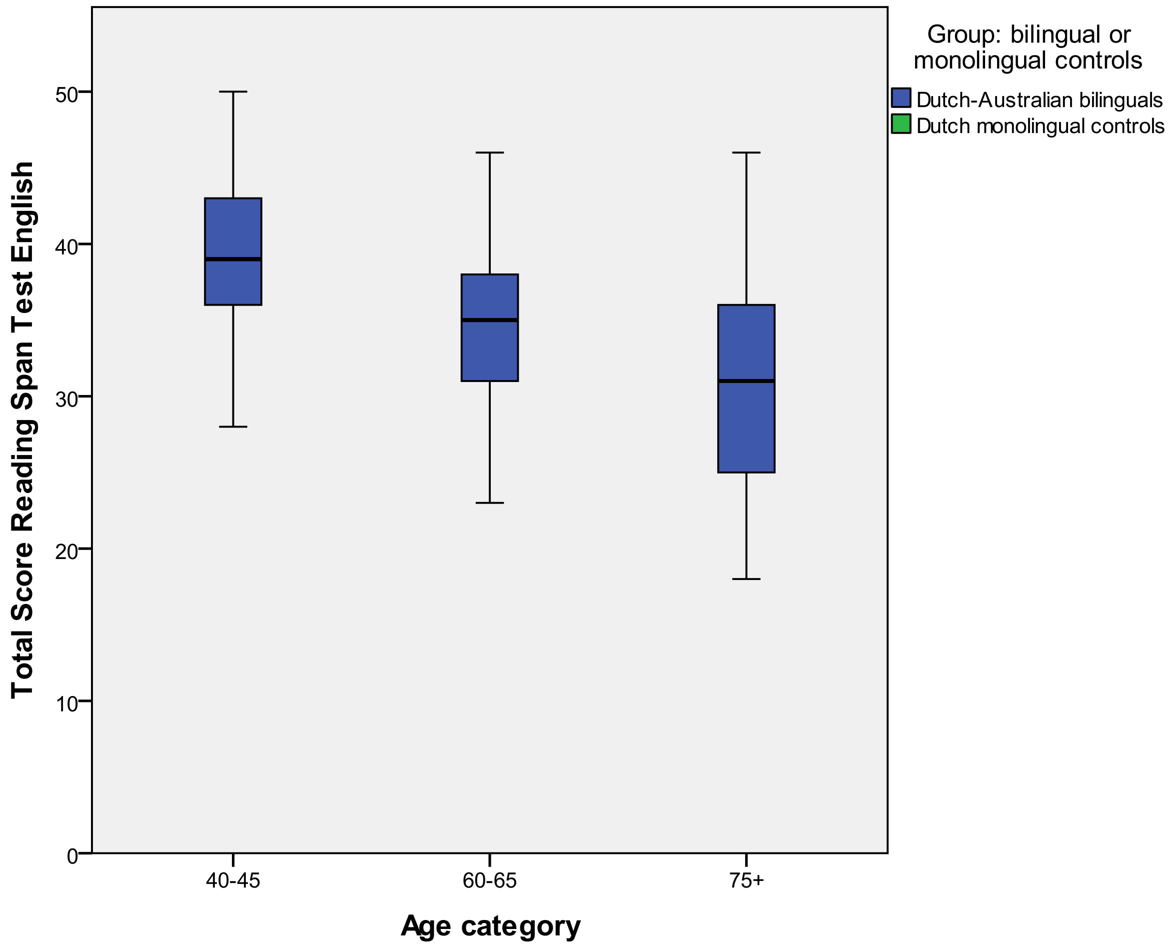

Figure 3. Results of reading span task English

The total score of the Dutch RST for bilinguals, D(64) = 0.07, *ns*, and Dutch controls, D(42) = 0.07, *ns*, both showed a normal distribution. The results for the three age groups were normally distributed as well with the following results for the 40-45 (D(27) = 0.12, *ns*), the 60-65 (D(40) = 0.08, *ns*), and the 75+ age group (D(39) = 0.10, *ns*). The variances were equal between language groups, F(1, 104) = 0.729, *ns*, and the same applied to age groups, F(2, 103) = 0.167, *ns*. Furthermore, the total score of the English reading span task had a normal distribution, D(64) = 0.07, ns, and the same applied between the three age groups: 40-45 (D(17) = 0.10, *ns*), the 60-65 (D(21) = 0.11, *ns*), and the 75+ age group (D(26) = 0.12, *ns*). The variance was equal between age groups, F(2, 61) = 0.196, *ns*.

For the RST NL, there was a significant relationship between the task and age, $r_s = -.54$, $p < .01$, for all participants. In other words, working memory decreased with age and older participants were likelier to show poorer results in comparison to those in the youngest age group. The same applied for LoR for the bilinguals, $r_s = -.49$, $p < .01$, but this was likely due to age as well. However, there was no correlation with group, which means that both groups performed similarly and the control group did not perform significantly better.

The results of the RST NL were similar to that of the BDST in that there were significant relationships with two other working memory tasks, the RST EN, $r_s = .81$, $p < .01$, and BDST, $r_s = .39$, $p < .01$. There was a significant correlation with the Simon task (acc), $r_s = .42$, $p < .01$. Furthermore, there was a significant relation between the RST NL and two language tasks: the GJT, $r_s = .50$, $p < .01$, and PPVT NL, $r_s = .40$, $p < .01$.

The RST NL showed a significant relation with an active lifestyle. This was for active life (2), $r = .24$, $p < .05$, for all participants. When the same factor was examined per language group, it showed that this factor had a significant effect on only one of the two groups. The results for the bilinguals was non-significant, $r = .29$, *ns*, but for the monolinguals it was significant, $r = .18$, $p < .05$. The control group did show a significant relationship in active lifestyle (1), $r = .30$, $p < .05$, but the correlation was non-significant for the bilinguals, $r = .65$, *ns*. This showed that a socially active lifestyle had a positive influence on the results.

The results of the RST English are similar to that of the RST Dutch. There was a significant relationship between the task and age of testing, $r_s = -.60$, $p < .01$, as well as length of residence, $r_s = -.43$, $p < .01$. Furthermore, the RST EN was significantly related to the BDST, $r_s = .41$, $p < .01$, Simon task (acc), $r_s = .45$, $p < .01$, and GJT NL, $r_s = .32$, $p < .05$.

3.1.3 Simon task

The results that were used for the statistics was the Simon effect, the differences in reaction time between the congruent and incongruent trials, which was measured in ms. Another score of the Simon task was accuracy scores of the congruent and incongruent trials and there were 24 trials in total. For the Simon task (effect), the bilingual group had a mean score of 37.46 with a standard deviation of 70.50, while the monolingual group had a score of 25.39 and a standard deviation of 63.32. This shows that the control group overall had a smaller difference in reaction time. The accuracy scores of the Simon task showed that, the bilingual group had a mean score of 20.50 with a standard deviation of 4.17, while the monolingual group had a score of 20.07 and a standard deviation of 4.91. The bilingual group performed slightly better in Simon task (acc). Combined this showed that the control group was faster, but less accurate than the control group. Table 7 and Figure 4 show the results of the Simon effect for the bilinguals and Dutch controls in each age group:

Table 7. Results of the Simon task (effect): mean and standard deviation

		Dutch-English bilinguals			**Dutch control group**		
	Age category	*40-45*	*60-65*	*75+*	*40-45*	*60-65*	*75+*
Simon Task (effect)	*Mean*	31.00	46.10	34.71	-6.60	25.40	46.52
	St. dev.	58.81	66.68	82.87	56.44	68.69	60.48

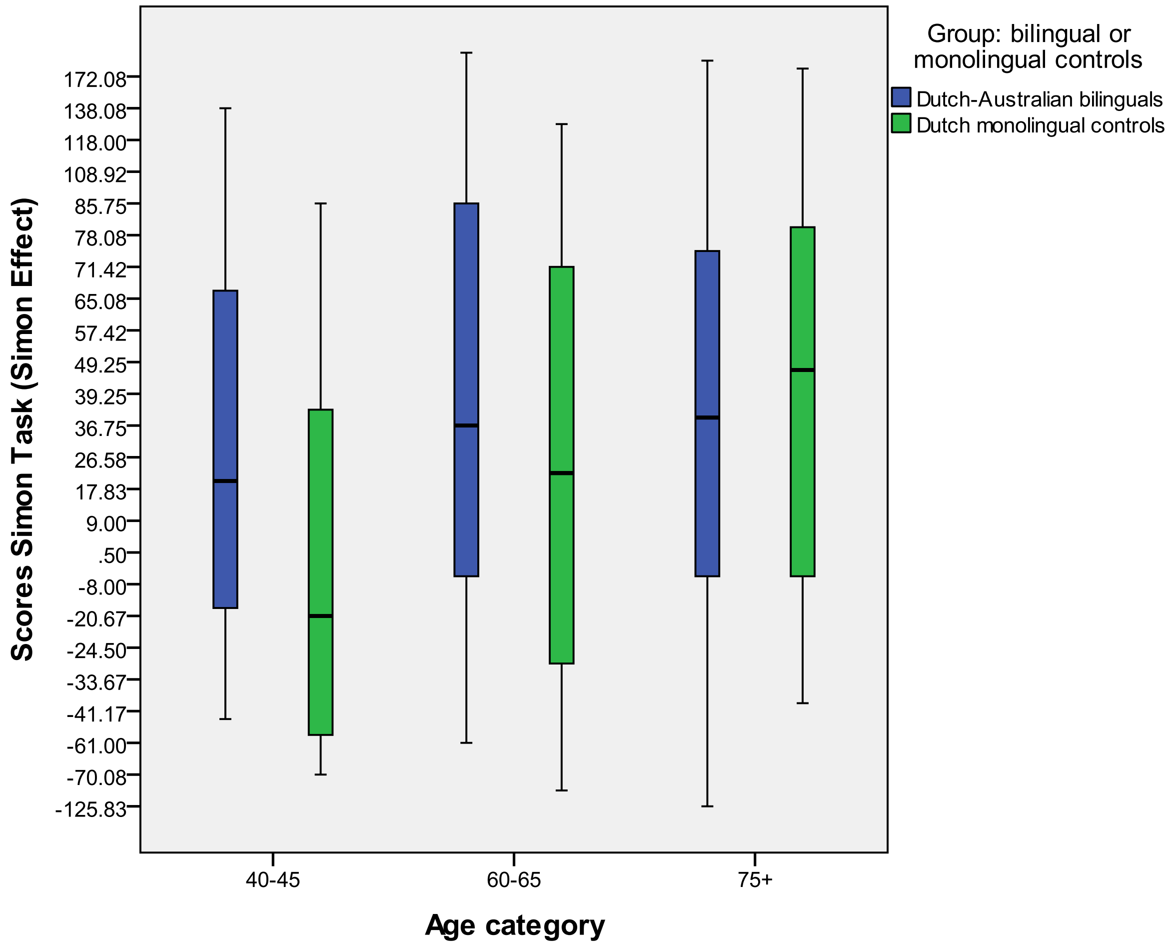

Figure 4: Results of the Simon task (effect)

The total score of the Simon task (effect) for bilinguals, D(60) = 0.06, *ns*, and Dutch controls, D(42) = 0.14, *ns*, both had a normal distribution. The results for the three age groups had a normal distribution as well with the following results for the 40-45 (D(25) = 0.11, *ns*), the 60-65 (D(37) = 0.10, *ns*), and the 75+ age group (D(36) = 0.10, *ns*). The variances were equal between language groups, F(1, 96) = 0.018, *ns*, and the same applied to age groups, F(2, 95) = 0.411, *ns*.

The results of the accuracy scores of the Simon task can be found in the following Table (8) and Figure (5):

Table 8. Results of the Simon task (acc): mean and standard deviation

		Dutch-English bilinguals			**Dutch control group**		
	Age category	*40-45*	*60-65*	*75+*	*40-45*	*60-65*	*75+*
Simon Task (Acc)	*Mean*	23.41	19.65	18.61	22.13	21.00	17.08
	St. dev.	0.795	5.603	4.793	1.642	3.775	6.487

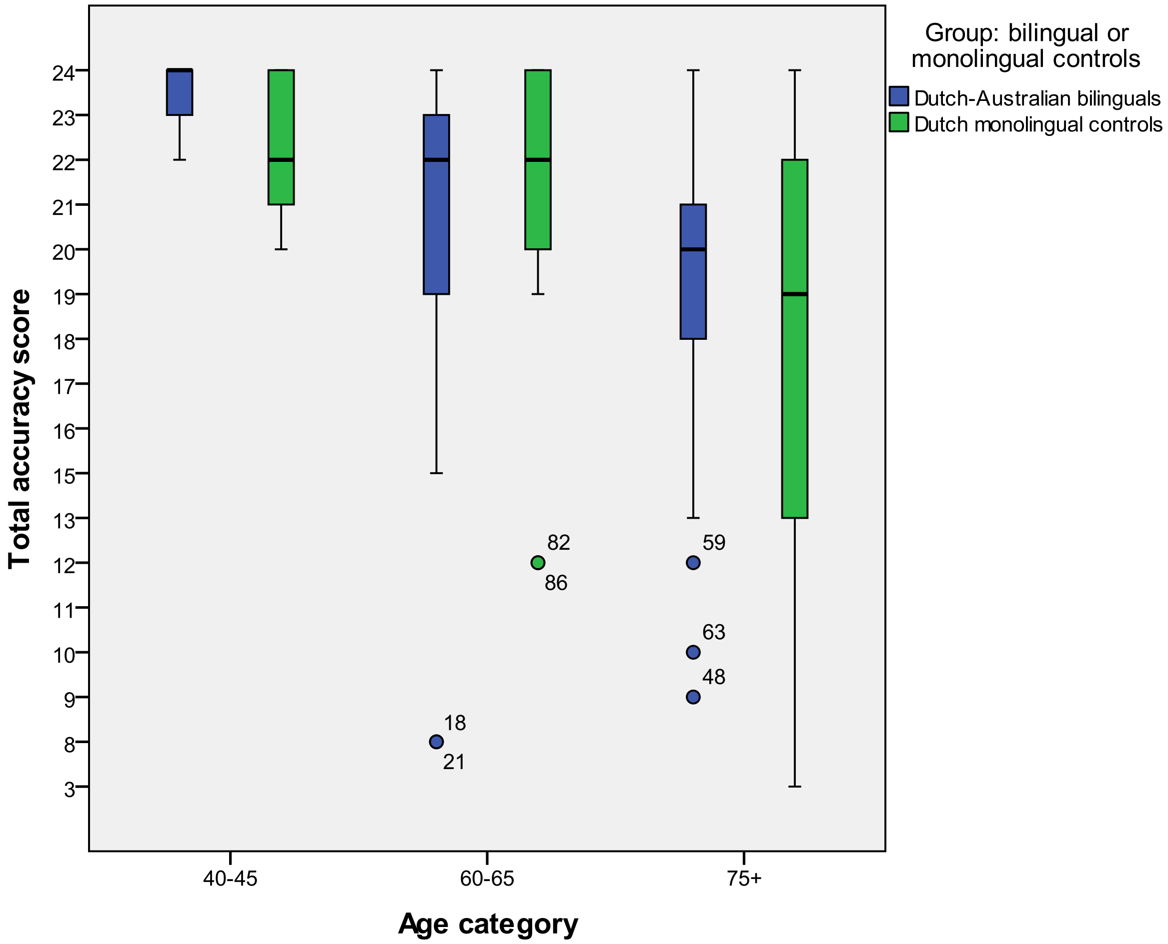

Figure 5: Results of the Simon task (acc)

The total score of the Simon task accuracy scores for bilinguals, D(60) = 0.23, $p < .05$, and Dutch controls, D(38) = 0.25, $p < .05$, were both significantly non-normally distributed. The results for the three age groups were significantly non-normally distributed as well with the following results for the 40-45 (D(25) = 0.31, $p < .05$), the 60-65 (D(37) = 0.26, $p < .05$), and the 75+ age group (D(36) = 0.23, $p < .05$). The variances were equal between language groups, F(1, 96) = 0.751, *ns*, but this did not apply to age groups, F(2, 95) = 9.113, $p < .05$.

The Simon task (effect) only significantly correlated with the C-test NL, $r_s = -.31$, $p < .05$, in the bilingual group. There were no correlations with age at testing, length of residency, group, active lifestyle, or any other task.

For the Simon task (acc), there were several significant correlations. Age, $r_s = -.59$, $p < .01$, was a significant factor for all participants, in which the older participants had lower scores in comparison to young participants. There was a significant relation with LoR, $r_s = -.61$, $p < .01$, with the bilingual participants, which is most likely related to age. The group factor was only significant for the 40-45 age group, $r_s = -.49$, $p < .05$, showing mostly that there was little difference between bilinguals and controls, and active lifestyle was not significant.

The Simon task (acc) showed significant correlations with both the RST NL, $r_s = .42$, $p < .01$, which applied to all participants and RST EN, $r_s = .45$, $p < .01$ which applied to only the bilinguals. The results showed a significant relationship between the Simon task (acc) and BDST, $r_s = .34$, $p < .01$, as well. There were also significant correlations with the GJT NL, $r_s = .25$, $p < .01$, and PPVT NL, $r_s = .23$, $p < .01$, among all participants. The bilinguals showed significant relations between the Simon task (acc) and RST EN, $r_s = .45$, $p < .01$, and the 75+ group showed a significant relation between the Simon task (acc) and PPVT EN, $r_s = .44$, $p < .05$. Finally, there were significant correlations between the C-test and Simon task (acc) in the bilingual group, $r_s = -.28$, $p < .05$, and the controls, $r_s = .36$, $p < .05$, but not when all participants were combined. This is most likely because the group factor is significant in the C-test and the results are significantly different in both groups. The bilinguals performed worse than the controls in that task (for more details see 3.1.5).

3.1.4 Peabody picture vocabulary task

The scores that were used for the PPVT in both English and Dutch were the standardized results of the tasks. For the PPVT Dutch, the bilingual group had a mean score of 106.16 with a standard deviation of 9.97, while the monolingual group had a score of 103.86 and a standard deviation of 11.99. This shows that the bilingual group performed slightly more consistent and higher than the control group. Furthermore, the results show that the bilinguals had a mean score of 103.62 for the PPVT English with a standard deviation of 11.63 and this shows that the bilinguals had a strong command of their vocabulary in general. The following Table (9) and Figures (6+7) show the results of the PPVT in both English and Dutch for the bilinguals and the results of the Dutch PPVT for the control group.

Table 8. Results of the Peabody picture vocabulary task in both English and Dutch: mean and standard deviation

		Dutch-English bilinguals			**Dutch control group**		
	Age category	*40-45*	*60-65*	*75+*	*40-45*	*60-65*	*75+*
PPVT Dutch	*Mean*	108.12	106.67	103.83	97.70	109.95	99.15
	St. dev.	10.76	12.09	8.58	13.69	8.84	11.47
PPVT English	*Mean*	99.00	103.90	106.67	--	--	--
	St. dev.	13.13	11.89	9.51	--	--	--

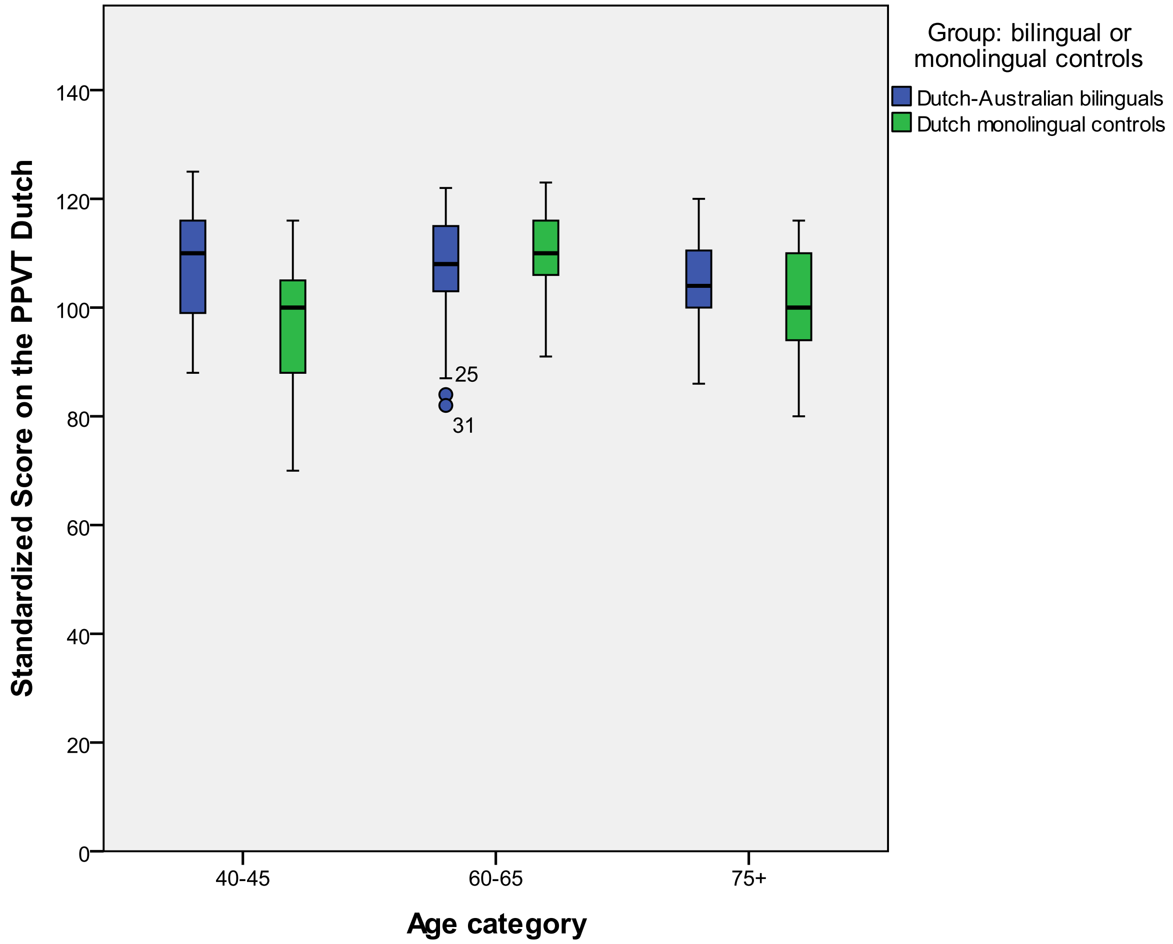

Figure 6: Results of the Peabody picture vocabulary task Dutch

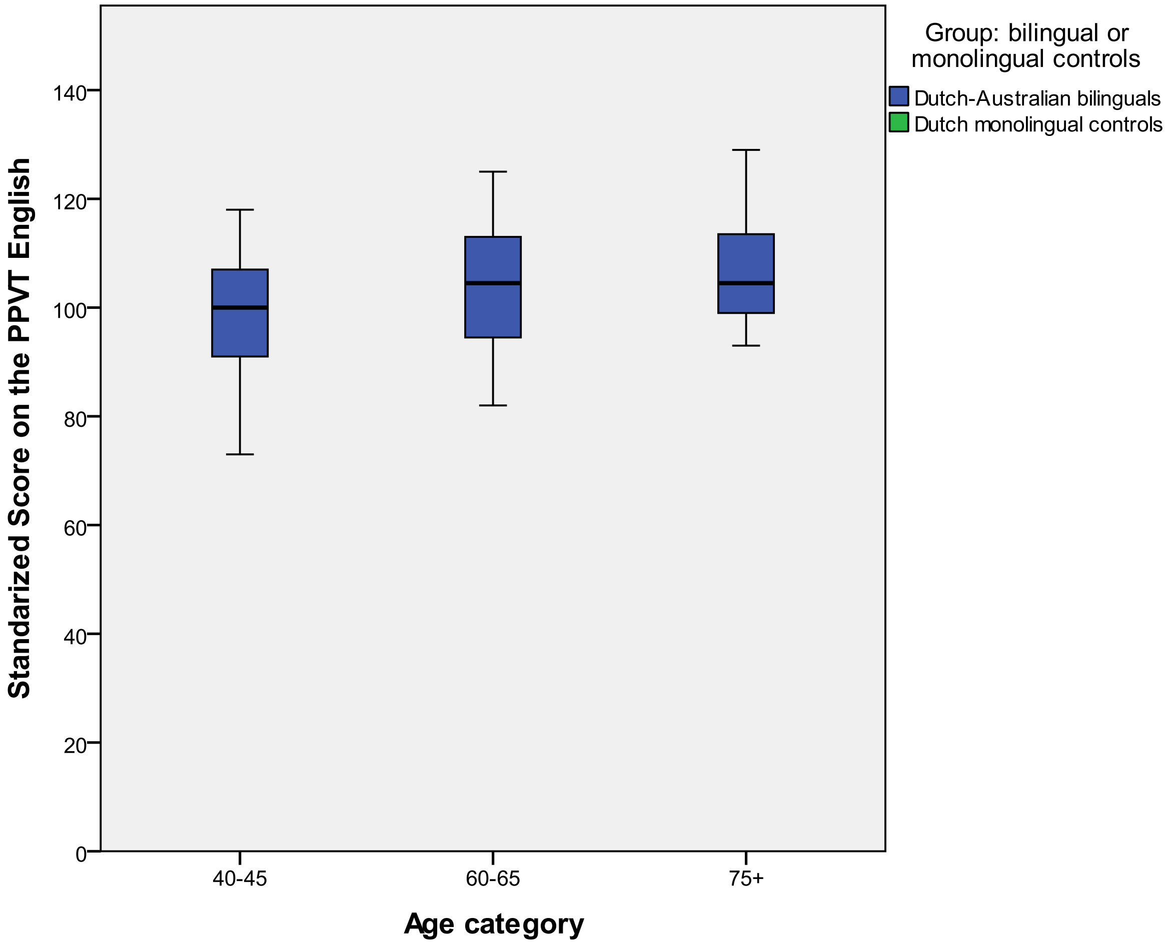

Figure 7: Results of the Peabody picture vocabulary task English

The total score of the Dutch PPVT for bilinguals, D(62) = 0.09, *ns*, and Dutch controls, D(42) = 0.09, *ns*, both had a normal distribution. The results for the three age groups had a normal distribution as well with the following results for the 40-45 (D(27) = 0.10, *ns*), the 60-65 (D(40) = 0.13, *ns*), and the 75+ age group (D(37) = 0.14, *ns*). The variances were equal between language groups, F(1, 102) = 1.148, *ns*, and the same applied to age groups, F(2, 101) = 1.086, *ns*. Furthermore, the total score of the English PPVT of the bilinguals had a normal distribution, D(61) = 0.09, ns, and the same applied between the three age groups: 40-45 (D(17) = 0.12, *ns*), the 60-65 (D(20) = 0.17, *ns*), and the 75+ age group (D(24) = 0.15, *ns*). The variance was equal between age groups, F(2, 58) = 1.546, *ns*.

There were several significant relationships for the PPVT in both the English and Dutch version. The correlation between the Dutch and English PPVT was $r_s = .46$, $p < .01$. Another factor that was significant to both the English and Dutch PPVT was LoR, but age at testing was not significant. This means aging did not affect the development of vocabulary in any participant, but LoR did have an influence. The correlations for LoR were, $r_s = -.26$, $p < .05$, for the Dutch version and, $r_s = .33$, $p < .05$, for the English test and this applied to the bilinguals only. This shows that the migration had a positive effect for their English vocabulary, but not for Dutch. Additionally, a partial correlation analyses was performed in which the age of testing was controlled for and it showed a significant relationship between LoR and PPVT EN, $r = -.36$, $p < .05$.

The correlations between tests showed that there was a relation between the PPVT NL and the RST NL, $r_s = .40$, $p < .01$, as well as with the GJT NL, $r_s = .37$, $p < .05$, and Simon task (acc), $r_s = .23$, $p < .05$, the results applied to all participants. The results between the Simon task (acc) and the PPVT were concentrated in the oldest age group for both versions and this applied to all participants in the Dutch version. There was a significant relation between PPVT NL and Simon task (acc), $r_s = .40$, $p < .05$, for all 75+ participants, and between the PPVT EN and Simon task (acc), $r_s = .44$, $p < .05$, for the 75+ bilinguals.

3.1.5 C-test

For the C-test, the participants could achieve a maximum score of 100 points per text. For the C-test, the bilingual group had a mean score of 81.07 with a standard deviation of 19.69, while the monolingual group had a score of 93.12 and a standard deviation of 5.85. This shows that the control group performed much better than the bilingual group with more consist and higher scores. The following results of the Dutch C-test were based on the mean of all the texts taken together. The results are shown in Table 9 and Figure 8:

Table 9. Results of the C-test Dutch: mean and standard deviation

		Dutch-English bilinguals			**Dutch control group**		
	Age category	*40-45*	*60-65*	*75+*	*40-45*	*60-65*	*75+*
C-test Dutch	*Mean*	79.13	72.95	86.68	93.90	93.00	88.42
	St. dev.	21.24	28.21	12.32	5.15	4.69	17.90

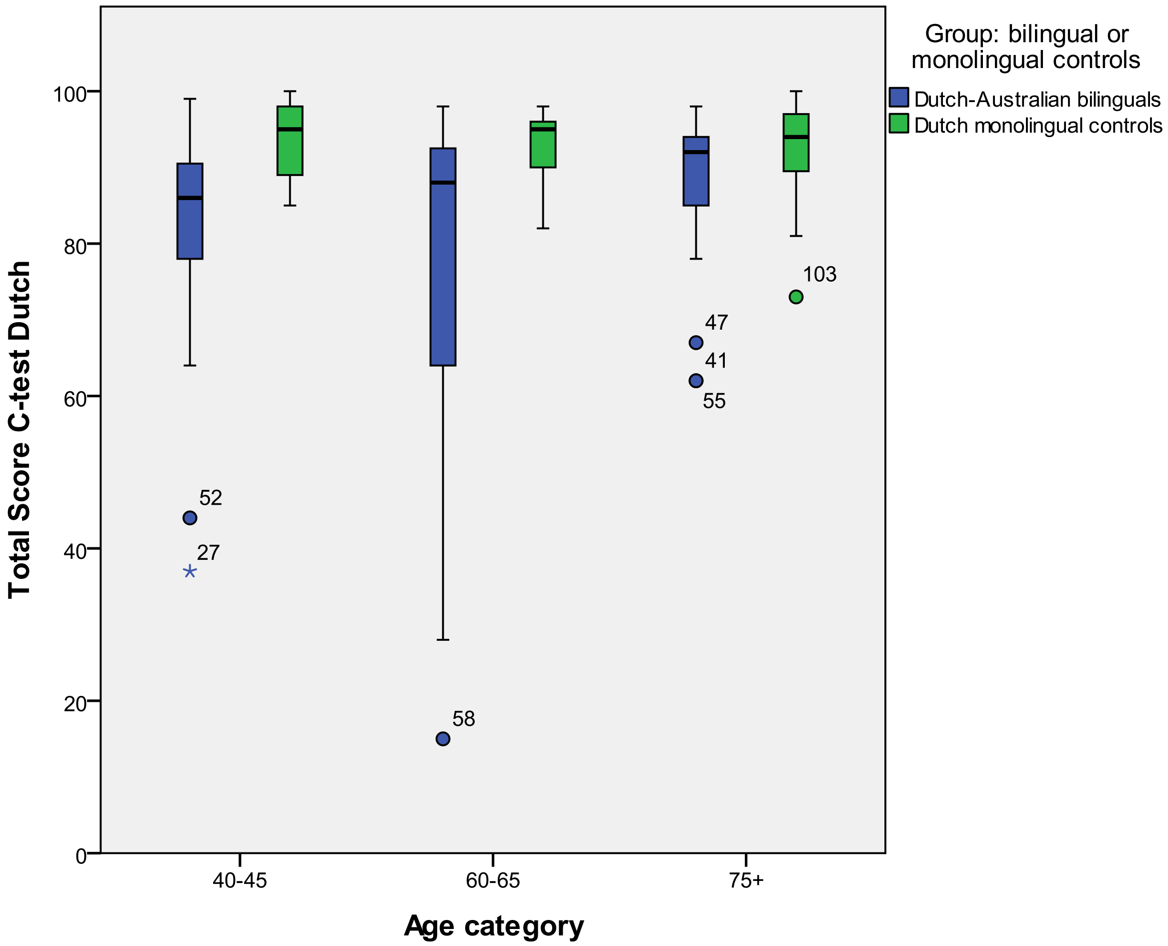

Figure 8: Results of the C-test Dutch

The total score of the C-test Dutch for bilinguals, $D(59) = 0.24$, $p < .05$, and Dutch controls, $D(39) = 0.18$, $p < .05$, were both significantly non-normally distributed. The results for the three age groups were significantly non-normally distributed as well with the following results for the 40-45 ($D(25) = 0.26$, $p < .05$), the 60-65 ($D(36) = 0.31$, $p < .05$), and the 75+ age group ($D(37) = 0.22$, $p < .05$). The variances were not equal between language groups, $F(1, 96) = 23.444$, $p < .05$ and the same applied to age groups, $F(2, 95) = 5.104$, $p < .05$.

For the C-test, the correlations showed that the group was a significant factor. The correlation between the group and the C-test was, $r = .36$, $p < .05$, in which the control group had an advantage. However, neither age nor length of residence was significant. Time did not affect performance. Furthermore, active lifestyle was not a relevant factor either.

The C-test showed significant negative relationships with the Simon task (effect), $r_s = -.31$, $p < .05$, and Simon task (acc), $r_s = -.28$, $p < .05$, but this was only with the bilingual group. The 75+ bilingual participants showed a significant negative relation between the C-test and PPVT EN, $r_s = -.51$, $p < .05$. For the control group, the C-test had a significant correlation with the Simon task (acc), $r_s = .36$, $p < .05$, and with the GJT NL, $r_s = .43$, $p < .01$.

3.1.6 Grammaticality judgment task

The results of the GJT Dutch were based on whether participants had correctly indicated whether a structure was grammatically correct or incorrect. There were 28 sentences in total. For the GJT Dutch, the bilingual group had a mean score of 23.82 with a standard deviation of 3.86, while the monolingual group had a score of 24.26 and a standard deviation of 3.72. Both the bilinguals and control group performed similarly. Table 10 and Figure 9 show the results of all participants:

Table 10. Results of the Grammaticality judgment task Dutch: mean and standard deviation

		Dutch-English bilinguals			Dutch control group		
	Age category	*40-45*	*60-65*	*75+*	*40-45*	*60-65*	*75+*
GJT Dutch	*Mean*	26.07	23.67	21.14	26.60	24.21	20.00
	St. dev.	2.92	3.29	6.54	1.78	2.94	7.98

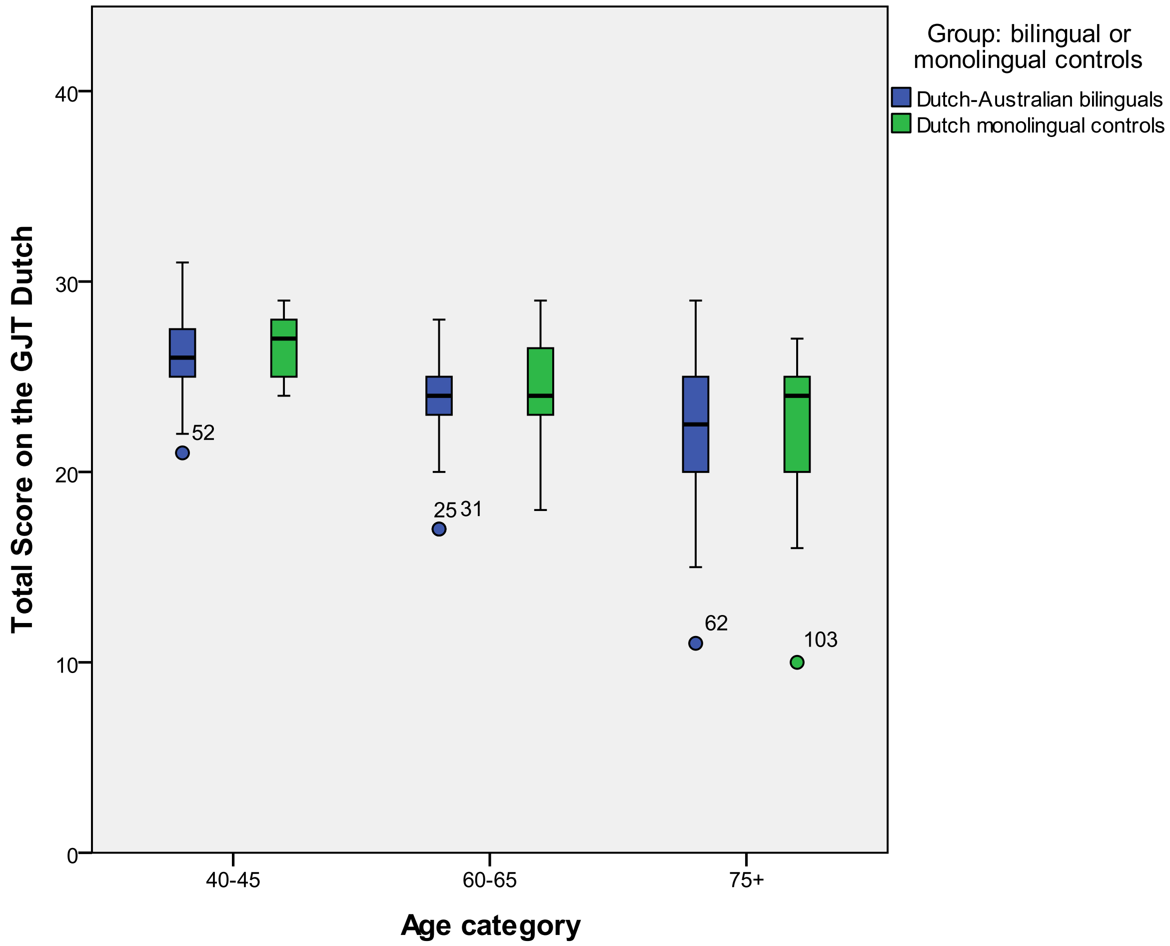

Figure 9: Results of the Grammaticality judgment task Dutch

The total score of the GJT Dutch for bilinguals, D(56) = 0.14, p < .05, and Dutch controls, D(40) = 0.20, p < .05, were both significantly non-normally distributed. The results for the three age groups were normal for the youngest (D(25) = 0.14, *ns*) and oldest age group (D(31) = 0.14, *ns*), but not for the 60-65 (D(40) = 0.17, p < .05) age group. The variances were equal between language groups, $F(1, 94) = 0.286$, *ns* but the same did not apply to age groups, $F(2, 93) = 4.719$, $p < .05$.

The GJT NL showed a significant relationship with the age of testing, $r_s = -.49$, $p < .01$, for all participants. This showed that age affected the participants' understanding of grammar, but LoR, active lifestyle, group were all non-significant factors. This means that there were no significant changes of the bilinguals' understanding of grammar due to migration or attrition.

With other language tasks, there were significant relationships with the PPVT NL, $r_s = .37$, $p < .01$, and RST NL, $r_s = .50$, $p < .01$, with all participants as well. Furthermore, there was a significant correlation with the RST EN, $r_s = .32$, $p < .05$, for the bilinguals and a significant relation between the GJT and the C-test, $r_s = .42$, $p < .01$, for the control group.

3.2 Age and cognition

To assess whether age had an influence on the cognitive performance in both monolingual and bilingual participants, a regression analysis was performed on the cognitive tasks (BDST, RST, and Simon task). It took place in two steps. Initially, the independent factor was age at testing, and the group variable (bilinguals versus controls) was added to the second step of the model. The group variable was added to determine whether there was a difference in results either due to attrition (in the RST) or a bilingual advantage. The regression analysis was run on the following tasks for all participants: BDST, RST NL, Simon task (effect), and Simon task (Acc). Only the Simon task (effect) produced non-significant results. Furthermore, the RST EN was used for a regression analysis as well, but only had age as a factor. This was to see if attrition had a confounding effect on working memory alongside age. The results of all tasks with significant results are presented.

The BDST showed significant correlations with group, $r = -.20$, $p < .05$, and age factors, $r_s = -.37$, $p < .01$. This means the bilingual group had an advantage, but all participants suffered from aging affects.

Table 11. Regression analysis BDST: Age and Group

Step		B	SE B	Β
1	Constant	10.55	.88	
	Age at testing	-.06	.01	-.41*
2	Constant	12.12	1.03	
	Age at testing	-.07	.01	-.43*
	Group	-1.00	.37	-.23*

Note: $R^2 = .17$ for Step 1, $\Delta R^2 = .05$ for Step 2 ($p < .01$). * $p < .01$

The RST NL showed a significant relation with age, $r_s = -.54$, $p < .01$, but group was not significant. The groups performed similarly and the older participants from both groups showed similar effects due to aging.

Table 12. Regression analysis RST NL: Age and Group

Step		B	SE B	β
1	Constant	52.84	2.60	
	Age at testing	-.26	.04	-.54*
2	Constant	51.65	3.15	
	Age at testing	-.26	.04	-.54*
	Group	.76	1.13	.06 *(ns)*

Note: $R^2 = .29$ for Step 1, $\Delta R^2 = .00$ for Step 2 (*ns*). * $p < .01$

The RST EN showed a significant relation with age, $r_s = -.60$, $p < .01$, similarly to that of the RST Dutch.

Table 13. Regression analysis RST EN: Age

Step		B	SE B	β
1	Constant	52.64	3.32	
	Age at testing	-.28	.05	-.58*

Note: $R^2 = .33$. * $p < .01$

The Simon task (acc) showed a significant negative correlation with age, $r_s = -.59$, $p < .01$, but group was not a significant factor.

Table 14. Regression analysis Simon task (acc): Age and Group

Step		B	SE B	β
1	Constant	29.90	1.83	
	Age at testing	-.15	.03	-.48*
2	Constant	30.70	2.18	
	Age at testing	-.15	.03	-.48*
	Group	-.54	.81	-.60 *(ns)*

Note: $R^2 = .23$ for Step 1, $\Delta R^2 = .00$ for Step 2 (*ns*). * $p < .01$

The results of the regression analysis showed overall that age was a stronger predictor than group for cognitive performance. The results showed little effect of either attrition or a bilingual advantage in the task with the exception of the BDST. The results demonstrated that aging caused a slow decrease in performance in all these cognitive tasks. There was little difference in the results between the two reading span tasks, even though the RST Dutch had more participants, but the results showed that the group factor was not important for that task. The only cognitive task in which group was a significant factor, BDST, it accounted for 5% of the variation in combination with group, the R^2 changed from .17 to .22, which could indicate a possible bilingual advantage.

The results for the Simon task were not significant for group for both Simon effect and accuracy scores. This is possibly because the scores combined show a difference in performance between the two groups but not individually. The mean scores of both effect and accuracy showed a trend that the bilingual group emphasized accuracy over speed and the control group vice versa. The scores of either task individually were not strong enough to show any group effects in the regression analyses.

3.3 Language attrition

To examine the effects of language attrition, regression analyses were run and this was done in two ways. The main factor to examine attrition for the present study was length of residence. This measure does not reflect the exposure the participants had to either English or Dutch while living in Australia and therefore might be difficult to show results. Regression analyses were run on the PPVT and RST in both languages to compare performance and see whether there was a trade-off between Dutch and English as attrition increases in the bilinguals. Furthermore, regression analyses were run on all Dutch language tasks with all participants using the factors age at testing and time. Age of testing in combination with group was used as a replacement for length of residence to run analyses with all groups to see if attrition caused a significant decrease in performance for the bilingual participants over time. There was a significant relation between the factors age of testing and length of residence, $r = .90$, $p < .01$, and showed that overall the oldest bilingual participants had lived in Australia the longest.

3.3.1 L1 versus L2

The first sets set of regression analyses were conducted in two steps for the analyses with the bilingual group only. The tests that were examined were the PPVT and RST in both English and Dutch and looked and used as predictor length of residence. The following tables show the results of all four tasks:

The PPVT NL showed a significant relation not only with its English counterpart, but with length of residence as well, $r_s = -.26$, $p < .05$. The length of residency in Australia had a negative influence on the development of Dutch vocabulary.

Table 15. Regression analysis PPVT NL: Length of residence

Step		B	SE B	B
1	Constant	110.46	2.70	
	Length of residence	-.11	.07	-.23 *(ns)*

Note: $R^2 = .05$.

Similarly to the PPVT NL, the PPVT EN had a significant relation with length of residence, $r_s = .33$, $p < .05$. This meant that living in Australia had a positive influence on their development of English when they stayed there longer.

Table 16. Regression analysis PPVT EN: Length of residence

Step		B	SE B	β
1	Constant	95.49	2.95	
	Length of residence	.22	.07	.39*

Note: $R^2 = .15$. * $p < .01$

The RST NL showed a significant relation with length of residence, $r_s = -.33$, $p < .05$, as well as with its English counterpart, in which participants who stayed longer in Australia showed poorer results.

Table 17. Regression analysis RST NL: Length of residence

Step		B	SE B	β
1	Constant	42.57	1.65	
	Length of residence	-.18	.04	-.52*

Note: $R^2 = .27$. * $p < .01$

For the RST EN, there was a significant correlation with length of residence, $r_s = -.43$, $p < .05$, similar to that of the RST Dutch.

Table 18. Regression analysis RST EN: Length of residence

Step		B	SE B	β
1	Constant	40.62	1.75	
	Length of residence	-.15	.04	-.44*

Note: $R^2 = .19$. * $p < .01$

The results showed that length of residence of residence was a significant predictor for both PPVT and RST. However, age of testing was a significant predictor for the RST as well. The predictors age of testing and length of residence would be difficult to tease apart in the RST since they correlated a lot. The PPVT did not have this problem, since correlations between of age of testing and PPVT for both English and Dutch was non-significant. Length of residence was a good predictor for PPVT English, but the results were non-significant for the Dutch version (sig = .09). However, length of residence was a good predictor for the PPVT EN. The longer a participant had been in Australia, the better it was for his or her English receptive vocabulary.

3.3.2 Bilinguals versus controls

The regression model used for the results of the Dutch language tasks (PPVT NL, C-test, and GJT) was the same as the one used to examine age effects in *age and cognition*. The first step of the model was to examine age of testing, before adding group effects in the second step. The following tables show the results of the GJT and C-test, but not the PPVT since it was non-significant.

The C-test showed a significant relation with group, r = .36, p < .01, but not with age at testing among the participants. The bilingual participants performed significantly worse compared to the controls.

Table 19. Regression analysis C-test: Age at testing and group

Step		B	SE B	Β
1	Constant	85.93	7.86	
	Age at testing	.00	.12	.001 *(ns)*
2	Constant	65.90	9.06	
	Age at testing	.05	.11	.04 *(ns)*
	Group	12.19	3.20	.36*

Note: R^2 = .00 for Step 1, ΔR^2 = .13 for Step 2 (*ns*). * p < .01

The relations of the GJT were different in comparison to the C-test. There was not a significant relation with group, but there was with age, r_s= -.49, p < .01, and the older participants performed more poorly.

Table 20. Regression analysis GJT: Age at testing and group

Step		B	SE B	Β
1	Constant	32.68	1.58	
	Age at testing	-.14	.03	-.50*
2	Constant	32.32	1.91	
	Age at testing	-.14	.03	-.50*
	Group	.23	.68	.030 *(ns)*

Note: R^2 = .25 for Step 1, ΔR^2 = .00 for Step 2 (*ns*). * p < .01

The predictors age of testing and group gave mixed results. Age of testing was a good predictor for GJT and group for the C-test. Overall, the proficiency of the bilingual group for Dutch was lower, as can been seen in the results of the C-test. The two language groups were not equal and the bilingual participants showed that their overall language proficiency was not or no longer as good as that of the control group. Any group effects, however, did not affect grammaticality judgment, but age was a good predictor for the decline in results for that test.

3.4 Language reversion

Regression analyses were run to ascertain whether active lifestyle, executive control, and language proficiency had an influence on language reversion. The analyses were run on the bilingual participants from the 60-65 and 75+ age groups, since language reversion, if it takes place at all, usually occurs later in life and therefore the youngest age group was excluded. During the sociolinguistic questionnaire, the participants had indicated whether they remained mostly indoors, had many social activities, or were both physically and socially active. Executive control of the L2 was determined by dividing participants in high and low performers, based on mean score of the Simon task (acc). An alternative explanation of language reversion was that it could take place if a person had not fully acquired the L2 in the first place. Therefore, a similar division of high and low performers was made based on the scores of the PPVT EN.

3.4.1 Active lifestyle

The results for active lifestyle showed that there were few significant correlations between task and active lifestyle. The tasks that showed a significant relation were the RST EN, $r = .28$, $p < .05$, and GJT NL, $r = .26$, $p < .05$, for the factor that compared the socially active people with the physically and socially active people. Of all the bilinguals that were included in the regression analyses, only 2 out of 42 people had an inactive lifestyle, and the rest were either socially active or both physically and socially active. None of the tasks showed that lifestyle was a relevant predictor and this includes the RST EN and GJT NL. The results of the analyses for these two tasks are given in the following two tables:

Table 22. Regression analysis RST EN: Age at testing and group

Step		B	SE B	Β
1	Constant	31.70	1.24	
	Non-active v. socially active	-2.70	4.97	-.08 *(ns)*
	Socially active v. physically and socially active	-3.90	2.15	.27 *(ns)**

Note: R^2 = .08. * p = .08

Table 23. Regression analysis GJT NL: Active lifestyle

Step		B	SE B	Β
1	Constant	22.22	.73	
	Non-active v. socially active	2.78	3.87	.11 *(ns)*
	Socially active v. physically and socially active	2.24	1.28	.27 *(ns)**

Note: R^2 = .08. * p = .09

While there were a few relevant correlations for active lifestyle, they were not significant enough after running the regressing analysis.

3.4.2 Executive control

To examine the effects of executive control, the participants were divided into two groups, to see if there was a difference in performance in the language tasks or reading span tasks. There were significant correlations with three tasks: RST EN, r = .36, p < .01, PPVT EN, r = .35, p

< .05, and the C-test NL, r = -.41, p < .01. The results of the regression analyses are in the following tables:

Table 24. Regression analysis RST EN: Executive control

Step		B	SE B	β
1	Constant	30.07	1.65	
	Low v. high	5.01	2.04	.36*

Note: R^2 = .36. * p < .05

Table 25. Regression analysis PPVT EN: Executive control

Step		B	SE B	β
1	Constant	100.33	2.79	
	Low v. high	7.70	3.33	.35*

Note: R^2 = .35. * p < .05

Table 26. Regression analysis C-test NL: Executive control

Step		B	SE B	β
1	Constant	91.79	5.19	
	Low v. high	-17.79	6.43	.41*

Note: R^2 = .17. * p < .01

Executive control was a significant predictor for both results of English tasks as well as a Dutch one, showing a difference in results. The difference in performance of these two groups is highlighted in the following table, which shows the mean and standard deviation of the high and low group for the three tasks:

Table 27. The mean and standard deviations of the RST EN, PPVT EN, C-test*

Task	RST EN			PPVT EN			C-test		
	N	Mean	St dev	N	Mean	St dev	N	Mean	St dev
Low	15	30.07	6.43	12	100.33	6.24	14	91.79	4.04
High	28	35.07	6.36	28	108.04	10.73	26	74.00	23.75

* This is based on the results of the Simon task (acc) scores in which groups were divided depending on whether they were above or below the mean.

These results show a trade-off in performance based on how well they did on the Simon task for executive control. The group with a lower performance did better in the Dutch task and worse in the English tasks, while the group with a high performance did well in the English tasks, but had more trouble with the Dutch one.

3.4.3 Language proficiency

An alternative explanation for language reversion was that participants might not have acquired their L2 in the first place. For this reason, the participants were divided into two groups (low and high) based on the mean results of the PPVT EN. There were significant correlations in two tasks: RST EN, $r = .34$, $p < .05$, and PPVT NL, $r = .40$, $p < .01$. The results of the regression analyses are in the following tables:

Table 28. Regression analysis RST EN: L2 language proficiency

Step		B	SE B	B
1	Constant	30.52	1.398	
	Low v. high	4.67	2.02	.34*

Note: $R^2 = .11$. * $p < .05$

Table 29. Regression analysis PPVT NL: L2 language proficiency

Step		B	SE B	B
1	Constant	101.40	1.89	
	Low v. high	7.69	2.74	.40*

Note: $R^2 = .16$. * $p < .01$

The results indicated that the people in the high performance group performed better in both the RST EN and the PPVT NL. The receptive vocabulary in English was a good indicator of the performance in Dutch. Furthermore, an improved English vocabulary seemed to have a positive effect on the RST in English as well.

Notes

[1] Most of the correlations were run using Spearman's correlation coefficient, since the results of some tests (BDST, C-test, and GJT) did not have a normal distribution. Exceptions were made when making correlations with categorical factors and in these cases Pearson's correlation coefficient were used. This applied to the factors group (bilingual or control) and active lifestyle. Furthermore, some correlations were applied to all participants as a whole, but correlations had been with only the bilinguals, the control group as well, or run per age group. (A full list of all significant correlations can be found in the appendix.)

The factor active lifestyle was split into dummy variables in which in the group that goes out a lot (but was not physically active) was set as base group. Active lifestyle (1) had as variable the group that remained indoors and active lifestyle (2) were the people who went out a lot and were physically active as well. These same dummy variables were used for the regression analyses as well.

Chapter 4: Discussion

4.1 Aging and cognition

Previous research had shown that as people age their cognitive functions decrease (Fisk & Warr, 1996; Brèbion, 2004) and this was replicated in the current research. The results of the BDST, RST NL and EN, and Simon task (accuracy) showed a decrease in results as people aged. An exception was the Simon task (effect), which showed no visible signs of results changing due to aging. The decrease in the BDST, RST NL and EN, and Simon task (acc) were visible in the mean scores in each of the tasks. Furthermore, the correlations and regression analysis showed that this decrease was significant and a good predictor for the results.

It was possible that the change in results was not only affected by age but that attrition could have a confounding effect as well, which reveal itself in the RST. The decline in results as people aged was not affected by a group factor in the RST, so it did not appear to matter that a participant was bilingual or not. The results between the Dutch and English RST were highly similar. The results showed similar means and standard deviations between the two groups for the RST NL, as well as similar results between the results of the English and Dutch version. The correlations between tasks were significant as well. This may suggest that attrition did not have a confounding effect on the working memory tasks. The results did not provide any evidence for a trade-off in performance due to attrition, since the group factor was not relevant in predicting the results.

The only cognitive test in which the group factor mattered was the BDST task in which the bilingual group had an advantage over the control group. This was the only cognitive task in which the results might suggest that there was a bilingual cognitive advantage (e.g. Bialystok & Martin, 2004; Carlson & Meltzoff, 2008). Conversely, the Simon task did not show a clear advantage in this area, since the factor group did not show significant correlations nor was good predictor in the regression analysis. This was most likely because the differences in strategies between the bilinguals and controls were revealed in the combination of two results from the Simon task (effect and accuracy). The individual results did not show a strong enough difference between the two groups.

4.2 Language attrition

The effects of attrition were measured in two ways by examining results between the Dutch and English tasks among the bilinguals and examining results between the bilinguals and controls.

The results between the L1 and L2 showed no difference in results between both RST, when tested for length of residence in the bilinguals. The results of the regression analyses when examining age and those that examined LoR produced similar results. This was due to the fact there was a significant correlation between age and LoR. The factor of aging was too strong to see if LoR had any influence.

The results of the PPVT were different for the bilinguals. The correlations showed that there was a significant negative correlation between the LoR and PPVT NL, and a significant positive relation between LoR and PPVT EN. This suggests that migration did have an effect on the development of their Dutch and English vocabulary. The question would be whether the decline in the results of the Dutch vocabulary was caused by attrition or bilingualism. However, the LoR failed to be a significant predictor in the regression analyses for Dutch, but it was significant for English.

The results for the PPVT NL for all participants showed that neither group nor age showed any significant differences in results in the regression analysis. In previous work by Burke & Shafto (2008), there were indications that semantic processes were not affected by aging. The semantic understanding of people continues to increase over time, so it was not odd that the PPVT results were not affected by age. The results showed that the mean score of the bilingual participants decreased as they aged. However, the decline in results of the bilingual participants in comparison to the controls was not enough to produce any significant differences between groups.

The results of the language tasks with the bilinguals and controls produced mixed results. The C-test was the only language task that showed that group mattered when analyzing the results of all participants. The correlations showed a significant difference between groups in which the bilingual group performed worse than the control group. There was difference in performance when looking at the mean scores and standard deviations between the age and language groups, in which mainly the 60-65 group had varying results. The other two bilingual groups had overall higher results with smaller deviations. Overall, the bilingual group produced lower results in the C-test and showing signs of reduced language proficiency in comparison to the control group. This could show signs of possible language attrition. Other research (e.g. Keijzer, 2007) had found similar results between bilinguals and control groups with the C-test, and since this task measures overall language proficiency, it is an indicator that deterioration had taken place in these participants.

The results of the GJT NL showed that there was a decline in results in both the bilingual group as the age increased. Furthermore, the variability in the results, the standard deviations, increased as well. The correlations showed that age at testing and the GJT had a significant relation. Age of testing was a significant predictor for the regression analysis as well, but the groups did not matter. This was to be expected, since only advanced cased of attrition should a difference in performance for syntax (Köpke, 2004).

4.3 Language reversion

Language reversion has so far established mainly as a social phenomenon in the literature, in which environmental circumstances and personal motivations play a strong role (de Bot & Clyne, 1989; Schmid & Keijzer, 2009). The present research sought to expand the understanding of what causes language reversion, by examining the effects of active lifestyle, executive control, and language proficiency have on language reversion on the bilingual participants in the two oldest age groups.

The participants were divided into three groups for active lifestyle. For the participants that were tested to examine the effects of language, there was not an equal division for lifestyle. Only 2 of the 42 participants indicated that they did not have a socially active lifestyle. The rest of the participants were equally divided between the socially active, and the socially and physically active participants. This bias between groups was and in future research will be hard to overcome since people who prefer to remain indoors and are not socially active are less likely to volunteer to participant in research.

While there were significant correlations between lifestyle and two tasks, of the two groups that had the most active lifestyle, the GJT NL and RST EN were not strong enough as predictors in the regression analyses. This could have had different effects if there more people with less social lifestyles had been included. Then the results may have been different. An active lifestyle or lack thereof could an important factor of the rate of cognitive decline. As people age, their cognitive functions start to decline, but there were not enough people to test how this interacts with lifestyle and whether it influences language development of the bilinguals. The hope was that people with lower cognitive functions would be more susceptible to language reversion, but also that people with a less active social life would be less inclined to use English regularly after retirement or when their children left home, which may cause language reversion to occur (Schmid & Keijzer, 2009).

Another factor that could be important for language reversion was executive control. If there was less executive control, then this could mean the participants have reduced inhibition, which could cause the language that is supposed to be inhibited to start to resurface, and that is the L1 in this case. For this reason, the participants were divided into two groups based on their scores of the Simon task (acc). The results showed significantly different patterns between the two groups based on these criteria showing a difference in performance between Dutch and English tasks. The tests that showed significant results were the RST EN, PPVT EN, and the C-test NL. Executive control was a good predictor in the regression analyses for these tasks. The low performing group and the high performing group showed signs of a trade-off: the high performing group had relatively high results in the English tasks and low in the Dutch one, while the opposite applied to the low performing group. This suggests that executive control, alongside other factors, can play a role in language reversion.

An alternative view of language reversion was that the participants might not have fully acquired the L2 in the first place (Neisser, 1984; de Bot & Clyne, 1989). The participants were divided into two groups based on their performance in the PPVT EN. The results showed significant correlations with the PPVT NL and RST EN. This suggests that participants with a well-developed vocabulary were more likely to maintain this in their L1 as well and possibly that the RST in English was easier when the participant showed signs of a higher proficiency in English.

4.4 Language change over the lifespan

The results of the bilingual participants showed signs of a complex interaction between language change, both attrition or language reversion, and cognition; which in turn were influenced by the environment people live in. There was a great deal of individual variation among participants based on how well people age. This supports research by de Bot (2010) that there is an interaction between the social, psychological, and language processing. Aging and cognitive decline that occurs as a part of aging can cause significant changes in language development in migrants. Cognitive decline might occur at a slower rate if the migrants had advantages by being bilinguals and their cognitive abilities were well developed. For this reason, the environment and lifestyle might play an important role. The current study could not conclusively show whether this mattered or not. The changes in cognition vary from person to person, but the state of a person's cognitive development was a good predictor for language reversion. There seemed to be a clear distinction. People with better-developed cognitive skills, in particular executive control, or whose cognitive skills were less affected by aging were better suited to maintain two languages in their minds.

Attrition in this study was mainly measured in LoR, since this was an objective measure, even though it would have been good to have measures that would in some way quantify the bilinguals' exposure to the L1 and L2. The variety in bilinguals made it hard to see if there was a trade-off in performance due to attrition. There was no clear evidence of this. The results between the RSTs showed no difference and the bilinguals scored as well at the controls. There might have been some bilingual advantage at work as well that could have countered the effects of a trade-off. It was clear that the language proficiency was affected, which could be observed in the C-test. There was little evidence that this reduced proficiency affected the performance in working memory in English tasks. When language proficiency in

English was examined as part of language reversion testing, it showed that people with high scores in PPVT EN, scored better in RST EN and PPVT NL as well. The vocabulary in English develops in concordance with Dutch it seemed among those who were high proficient. There was a positive effect for the RST EN, but not a clear trade-off with Dutch. It was not clear whether the opposite side of the Activation hypothesis (Paradis, 2000), in which inactivity would lead to a higher threshold and thereby affect cognitive performance, can be true or not.

At the same time, the results of the PPVT in Dutch of all bilingual participants as a whole showed that there was a negative correlation as the participants remained longer in Australia. This shows inactivity in the network that makes up the vocabulary, but there were few signs that this could lead to more cognitive resources being used and therefore have poorer results in the non-dominant language in the RST. If this was the case then it would argue in favor of the opposite of the Activation hypothesis (Paradis, 2000), but there was no evidence that working memory was different between the bilinguals and control group as a whole. Maybe it was that the words used in the RST were well known among all participants or that the task tests mainly working memory and language proficiency was not a strong factor. Most if not all participants were proficient in both L1 and L2. The task might not provide an accurate measure to see how language processing was affected by attrition.

Conclusion

The results of this study have presented a complex image. People undergoing attrition or language reversion are a highly heterogeneous group. To understand the changes in languages over a lifetime, cognitive changes that occur due to aging have to be taken into account, but also possibly bilingualism. However, the cognitive aspects are clouded by the social factors. People moving to different countries live in very different circumstances. The degree of attrition varies and some are prone to experience language reversion while others are not. Furthermore, even if someone is more prone to language reversion the circumstances might not be suitable for it to occur, if the L2 needs to be spoken frequently in daily life.

Future research should further examine interaction between cognition, aging, and language change in people who are part of the language attrition and reversion spectrum. This should be done while taking into account the social circumstances and motivations of the participants. A part of language reversion is determined by cognitive decline, but even though it declines, it does not decline the same way for everyone. Some experience strong decline of their cognitive abilities at the age of 60 in comparison to their youth, while some may show little signs at 75. There is a great deal of individual variation. To research language reversion, there have to be measures of cognitive abilities in elders. Furthermore, the social circumstance need to be controlled for and this includes and understanding of what languages the bilinguals are exposed to, how much they speak either language and, their social lives. The individual variation may provide clues why there is language change, such as language reversion and give a deeper understanding about the relation between language and cognition.

In the current research, there was not a clear link between working memory with relation to attrition or language reversion. There was some evidence that a better executive control led to a better performance in working memory in English. It would be interesting to further examine the relation between working memory and language change. The reading span task overall tasked the working memory so much that it was hard to see the influence of language. Maybe a different task is needed that would more strongly emphasize the language aspect rather than rely so heavily on working memory. A task that had a stronger emphasis on examining their language proficiency, instead of mainly looking at their working memory might reveal more about whether this hypothesis is true or not.

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Appendix

Correlations

Correlations were run using Spearman's correlation coefficient unless mentioned otherwise.

Group	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
All	BDST	Age at testing	107	-.370	.000	.137
All	BDST	RST NL	107	.393	.000	.154
All	BDST	Simon (acc)	99	.338	.001	.114
Bilingual	BDST	Age at testing	63	-.409	.001	.167
Bilingual	BDST	Length of residence	59	-.335	.010	.112
Bilingual	BDST	RST NL	63	.328	.009	.108
Bilingual	BDST	RST EN	63	.411	.001	.169
Bilingual	BDST	Simon (acc)	59	.380	.003	.144
Control	BDST	Age at testing	44	-.374	.012	.140
Control	BDST	RST NL	44	.553	.000	.306
75+	BDST	RST NL	26	.581	.002	.338

Group	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
All	RST NL	Age at testing	108	-.535	.000	.286
All	RST NL	BDST	107	.393	.000	.154
All	RST NL	Simon (acc)	100	.416	.000	.173
All	RST NL	PPVT NL	106	.404	.000	.158
All	RST NL	GJT NL	98	.499	.000	.249
Bilingual	RST NL	Age at testing	64	-.581	.000	.338
Bilingual	RST NL	Length of residence	60	-.494	.000	.244
Bilingual	RST NL	BDST	63	.328	.009	.108
Bilingual	RST NL	RST EN	64	.809	.000	.654
Bilingual	RST NL	Simon (acc)	60	.419	.001	.176
Bilingual	RST NL	PPVT NL	62	.430	.000	.185
Bilingual	RST NL	GJT NL	56	.470	.000	.221
Control	RST NL	Age at testing	44	-.417	.005	.174
Control	RST NL	BDST	44	.553	.000	.306
Control	RST NL	Simon (acc)	40	.414	.008	.171
Control	RST NL	PPVT NL	44	.381	.011	.145

Control	RST NL	GJT NL	42	.563	.000	.317
40-45	RST NL	PPVT NL	27	.414	.032	.171
60-65	RST NL	Simon (acc)	37	.414	.011	.171
60-65	RST NL	RST EN	20	.811	.000	.658
60-65	RST NL	PPVT NL	40	.517	.001	.267
60-65	RST NL	GJT NL	40	.413	.008	.171
75+	RST NL	BDST	26	.581	.002	.338
75+	RST NL	RST EN	26	.789	.000	.623

Group	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
Bilingual	RST EN	Age at testing	64	-.598	.000	.358
Bilingual	RST EN	Length of residence	60	-.430	.001	.185
Bilingual	RST EN	BDST	63	.411	.001	.169
Bilingual	RST EN	RST NL	64	.809	.000	.654
Bilingual	RST EN	Simon (acc)	60	.446	.000	.199
Bilingual	RST EN	GJT NL	56	.322	.015	.104
60-65	RST EN	Simon (acc)	20	.478	.033	.228
60-65	RST EN	RST NL	20	.811	.000	.658
75+	RST EN	RST NL	26	.789	.000	.623

Group	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
Bilingual	Simon effect	C-test NL	55	-.309	.022	.095
All	Simon (acc)	Age at testing	100	-.589	.000	.347
All	Simon (acc)	BDST	99	.338	.001	.114
All	Simon (acc)	RST NL	100	.416	.000	.173
All	Simon (acc)	PPVT NL	98	.226	.025	.051
All	Simon (acc)	GJT NL	90	.254	.016	.065
Bilingual	Simon (acc)	Age at testing	60	-.655	.000	.429
Bilingual	Simon (acc)	Length of residence	56	-.612	.000	.374
Bilingual	Simon (acc)	BDST	59	.380	.003	.144
Bilingual	Simon (acc)	RST NL	60	.419	.001	.176
Bilingual	Simon (acc)	RST EN	60	.446	.000	.199
Bilingual	Simon (acc)	C-test NL	55	-.282	.037	.080
Control	Simon (acc)	Age at testing	40	-.462	.003	.213
Control	Simon (acc)	RST NL	40	.414	.008	.171
Control	Simon (acc)	C-test NL	37	.360	.029	.130
60-65	Simon (acc)	RST NL	37	.414	.011	.171
60-65	Simon (acc)	RST EN	20	.478	.033	.228
75+	Simon (acc)	PPVT NL	34	.402	.018	.162
75+	Simon (acc)	PPVT EN	21	.440	.046	.194

Group	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
All	PPVT NL	GJT NL	96	.374	.000	.140
All	PPVT NL	RST NL	106	.404	.000	.163
All	PPVT NL	Simon (acc)	98	.226	.025	.051
Bilingual	PPVT NL	Length of residence	58	-.260	.049	.068
Bilingual	PPVT NL	PPVT EN	61	.461	.000	.213
Bilingual	PPVT NL	GJT NL	54	.446	.001	.199
Bilingual	PPVT NL	RST NL	62	.430	.000	.185
Control	PPVT NL	RST NL	44	.381	.011	.145
40-45	PPVT NL	RST NL	27	.414	.032	.171
40-45	PPVT NL	GJT NL	25	.654	.000	.428
60-65	PPVT NL	RST NL	40	.517	.001	.267
60-65	PPVT NL	PPVT EN	20	.614	.004	.377
60-65	PPVT NL	GJT NL	40	.430	.006	.185
75+	PPVT NL	Simon (acc)	34	.402	.018	.162
75+	PPVT NL	PPVT EN	24	.509	.011	.259

Group	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
Bilingual	PPVT EN	Length of residence	57	.334	.011	.111
Bilingual	PPVT EN	PPVT NL	61	.461	.000	.213
60-65	PPVT EN	PPVT NL	20	.614	.004	.377
75+	PPVT EN	Simon (acc)	21	.440	.046	.194
75+	PPVT EN	PPVT NL	24	.509	.011	.259
75+	PPVT EN	C-test NL	23	-.511	.013	.261

Group	Control Factor	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
Bilingual	Age of testing	PPVT EN	Length of residence	39	.360	.021	.130

Group	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
All	GJT NL	Age at testing	98	-.487	.000	.237
All	GJT NL	PPVT NL	96	.374	.000	.140
All	GJT NL	RST NL	98	.499	.000	.249
All	GJT NL	Simon (acc)	90	.254	.016	.065
Bilingual	GJT NL	Age of testing	56	-.459	.000	.210
Bilingual	GJT NL	PPVT NL	54	.446	.001	.199
Bilingual	GJT NL	RST NL	56	.470	.000	.221

Bilingual	GJT NL	RST EN	56	.322	.015	.104
Control	GJT NL	Age at testing	42	-.461	.002	.213
Control	GJT NL	C-test NL	39	.427	.007	.182
Control	GJT NL	RST NL	42	.563	.000	.317
40-45	GJT NL	PPVT NL	25	.654	.000	.428
60-65	GJT NL	RST NL	40	.413	.008	.171
60-65	GJT NL	PPVT NL	40	.430	.006	.185

Group	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
Bilingual	C-test NL	Simon effect	55	-.309	.022	.095
Bilingual	C-test NL	Simon (acc)	55	-.282	.037	.080
Control	C-test NL	GJT NL	39	.427	.007	.182
Control	C-test NL	Simon (acc)	37	.360	.029	.130
75+	C-test NL	PPVT EN	23	-.511	.013	.261

Group[1]	Variable 1	Variable 2	N	Correlation (r)	Significance	R square
All	Group[2]	BDST	107	-.203	.036	.041
All	Group	C-Test NL	100	.358	.000	.128
40-45	Group	Simon (acc)	25	-.487	.014	.237
40-45	Group	PPVT NL	27	-.402	.038	.161
40-45	Group	C-test NL	25	.431	.031	.186
60-65	Group	C-test NL	36	.451	.006	.203
75+	Group	BDST	39	-.425	.007	.181
All	Active lifestyle[3] (2)	RST NL	97	.238	.019	.056
Bilingual	Active lifestyle (1)	RST NL	64	-.058	.648 (*ns*)	
Bilingual	Active lifestyle (2)	RST NL	54	.293	.031	.086
Control	Active lifestyle (1)	RST NL	44	.303	.045	.092
Control	Active lifestyle (2)	RST NL	43	.178	.253 (*ns*)	

[1] Pearson correlation

[2] The groups are Dutch-English bilinguals and the Dutch control group.

[3] Active lifestyle was split into dummy variables in which in the group that goes out a lot (but was not physically active) was set as base group. Active lifestyle 1 had as variable the group that remained indoors and active lifestyle 2 were the people who went out a lot and were physically active as well.