



# THE UNIVERSITY *of* EDINBURGH

## Edinburgh Research Explorer

### The effects of language use on lexical processing in bilinguals

**Citation for published version:**

de Bruin, A, Della Sala, S & Bak, T 2016, 'The effects of language use on lexical processing in bilinguals' Language, Cognition and Neuroscience, vol. 31, no. 8, pp. 967-974. DOI: 10.1080/23273798.2016.1190024

**Digital Object Identifier (DOI):**

[10.1080/23273798.2016.1190024](https://doi.org/10.1080/23273798.2016.1190024)

**Link:**

[Link to publication record in Edinburgh Research Explorer](#)

**Document Version:**

Peer reviewed version

**Published In:**

Language, Cognition and Neuroscience

**Publisher Rights Statement:**

This is an Accepted Manuscript of an article published by Taylor & Francis in Language, Cognition and Neuroscience on 07/06/2016, available online:  
<http://www.tandfonline.com/doi/full/10.1080/23273798.2016.1190024>

**General rights**

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

**Take down policy**

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact [openaccess@ed.ac.uk](mailto:openaccess@ed.ac.uk) providing details, and we will remove access to the work immediately and investigate your claim.



Running head: Language use and lexical processing

## **The effects of language use on lexical processing in bilinguals**

Angela de Bruin<sup>1\*</sup>, Sergio Della Sala<sup>1,2</sup>, Thomas H. Bak<sup>1,2</sup>

- 1) Human Cognitive Neuroscience, Psychology, University of Edinburgh, Edinburgh, UK
- 2) Centre for Cognitive Ageing and Cognitive Epidemiology, Psychology, University of Edinburgh, Edinburgh, UK

Angela de Bruin (corresponding author)  
University of Edinburgh  
7 George Square  
Edinburgh EH8 9JZ - United Kingdom  
Phone: +44 (0) 131 650 3426  
Fax: +44 (0) 131 651 3230  
Email: [angela.debruin@ed.ac.uk](mailto:angela.debruin@ed.ac.uk)

Sergio Della Sala  
University of Edinburgh  
7 George Square  
Edinburgh EH8 9JZ - United Kingdom  
Phone: +44 (0) 131 651 3242  
Email: [sergio@ed.ac.uk](mailto:sergio@ed.ac.uk)

Thomas H. Bak  
University of Edinburgh  
7 George Square  
Edinburgh EH8 9JZ - United Kingdom  
Phone: +44 (0) 131 650 3441  
Email: [thomas.bak@ed.ac.uk](mailto:thomas.bak@ed.ac.uk)

Word count paper: 3000

**Abstract**

Bilingualism has been associated with slower lexical processing in both languages, but it remains unclear to what extent this effect may be modulated by language use. We compared older English monolinguals with two groups of older bilinguals on lexical processing tasks. Both acquired English and Gaelic during childhood, but while *active bilinguals* continued to use both languages, *inactive bilinguals* mostly used English. All three groups showed similar accuracy in English. However, in reaction times, active, but not inactive bilinguals were slower than monolinguals. We conclude that language use can modulate effects of bilingualism on lexical tasks.

Keywords: bilingualism; lexical processing; language use; language proficiency

## Introduction

Bilinguals tend to perform worse than monolinguals on lexical tasks, for example by showing slower and less accurate picture naming in both the dominant language as well as the second language (e.g., Gollan, Montoya, Fennema-Notestine, & Morris, 2005; Ivanova & Costa, 2008), more tip-of-the-tongue experiences (e.g., Gollan & Acenas, 2004), smaller vocabulary sizes in each language (e.g., Bialystok & Feng, 2009), and by naming fewer items on verbal fluency tasks (e.g., Rosselli et al., 2000). This could result from parallel activation of both languages, even if only one is needed (e.g., Dijkstra & Van Heuven, 2002). Competition from the active non-target language could delay or weaken lexical access in the target language (Inhibitory Control model, Green, 1998).

Language proficiency and competence have been suggested to modify the amount of competition from one language on another, but the effects of language use remain understudied. The ‘weaker links hypothesis’ (Michael & Gollan, 2005) has suggested that a bilingual uses each language less often than a monolingual, which could lead to weaker links between concepts and words. Hence, not only language competence and proficiency, but also their active use could modulate lexical processing.

In this study, we examined the effects of language use on lexical performance. If a bilingual raised fluently in two languages continues to speak only one, is their lexical processing still affected by the inactive language? If the bilingual difficulty in lexical processing is due to language **proficiency** independent of use, the effects should persist once a bilingual has reached a high proficiency in both languages, even if they continue to speak only one. In contrast, if not only language competence but also actual use affects lexical processing, inactive bilinguals who only use one of their languages should perform more similar to monolinguals.

The Gaelic-English population of the Hebrides (Scotland) is particularly well-suited to address this question. For much of the 20<sup>th</sup> century, Gaelic was the predominant language in families and communities while English was the exclusive language of schooling and, to a large extent, working life. Accordingly, many older adults who grew up in the Hebrides acquired both Gaelic and English during childhood and reached full proficiency in both. However, over the past decades, Gaelic use was also reduced in more informal community settings. While some Gaelic-English bilinguals continued to use both Gaelic and English, others moved to a predominant or even exclusive use of English.

Against this background, we compared three groups: Gaelic-English bilinguals who continued to use both languages throughout their lives (*active bilinguals*); Gaelic-English bilinguals who used almost exclusively English for much of their adult life (*inactive bilinguals*); and English-speaking *monolinguals*.

## **Method**

### ***Participants***

Seventy-six older adults (25 men) participated in this study. All were born and raised on the Hebrides and were living on the Isles of Lewis, Harris, Islay, Mull, or Skye. The mean age of participants was 70.91 years ( $SD = 6.82$ , range = 60-89 years). Twenty-eight active Gaelic-English bilinguals still used both languages on a daily basis. Twenty-four inactive Gaelic-English bilinguals used mainly or only English. All active and inactive bilinguals had acquired Gaelic and English during childhood. Gaelic was acquired by all participants from birth. The average age of acquisition for English was 4.3 years old for active bilinguals and 3.8 years old for inactive bilinguals. Twenty-four adults were English monolinguals with no or very limited proficiency in Gaelic. The isolated location of these islands leads to a

relatively homogeneous population and participants in the three language groups had similar backgrounds (see Table 1).

[Insert Table 1 about here]

Participants were asked to rate their proficiency in Gaelic on a scale from 1 ('no proficiency') to 10 ('excellent proficiency') in terms of speaking, understanding, reading, and writing.

Similarly, for language use, they were asked to score their language use in Gaelic and English on a scale from 1 ('never') to 10 ('always') for five time frames: childhood at home, childhood at school, later life at work, later life at home, and after retirement (i.e., at the moment of testing). Although this was not required, most participants who provided a high score for English provided a low score for Gaelic and vice versa.

### *Language use*

Active and inactive bilinguals reported similar usage of Gaelic and English during childhood at home and school, but different patterns during later life (Appendix A and Figure 1). The *active bilinguals* still used both Gaelic and English on a daily basis, mainly with family members, neighbours, and through Gaelic radio and television programmes. The frequency of use varied from equal use of both languages to Gaelic-dominant speakers, although even the latter used English frequently as well. Active bilinguals reported frequent language switching within conversations as well as sentences. The *inactive bilinguals* used predominantly English and reported using Gaelic only monthly or less. The most common reasons to use English instead of Gaelic were marrying an English-speaking spouse, the general decrease of Gaelic speakers in the direct environment, and an increase of English-speaking immigrants. The third

group consisted of *monolinguals*, who reported no or very little use of Gaelic during all five time frames.

A significant effect of language group on language use was found in all five time frames for both languages. Post-hoc comparisons (see Appendix A) showed that active and inactive bilinguals did not differ in Gaelic and English use during their childhood. Both groups predominantly used Gaelic at home, but had to use English at school. Although active and inactive bilinguals were highly similar during their childhood, only active bilinguals continued to use both languages during their later life. Active bilinguals used more Gaelic than inactive bilinguals in later life at work and at home and this difference continued after retirement. Conversely, active bilinguals used less English than inactive bilinguals and monolinguals across their later life. The inactive bilinguals and monolinguals used similar amounts of English and Gaelic during their later life at home. However, after retirement, inactive bilinguals used Gaelic more often and English less often than the monolinguals.

[Insert Figure 1 about here]

### *Proficiency*

Gaelic and English proficiency self-ratings are provided in Table 2. For Gaelic proficiency, the three language groups differed significantly in terms of speaking ( $\chi^2(2) = 60.18, p < .001$ ), understanding ( $\chi^2(2) = 56.82, p < .001$ ), reading ( $\chi^2(2) = 47.98, p < .001$ ), and writing ( $\chi^2(2) = 44.91, p < .001$ ). Pair-wise comparisons showed higher scores for bilinguals than monolinguals (i.e., English monolinguals reported having no or very little Gaelic proficiency) and higher proficiency for active bilinguals than inactive bilinguals (all  $ps < .05$ ). Regarding English proficiency, the three language groups only differed significantly for speaking ( $\chi^2(2) = 7.61, p = .022$ ). Pair-wise comparisons showed that active bilinguals had a significantly

lower self-rating than monolinguals, with no difference between inactive bilinguals and monolinguals ( $p > .05$ ). No group differences were found in understanding, reading, and writing.

[Insert Table 2 about here]

### ***Tasks***

Lexical processing speed was measured in a picture-word matching task. Participants saw pictures accompanied by a written word that either formed a match or mismatch and were asked to indicate with a button press the match (e.g., picture of a bird accompanied by the word ‘bird’) or mismatch (e.g., picture of a bird accompanied by the word ‘apple’). The picture was always presented on the left side of the screen, the word on the right side; both remained on the screen until a response was given. Both accuracy and response times (RTs) were measured. Sixty picture-word pairs (based on Dawson, 2013) were presented in both Gaelic and English. Half of the words were nouns, half verbs, and all were non-cognates (see Appendix B for stimulus materials). Pictures were easily recognisable black-white drawings from An Object and Action Naming Battery (Druks & Masterson, 2000). The pictures were presented in blocks of Gaelic and English with the order of languages counterbalanced across participants. The order of the pictures was randomised within the language block. For half of the participants, a word was part of a matched pair; for the other half, the word was part of a mismatch. Each picture and each word were presented once per language. English monolinguals only completed the English picture-word matching task.

As part of the dementia screening (Addenbrooke’s Cognitive Examination-III, ACE-III, Hsieh, Schubert, Hoon, Mioshi, & Hodges, 2013), participants also completed a letter fluency and category fluency test. In the category task, they were asked to name as many



animals as possible in 60 seconds. In the letter fluency task, they were asked to name words starting with a 'P'. The dementia screen and fluency tasks were completed in English. The participants also completed several non-verbal cognitive tests, which have been reported elsewhere (de Bruin, Bak, & Della Sala, 2015).

### ***Data-analysis***

Self-ratings on language use and proficiency from the questionnaire were analysed using the non-parametric Kruskal-Wallis test. Data from the picture-word matching task were analysed using a linear mixed effects analysis for RTs and a generalized linear mixed effects analysis for accuracy. To normalise their distribution, RTs were log transformed. To compare language groups in the English task, language group and word class and their interaction were included as fixed effects. We furthermore included self-rated Gaelic proficiency. In order to directly examine effects of language use in a continuous rather than categorical manner, we reran the model with self-rated English use instead of language group. In the second analysis, comparing active and inactive bilinguals in English and Gaelic, we included language group, language, and word class in the model, as well as their interactions as fixed effects. As random effects, we included intercepts and slopes for subjects, items, and word length<sup>1</sup>. Z-scores (for accuracy) and T-scores (for RTs) greater than 2 were interpreted as significant effects (see Meier & Kane, 2013; Coderre & Van Heuven, 2014). For the RT analysis, incorrect answers as well as RTs more than 2.5 *SDs* above the mean were excluded. Two Gaelic words received low accuracy scores (*bee/beach*: 57.14%; *cherry/siris*: 64.29%) from active Gaelic-English bilinguals and were removed from all analyses.

## **Results**

### ***Picture-word matching task***

#### *Comparison of bilinguals and monolinguals on the English task*

English accuracy was close to ceiling for all three groups and was therefore not analysed further. RTs (see Table 3) showed a main effect of word class, with nouns ( $M = 1478.72$ , 95% confidence interval (CI):  $\pm 123$ ) being processed faster than verbs ( $M = 1657.58$ , 95% CI:  $\pm 145$ ,  $t = 3.11$ ). Self-rated Gaelic proficiency was a significant predictor of English RTs ( $t = 2.69$ ). There was furthermore an effect of language group. Monolinguals ( $M = 1346.99$ , 95% CI:  $\pm 109$ ) were faster in the English task than active bilinguals ( $M = 1750.10$ , 95% CI:  $\pm 187$ ,  $t = 4.06$ ). RTs of inactive bilinguals ( $M = 1577.02$ , 95% CI:  $\pm 166$ ) fell in-between and did not differ significantly from either group ( $t < 2$ , see Figure 2). There was no interaction between word class and language group ( $t < 2$ ).

To ensure that differences between language groups were related to language use, we reran the analysis with self-rated English language use during retirement as a continuous variable. This confirmed the effects of language use: the higher the amount of English use, the faster performance on the English task ( $t = -3.775$ ).

[Insert Table 3 and Figure 2 about here]

#### *Comparison of active versus inactive bilinguals in Gaelic*

Accuracy scores showed that Gaelic items ( $M = 89.56$ , 95% CI:  $\pm 1.79$ ) were less accurate than English ones ( $M = 97.18$ , 95% CI:  $\pm .68$ ,  $z = -2.69$ ). There was a main effect of language group ( $z = -2.53$ ) and an interaction between language group and language ( $z = -2.62$ ), suggesting that inactive bilinguals were less accurate than active bilinguals in Gaelic (respectively  $M = 85.07$ , 95% CI:  $\pm 2.85$ , and  $M = 93.40$ , 95% CI:  $\pm 1.79$ ; see Figure 3). However, for both active and inactive bilinguals, accuracy in English was higher than in Gaelic.

RTs (see Table 4) showed that Gaelic items ( $M = 2544.21$ , 95% CI:  $\pm 283$ ) were answered more slowly than English words ( $M = 1670.22$ , 95% CI:  $\pm 126$ ,  $t = 4.12$ ) and nouns ( $M = 1949.67$ , 95% CI:  $\pm 192$ ) were processed faster than verbs ( $M = 2264.75$ , 95% CI:  $\pm 267$ ,  $t = 3.41$ ). There was an interaction between language group and language, with the difference between Gaelic and English being larger for inactive bilinguals than active bilinguals ( $t = 2.21$ ). However, again, both bilingual groups were faster in English than Gaelic. There were no other main effects or interactions ( $ts < 2$ ).

[Insert Table 4 and Figure 3 about here]

### *Verbal fluency tasks*

A linear regression on the fluency data showed that both self-rated Gaelic proficiency ( $b = .67$ ,  $t = 2.58$ ,  $p = .012$ ) and language group ( $b = 3.75$ ,  $t = 3.77$ ,  $p < .001$ ) were significant predictors, with monolinguals producing most items ( $M = 19.75$ ,  $SD = 4.80$ ), followed by inactive bilinguals ( $M = 17.88$ ,  $SD = 5.47$ ), and active bilinguals ( $M = 16.04$ ,  $SD = 4.86$ ). Post-hoc tests showed that only active bilinguals differed significantly from monolinguals ( $p = .027$ ), with no significant differences between monolinguals and inactive bilinguals ( $p = .394$ ) or active and inactive bilinguals ( $p = .406$ ). On the letter fluency task, monolinguals ( $M = 14.42$ ,  $SD = 5.91$ ), inactive bilinguals ( $M = 14.33$ ,  $SD = 5.57$ ), and active bilinguals ( $M = 13.14$ ,  $SD = 4.97$ ) performed similarly ( $b = .65$ ,  $t = .86$ ,  $p = .392$ ).

### **Discussion**

We examined the effects of bilingualism and language use on lexical processing by comparing active bilinguals, inactive bilinguals, and monolinguals. All bilinguals grew up speaking Gaelic and English at a very high proficiency level. Yet whereas active bilinguals

continued to use both languages during adulthood, inactive bilinguals moved to a predominant or exclusive use of English.

On the picture-word matching task, English accuracy was close to ceiling for all three groups, showing that even active bilinguals had a very high proficiency in English. The response times, however, showed an effect of language use. Active bilinguals were slowest on the English task, followed by inactive bilinguals and monolinguals. Inactive bilinguals did not differ significantly from either active bilinguals or monolinguals. An additional analysis with language use as a continuous predictor, however, showed a significant effect of language use on English RTs. Previous studies (cf., Bialystok, 2009, for an overview) have found similar lexical difficulties in bilinguals compared to monolinguals. Verbs showed slower RTs than nouns (see e.g., Mätzig, Druks, Masterson, & Vigliocco, 2009), but the effects of language use were similar for both word classes.

A similar pattern of results was observed on the verbal fluency, a task in which the performance in the native tongue can be modified by learning further languages (Vega-Mendoza, West, Sorace & Bak, 2015). On the category fluency task, active bilinguals performed significantly worse than monolinguals, while performance of the inactive bilinguals fell in-between the two groups. No effects of bilingualism were found on the letter fluency task (see e.g., Rosselli et al., 2000). Together with the picture-word matching task, this suggests that language use affects both lexical perception as well as production.

The bilingual lexical disadvantage is commonly explained by two main theories. The Inhibitory Control (IC) model poses that the disadvantage results from competition from the non-target language slowing down the bilingual's performance. The 'weaker links hypothesis' suggests that bilinguals use each of their languages less often, thus leading to weaker links between words and concepts. Our findings firstly show an effect of Gaelic proficiency on English RT performance, thus confirming the importance of language proficiency and

supporting the IC model. However, above these proficiency effects, those who used Gaelic more often also responded more slowly to English words. The performance of inactive bilinguals suggests that the effects of bilingualism on lexical processing may be modulated by the actual use of two languages, thus supporting the ‘weaker links hypothesis’ (Michael & Gollan, 2005). However, our results can reconcile these two theories if the IC model incorporates language use as a modifying variable. In such case, not only lower proficiency, but also lower use of a language (and thus a weaker link between the words and concepts in that language), could lead to lower levels of competition. Infrequent language use could lower the activation level of the second language and could thus cause less language competition in lexical tasks. Thus, inactive bilinguals are less hindered by Gaelic when completing an English task than active bilinguals.

The slower lexical processing in active bilinguals is not likely to be due to lack of exposure to English. All participants have received their education in English and live in an environment dominated by English. This dominance is particularly pronounced for the written language, which was the basis of the picture-word matching task. Indeed, self-rated English reading and writing scores were high for all language groups ( $> 9$ ) and showed little variability. In the picture-word matching task itself, all three language groups scored at ceiling in terms of English accuracy. Yet those who used the language more often were also faster in the picture-word matching task. We suggest therefore that the amount of use of the target language together with the amount of use of the non-target language can influence the speed of lexical processing.

Our study only included participants above the age of 60. Although cognitive ageing could affect language processing, single word processing tasks appear relatively stable in older adults (Burke, 1997). Furthermore, the average age was similar across all three groups.

The Adaptive Control Hypothesis (Green & Abutalebi, 2013) classifies three language contexts (single language, dual language, dense code-switching) that enable different types of language use and could have different effects on performance in both cognitive and lexical tasks. Our findings extend this hypothesis by demonstrating how language use and context can change dramatically within the same individual throughout their lifetime. We propose, therefore, that in future studies language use should form part of the basic characterisation of bilingual populations as much as age of acquisition and proficiency.

### **Acknowledgements**

We would like to thank Wilson McLeod, Rob Dunbar, and Amy Dawson for their help with the stimulus materials and their useful feedback.

## References

- Bialystok, E. (2009). Bilingualism: The good, the bad, and the indifferent. *Bilingualism: Language and Cognition*, 12(1), 3-11.
- Bialystok, E., & Feng, X. (2009). Language proficiency and executive control in proactive interference: Evidence from monolingual and bilingual children and adults. *Brain and Language*, 109(2), 93-100.
- Burke, D. M., & MacKay, D. G. (1997). Memory, language, and ageing. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 352(1363), 1845-1856.
- Coderre, E. L., & van Heuven, W. J. (2014). The effect of script similarity on executive control in bilinguals. *Frontiers in psychology*, 5.
- Dawson, A. (2013). Object and action picture naming ability in Gaelic-English bilinguals. Dissertation, Queen Margaret University, Edinburgh.
- Druks, J., & Masterson, J. (2000). *An Object and Action naming Battery*. East Sussex: Psychology Press Ltd.
- de Bruin, A., Bak, T. H., & Della Sala, S. (2015). Examining the effects of active versus inactive bilingualism on executive control in a carefully matched non-immigrant sample. *Journal of Memory and Language*, 85, 15-26.
- Dijkstra, T., & Van Heuven, W. J. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition*, 5(03), 175-197.
- Gollan, T. H., & Acenas, L-A. R.. (2004). What is a TOT? Cognate and translation effects on tip-of-the-tongue states in Spanish-English and tagalog-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 30(1), 246-269.

- Gollan, T. H., Montoya, R. I., Fennema-Notestine, C., & Morris, S. K. (2005). Bilingualism affects picture naming but not picture classification. *Memory & Cognition*, *33*(7), 1220-1234.
- Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition*, *1*(2), 67-81.
- Green, D. W., & Abutalebi, J. (2013). Language control in bilinguals: The adaptive control hypothesis. *Journal of Cognitive Psychology*, *25*(5), 515-530.
- Hsieh, S., Schubert, S., Hoon, C., Mioshi, E., & Hodges, J. R. (2013). Validation of the Addenbrooke's Cognitive Examination III in frontotemporal dementia and Alzheimer's disease. *Dementia and Geriatric Cognitive Disorders*, *36*(3-4), 242-250.
- Ivanova, I., & Costa, A. (2008). Does bilingualism hamper lexical access in speech production?. *Acta Psychologica*, *127*(2), 277-288.
- Mätzig, S., Druks, J., Masterson, J., & Vigliocco, G. (2009). Noun and verb differences in picture naming: Past studies and new evidence. *Cortex*, *45*(6), 738-758.
- Meier, M. E., & Kane, M. J. (2013). Working memory capacity and Stroop interference: global versus local indices of executive control. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *39*(3), 748-759.
- Michael, E. B., & Gollan, T. H. (2005). Being and becoming bilingual: Individual differences and consequences for language production. In J. F. Kroll & A. M. B. De Groot, *Handbook of bilingualism: Psycholinguistic approaches* (389-407). Oxford University Press.
- Rosselli, M., Ardila, A., Araujo, K., Weekes, V. A., Caracciolo, V., Padilla, M., & Ostrosky-Solís, F. (2000). Verbal fluency and repetition skills in healthy older Spanish-English bilinguals. *Applied Neuropsychology*, *7*(1), 17-24.



Vega-Mendoza, M., West, H., Sorace, A., & Bak, T. H. (2015) The impact of late, non-balanced bilingualism on cognitive functions. *Cognition*, 137, 40-46.

**Footnotes**

<sup>1</sup> We entered number of phonemes as a measurement of word length as participants reported covert vocalisation of the written words. Entering number of letters instead of phonemes did not affect the results.

## Appendix A

Means and standard deviations (in parenthesis) of self-rated language use during five time frames for Gaelic and English.

	<b>Active</b>	<b>Inactive</b>	<b>Monolingual</b>	<b>Statistics</b>
	<b>bilingual</b>	<b>bilingual</b>		Active vs. inactive
				Active vs. monolingual
				Inactive vs. monolingual
<b>Gaelic</b>				
Childhood home	9.50 (1.35)	8.79 (2.00)	1.42 (1.84)	$\chi^2(2) = 4.643, p = .407$
				$\chi^2(2) = 38.164, p < .001$
				$\chi^2(2) = 33.521, p < .001$
Childhood school	2.46 (1.53)	2.33 (2.10)	1.04 (.20)	$\chi^2(2) = 3.932, p = .470$
				$\chi^2(2) = 22.702, p < .001$
				$\chi^2(2) = 18.771, p = .001$
Work	4.64 (2.15)	1.88 (1.15)	1.17 (.38)	$\chi^2(2) = 24.685, p < .001$
				$\chi^2(2) = 36.726, p < .001$
				$\chi^2(2) = 12.042, p = .046$
Later life home	7.42 (2.59)	1.71 (1.08)	1.08 (.28)	$\chi^2(2) = 31.051, p < .001$
				$\chi^2(2) = 40.030, p < .001$
				$\chi^2(2) = 8.979, p = .133$
After retirement	7.14 (2.43)	2.58 (1.28)	1.04 (.20)	$\chi^2(2) = 25.098, p < .001$
				$\chi^2(2) = 45.473, p < .001$
				$\chi^2(2) = 20.375, p = .001$

---

**English**

Childhood home	1.75 (1.48)	2.29 (1.90)	9.54 (1.86)	$\chi^2(2) = 4.580, p = .433$ $\chi^2(2) = 37.830, p = .001$ $\chi^2(2) = 33.25, p = .001$
Childhood school	9.29 (1.27)	8.83 (2.24)	9.96 (.20)	$\chi^2(2) = .068, p = .988$ $\chi^2(2) = 10.506, p = .019$ $\chi^2(2) = 10.438, p = .025$
Work	5.50 (2.27)	8.67 (1.55)	9.75 (.68)	$\chi^2(2) = 24.408, p < .001$ $\chi^2(2) = 37.116, p < .001$ $\chi^2(2) = 12.708, p = .035$
Later life home	3.68 (2.54)	9.00 (1.32)	9.83 (.56)	$\chi^2(2) = 29.988, p < .001$ $\chi^2(2) = 39.905, p < .001$ $\chi^2(2) = 9.917, p = .099$
After retirement	3.75 (2.07)	7.75 (1.62)	9.92 (.41)	$\chi^2(2) = 24.601, p < .001$ $\chi^2(2) = 45.122, p < .001$ $\chi^2(2) = 20.521, p = .001$

---

## Appendix B

Stimulus list of the thirty nouns and thirty verbs used in the picture-word matching task. An asterisk indicates that the item was excluded from further analysis. English nouns had an average word length of 5.39 ( $SD = 1.47$ ) letters and 3.96 ( $SD = 1.24$ ) phonemes. English verbs had an average word length of 7.10 ( $SD = .75$ ) letters and 5.33 ( $SD = .60$ ) phonemes. Gaelic nouns had an average word length of 6.11 ( $SD = 2.30$ ) letters and 4.64 ( $SD = 1.42$ ) phonemes. Gaelic verbs had an average word length of 8.83 ( $SD = 1.92$ ) letters and 6.57 ( $SD = 1.45$ ) phonemes. Although verbs were significantly longer than nouns, there was no significant difference between Gaelic and English items in word length.

Nouns		Verbs	
English	Gaelic	English	Gaelic
butterfly	dealan-dè	barking	a' comhartaich
anchor	acair	biting	a' bideadh
arrow	saighead	blowing	a' sèideadh
axe	làmhag	combing	a' cìreadh
bath	amar	digging	a' cladhach
beard	feusag	dreaming	a' bruadar
bee*	beach*	fishing	ag iasgach
bell	clag	floating	a' fleodradh
candle	coinneal	jumping	a' leumadh
cheese	càise	kicking	a' breabadh
cherry*	siris*	kissing	a' pògadh
comb	cìr	knitting	a' fighe
crack	sgàin	knocking	a' gnogadh
duck	tunnag	licking	ag imlich

---

elephant	ailbhean	melting	a' leaghadh
feather	ite	peeling	a' rùsgadh
flag	bratach	pouring	a' dòirteadh
kettle	coire	raking	a' ràcadh
knot	snaidhm	roaring	a' beucaich
ladder	àradh	sailing	a' seòladh
mouse	luch	shaving	a' bearradh
pig	muc	sinking	a' dol fodha
sandwich	ceapaire	sneezing	a' sreothartach
sausage	isbean	snowing	a' cuir an t-sneachd
sheep	caora	stroking	a' sliobadh
shirt	lèine	swimming	a' snàmh
shower	frasair	tickling	a' diogladh
sword	claidheamh	tying	a' ceangal
whistle	feadag	weaving	a' fighe
witch	bana-bhuidseach	yawning	a' meananaich

---

**Figure captions**

Figure 1. *Gaelic and English language use per time frame for the three language groups (active bilinguals, inactive bilinguals, monolinguals). Error bars indicate +/- 1 s.e.m.*

Figure 2. *Reaction times from the picture-word matching task in English (left) and Gaelic (right) per language group. Error bars indicate +/- 1 s.e.m.*

Figure 3. *Accuracy scores from the picture-word matching task in English and Gaelic per language group. Error bars indicate +/- 1 s.e.m.*