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The impact of late, non-balanced bilingualism on cognitive performance

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1 **ABSTRACT**

2 We present a study examining cognitive functions in late non-balanced bilinguals
3 with different levels of second language proficiency. We examined in two experiments a total
4 of 193 mono- and bilingual university students. We assessed different aspects of attention
5 (sustained, selective and attentional switching), verbal fluency (letter and category) as well as
6 picture-word association as a measure of language proficiency. In Experiment 2 we also
7 compared students in their first/initial (Y1) and fourth/final (Y4) year of either language or
8 literature studies. There were no differences between both groups in category fluency. In
9 selective attention, bilinguals outperformed monolinguals in Y1 and this difference remained
10 significant in Y4 despite overall improvement in both groups. Contrasting results were found
11 in attentional switching and letter fluency: while no differences were found in Y1 in both
12 tasks, in Y4 there was an advantage for bilinguals in attentional switching and for
13 monolinguals in letter fluency. We conclude that overall late-acquisition non-balanced
14 bilinguals experience similar cognitive effects as their early-acquisition balanced
15 counterparts. However, different cognitive effects may appear at different stages of adult
16 second language acquisition.

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22 **1. Introduction**

23 *1.1. The Cognitive Effects of Bilingualism*

24 Substantial evidence suggests that bilingualism can influence cognitive functions¹. In
25 the linguistic domain, bilinguals show a disadvantage compared to monolinguals in reaction
26 time and accuracy in lexical access tasks such as picture naming²⁻⁴, attributed to either
27 parallel activation of words from different languages and the necessity to inhibit competing
28 non-target items⁵ or to a reduced-frequency of use of each of the bilingual's language^{6, 7}. In
29 contrast, a bilingual advantage has been reported for tests of executive functions, such as
30 attentional control⁸⁻¹², inhibition¹⁰ and switching^{13, 14}. These differences continue across the
31 lifespan^{12, 15-17} and might contribute to a later onset of dementia in bilinguals^{16, 18, 19}. It has
32 been hypothesised that these effects come from higher demands posed on executive control
33 through inhibition and switching between languages associated with bilingualism⁵. In some
34 tasks, such as verbal fluency (VF), bilingual performance has shown both advantages and
35 costs. In some category fluency studies, bilinguals have been reported to underperform²⁰⁻²²,
36 while in others to outperform monolinguals²³. Other authors have reported no influence of
37 bilingualism on category fluency²⁴. A similar pattern of conflicting results exists in letter
38 fluency^{20, 24}.

39 While current debates often focus on the specific nature of the tasks employed^{13, 14, 25-}
40 ²⁷, less attention has been paid to the characteristics of the bilingual speakers and their
41 bilingualism. Most research has been devoted to "classical" bilingualism: a simultaneous or
42 early consecutive childhood acquisition and balanced command of two or more languages. It
43 remains unclear to what extent bilingualism effects can also be detected in individuals who
44 acquire their second language in late childhood or adulthood without reaching native-like
45 proficiency. Studies of late-acquisition bilingualism produced so far conflicting results. Luk
46 et al. (2011) found a bilingual advantage only in early-acquisition bilinguals²⁸, while other

47 studies found it in early as well as late-acquisition bilinguals^{17, 27, 29, 30}. Also regarding the
 48 importance of the number of languages involved, previous studies came to conflicting
 49 results³¹. Some found a beneficial effect only in multi- but not in bilinguals³² or reported a
 50 correlation between the number of languages and cognitive performance¹⁵. Others found only
 51 a weak effect of multilingualism¹⁷ or no effect at all¹⁶.

52 Against this background, our study set out to examine non-balanced bilinguals who
 53 acquired their second language in late childhood/early adulthood. We employed non-verbal
 54 auditory tests assessing different aspects of attention²⁷ and examined the difference in
 55 performance in students in their first/initial and fourth/final year, relating cognitive changes
 56 to the increase in L2 proficiency.

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58 **2. Experiment 1**

59 **2.1 Methods**

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61 *2.1.1. Participants*

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63 Sixty-six University of Edinburgh students (mostly in their 4th year) took part in this
 64 experiment. All were native English speakers.

Table 1. Demographic data of the participants.

	Experiment 1			Experiment 2			
	Monolinguals	Bilinguals	Multilinguals	Year 1		Year 4	
	Monolinguals	Bilinguals	Multilinguals	Monolinguals	Bilinguals	Monolinguals	Bilinguals
Total (N)	18	16	17	24	32	22	37
Age Mean (SD)	21.78 (2.18)	22.44 (1.97)	20.82 (1.70)	19.67 (1.76)	18.75 (.67)	22.09 (1.11)	21.70 (1.37)
Gender ratio Females/Males	12/6	13/3	14/3	15/9	23/9	15/7	25/12

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66 The *Monolingual participants* (N=18) did not speak any language other than English
 67 beyond basic level. The *Bilingual participants* (N=16) had Spanish as their second language
 68 (L2) and no knowledge of other languages. The *Multilingual participants* (N=17) knew at

69 least one more language in addition to English and Spanish, but their knowledge of Spanish,
70 as indicated in the language questionnaire (Appendix), was better/comparable to that of other
71 foreign language(s). Fourteen participants were excluded because Spanish was not their main
72 L2, one because of incomplete data. Age and gender differences were not significant (chi-
73 square and t-tests all $ps > .05$) (Table 1).

74

75 2.1.2 Tasks

76 2.1.2.1 Picture Name Verification Task (PNVT)

77

78 The PNVT measures accuracy and speed with which a picture-name combination is
79 judged to be correct or not and provides, therefore, an objective measure of L2 proficiency.
80 The stimuli were 42 pictures depicting clothing, furniture and body parts with corresponding
81 written names in English and Spanish respectively. None of the words were cognates. There
82 was no difference in the number of graphemes between English ($M=5.36$) and Spanish
83 ($M=5.57$) words ($t(41) = -1.013, p > .05$). Colour pictures of the objects were displayed on a
84 white background for 350 ms. before the word appeared next to the image. Both picture and
85 word remained on the screen until the participant responded. The presentation order was
86 randomised. The task was produced and administered using E-prime 2.

87

88 2.1.2.2 Test of Everyday Attention (TEA)

89 The TEA³³ is a well-established clinical assessment tool, recently applied to measure
90 executive functions in bilinguals²⁷. We selected three subtests, examining different aspects of
91 attention: *Elevator Task (ET)*, *Elevator Task with Distraction (ETD)* and *Elevator Task with*
92 *Switching (ETS)*. ET assesses sustained attention: prompted by recording, participants count
93 seven strings of tones, presented at irregular intervals. ETD measures selective attention
94 asking participants to count low tones while ignoring high-pitch ones over ten trials. ETS

95 requires switching: participants have to use high and low pitch tones as cues for the direction
96 (upwards and downwards, respectively) in which to count ten strings of tones. All tasks were
97 presented through loudspeakers.

98

99 *2.1.2.3 Verbal Fluency (VF)*

100 The VF tasks consisted of letter and category fluency. Participants were asked to
101 produce as many words as possible within 60 seconds, beginning with the letter F, M and P
102 (letter fluency) or belonging to the category of animals, foods and degree courses (category
103 fluency)^{20, 21, 34, 35}.

104

105 *2.1.2.4 Language Questionnaire*

106 Participants completed a language questionnaire (Appendix), rating their command of
107 each language in expression, comprehension, reading and writing on a 5-point scale
108 (basic/weak/moderate/advanced/fluent). Total proficiency score was calculated by adding
109 proficiency levels in all domains. The questionnaire was completed after all other tasks.

110

111 *2.1.3 Statistical Analysis*

112 Analyses of Variance (ANOVAs) and independent and related t-tests (as appropriate)
113 were performed to compare mean differences between and within groups. Correlational
114 analyses were conducted using Pearson's correlation coefficients. Analyses of variables not
115 meeting the assumption of normality were conducted using non-parametric tests. All analyses
116 were performed using SPSS for Windows v.19.

117

118 **2.2. Results**

119 *2.2.1 PNVT*

120 There were no significant differences in *accuracy* to English words between the three
 121 groups ($H(2) = .82, p = .664$). The bilingual and multilingual groups were significantly less
 122 accurate for Spanish than for English words (bilinguals: $z = -2.067, p = .039$; multilinguals:
 123 $z = -2.217, p = .027$), with no difference between bilinguals and multilinguals ($p = .380$)
 124 (Table 2).

Table 2. Summary of mean group performance on Experiment 1

	Monolinguals	Bilinguals	Multilinguals
Accuracy L1	97.84 (2.97)	98.21 (2.95)	98.32 (2.35)
Accuracy L2	n/a	90.77 (12.83)	94.96 (4.90)
ET	97.62 (5.48)	100.00 (.00)	100.00 (.00)
ETD	80.00 ^{b, c} (22.23)	94.38 ^a (11.53)	94.71 ^a (8.74)
ETS	77.22 (22.44)	93.13 (10.78)	82.35 (21.95)
Verbal Fluency			
F	17.78 (5.47)	17.50 (4.55)	15.47 (4.46)
P	16.39 (3.90)	17.44 (4.86)	15.29 (3.06)
M	15.50 (4.20)	17.31 (4.30)	15.59 (3.64)
Letter Total	49.67 (11.09)	52.25 (11.93)	46.35 (8.83)
Animals	25.72 (5.22)	23.94 (6.70)	25.18 (5.86)
Food	25.56 (5.61)	25.69 (6.36)	23.82 (4.31)
Degrees	21.44 (3.70)	19.44 (4.52)	20.29 (3.64)
Category Total	72.72 (12.20)	69.06 (15.63)	69.29 (11.97)

Notes: Accuracy and performance in ET, ETD and ETS are expressed in percentages.

For each verbal fluency task, the number of correct words per minute is reported.

SD given in parentheses.

Significant differences ($p < .05$) are reported on this table as follows:

a: ≠ monolinguals, b: ≠ bilinguals, c: ≠ multilinguals

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127 2.2.2 *PNVT in relation to L2 Proficiency*

128 There was a significant positive correlation between self-rated proficiency in Spanish
129 and accuracy to Spanish words in bilingual and multilingual groups, $r_s = .722, p (2\text{-tailed}) <$
130 $.001$.

131

132 2.2.3. *TEA*

133 Prior to analysis, raw scores of the TEA tasks were transformed into percentages.

134 Ninety-four percent of participants performed at ceiling on ET. The few who made an error

135 were monolinguals, but due to the small number of errors the difference failed to reach

136 significance ($H(2) = 5.73, p = .057$). A significant group effect was found on ETD ($H(2) =$

137 $9.13, p = .010$). Pairwise adjusted p -values comparisons showed that both bilinguals and

138 multilinguals scored higher than monolinguals ($p = .020$ and $p = .041$, respectively), with no

139 difference between them ($p > .05$). On ETS, there was a trend towards a better performance

140 in bi- and multilinguals, but it did not reach significance ($H(2) = 5.51, p = .064$).

141

142 2.2.5 *Verbal Fluency (VF)*

143 No significant differences were found between the three letters or the three

144 categories across groups (all $ps > .05$) (Table 2). More words were produced in category than

145 in letter fluency: monolinguals: $t(17) = 7.343, p < .001$; bilinguals: $t(15) = 5.486, p < .001$,

146 and multilinguals: $t(16) = 9.037, p < .001$, with no differences between the groups in overall

147 score of category or letter fluency ($ps > .05$).

148

149 **3. Experiment 2**

150 Results from Experiment 1 suggest that late, unbalanced bi/multilinguals performed

151 better than monolinguals on one of the attentional tasks (ETD), showed a trend towards a

152 better performance on another (ETS) and no differences on VF. Experiment 2 set out to
153 explore these findings in more detail, examining the influence of increased exposure to and
154 proficiency in L2 taking place during language studies. To this end, we compared the
155 performance of first (Y1) and fourth (Y4) year students of Spanish/Italian and of
156 literature/humanities. As we found no significant differences in performance between the
157 Spanish and Italian language groups (all $ps > .05$), both groups were analysed together. Also,
158 since the bi- and multilingual groups in Experiment 1 did not show major differences, we
159 merged the two groups into one bilingual group. Thus, the focus of Experiment 2 is on the
160 differences in performance between Y1 and Y4 in language and literature students.

161

162 **3.1 Methods**

163 *3.1.1 Participants*

164 A total of 127 first and fourth year students at the University of Edinburgh took part
165 in the experiment. Twelve participants were excluded following the same criteria as in
166 Experiment 1. Age and gender differences between groups were not significant (Table 1).

167

168 *3.1.2 Tasks*

169 The tasks and procedures were the same as in Experiment 1. A parallel version of
170 PNVNT was developed for Italian, containing the same items as the English-Spanish version,
171 but paired with Italian words. Given that no differences were found between the letters and
172 categories in Experiment 1, we reduced the length of our test by restricting it to the letter *P*
173 and category *animals*.

174

175 *3.1.3 Language Questionnaire*

176 Participants completed the same language questionnaire as in Experiment 1, but in
 177 addition we also enquired about musical experience (Appendix). No significant differences
 178 were found between the groups.

179

180 3.1.4. Statistical Analysis

181 Parametric and non-parametric tests as well as *post-hoc* pairwise comparisons and
 182 correlational analyses were carried out when appropriate. Because of the larger number of
 183 participants in this study, between subjects 2x2 ANOVAs with factors *group* (mono- and
 184 bilinguals) and *year of study* (first and fourth) were carried out to explore possible
 185 interactions.

186

187 3.2. Results

188 3.2.1 PNVT

189 No differences were found between the groups ($F(1, 111) = .010, p = .922, \eta_p^2 = .000$)
 190 or years of study ($F(1, 111) = 3.797, p = .054, \eta_p^2 = .033$) in the accuracy for English words (a
 191 non-significant trend towards improvement occurred in both groups, see Table 3). The
 192 bilingual group was more accurate to respond to English (L1) than to L2 words in both Y1
 193 and Y4 (all $ps < .002$).

Table 3. Summary of mean group performance on Experiment 2.

	Year 1		Year 4	
	Monolinguals	Bilinguals	Monolinguals	Bilinguals
Accuracy L1	97.42 (3.51)	97.55 (3.28)	98.67 (1.65)	98.43 (2.56)
Accuracy L2	n/a	89.86 ^b (7.12)	n/a	96.24 ^b (3.81)
ET	99.40 (2.92)	98.66 (4.23)	98.70 (6.09)	99.23 (3.27)
ETD	68.75 ^{a,b} (16.24)	81.25 ^{a,b} (15.19)	83.18 ^{a,b} (19.85)	93.78 ^{a,b} (15.52)

ETS	63.75 ^b (7.70)	66.25 ^b (17.37)	73.18 ^{a,b} (22.76)	87.84 ^{a,b} (14.17)
Letter Fluency	19.13 ^b (6.08)	18.87 (4.66)	22.73 ^{a,b} (7.29)	18.46 ^a (4.56)
Category Fluency	25.96 ^b (6.03)	27.06 (4.30)	29.64 ^b (5.17)	28.19 (4.50)

Notes: Accuracy and performance in ET, ETD and ETS are expressed in percentages.
 For each verbal fluency task, the number of correct words per minute is reported.
 SD given in parentheses.
 Significant differences ($p < .05$) are reported on this table as follows:
 a: monolinguals \neq bilinguals, b: Year 1 \neq Year 4

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With regards to words in L2, Y4 bilinguals were significantly more accurate ($U =$

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245.50, $z = -4.23$, $p < .001$) than Y1 bilinguals (Table 3, Fig. 1).

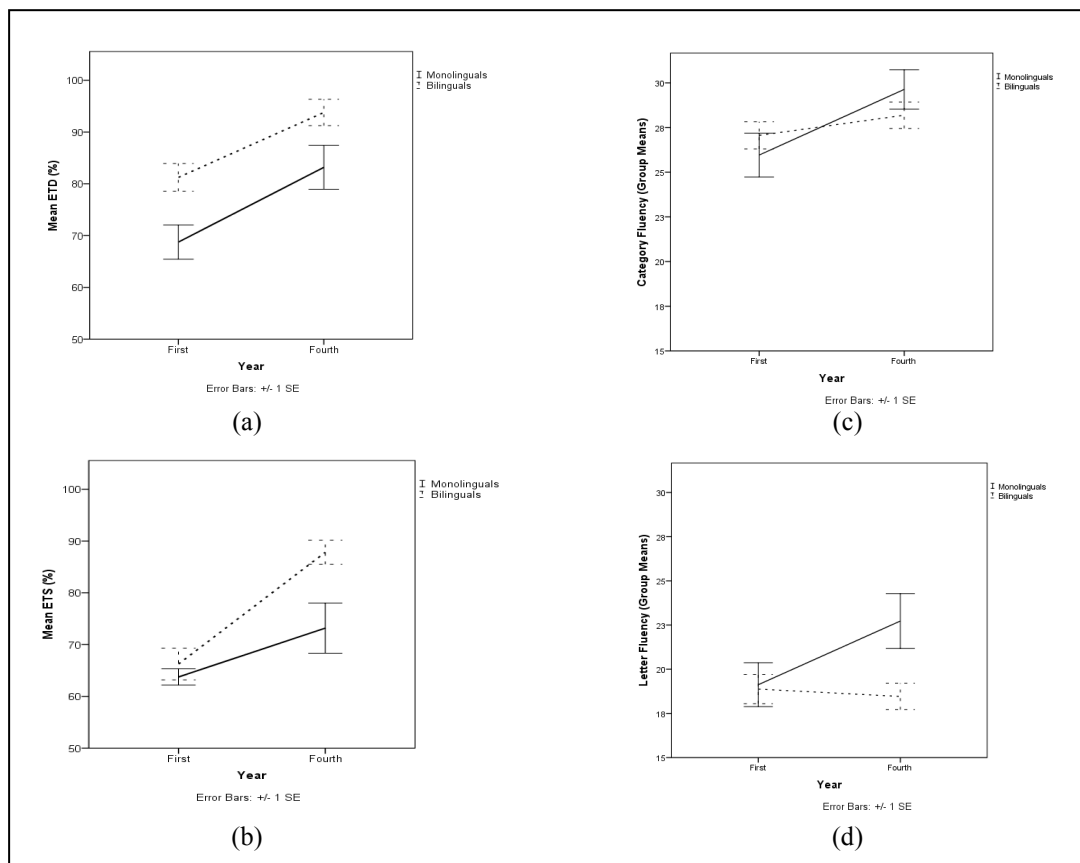


Figure 1. Experiment 2 - Changes in performance between Year 1 and Year 4 on: (a) TEA ETD, (b) TEA ETS, (c) Category Fluency, and (d) Letter Fluency (For the TEA tasks we report the percentage of correct trials, for the verbal fluency tasks, the number of correct words per minute).

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201 3.2.2 *PNVT in relation to L2 Proficiency*

202 A significant positive correlation between self-rated L2 proficiency and accuracy to

203 L2 words was found for the bilingual group, $r_s = .433$, p (2-tailed) $< .001$.

204

205 3.2.3. *TEA*206 No effects or interactions were found on ET (all $ps > .05$). On ETD, both groups207 improved significantly from Y1 to Y4 ($F(1,111) = 18.406$, $p < .001$, $\eta_p^2 = .142$), but bilinguals208 performed better than monolinguals in both years ($F(1,111) = 13.509$, $p < .001$, $\eta_p^2 = .108$),209 with no significant interaction ($F(1) = .091$, $p = .763$, $\eta_p^2 = .001$).210 On ETS, there were main effects of group ($F(1,111) = 7.797$, $p = .006$, $\eta_p^2 = .066$) and211 year of study ($F(1,111) = 25.491$, $p < .001$, $\eta_p^2 = .187$), and a significant interaction ($F(1) =$ 212 3.915 , $p = .050$, $\eta_p^2 = .034$): both groups performed equally in Y1, but by Y4 a significant

213 bilingual advantage was noted (Fig. 1).

214

215 3.2.4 *Verbal Fluency (VF)*216 More words were produced in category than letter fluency in all groups (all $ps < .01$).

217 With regards to letter fluency, monolinguals produced more words than bilinguals overall

218 ($F(1,111) = 4.600$, $p = .034$, $\eta_p^2 = .040$), with a tendency towards significance for the219 interaction between language group and year ($F(1,111) = 3.638$, $p = .059$, $\eta_p^2 = .032$): both

220 groups performed equally in Y1, but a monolingual advantage was observed in Y4 (Fig. 1).

221 In category fluency Y4 students produced more words than Y1 students ($F(1,111) = 6.528$, p 222 $< .012$, $\eta_p^2 = .056$), with no differences between the language groups, and no interaction ($ps >$ 223 $.05$).

224

225

226 **4. Discussion**

227 Our results suggest that late non-balanced bilinguals experience similar cognitive
228 costs and benefits as their early-acquisition balanced counterparts. A consistent effect across
229 both experiments was a bilingual advantage on ETD, measuring selective attention and,
230 therefore, inhibition of irrelevant stimuli: a task previously reported to be particularly
231 sensitive to late-acquisition bilingualism²⁷. In Experiment 1, there was no additional benefit
232 of multilingualism over bilingualism. If the reason for a bilingual advantage on this task lies
233 in the constant necessity of suppressing the irrelevant language⁵, knowing two languages is
234 likely to lead to a ceiling effect, with no further benefit of additional languages. In
235 Experiment 2, the bilingual effect on ETD was already present in Y1 students, in whom the
236 levels of L2 proficiency were relatively modest, and persisted, despite an overall
237 improvement in performance in both groups, into Y4. It is possible that this effect in Y1 can
238 be explained by the fact that some students had previous knowledge of L2 and by the time of
239 testing had completed one term of intensive language study. However, we cannot exclude
240 that superiority on the abilities underlying this test could be a pre-existing cognitive feature
241 predisposing to language studies.

242

243 The results on ETS showed a different pattern: all groups performed equally in Y1 but
244 a bilingual advantage appeared in Y4, by which time the bilingual group reached a
245 considerable level of proficiency, as witnessed by significant improvement in accuracy of
246 their L2 responses on PNVT. ETS is a complex task requiring two different processes:
247 inhibition and switching. The latter involves release of inhibition and a potential negative
248 priming effect³⁶, which may be more marked for adult L2 learners, especially in the initial

249 stages. The improvement on ETS in Y4 could be linked, therefore, to the higher proficiency
250 in L2 and the increased opportunities for switching between languages.

251 In VF, an interesting difference was observed between category and letter fluency. In
252 category fluency, no significant differences were found between the mono- and bilingual
253 groups. In contrast, the letter fluency showed a change in performance between Y1 and Y4,
254 not dissimilar to ETS but in the opposite direction. While there was no difference between
255 mono- and bilinguals in Y1, in Y4 the monolinguals outperformed the bilinguals. Since the
256 monolingual group consisted mainly of literature students, this reverse pattern might well
257 reflect four years of intensive engagement with English language in reading, writing and
258 speaking. This finding also suggests that the monolingual participants in our study were
259 comparable in their general cognitive capacity as well as in their academic activities to the
260 bilingual ones. Both language and literature studies showed an improvement in test
261 performance from Y1 to Y4, but it affected different cognitive domains.

262

263 Our study has limitations: some students had previous L2 knowledge, so we could not
264 measure their performance at “point zero” of L2 acquisition. We were also not able to
265 compare the same students across their 4-years courses and thus cannot exclude selection
266 biases. However, when designing our study we made a particular effort to minimise potential
267 confounding variables by keeping the sample as homogenous as possible. All participants
268 were students with the same native tongue (English); the L2 was either Spanish or Italian,
269 languages closely related in grammar and vocabulary. In Experiment 2 we were particularly
270 cautious to select the closest possible monolingual control group: students of English
271 literature and humanities from the same university. Both language and literature students had
272 to fulfil the same strict academic criteria in order obtain admission³⁷ and later to progress
273 from the pre-honours (Y1-2) to the honours (Y3-4) stage (interestingly, the percentage of

274 students who progressed into the honours programme in the three subject areas was
275 practically identical: 92.4% for Spanish, 94.3% for Italian and 92.6% for English). The type
276 of academic activities they engaged in was also broadly comparable, with the main difference
277 being that language students had to read, write, listen and speak in different languages, the
278 literature students mainly in one, English. Accordingly, the greatest improvement for
279 literature students was in letter fluency (specific to English), and for language students in the
280 more general task of attentional switching.

281

282 While in some current debates attempts have been made to reduce the effects of
283 bilingualism to a simple difference on a single task²⁶, our study emphasises the complex and
284 multidimensional nature of this phenomenon³⁸. We suggest that the potential effects of
285 bilingualism on cognition can be positive (e.g. selective attention) as well as negative (e.g.
286 increased speed of lexical access). Some may occur early in the acquisition of L2 or even
287 predate it as a cognitive marker (e.g. ETD), others seem to appear only when reaching
288 considerable levels of L2 proficiency (ETS). More research is needed to explore these
289 differences in more detail. So far, it seems that the cognitive effects of learning L2 in
290 adulthood are not radically different from those of learning one in childhood: a result of
291 considerable interest and relevance to millions of adult L2 learners worldwide.

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