M.A. Thesis

Bilingualism effects on executive functioning: the case of Irish-English and Catalan-Spanish bilinguals

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Abstract

Based on the extensive research addressing the beneficial effects of speaking multiple languages, this study explored the impact of bilingualism on the executive functions of interference and switching. We did so by examining the role of *interactional contexts* of language switching (Green & Abutalebi, 2013), *language typological distance* and *onset of bilingualism* (early *vs* late bilinguals).

We compared three groups of adults, (*i*) Catalan-Spanish bilinguals (*ii*) Irish-English bilinguals and Irish monolingual speakers of English (*iii*), on two interference tasks (Flanker and Multi-Source Interference Task) and two switching tasks (Trail-Making Test and Global-local task).

Bilingual advantages in both interference and switching tasks were observed for Irish-English bilinguals compared to Irish monolinguals. However, the two bilingual groups performed similarly in interference tasks. In the switching tasks, we found that (a) Catalan high-switchers outperformed Irish high-switchers in the TMT, but (b) Irish bilinguals experienced reduced mixing costs compared to the Catalan bilinguals in the Global-local task. Finally, within the Irish high-switchers, late-sequential bilinguals had greater switching skills than early-sequential bilinguals. These findings suggest that the diversity of bilingual experiences affects different aspects of executive functions.

Keywords: executive functions, language typological distance, language switching, onset of bilingualism, bilingualism, bilingual populations, Ireland, Catalonia.

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Acronyms

ACH = Adaptive Control Hypothesis

ANOVA = Analysis of Variance

EF = Executive Functions

HDI = Human Development Index

IQ = Intelligence Quotient

L1 = first language

L2 = second language

LMM = Linear Mixed Model

M = Mean

ms = milliseconds

MSIT = Multi-Source Interference Task

N = Number

PED = Parent’s Education

RQ = Research Question

RT = Reaction Times

SD = Standard Deviation

SES = Socio-Economic Status

TMT = Trail-Making Test

WM = Working Memory

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1. Introduction

There has been an influential body of research investigating the potential effects that bilingualism might bring to cognition. It has been hypothesised that, over time, this practice alters the nature of executive processing in verbal as well as nonverbal tasks (Bialystok, Craik, Green, & Gollan, 2009).

Over the years, the difficulty to match groups of monolinguals and bilinguals on a number of external factors (such as age, socio-economic status, cultural background, etc.) caused a general scepticism about the bilingual-advantage hypothesis (Paap, Johnson, & Sawi, 2016). Moreover, research on bilingualism raises questions when assessing one's degree of bilingualism. Should we account for proficiency or language use? How much should we rely on language history?

The aim of the present study is to explore to what extent active bilingualism impacts cognitive functions by administering tasks which are not related to language itself. We focused on the extensive literature of bilingualism and cognition, but delved deeper into the diversity of bilingual experiences. Two types of bilingualism (Spanish-Catalan and Irish-English) are analysed and compared. A key issue to clarify is the role that language typological distance may play. In doing so, language switching in interaction contexts (as described in the *Adaptive Control Hypothesis* by Green and Abutalebi, 2013) will be considered.

In the next section, we will address studies supporting or challenging a bilingual advantage. Attention will be paid to the role of some moderator variables when dealing with 'matched' samples of monolinguals and bilinguals. Thereafter, we will focus on the bilinguals' language profiles in terms of language use, language dominance and L2 acquisition, and conclude by reflecting on the language context as a key factor.

2. Literature review

2.1. The cognitive component: executive functions

Miyake et al. (2000) advanced a *Unity-and-Diversity* model to explain the relationships underlying executive functions (EFs), which are "correlated with one another, but clearly separated" (p.49). They can be identified as s*hifting* (also called 'switching'), *updating* and *inhibition.* With respect to the latter, Friedman and Miyake (2004) provided evidence to support the idea that it is a family of functions, rather than a single unitary construct. For the present study, particular attention is paid to the so-called *resistance to distractor interference*, specifically concerning the ability to suppress irrelevant information.

A common complication in experimental studies advanced by de Bot (2017) is grounded in the fact that: "[d]ifferent components of executive function may be positively correlated, uncorrelated or negatively correlated with one another, depending on the task" (2017, p.28). This phenomenon is partially related to what is known as the *task impurity problem* and the enigma over the unity or separability of the EFs: no correlation between tasks measuring different constructs does not necessarily imply that the underlying components are actually independent, rather the instruments used might be partially unreliable (Miyake et al., 2000).

2.2. Cognitive control and bilingualism

The occurrence of speaking two languages requires a certain degree of language control so that the relevant language at hand is selected while blocking the potential *interference* of the unwanted (yet, activated) language (see Morales, Gómez-Ariza, & Bajo, 2016). As far as interference tasks are concerned, research has found *speed advantages* displayed by bilingual children (Bialystok, 2010; Martin-Rhee & Bialystok, 2008), young adults (Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009, in high-monitoring versions of the Flanker test) and older adults (Bialystok, Klein, Craik, & Viswanathan, 2004). For review, see Hilchey and Klein (2011).

With regards to switching abilities, it has been assumed that, beyond language control, switching between two languages on a daily basis may affect cognitive flexibility, which is calculated through switch and mixing costs in switching tasks (Monsell, 2003). In task-switching paradigms, *switch cost* refers to the time needed to switch from one task to another and is calculated as the reaction-time difference between switch trials and repeat trials. Conversely, *mixing cost* denotes the phenomenon of slowing down because of a "task-set reconfiguration" (Friedman & Miyake, 2004, p.120) in blocks where both tasks are involved, in contrast with fixed blocks where the focus is required on one task only. The body of research on bilingualism and task-switching has found a bilingual advantage in switch costs, but no significant differences for mixing costs (Hartanto & Yang, 2016; Prior & Gollan, 2011; Prior & Macwhinney, 2010; but no reduced switch costs in Garbin et al., 2010) (**for a full review**, **Appendix A**). Furthermore, brain-imaging studies provided evidence for non-verbal disparities between monolinguals and bilinguals. Garbin et al. (2010)

demonstrated an overlap in brain region recruitment: when tested on non-verbal switching tasks, bilinguals recruited the same cerebral regions (left frontal cortex) responsible for language control, whereas monolinguals proved to use distinct regions depending on the nature of the task at hand (Anderson, Chung-Fat-Yim, Bellana, Luk, & Bialystok, 2018).

2.2.1. The other side of the coin

In recent years, de Bruin, Treccani, & Della Sala (2015) posed the question of whether studies on bilingualism may have suffered from publication biases that contributed to create “the accepted wisdom of a cognitive advantage in bilinguals” (p.1). An argument they put forward is that studies supporting bilingual advantages usually reported less EF tasks than studies challenging these hypotheses. Moreover, the direction of causality between bilingualism and EF abilities is often ambiguous, especially in late sequential bilinguals (i.e. L2 learners) (Paap et al., 2016).

Antón, Carreiras, and Duñabeitia (2019) tested young adult bilinguals from the Basque Country in an extensive test-battery[1] and did not find significant differences between bilinguals and monolinguals in EF tasks. However, they hypothesised that bilingualism may have positive effects on working memory, which consequently may be transferred into an enhancement of some EF processes. This is in line with studies showing that working memory abilities correlate with controlled attention (Namazi & Thordardottir, 2010).

2.2.2. The importance of moderator variables

The mixed findings reported above led researchers to investigate the ‘hidden’ variables that make the difference in cases of ‘matched samples’ of bilinguals and monolinguals. As a matter of fact, one of the major difficulties concerning effects of bilingualism *per se* consists in controlling important factors that may not be apparently related to the ability to speak multiple languages. The rationale behind it is quite straightforward. Experience shapes our brain: bilingualism is undeniably one of these life-changing experiences, but not the only one.

With respect to the *socioeconomic status* (SES), in replicating studies implementing the Simon task Morton & Harper (2007) found significantly smaller

[1]One of the tasks was a high-monitoring version of the Flanker test with an equal amount of incongruent and congruent trials.

Simon effects among bilinguals from higher SES families. After controlling for SES, no bilingual advantages were revealed, a finding also supported in more recent years by Antón et al. (2019) and Namazi and Thordardottir (2010). This is not surprising since lower SES has been associated with poorer EF performance in inhibition tasks among monolingual populations as well (Sarsour et al., 2011)[2]. However, there is no agreement on how to reliably measure SES and each study has treated SES differently at a methodological level: it is often controlled by choosing homogenous (often middle-class) neighbourhoods (Bialystok, 2010; Bialystok, Craik, & Luk, 2008) or operationalised either as parent's education level (PED) (Blom, Küntay, Messer, Verhagen, & Leseman, 2014; de Bruin, Bak, & Della Sala, 2015; Paap & Greenberg, 2013) or as a combination of education and occupation (Kirk, Fiala, Scott-Brown, & Kempe, 2014). Much more thoroughly, Morton and Harper (2007) composed their participants' SES scores combining PED and total family income.

Another important issue that Morton and Harper (2007) addressed in their research is to recruit only non-immigrant subjects, as *immigration status* may sometimes confound some findings of studies related to SES and bilingualism. Matched in SES with monolingual peer groups, bilinguals have been shown to better cope with conflictual information (Engel de Abreu, Cruz-Santos, Tourinho, Martin, & Bialystok, 2012) as well as with working memory tasks (Blom et al., 2014). Nevertheless, in both studies the populations were composed by immigrants: in Engel de Abreu et al. (2012) the subjects were all Portuguese bilinguals from Luxembourg[3], while in Blom et al. (2014) Turkish-Dutch sequential bilinguals were compared to a Dutch monolingual group. Others deliberately decide not to control for immigration forwarding the belief that SES and immigration status counterbalance each other by cancelling the other's effects (Paap et al., 2016). However, there is counterevidence showing no differences when exploring immigration status in SES-matched populations (Kirk et al., 2014).

Interestingly, *multilinguals* are included into the sample in many studies on bilingualism and cognition. Some authors have demonstrated how knowledge of additional languages positively affects inhibitory control (Paap & Greenberg, 2013). Other studies found how trilinguals and simultaneous bilinguals perform better in

[2] Yet, SES appeared to have no effects on cognitive flexibility such as task-switching.
[3] The Portuguese bilingual group was matched with an ethnically comparable group in Northern Portugal.

conflict resolution tasks than late bilinguals (L2 learners) do, but not significantly so (Poarch & van Hell, 2012).

As expected, *age* appears to be one of the determinants of cognitive decline, with a consequent loss of speed and inhibitory ability (Craik & Bialystok, 2005). However, older bilinguals seem to experience a reduced loss in their interference capability (Bialystok et al., 2004). On top of all these circumstances, lifestyle may affect cognition. In correlational EF studies, positive associations emerged with *musical training* (Hou et al., 2014) and with *video-gaming* (Bialystok, 2006).[4]

Considering all of the above, it may be hazardous to generalise an indisputable bilingual advantage over monolinguals in non-verbal cognitive skills, especially when: (a) there exists "a flurry of reports" on bilingual advantages (Prior & Gollan, 2011, p.682) with mixed results and (b) the population of bilinguals is heterogeneous in terms of background variables.

2.3.The role of language use

Determining a degree of bilingualism (Anderson et al., 2018) happens to be very challenging. Multifarious components interact and contribute to make the bilingual experience unique: age of onset, language of formal education, proficiency, language dominance/balance and context, to mention just a few. Therefore, rather than a categorical variable, bilingualism should be seen as a continuum (Luk & Bialystok, 2013), "something that is dynamic and constantly changing" (de Bot, 2017, p.21).

When reviewing task switching, Monsell (2003) claimed: "the cognitive task we perform at each moment, and the efficacy with which we perform it, results from a complex interplay of deliberate intentions […] and the availability, frequency and recency of the alternative tasks afforded by the stimulus and its context." (2003, p.134). Factors such as availability, frequency and recency are transferable concepts when dealing with language control. One's degree of bilingualism may vary depending on whether a given language is available in the environment, how often and how recently it was spoken. There might be situations in which bilinguals stick to only one language (monolingual mode), other times in which they switch back and forth between two languages (bilingual mode) (Grosjean, 1989).

[4]The researcher demonstrated how video-gamers were overall faster in most conditions of the Simon task, while bilinguals were faster when a high-monitoring conflict was present. Once again, only demanding tasks appear to trigger some bilingual advantage.

2.3.1. Language use and task-switching studies

In relation to EF studies, Prior and Gollan (2011) conducted a study to determine whether good language switchers were also good task-switchers by recruiting two different populations: Spanish-English and Mandarin-English bilinguals. When matched in proficiency scores and SES, the former group, who on average reported more daily rates of switching, showed better performance on verbal and non-verbal (colour-shape judgment) switching tasks. The authors suggested that the key factor leading to switch advantages was therefore *language switching* and in general language use, rather than proficiency, a view first proposed by Morton and Harper (2007). Paap and Greenberg (2013) found the relationships between language switching and task-switching performance to be inconsistent in their pool of participants who reported to speak and "switch" between the two languages every day. Yet, as carefully observed by Verreyt and colleagues (2015), they did not gather specific information on language switching, but inferred it from their subjects' language use.

2.3.2. Language use and inhibition studies

In Belgium, Verreyt et al. (2015) reported evidence that balanced switching bilinguals showed better performance in inhibition tasks[5] (global speed advantage and better conflict-resolution) than both balanced and unbalanced non-switching bilinguals, who were matched for age, sex, IQ level, proficiency and immigration status. Their findings corroborate the hypothesis that language switching experience plays a crucial role when performing non-verbal tasks. Nevertheless, they underline that the enhancement derived by language switching may be due to the fact that the two languages considered (French-Dutch) overlap in their lexicons: bilinguals are forced to constantly make the effort to select one language and avoid interference from the other. That being so, in another bilingual population whose languages do not lexically overlap the effort required would be less demanding and, as such, no benefit would be triggered. This hypothesis would explain why previous research did not find EF advantages in bilinguals residing in active bilingual communities such as North Wales (Gathercole et al., 2014) and the Basque Country (Antón et al., 2019). Interestingly, it is worth noting that many studies involving Celtic-language speakers have failed to demonstrate a

[5] They implemented the 75%-25% proportion as in Costa et al. (2009) in both the Flanker and Simon tasks.

bilingual advantage in adult and elderly populations (de Bruin et al., 2015; Kirk et al., 2014). However, Gathercole et al. (2014) did not carefully explore bilinguals' patterns of language use. Their evaluation of language dominance was predominantly driven by participants' "origin home language", a variable that might be relevant for children, but not for adults.

2.3.3. Language dominance

Operationalising *language dominance* does not result in a simple procedure and differs among studies depending on the factors chosen to assess it. Proficiency remains the crucial and preferred variable of comparison to split the bilingual population into "balanced" and "unbalanced" in order to establish a degree of dominance (Hulstijn, 2012). For instance, when investigating the relationship between language balance and EF performance with pre-schoolers and sixth-grade Hebrew-Russian bilinguals, Prior, Goldwasser, Ravet-Hirsh, Schwartz, and Schwieter (2016)[6] objectively determined "language balance" by administering vocabulary tests. Moreover, they supported the view that well-balanced bilinguals (in terms of proficiency) will also on average be better language-switchers, as they are equally comfortable in either language (see also Prior & Gollan, 2011). Differently, in Goral, Campanelli, & Spiro (2015) balance was assessed by considering both language proficiency and language use.

Aside from methodological dissimilarities, researchers have started to query the convenience and, more importantly, the efficiency of obtaining an overall language dominance measure among bilingual populations. As suggested by Treffers-Daller (2015), we ought to aim for "fluent bilinguals" rather than constrain the notion of bilingualism to a "perfect balance" (p.243). Still, assessing and controlling for proficiency and language use remain a major objective, especially when they might explain variance obtained within the sample or, more importantly, when strong claims are made on the assumption of testing "fully fluent" bilinguals.

2.3.4. Onset of bilingualism

In 2015, Yow and Li investigated the effects of dominance and age of L2 acquisition on a series of EF tasks. Their findings showed how bilinguals benefit from being

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[6] Their study showed how only balanced bilinguals (in the older group) performed the Flanker test significantly better than monolinguals, showing an advantage in inhibitory control, but not in cognitive flexibility. In fact, they had mixed blocks where participants were asked to switch their focus between peripheral and central arrows.

‘balanced’ in terms of language use by better coping Stroop effects and mixing costs. In addition, they found that *early* bilinguals performed better in the Stroop task, fostering the idea that they probably benefitted from the early exposure to the two languages. Conversely, previous studies conjectured that potential benefits in EFs might be ascribed to the age of L2 acquisition, since sequential bilinguals may switch less mechanically, thus recruiting more controlled attention (Namazi & Thordardottir, 2010).

2.3.5. Language switching: the context as a key factor

The inconsistent results displayed in the literature concerning bilingualism and EFs might be also explained in light of the fact that, depending on the *language context* bilinguals are immersed in, different effects are taking place[7]. Recently, Timmer, Christoffels, & Costa (2018) showed how, when immersed in a more L2-dominant context, unbalanced bilinguals (L1 Dutch-L2 English) experienced asymmetric switch costs on verbal switching tasks, such that switching into the weaker language required more effort.

Collecting information about participants’ conversational language use on a daily basis is essential to analyse whether they are usually immersed in (i) ‘single-language contexts’, where switching does not occur often; (ii) ‘dual-language contexts’, in which switching may occur, usually because the two languages are used with different interlocutors; (iii) ‘code-switching contexts’, for which they switch within sentences (see interactional contexts in Green & Abutalebi, 2013). According to the authors, demands on language control processes are major in dual-language contexts as the bilingual speaker needs to resist switching into the other activated language and speaking the ‘inappropriate’ language with the ‘wrong’ interlocutor. In case of single-language contexts, an interference control process is still taking place, but not a task-engagement and disengagement practice (**Figure 1**).

Studies exploring the effects on dual-language contexts provided evidence for increased conflict resolution ability (Wu & Thierry, 2013) and reduced switch costs (Hartanto & Yang, 2016). However, de Bruin et al. (2015) failed to find significant results in a bilingual population, after examining different language contexts. Lastly, Ooi, Goh, Sorace, & Bak (2018) tested two populations of bilinguals in Edinburgh and

[7] Contrasting results may be due to the fact that language switching and interactional context are not often controlled for, as in Paap & Greenberg (2013) or Costa et al. (2009).

Singapore, that differ in their language switching contexts. Besides the fact that their findings yielded a bilingual advantage in dual-language contexts, their approach contributes a move from the idea of 'bilingualism' as a unitary category to different 'bilingualisms'.

Demands on language control processes in bilingual speakers as a function of the interactional context relative to demands on the processes in monolingual speakers in a monolingual context

	Interactional contexts		
Control processes	*Single language*	*Dual language*	*Dense code-switching*
Goal maintenance	+	**+**	=
Interference control: conflict monitoring and interference suppression	+	**+**	=
Salient cue detection	=	+	=
Selective response inhibition	=	+	=
Task disengagement	=	+	=
Task engagement	=	+	=
Opportunistic planning	=	=	**+**

+indicates the context increases the demand on that control process (more so if bolded); =indicates that the context is neutral in its effects. Please see main text for explanation of the control processes.

Figure 1. *Control processes in different interactional contexts (from Green & Abutalebi, 2013).*

3. The present study

3.1. Aims

The present study seeks to explore the effects of (a) *language switching*, (b) *language typological distance* and (c) *onset of bilingualism* on EFs, such as task switching and interference, by using non-verbal tasks, some of which are seldom used in the field. In terms of language switching, we follow the research line adopted in Verreyt et al. (2015) and overcome some of their limitations by adding a group of monolinguals and an objective measure of proficiency. Similarly to Ooi et al.'s work (2018), two bilingual populations in different countries were considered but, differently from their study, we included only bilinguals that were speaking two language pairs: Catalan-Spanish and Irish-English. To the best of our knowledge, this is the first study designed as such. Our second goal is to expand the investigation into the role of typological distance and amount of lexical overlap between two paired languages.

3.2. Research questions

These aims led to the following research questions (RQs):

1. Within bilinguals, does a *regular use* of the two languages result in a superior ability to resist distractor interference and switching ability, compared to monolinguals?
2. For bilinguals only, does regular *language switching* in dual-language contexts result in a switching or inhibition advantage?
    2.1. Does *language typological distance* play a role in EF tasks?
    2.2. Does *onset of bilingualism* play a role?

With regards to switching, most of the predictions are grounded in Green and Abutalebi's *Adaptive Control Hypothesis* (2013). For RQ1, we hypothesise that for the bilinguals the occurrence of speaking the two languages of theirs may lead to an effective enhancement of interference resistance. For RQ2, we may expect that fluent bilinguals that switch their languages within the same context (dual-language) may perform better than bilinguals who are on average more immersed in single-language contexts. For RQ2.1, as suggested by Verreyt et al. (2015), the larger the amount of lexicon shared, the larger the effort to keep the two languages separate. One of our predictions is that Catalan-Spanish bilinguals will probably experience smaller switch costs due to their constant training in switching between the two languages. However, it might be also reasonable to think that Spanish and Catalan are too closed in terms of typology to trigger any advantage. For RQ3, we may expect that sequential bilinguals will show an EF advantage as a consequence of their enhanced language control.

For our purpose, we recruited bilinguals who actively spoke their two languages. One might inquire to what extend Cummins' *Threshold Hypothesis* (1976), related to language proficiency, can be applied to language use, specifically on language switching. Furthermore, the current study involves one bilingual population (Irish bilinguals) which, as far as we know, has never been examined in bilingual-advantage studies.

4. Methodology

4.1. Participants

A total of 83 adults took part in the present study: 35 Catalan-Spanish bilinguals from Catalonia, 35 Irish-English bilinguals and 13 English monolingual speakers from the North of Ireland. However, 26 out of 69 bilinguals were excluded in the analysis due to their dominant language use for one language over the other (see results section). All the participants reported to live in their respective country from birth or for more than 20 years. For details, see **Table 1**.

4.1.1. Catalonia: Barcelona

The Catalan-Spanish bilinguals were mostly teachers recruited from primary and secondary schools in the metropolitan area and some students from the University of Barcelona. Catalonia is an active bilingual society where the two co-official languages often coexist. Catalan has been adopted more and more as the language of instruction and means of communication in intensive immersion programmes in schools (Vila i Moreno, 2008). This practice is the consequence of a process of preservation of this autochthonous language, especially since "non-Catalan speakers in Catalan speaking territories do not feel the need to learn Catalan" (2008, p.43) and interact in Castilian Spanish with locals. As a result, the population is Catalan-dominant in respect to their language use as confirmed in the present study, where 12 out of 18 bilinguals stated that they speak more Catalan than Spanish in their daily life.[8]

4.1.2. The North of Ireland: Belfast

The English-speaking monolinguals and the Irish-English bilinguals were from the city of Belfast, where approximately 20% of the Irish-speaking population of Northern Ireland reside (Kaplan & Baldauf, 2005). We selected only literate active bilinguals that spoke Irish at their workplace (Irish-medium schools, language associations and community centres, radio stations, etc.). It is important to underline that the Irish-speaking community is not randomly spread around the city, but there exist concentrations of Irish-speaking neighbourhoods. Most of our participants came from west Belfast, the so-called "neo-Gaeltacht"[9] (Maguire (1987) as cited in Kaplan & Baldauf, 2005, p.280), which can be considered a functional minority bilingual society within a larger English-speaking dominant environment. Even if not recognised in the region as an official language, which itself is a contentious political issue, Irish is the medium of instruction in immersion programmes offered in some primary and secondary schools as a way to promote the rejuvenation of this minority language and educate fluent bilinguals.

[8] Seventeen out of the 26 excluded participants were in fact Catalan-dominant speakers.
[9] The Gaeltacht areas are regions in which Irish is recognised as the primary means of communication.

	Group			
	Catalan bilinguals (N=18)	**Irish bilinguals** (N=26)	**Irish monolinguals** (N=13)	Tests ** p< .05* *** p< .01*
	Mean (SD)			
Age (years)	41.89 (13.04)	37.15 (10.96)	42.77 (19.02)	*H* (2, 57) = 1.167
Gender (F:M)	12:6	12:14	6:7	
Education [a]	4.11 (.83)	4.38 (.852)	3.38 (1.19)	*H* (2, 55) = 7.111, *
IQ [b]	8.56 (1.86)	8.27 (2.07)	7.62 (2.87)	*H* (2, 55) = .742
SES [c]	6.17 (.92)	5.65 (1.23)	5.92 (1.26)	*H* (2, 57) = 1.850
Age of L1 acquisition (y.s)	.17 (.71)	0	0	*H* (1,44) = .107
Age of L2 acquisition (y.s)	**1.50** (3.42)	**7.04** (5.90)	-	*H* (1,44) = 9.181 **
Balanced exposure [d]	10.11 (8.98)	17.77 (11.27)	-	*t* (42) = -2.401
L1 proficiency [e]	37.72 (2.70)	38.46 (2.39)	40 (0)	*H* (1,44) = 2.565
L2 proficiency [e]	37.78 (1.83)	36.23 (4.85)	-	*H* (1,44) = .025
Third languages [f]	1.11 (.83)	.54 (.71)	.46 (.78)	-
Language use [g]	.53 (.11)	.46 (.10)	-	*t* (42) = 1.958
Language switching [h]	24.83 (5.15)	22.50 (4.06)	-	*t* (42) = 1.679

[a] Rated on a scale from 1 (Less than secondary school) to 6 (PhD).
[b] Sum of the correct responses from the Raven's Matrices – max=12.
[c] Rated on a scale from 0 (very low) to 10 (very high).
[d] Composed by subtracting L2 exposure from L1 exposure (absolute value). 0 indicates "perfect balance".
[e] Sum of the self-reported proficiency in the four skills ranging from 0 to 10 (max=40).
[f] A point was given for each additional language known.
[g] Average self-reported language use in different contexts. 0.5 represents perfect balance, below 0.5 represents L1 dominance and above 0.5 L2 dominance.
[h] Sum of self-reported language switching in different contexts ranging from 1 (never) to 5 (always) – max=35.

Table 1. *Participants' characteristics (N = 57).*

According to the Latest Human Development Index[10] (2018), both countries fall within the "very high human development group". Despite the fact that 42.3% of the Irish bilinguals and 77.8% of Catalan bilinguals knew another language, they did not speak those additional languages as often as their two relevant languages. Four monolinguals reported some knowledge of other languages, but at a very low proficiency.

4.2. Design

This cross-sectional experiment involved 6 tasks performed in a single session, for a total of 25-35 minutes. See **Table 2** for a summary. To avoid order effects related to the single tasks, within each paradigm the tests were counterbalanced across participants (**Appendix E**).

[10] For Northern Ireland, the HDI value of UK was taken (0.922); for Catalonia, Spain (0.891). These indexes have been used in Ooi et al. (2018) – http://hdr.undp.org/en/2018-update.

Tasks	Construct analysed	Time (minutes)
Flanker test	Resistance to Distractor Interference	4
Multi-Source Interference Task	Resistance to Distractor Interference	5
Global-Local Test	Switching	5
Trail-Making Test	Switching	4
Animacy-judgement task	Lexical access	5
Raven's Matrices	Non-verbal IQ	5-10

Table 2. *Tasks.*

4.3. Materials

4.3.1. Language background questionnaire[11]

The language background questionnaire was predominantly based on two validated questionnaires, the BLP (*Bilingual Language Profile*) by Birdsong et al. (2012) and the LSBQ (*Language and Social Background Questionnaire*) created by Anderson et al. (2018).

Section (I) gathered data regarding participants' age, sex, current country of residence, immigration status, ethnicity, formal education, and socio-economic status.

In section (II), questions aimed to assess their age of acquisition of each language, additional languages spoken, language of formal education, language exposure in the workplace and in the family.

In section (III), a definition of language switching was included: "Switching between the two languages here refers to the habit of changing the language of interaction while speaking. For example, it might happen when *within the same context* you speak Irish to one person and English to another or when you are with another Irish bilingual and you interact in both languages, switching back and forth from one language to another". To assess their degree of immersion in dual-language or single-language contexts, we asked our participants to rate the percentages of use and the frequency of switching in specific *contexts* (home, work, social setting, commercial/government services) and with specific *interlocutors* (relatives, friends, neighbours). This choice was made due to the fact that, depending on different contexts

[11] See Appendix C.

bilinguals, may be led by "processing contextual cues" (Morales, Gómez-Ariza, & Bajo, 2016, p.280) to select one language rather than another.

In section (III) they reported their self-proficiency for the four skills for each language on a 10-point Likert scale. Finally, section (V) covered lifestyle and cognitive training activities, such as playing videogames, instruments, chess/board games, doing crosswords/puzzles/sudoku, playing with phone apps.

In the experimental group, both Catalan and Irish bilinguals complete two equivalent questionnaires, which differed only in the language used (English and Spanish), while the Irish monolinguals filled out a shorter version.

4.3.2. Nonverbal tasks: general considerations

All the tasks were computerised and administered through DMDX (Forster & Forster, 2003), except for the switching tasks that were run using Inquisit (v.4) by Millisecond. The nature of the tasks' stimuli was carefully chosen to not overly resemble stimuli of tasks previously performed in order to prevent a priming effect due to an "associative retrieval" (Monsell, 2003, p.138). Additionally, none of the tasks included colours as target stimuli since participants were not tested for defective colour vision. However, in the adapted version of the MSIT colours were distractors, but instead of the original contrast red-green, the dichotomy red-blue was preferred since it is used in well-known tasks (i.e. the Simon task).

In the construction of the non-verbal EF tasks, findings showed that when there is an equal amount of trials (50%-50% - "high-monitoring versions"), a bilingual advantage is proved by overall faster RTs because of consistent switching. Conversely, in the version with 75% of congruent trials, bilinguals are better at focusing and resisting distractor interference, the so-called "magnitude of the conflict effect" (Costa et al., 2009, p.141). Given these assumptions, switching tasks were designed with 50% of congruent trials, whereas interference tasks were built with the 75% congruent version to better analyse the conflict factor.

4.3.2.1. Interference tasks

For the interference tasks, a fixation cross was presented for 400 ms, then the stimulus was presented until the participants' response (or for a maximum of 1700 ms) and a 400 ms interval between the response and the next trial. Participants were warned when a new block was about to start.

4.3.2.1.1. Flanker test

Used in a large body of research on EF in different versions (Costa et al., 2009; Paap & Greenberg, 2013; Prior et al., 2016), the Flanker test is specifically designed to tap into *Resistance to Distractor Interference* (Friedman & Miyake, 2004).

Participants were presented with five arrows on the screen and instructed to indicate the direction of the central arrow only by pressing two buttons on the keyboard as fast as they could. The trials presented may be congruent (→→→→→) or incongruent (→→←→→). In the present study, three blocks were included. The first block included 10 *neutral* conditions with a single arrow pointing either left (←) or right (→). The second block consisted of 8 *practice* trials in which all five arrows were appearing on the screen and helped participants familiarise themselves with the task. For both the blocks participants were given feedback on their responses. The third block was the actual experiment and contained a total of 66 randomised trials (2 false starts and 64 experimental trials) with 75% of trials being congruent (16 incongruent and 48 congruent).

4.3.2.1.2. Multi-Source Interference Task (MSIT)

In this test, patterned on the one used in Wenzel, Kubiak, & Conner (2014), participants were presented with a 3-digit sequence and asked to indicate the central digit as quickly as possible. Similarly to the Flanker test, the MSIT taps into resistance to distractor interference. However, the distractor cues are not directional, but consist of different size and colour from the target digit. Differently from the original MSIT, the target digit was always maintained in the second position due to an observation made in Huili et al. (2008, p.113).

The whole experiment consisted of three blocks. As in Wenzel et al. (2014), the first block presented 12 neutral trials with one central digit and the two distracting letters "x". The second block had 8 practice trials and the third block consisted of 82 trials (2 false starts and 80 experimental trials) with 75% being congruent trials (N=60). Only in the neutral and practice blocks did participants receive feedback. The potential distraction was given by the incongruity between colour and digit, when the target digit was the same colour as one of the distractors. However, an additional distraction was presented in the size of the colour-unique distractor being the largest of the digits (**Figure 2**).

Neutral Congruent Incongruent

Figure 2. *MSIT conditions.*

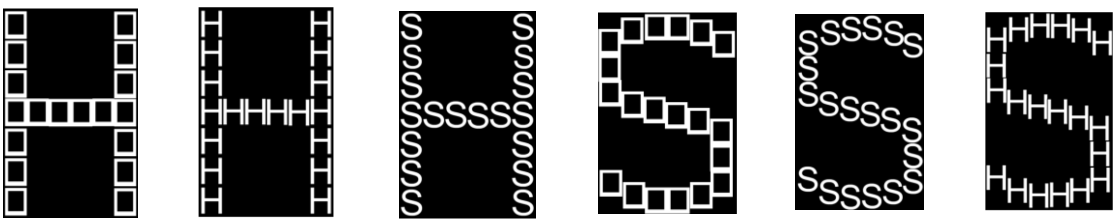
4.3.2.2. Switching tasks

Two switching tasks were chosen and run with Inquisit-by-Millisecond: the Global-Local task and the Trail Making Test (for correlations between the tasks, see Bialystok, 2010).

4.3.2.2.1. Global-Local test

In this test, classified as a task measuring shifting ability (Miyake et al., 2000), participants were presented with capital letters (either H or S) that are made of the same letter (*congruent*, e.g. a H-shape made of Hs) or the other letter (*incongruent*, e.g. a H-shape made of Ss). A fixation cross and a beep signalled the start of each trial, the stimulus was presented for 2000 ms, then covered by a mask, with the next trial only beginning after the participants' response.

In the first block they were asked to identify the overall shape of the letter (*global* shape). The 20 randomised trials contained stimuli that could be congruent, incongruent or neutral (**Figure 3**). In the second block the target letter was the individual letter-element (*local* shape). There were 20 trials randomly presented: congruent, incongruent and neutral (big squares made of small Hs or Ss).



Neutral H Congruent H Incongruent H Neutral S Congruent S Incongruent S

Figure 3. *Global block conditions.*

Some parameters of the Inquisit script were modified to create a mixed block with 35 trials, where participants were asked to shift their attention between the global or the local shape task depending on the size of the indicators at the bottom (**Figure 4**).

Figure 4. *Indicators in the mixed block.*

4.3.2.2.2. Trail-Making Test (TMT)[12]

The second switching task was a computerised version of the TMT consisting of two parts (Trails A and B). Trail A presented 25 numbered circles scattered across the screen and required participants to click on each numbered circle in order from Start (circle 1) to End (circle 25). In Trail B participants were asked to perform the same task by alternating numbers and letters (1-A-2-B-3-C, etc…) while additional distracting circles appeared on the screen. Each trail was preceded by a small practice of five items. In case of errors, a small message would have come up on the screen.

Used with adults in Goral et al. (2015) and Hou et al. (2014), Trail A measured visual-spatial attention, whereas Trail B includes EF constructs such as switch cost. Arbuthnott and Frank (2000) validated the use of B/A ratio as a successful indicator the executive control function of switching, although in recent years it was claimed that the B-A difference scores would be a better index of task-switching (Sánchez-Cubillo et al. 2009).

4.3.3. Lexical access: animacy-judgement task

We administered a speeded lexical access task in order to control for participants' proficiency and potential language dominance. Subjects were instructed to indicate whether a word appearing on the screen was animate (e.g. people or animals) or inanimate (e.g. objects) and respond as fast as they could. There was a small practice block (6 items) before the experimental block, which consisted of 42 items (2 false

[12]The Inquisit script followed the TMT version described in Reitan (1958).

starts+20+20). Participants had a maximum of 2 seconds to respond to each item. For a **full description**, see **Appendix D**.

As observed in Hulstijn (2012), this objective task together with the subjective self-reported proficiency on the two languages may be a good way to establish participants' "language (non) dominance".

4.3.4. Raven's Matrices

Participants' general intelligence was measured using Set 1 of the *Ravens Advanced Progressive Matrices* (Raven, Court, & Raven, 2001). This test, employed in several studies on bilingualism (Costa et al., 2009; Paap & Greenberg, 2013; Verreyt et al., 2015), is known to assess subjects' fluid intelligence, not strictly related to language ability, but rather concerning the capacity to manage problems by dividing them into simpler segments (Carpenter, Just, & Shell, 1990).

The test consisted of 12 different items, which were missing a piece. Participants had to find the missing piece by choosing one of the 8 options available on the bottom of the screen. Participants were advised to not rush, even though they were given a limited time to answer (1 minute/item).

4.3. Procedure

All the Irish participants were tested in a quiet room either in their own homes or in their workplace. Catalan bilinguals were tested in a quiet room at either work, home or place of study at the University of Barcelona. Experimental sessions were conducted in English for the Irish speakers and in Spanish for the Catalan speakers. In both locations, participants completed all the tasks individually in the same experimental session, except the questionnaire, which was filled out either beforehand or after.

The tests were administered through a HP ProBook 650 G1 personal computer running Windows 7 Professional. Participants were asked to place themselves 1 metre from the screen (15.6" monitor). After signing an informed consent, participants went through the test-battery following this fixed order of four paradigms: interference tasks, switching tasks, lexical access tests, general intelligence test. For a visual view of the counterbalanced order, see **Appendix E**.

5. Results

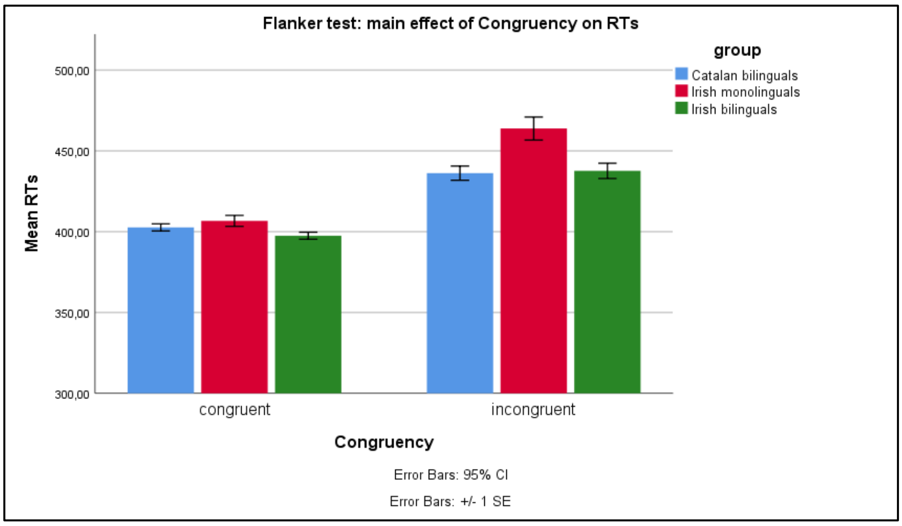
Reaction time data for all the tasks were screened for accuracy and for extreme values by removing response latencies that fall below and above 2.5 personal standard deviations. First, we analysed the conditions of each task. Afterwards, we included *Language Group* as a between-subject factor in order to answer our research questions.

5.1. Lexical access task

With regard to the lexical access task, independent sample *t*-tests for the mean RTs were run to guarantee that Irish bilinguals and monolinguals did not significantly differ for English, $t(46) =.002$, $p =.965$. No differences were found between Catalan-Spanish and Irish-English bilinguals in relation to their 'balancedness' in the lexical access task, $t(65) =1.856$, $p=.178$. The balance score in the lexical access tasks and self-reported proficiency marginally correlated, $r_s=.256$, $p<.05$. By splitting the file per group, for the Irish group the correlation was stronger ($r_s=.427$, $p<.05$), than for the Catalan bilinguals ($r_s=.085$, $p>.1$) (Appendix F.1.).

5.2. Interference tasks

For the Flanker test, a linear mixed model (LMM) was run considering *Congruency* and *Group* as fixed factors and *Subject* and *Item* as random variables. We included *Group* in order to see whether there was a significant speed advantages for bilinguals compared to monolinguals. As expected, there was a main effect of *Congruency*, so that incongruent trials were significantly more difficult than congruent trials, $F(1, 111.35)=374.74$, $p<.001$ **(Graph 1**).



Graph 1. *Effect of Congruency on RTs in the Flanker test.*

There was no main effect of *Group*, but the *Group*Congruency* interaction was significant (p=.002). Bonferroni-adjusted pairwise comparisons showed a significant difference between incongruent and congruent trials (p<.001) for all the groups, whereas differences between groups did not reach significance (p>.1). Although the bilinguals (Catalan M= 418.98, SE=12.30; Irish M=417.02, SE=12.12) were overall faster than monolinguals (M=433.28, SE=19.89), the global speed advantage was not statistically significant (p>.1) (**Appendix F.2**.). After aggregating and restructuring the data, a personal inhibition score was computed by subtracting the mean RT of congruent trials from the mean RT of the incongruent trials.

With respect to the MSIT, a similar test-check was run with *Congruency* and *Response Type* (1, 2 or 3) as fixed factors. There was a main effect of *Congruency* for the all groups (p<.001) but no significant *interactions*. Moreover, there was main effect of *Response Type* for Irish bilinguals (**Appendix F.3.**).

5.3. Switching tasks

The TMT was analysed by running paired *t*-tests for each language group. Although Trail A was always faster to complete than Trail B, the difference in time was significant for the Catalan bilinguals, $t(32)$=-3.17, p=.003, almost approached significance for the Irish bilinguals, $t(34)$=-1.98, p=.056, but was not significant for the monolinguals, $t(13)$=-1.55, p=.146 (**Appendix F.4**.).

In relation to the global-local task, after screening data for accuracy and extreme values, we further screened for RTs below 250 ms and above 2500 ms, as in Bialystok (2010). For reaction times, we only included participants that scored at least 70% accurate in the mixed block and at least 80% of the trials in each of the fixed blocks to compute reliable mixing and switch costs[13]. For each language group, there was a main effect of *Block* (mixed block significantly more difficult than local and global block, all *p*s< .001), main effect of *Congruency* (being that the fastest reaction was for neutral followed by congruent, then incongruent, all *p*s< .01) and main effect of *Switch (*faster response latencies for repeat trials than for switch trials, all *p*s<.01). There were no significant *interactions* (see **Appendix F.5**.). After aggregating and restructuring, *switch costs* were computed by subtracting the repeat trials from the switch trials, as

[13] For this test, we could run the statistical tests with the scores of 39 participants.

well as *mixing costs*, by subtracting the fixed blocks from the non-switch trials in the mixed block.

5.4. Comparability of the samples

Bilinguals who reported using one of their languages less than 30% of the time were excluded from the analysis. After this screening for language use, we had an eligible pool of 18 Catalan, 26 Irish bilinguals and 13 Irish monolinguals.

Since the language groups were not normally distributed if taken separately, some non-parametric tests (Kruskal-Wallis) were run to make sure that the three groups were comparable on the basis of some demographics (see **Table 1** in Participants' section). The subjects did not differ in lifestyle either: *videogames* $H(2, 57)=.158$, $p=.924$; *crosswords* $H(2, 57)=4.756$, $p=.09$; *phone apps* $H(2, 57)=5.266$, $p=.72$; *instruments* $H(2, 57)=.837$, $p=.65$; *chess* $H(2, 57)=.041$, $p=.97$.

When analysing our participants' bilingual experience, we ascertained that they did not differ in terms of *balanced proficiency* obtained with the lexical access task, $H(1, 43)=.386$, $p=.535$; *self-reported mean proficiency*, $H(1, 44)=.169$, $p=.681$; balanced exposure to the two languages, $t(42)=-2.401$, $p=.317$. Very importantly, there were no significant differences with respect to their regular *language use*, $t(42)=1.958$, $p=.835$ or to their *language switching*, $t(42)=1.679$, $p=.312$. A cluster analysis was performed to compute language switching as a categorical variable, thus functioning as our second main factor. The resulting sample consisted of 20 switchers (10 Catalan, 10 Irish) and 24 non-switchers (8 Catalan, 16 Irish).[14]

A significant difference was reported with regard to the *age of L2 acquisition*, $H(1, 44)=9.181$, $p=.002$. This was not surprising, since all the Catalan were either simultaneous or early sequential bilinguals, whereas the Irish bilinguals were equally split between early sequential and late sequential bilinguals. Therefore, we took this variable into account and created a new categorical variable for the Irish bilinguals only (2 levels: early *vs* late-sequential bilinguals) in order to analyse its effects at a later stage.

[14] The final cluster centers obtained were 20.17 for the non-switchers and 27.40 for the switchers (on a scale ranging from 5 to 35).

Within each language group, the distributions for the interference and the switching tasks were normal (**Appendix G.1**.). Descriptive statistics are reported in **Table 3**.

	Flanker	MSIT	Trail A	Trail B	TMT: B-A	SWITCH cost	MIXING cost
Irish	53.30	24.50	54855.92	65065.23	10209.31	245.08	311.64
monolinguals	(27.07)	(32.78)	(13610.97)	(23459.02)	(23675.13)	(123.61)	(297.53)
Irish	36.87	34.49	47322.17	55827.87	8505.71	201.08	277.18
bilinguals	(17.92)	(35.33)	(9960.96)	(17626.81)	(19387.16)	(121.15)	(134.67)
Catalan	31.01	40.85	56491.19	60816.12	4324.93	207.82	287.65
bilinguals	(19.50)	(39.89)	(14270.86)	(9589.01)	(14823.86)	(161.86)	(257.66)

Table 3. *Descriptive statistics for the experimental tasks for each group.*

5.5. Correlations

We analysed the relationship between the tasks, but they did not correlate strongly with one another. When extended the analysis between the dependent variables and background variables (e.g. age, onset of bilingualism, language exposure, etc.), we noticed that MSIT inhibition scores weakly correlated with onset of bilingualism (r=.327*) and with language switching (r=.379*); the Flanker test weakly correlated with balanced exposure (r= .370**) (**Appendix H.1.**).

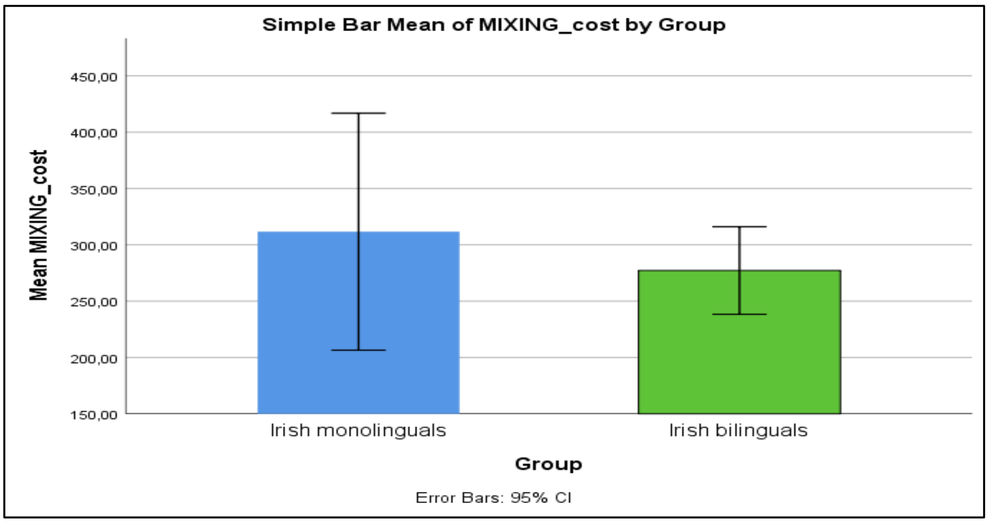
5.6. Irish bilinguals *vs* monolinguals

First, we investigated the effect of bilingualism on the performance of the EF tasks (see comparability of the samples in **Appendix G.2**.). As we can see from the descriptive statistics, Irish bilinguals performed better than monolinguals in most of the tasks[15]. However, the difference did not reach significance in any of the cases for the interference tasks or for the TMT. With regard to the global-local task, nothing significant emerged for switch costs whereas mixing costs were significantly smaller for bilinguals (M=277.19, SD=134.67) than for monolinguals (M=311.64, SD=297.53), $t(18)$=.354, p=.03 (**Graph 2**). We also analysed the data by running a two-way ANOVA with *SES* and *Group* as fixed factors. When taking *SES* into account, the Flanker effect was significantly different in favour of the bilinguals $F(1,35)$=4.758, p=.036, η^2=.120; switch costs were also significantly reduced for bilinguals, but only when considering the lower SES level, M_{diff}= -155.495, p=.034, η^2=.189. When

[15] In the MSIT, monolinguals were actually faster. However, there was a methodological drawback of the task, which could have made the test an unreliable measure.

Education was entered as a co-factor in a two-way ANOVA with *Group*, the analysis did not yield significant results[16] (for details, see **Appendix H.2.**).

5.7. Bilinguals: Catalan *vs* Irish



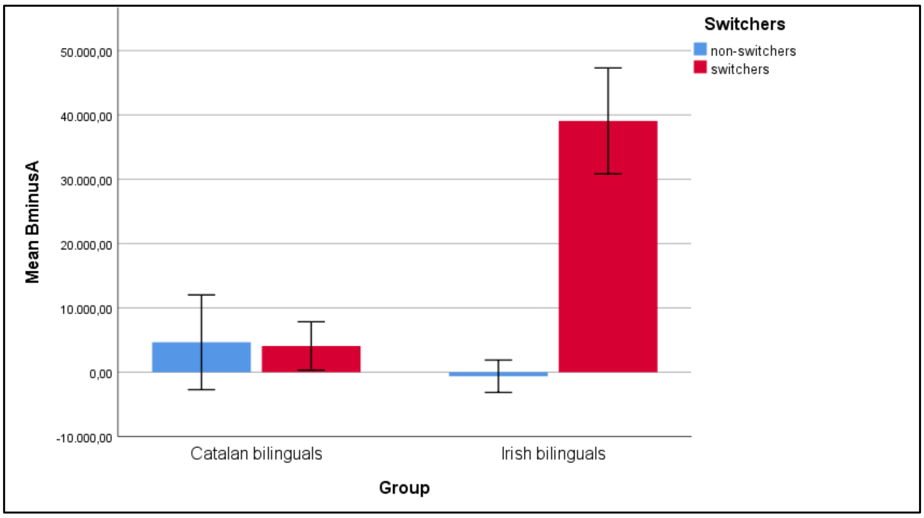
Graph 2. *Mixing costs for the Irish population.*

After checking the comparability of the samples (**Appendix G.3.**), who clearly differed in terms of age of onset for the L2, we included only simultaneous and early sequential bilinguals.[17] For both the interference tasks, a two-way ANOVA with *Language Typology* (Irish or Catalan) and *Language switching* (switchers vs non-switchers) as between-subject factors was run to analyse their effects on the inhibition scores. Neither main effects nor interactions were significant. For the TMT, a two-way ANOVA revealed a main effect of *Language Typology*, in which Catalans were significantly faster (M=4360.23, SD=3436.31) than Irish bilinguals (M=19216.37, SD=4175.60), $F(1, 24)=7.547$, p=.011, η^2=.239. There was also a main effect of *Switching*, non-switchers (M=2003.91, SD=3529.03) being surprisingly faster than switchers (M=21572.69, SD=4097.54), $F(1,24)=13.09$, η^2=.353. The *Group*Switching* interaction was also significant (p=.001) and further analysed. Bonferroni-adjusted pairwise comparisons reported that Catalan switchers were much faster than Irish switchers (M_{diff} =34989.61, p<.001, η^2=.432). Although the difference

[16] We included *Education* in our analysis, since the two groups significantly differ according to this variable.

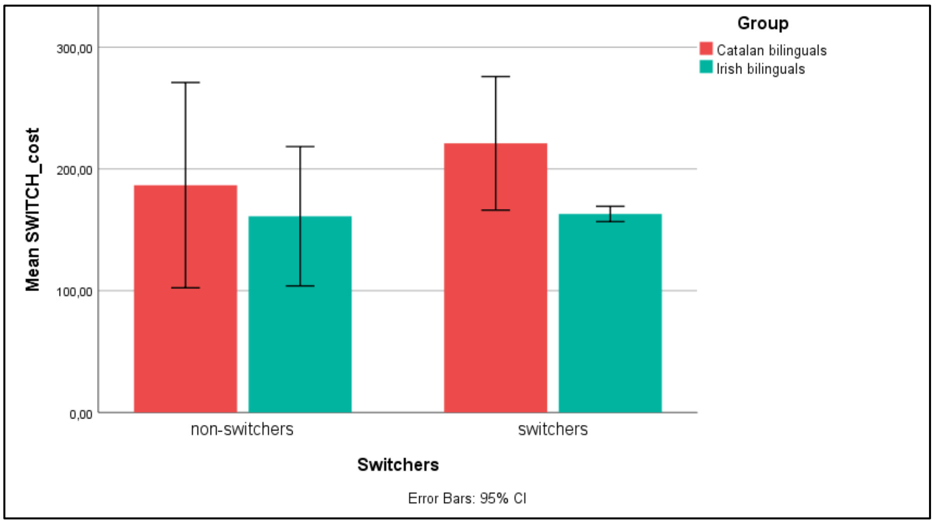
[17] The only significant difference between Irish and Catalan simultaneous bilinguals consisted of their SES level, that being Irish coming from lower SES families.

between Catalan switchers and non-switchers was almost inexistent, Irish non-switchers outperformed Irish switchers, M_{diff} = 39702.25, p<.001, η^2=.485 (**Graph 3**).



Graph 3. *B-A differences considering Switching*Language Typology*

With regard to the Global-Local task, we first analysed switch costs[18]. There was no effect of *Switching*, $t(20)$=-.467, p=.328, but a main effect of *Language Typology*, in which Catalan (M=207.82, SD=161.86) were significantly slower than Irish bilinguals (M=161.98, SD=90.80), $t(20)$=.767, p=.007 (**Graph 4**).



Graph 4. *Switch costs for Irish vs Catalan bilinguals.*

Mixing costs were similar for both Irish (M=274.90, SD=165.81) and Catalan bilinguals (M=287.94, SD=273.29). Switchers had reduced mixing costs (M=187.57, SD=178.81) than non-switchers (M=339.04, SD=239.73), but the difference did not reach significance, $t(14)$=1.334, p=.644. For more details, see **Appendix H.3**.

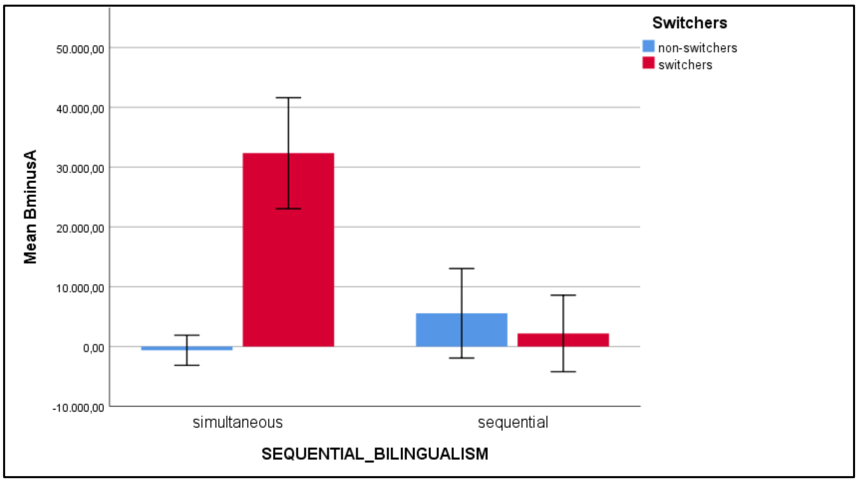
[18] T-tests were preferred to ANOVAs since we had a small sample for the analysis.

5.8. Irish bilinguals: early vs late-sequential bilinguals

A third analysis was conducted to investigate whether differences in age of onset for the L2 had any effect on performance. We selected only Irish bilinguals, who were equally split between early (range = 0-5) and late sequential bilinguals (range = 8-20) distributed in the two groups (13 per group)[19] and created a new categorical variable (*Sequential-Bilingualism*). See **Appendix G.4.** for comparability.

For the interference tasks (both Flanker and MSIT), two-way ANOVAs did not report any main effects or significant *Switching*Language Typology* interactions. By running further independent *t*-tests, it was noticed that early bilinguals were better at inhibiting in the MSIT, approaching significance, $t(24)=1.513$, $p=.053$.

With respect to the TMT (B–A), a two-way ANOVA revealed again a main effect of *Switching*, as non-switchers outperforms switchers, $F(1, 20)=4.961$, $p=.038$, but there was no strong effect of *Sequential-Bilingualism*, $p=.086$. There was a significant *interaction* ($p=.013$), which was further analysed. Bonferroni-adjusted pairwise comparisons showed that, within the group of switchers, sequential bilinguals outperformed simultaneous bilinguals, $M_{diff} = 30142.50$, $p=.010$, $\eta^2=.291$. As we have seen before, within simultaneous bilinguals, non-switchers completed the task significantly faster than the switchers, $M_{diff} =32960.75$, $p=.001$, $\eta^2=.405$ (**Graph 5**).



Graph 5. *B-A differences considering Switching*Sequential-Bilingualism*

Since age was significantly different in the Irish population, we further investigated if simultaneous switchers were significantly older than the simultaneous non-switchers.

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[19] The two samples were matched for all the variables, expect for age: simultaneous were significantly younger, $M=31.67(6.43)$ than sequential bilinguals, $M=41.86(12.02)$.

However, not only were the two groups comparable in terms of age ($H(1, 13)$=.049, p=.825), simultaneous non switchers were slightly older.

In the analysis of the global-local task, the main effects of *Sequential-Bilingualism* and *Switching*, nor their *interactions* reached significance. Yet, a trend for switchers to experience reduced switch costs (M=165.76, SD=86.25) compared to non-switchers (M=217.04, SD=133.74) was observed; likewise, switchers also experienced reduced mixing costs (M=210.40, SD=156.23) compared to non-switchers (M=307.19, SD=130.28). For details, see **Appendix H.4**.

6. Discussion

6.1. The effect of bilingualism

Concerning RQ1, we set out to investigate the beneficial effects that bilingualism may bring for EFs and found evidence to support a bilingual advantage. We observed an overall speed advantage in reduced mixing costs, which corroborates the hypothesis that the daily use of two languages reinforces bilinguals' "conflict-monitoring system" (see Botvinick et al.'s theory as cited in Hilchey & Klein, 2011). Furthermore, when taking SES into account, it was also visible that (*i*) bilinguals from lower-SES families experienced a switching advantage (reduced switch costs) and (*ii*) all the bilinguals had higher conflict resolution ability (Flanker test), irrespective of interactional contexts, in line with the predictions proposed in Green and Abutalebi (2013). Hence, we concur with Paap and Greenberg's view (2013) that controlling for SES is a priority in EF and bilingualism studies.

6.2. Bilingual populations

Our second RQ broadened the investigation to different "bilingualisms" (Ooi et al., 2018) and their potential discrepancies. As expected, we did not find significant differences in interference tasks but, when turning our attention to switching tasks, two main outcomes are worth discussing.

Firstly, Spanish-Catalan high-switchers were faster than Irish high-switchers in the Trail-making Test. Going back to the interactional contexts (here, p.9), we see that the demands of "opportunistic planning" are specifically intensified in dense code-switching contexts, for which bilinguals adapt "the words of one language to fit into the syntactic frame of another" (Green & Abutalebi, 2013, p.520). If this idea were to be transferred to the Catalan bilinguals' experience, we may hypothesise that Catalan high-switchers, who often find themselves in dual-language contexts, experience also more code-switching. Due to the closeness between Spanish and Catalan, the two lexical systems are constantly activated and the effort of switching into the other language is slightly perceived or at least not as much as Irish switchers when switching between English and Irish.

Secondly, regardless of the amount of language switching, the Irish bilinguals experienced reduced mixing costs compared to the Catalan bilinguals in the global-local task. This test demands high switching ability due to the random set-switches as well as great conflictual resolution within each trial. Because of the constant lexical activation of both languages, Catalan bilinguals are not necessarily required to suppress interference, especially since they live in an active bilingual society where the two languages co-exist. The mixed block of the global-local task presupposed a certain amount of switching ability (switch *vs* repeat) as well as inhibition capability (congruent *vs* incongruent). Irish bilinguals may have demonstrated to better cope with conflictual information in switching tasks because of the superior demands of language control that the use of their two languages implies. Moreover, the fact that they live in *both* functional bilingual neighbourhoods *and* "diglossic sociolinguistic environments" (Costa et. al., 2009) where English is the dominant language strengthens their language awareness, which is remarkably susceptible to "the *situation*, the *topic*, the *interlocutor*, etc." (Grosjean, 1989, p.6).

6.3. The effect of onset of bilingualism on EF tasks

Finally, we aimed to explore the amount of variance explained by sequential bilingualism and found that, within the Irish high-switchers, sequential bilinguals had greater switching skills than simultaneous bilinguals. Our results point in the opposite direction of Yow and Li's findings (2015), which support a greater bilingual benefit among early bilinguals. We agree with the authors that the constant practice of engaging conversations in both languages contributes to an EF enhancement, but we reject the hypothesis that the earlier, the better. Early bilinguals who regularly switch grew up speaking the two languages naturally and switching between them interchangeably. On the other hand, it is reasonable to think that sequential bilinguals possess a deeper awareness of the two linguistic systems in their mind, due to their cognitive maturity when acquiring the L2. Thus, we hypothesise that it is this enhanced language awareness that may bring some benefit to fluent active sequential bilinguals when performing non-verbal tasks. Still, the ambiguity on the direction of causality between L2 acquisition and enhanced EF abilities remains. (Paap et al., 2016). Have sequential bilinguals developed stronger EF abilities because of their enhanced language control? Or… have those bilinguals become fluent switchers because, in first place, they had high EF skills? Longitudinal studies could help disambiguate this cause-effect relationship.

7. Conclusions

7.1. General discussion

In a field of research which has widely carried out EF studies with very young and elderly populations, this study shed some light on the under-investigated population of adult bilinguals, by confirming previous findings on EF enhancement in bilinguals and providing additional evidence for differences in two types of bilingualism.

Interestingly, unlike other studies involving English-Gaelic bilinguals (de Bruin et al., 2015; Kirk et. al, 2014), our study found significant differences in EFs between bilinguals and monolinguals. A possible explanation might be that our sample consisted of younger adults who were immersed in both single and dual-language contexts. Consequently, our research adds to the growing body of literature on the effects of interactional contexts on bilinguals' performance in EF tasks. The practice of switching between two languages should be embedded in context in order to better understand the control processes bilinguals undergo. Additionally, we observed that closeness between two languages and L2 acquisition may be factors affecting EF abilities.

Since we directly compared two bilingual populations from different countries, we made some assumptions about their comparability. Of course, we cannot exclusively attribute the differences between Irish and Catalan bilinguals to their language profiles. They lived in disparate societies with different cultural backgrounds. The need to disentangle bilingualism from culture (Paap & Greenberg, 2013) was partially solved by first comparing Irish bilinguals with a relatively matched monolingual group. If anything, our Catalan bilinguals shared similar cultural background with other populations formerly seen in EF studies (Costa et al., 2009; Garbin et al., 2010).

In a literature with so many contrasting findings, these results seem to confirm what de Bot (2017) wisely suggested: "rather than trying to find 'the' BA it is better to see what advantages bilingualism may bring for different populations and tasks" (2017, p.28).

7.2. Limitations

Finally, the present study is subject to important limitations, the major being the small sample size analysed, which constrains generalisability of the results. A great effort was made to test a sample which was comparable on a number of demographic and lifestyle variables. However, we acknowledge that ours was a very heterogeneous participant pool.

With regard to the tasks implemented, the MSIT failed to prompt any particular finding, although congruency had significant effects on response latencies. This may be probably due to the modification to the task that simplified it and reduce its effectiveness. That being so, the absence of significant results supports the idea that bilingual advantages are triggered by high-demand tasks. Furthermore, the global-local task suffered from a limited amount of trials, which is not ideal in terms of instrument reliability[20]. The choice was driven by time constraints, as the procedure involved an extensive test-battery. Nevertheless, the task was remarkably demanding in terms of switching and controlled-attention, so a few test-takers were excluded due to accuracy rates being too low.

Another limitation to be borne in mind is that the estimates of important variables (i.e. language use/switching) were obtained through the language questionnaire. Self-reported assessments are highly subjective, thus caution is needed. Moreover, questions on language switching were specifically designed to elicit percentages concerning dual-language contexts only. Especially when considering multiple social contexts (which can be single *and* dual), respondents may have under- or overstated their switching rate. Another point is that, as in the LSBQ by Anderson et al. (2018), our questionnaire included items on participants' additional languages, but it was not designed to measure multilingualism.

Lastly, one may question why bilinguals speaking typologically distant languages in previous experiments (Basque-Spanish in Antón et al., 2019; English-Gaelic in de Bruin et al., 2015) failed to demonstrate advantages in EF tasks. We

[20] However, there have been noticeable studies using a small amount of trials (Bialystok et al., 2004; Kirk et al., 2014).

propose that bilingual advantages are triggered because of a combination of language distance *and* interactional contexts in high-demand tasks.

Words: 9456.

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Appendix A. *Language switching studies*

Study	Participants	Proficiency	Language Use	Switching	Tasks: Findings	Observations
Prior & Macwhinney (2010) **BILINGUALS *vs* MONOLINGUALS**	44 bilinguals (*M*=19.5) (English + another) & 45 monolinguals (*M*=18.7) From Pennsylvania	Self-rated (1-10) + PPVT for English only	% daily use of English	N/A	Colour-shape Task √ **switch cost** X mixing costs)**	*They did not include Simon and Flanker test results in the paper because not significant results*
Garbin et al. (2010) **BRAIN REGION ACTIVATION IN BILINGUALS**	19 Catalan-Spanish bilinguals (*M*=20) & 21 Spanish monolinguals (*M*= 22) From Valencian country	Self-rated in the questionnaire	Self-reported "used both languages continuously throughout their lives" (p.1273)	Self-reported "regularly having to switch between Spanish and Catalan depending on the interlocutor." (p.1273)	Colour-shape Task √ **Reduced switch costs** for bilinguals √ Same brain activation for bilinguals	
Prior & Gollan (2011) **SWITCHERS *vs* NON-SWITCHERS**	41 Spanish-English switchers (*M*=20) & 43 Mandarin-English non-switchers (*M*=19.4) + control group (*M*=20.2) From San Diego	Self-rated (1-7) + vocabulary and verbal fluency tests	% of daily use "currently" and "when growing up"	Self-rated (1-5) Switching at the moment and when growing up	Colour-shape Task √ **Reduced switch costs** for Spanish-English (switchers) X mixing costs	
Paap & Greenberg (2013) **BILINGUALS *vs* MONOLINGUALS**	122 simultaneous/early-sequential bilinguals (English-another) & 151 monolinguals from San Francisco (US)	Speaking and listening Self-rating (1-6)	Percentages of daily use? (only implied on p. 251)	**N/A**	Simon Task + Flanker Task + Colour-shape Task **X**	*No control of immigration status*
Gathercole et al. (2014) **"FULLY FLUENT" BILINGUALS**	150+ Welsh-English simultaneous-early sequential bilinguals (range: 18-90ys) (+ control group)	Vocabulary and grammar tests "when possible" (p. 4)	Dominance considering on the "origin home language" (p.4)	**N/A**	Simon task Card sorting task **X**	*No control of recency/frequency of language use*

Study	Participants	Proficiency	Language Use	Switching	Tasks: Findings	Observations
Kirk, Fiala, Scott-Brown, & Kempe (2014) **ELDERLY IMMIGRANT VS NON-IMMIGRANT BILINGUALS**	16 Gaelic-English bilinguals 16 immigrant bilinguals (English-another) 16 bidialectals 16 monodialectal (passive knowledge of the dialect) 16 monolinguals From Scotland & England (*M*=**70.8**)	Self-rated + vocabulary subscale from WASI (*English only*)	% daily use of different varieties of English/Scots	**N/A**	Simon task X No effect of immigration and ethnicity effect	*Controlling for SES (participants' occupations 1-4), IQ, immigration status, ethnicity*
Goral, Campanelli, & Spiro (2015) **DOMINANT *vs* BALANCED OLDER BILINGUALS**	106 Spanish-English bilinguals (*M*=63.4) From US	Self-rated (1-7)	Likert scale (1-7) 1 = Spanish only 4 = Equal 7 = English only	**N/A**	Simon task √ small age-related Simon-effect in **dominant** bilinguals (larger for balanced) X TMT	*i. Predictors failing to explain variance: L2 acquisition and education* *ii. Dominance: measured based on proficiency & use*
Verreyt, Woumans, Vandelanotte, Szmalec, & Duyck (2015) **BALANCED *vs* UNBALANCED**	Dutch-French bilinguals (*M* = 21.1) 28 unbalanced (in proficiency/use) 17 balanced non-switchers 20 balanced switchers From Belgium	Self-rated (1-7)	Use in days/week	Scale (0–7) "How often are you in a situation in which you switch between languages?" *(in supplementary material)*	Simon task + Flanker task √ **reduced interference effects** for balanced bilinguals	*No control of SES*
de Bruin, Bak, & Della Sala (2015) **ACTIVE *vs* INACTIVE**	28 Gaelic-English active bilinguals 24 G-E inactive bilinguals 24 English monolinguals (*M* = **70.91**) From Scotland	Self-rated (1-10) + Picture-naming tasks	Self-rated (1–10) for different time frames of their lives	Scale (1–4) - On a daily basis - In a conversation - In a sentence	Simon arrows task + Colour-shape task X	

Study	Participants	Proficiency	Language Use	Switching	Tasks: Findings	Observations
Yow & Li (2015) **BALANCED *vs* UNBALANCED** **SIMULTANEOUS *vs* SEQUENTIAL BILINGUALS**	72 English-Mandarin bilinguals (*M*=20.93) From Singapore	Self-rated (1-10)	% weekly use of each language	Self-rated (1-5)	Stroop task Number-letter task √ reduced Stroop effects & **mixing costs** for **balanced** bilinguals √ smaller Stroop effect for **early bilinguals**	*No control of SES*
Hartanto & Yang (2016) **DUAL *vs* SINGLE-LANGUAGE CONTEXTS**	75 single-language context bilinguals 58 dual-language context bilinguals From Singapore	Self-rated + language tests	% L1 daily use % L2 daily use	Self-rated (1 = never; 5 = always) Switch: - within the same context - in different contexts (for work, place, family, others)	Colour-shape task √ **reduced switch cost** for dual-language context bilinguals X mixing costs	*First study testing the Adaptive Control Hypothesis by Green and Abutalebi (2013).*
Ooi, Goh, Sorace, & Bak (2018) **SWITCHERS IN DUAL-LANG CONTEXTS *vs* NON-SWITCHERS IN SINGLE-LANGUAGE**	In Singapore: 70 switching simultaneous bilinguals in Singapore (*M*=21.8) In Edinburgh: 63 non-switching late bilinguals (*M*=22.1) 48 non-switching simultaneous/early sequential bilinguals (*M*=21.3) 64 English monolinguals (*M*=21.4)	Self-rated (1-4)	Amount of use (daily, weekly, monthly, yearly) Language use during childhood and adulthood in different contexts (family, work, friends, neighbours, etc.)	Self-rated a. switching frequency (quantitative: (1) once a year, once a month, few times a month, few times a week, (5) every day) b. Switching tendency (qualitative: 1= always sticking to one language; 4 = always mixing languages)	Attentional-control tasks: ANT & Auditory Elevator task √ **smaller conflict effect** in ANT for bilinguals in **dual-language** contexts √ non-switching late bilinguals better on Elevator	*No control of SES and immigration*

Table A.1. *Language switching studies with non-verbal tasks (comments in italic).*

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INFORMED CONSENT
"Bilingual populations and and executive functions"

You are invited to participate in a research study investigating the relationship between bilingualism and advantages in cognitive functions. Your participation will help the researchers better understand the processes linked with executive functions and the role played by being bilingual. You were selected as a possible participant in this study because **you are a native speaker of Irish and English.** We ask that you read this form and ask any questions you may have before agreeing to be in the study.

The study is being conducted by **Elisa Gambicchia**, Master student in the official MA programme *Applied Linguistics and Language Acquisition in Multilingual Contexts*, under the supervision of **Prof. Joan C. Mora**, Department of Modern Languages and Literatures and English Studies at the Universitat de Barcelona, Spain.

STUDY PURPOSE:
The purpose of this study is to better understand how bilinguals perform in cognitive tasks compared to monolinguals.

PROCEDURES FOR THE STUDY:
The total amount of time will be 45 minutes approximately. If you agree to be in the study, you will be asked to do the following tasks:

1) Fill out a language background questionnaire (10-15 mins).
2) Inhibition and switching tasks on the computer (20 minutes).
3) Semantic classification tasks in Irish and in English on the computer (5 minutes).
4) One logic task on the computer (5 minutes).

CONFIDENTIALITY
Efforts will be made to keep your personal information confidential. All the data collected in this study will be anonymized and secured in a safe place and your identity will be held in confidence in reports in which the study may be published, and databases in which results may be stored. Only the investigators of this study will have access to your audio recordings (if any), and your recordings and data will be de-identified so that your identity will not be associated with your test scores.

CONTACTS FOR QUESTIONS OR PROBLEMS
For questions about the study, contact the researcher Elisa Gambicchia at egambiga7@alumnes.ub.edu or send a message to this number (+39) 333 4380446.

VOLUNTARY NATURE OF STUDY
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty.

Name and surname: [ ]

Yes, I consent to participate in the study.

Signature [ ]

Date: ____ / ____ / ________

Day Month Year

e-mail: ________________________________

UNIVERSITAT DE BARCELONA
HOJA DE INFORMACIÓN SOBRE EL ESTUDIO
"Bilingual populations and executive functions"

Se le invita a participar en un estudio en el que se investiga la relación entre bilingüismo y ventajas en habilidades cognitivas. Su participación ayudará a los investigadores a comprender mejor los procesos relacionados con el bilingüismo y las funciones cognitivas. Usted fue seleccionado como posible candidato porque **el español y el catalán son sus lenguas maternas**. Le rogamos que lea este documento y que haga las preguntas que crea necesarias antes de dar su consentimiento para formar parte del estudio.

La investigación será llevada a cabo por **Elisa Gambicchia**, estudiante en Máster oficial de *Lingüística Aplicada y Adquisición de Lenguas en Contextos Multilingües* y por **Joan Carles Mora**, profesor del Departament de Lenguas y Literaturas Modernas y de Estudios Ingleses, Universitat de Barcelona, España.

OBJETIVO DEL ESTUDIO

El objetivo de este estudio es comprender mejor la relación entre bilingüismo y funciones cognitivas.

PROCEDIMIENTOS PARA EL ESTUDIO

La duración estimada para completar su participación es de 45 minutos. Si está de acuerdo en participar en el estudio, usted realizará las siguientes tareas en el siguiente orden:

1. Rellenar un cuestionario sobre sus antecedentes lingüísticos (10-15 minutos).
2. Una actividad de inhibición y de switching en un ordenador (20 minutos).
3. Una actividad de discriminación semántica en catalán y en español (5 minutos).
4. Una actividad de lógica (5 minutos).

CONFIDENCIALIDAD

Se hará todo lo posible para mantener la confidencialidad de sus datos personales. Se mantendrá su anonimidad en los informes relacionados con las publicaciones que se deriven de este estudio y en las bases de datos en las que se almacenarán sus datos. Únicamente el investigador principal y sus co-investigadores tendrán acceso a sus respuestas electrónicas.

CONTACTO

Para preguntas relacionadas con este estudio, escriba a la investigadora Elisa Gambicchia (egambiga7@alumnes.ub.edu) o envie un mensaje al (+39) 333 4380446.

NATURALEZA VOLUNTARIA DEL ESTUDIO

La participación en este estudio es voluntaria. Usted puede decidir no tomar parte o abandonarlo en cualquier momento. El hecho de rechazar seguir participando en este estudio no resultara en pena alguna.

Nombre y apellidos:

Sí, doy mi consentimiento para participar en este estudio.

Firma

e-mail: ____ Data: ____ / ____ / ________
Día Mes Año

Appendix C. *Language Background questionnaire*

Both the English and the Spanish versions of the questionnaire were piloted with one native bilingual of each language pair. With regard to the English version, some modifications were made in the section about education level assessment to fully match the Northern Irish school system. Similarly, for the Spanish version, after some considerations, questions about the language use with community groups were deleted since it is an active reality in the North of Ireland, but not in Catalonia.

Here we present the English version of the questionnaire, which was administered to the Irish bilinguals.

Language Background Questionnaire		
BIODATA	First Name	
	Surname	
	Age	
	Sex	☐ Female ☐ Male ☐ Prefer not to say
	Current place of residence: **City**, County	
	Current place of residence: **Country**	
	How many years have you spent in this country?	Since birth, 1,2, […], 20+
	Highest level of **formal education**	☐ Secondary school (GCSE level) ☐ Secondary school (A level) ☐ Some university ☐ University (BA, BS) ☐ Masters ☐ PhD/MD/JD
	Where would you place yourself on your country's **socioeconomic scale**?	10-point Likert scale: 1 (Low) to 10 (High)
I. LANGUAGE HISTORY	At what age did you **start learning** a) ENGLISH? b) GAEILGE?	Since birth, 1,2, […], 20+
	Do you speak **any other language(s)?** If yes, specify the language(s)	
	How **well** do you speak your 3rd language?	10-point Likert scale: 1 (Not well at all) to 10 (Very well)
	How **often** do you speak your 3rd language?	Frequency scale: ☐ Always ☐ Often Sometimes ☐ Hardly ever

		☐ Never
	How many **years of classes** (grammar, history, maths, etc.) have you had in a) ENGLISH? b) GAEILGE? (primary school through university)	Range: 0 to 20+
	How many years have you spent in a **family** where a) ENGLISH b) GAEILGE is spoken?	Range: 0 to 20+
	How many years have you spent in a **work environment** where a) ENGLISH b) GAEILGE is spoken?	Range: 0 to 20+
II. LANGUAGE USE	How many **daily hours** do you speak on average a) ENGLISH? b) GAEILGE?	Range: Less than one hour, 1 hour, 2 hours, […], 8+ hours
	How much do you speak Gaeilge-English **IN GENERAL**?	Range from 100% Gaeilge - 0% English to 0% Gaeilge - 100% English
	How much do you speak Gaeilge-English **a) AT HOME?** **b) AT WORK/SCHOOL?** **c) IN SOCIAL SETTINGS?** **d) IN COMMERCIAL /GOVERNMENT SERVICES?** **e) WITH YOUR RELATIVES?** **f) WITH YOUR FRIENDS?** **g) WITH YOUR NEIGHBOURS?** h) **WITH YOUR COMMUNITY GROUPS?**	Range from 100% Gaeilge - 0% English to 0% Gaeilge - 100% English
	How often do you **switch** between the two languages a) AT HOME? b) AT WORK/SCHOOL? c) IN SOCIAL SETTINGS?	Frequency scale: Always Often Sometimes Hardly ever Never

<table>
<tr><td></td><td>d) IN COMMERCIAL /GOVERNMENT SERVICES?
e) WITH YOUR RELATIVES?
f) WITH YOUR FRIENDS?
g) WITH YOUR NEIGHBOURS?
h) WITH YOUR COMMUNITY GROUPS?</td><td></td></tr>
<tr><td></td><td>Do you switch between the languages…?</td><td>☐ Always CONSCIOUSLY
☐ Usually consciously
☐ Usually unconsciously
☐ Always UNCONSCIOUSLY</td></tr>
<tr><td></td><td>How often do words in English come to mind when speaking GAEILGE?</td><td>Frequency scale</td></tr>
<tr><td></td><td>How often do words in Gaeilge come to mind when speaking ENGLISH?</td><td>Frequency scale</td></tr>
<tr><td>III. LANGUAGE PROFICIENCY</td><td>How well do you speak
a) ENGLISH?
b) GAEILGE?</td><td>10-point Likert scale: 1 (Not well at all) to 10 (Very well)</td></tr>
<tr><td></td><td>How well do you understand
a) ENGLISH?
b) GAEILGE?</td><td>10-point Likert scale: 1 (Not well at all) to 10 (Very well)</td></tr>
<tr><td></td><td>How well do you read
a) ENGLISH?
b) GAEILGE?</td><td>10-point Likert scale: 1 (Not well at all) to 10 (Very well)</td></tr>
<tr><td></td><td>How well do you write
a) ENGLISH?
b) GAEILGE?</td><td>10-point Likert scale: 1 (Not well at all) to 10 (Very well)</td></tr>
<tr><td>IV. BRAIN TRAINING</td><td>In an average week, do you usually do any of these activities?
a) Play videogames
b) Do crosswords/ puzzles/ sudoku
c) Play with phone apps
d) Play an instrument
e) Play chess/similar board games</td><td>☐ Every day
☐ 5-6 days a week
☐ 3-4 days a week
☐ 1-2 days a week
☐ Not during the average week</td></tr>
</table>

Appendix D. *Lexical access tasks: items*

Forty-eight common words were selected for each language: 24 animate and 24 inanimate items. It was assured that the words were the same for each language pair, but not across all the four languages. Particular attention was paid to avoid abstract concepts, homographs (e.g. “bean” is “woman” in Irish) and cognates (at least for the experimental items).

For the Catalan-Castilian Spanish tests, some words were selected from Costa, Santesteban and Ivanova (2006). Additional words were selected by the researcher and checked by two native Catalan-Spanish bilinguals.

For the Irish and English test, the words were selected from frequent lists from different websites and double-checked by two native bilinguals. Additionally, when selecting the Irish vocabulary, very common words that could have potentially created doubts in terms of animacy were discarded (e.g. natural elements, fruits or vegetables) since in some cultures, included the Irish one, these entities may be considered more “alive” than not. It is worth noting that, due to the nature of the Irish spelling, words in Irish were generally longer than their English equivalents.

Since they were all separate tests, instructions were given in the language of the specific test (e.g. Catalan instructions for the Catalan language test). The test consisted of 4 practice items and 20 test items for each Language, as shown in Table D.1. and Table D.2.

Items	*IRISH*	*ENGLISH*	**Type**
Practice	Dochtúir	Doctor	animate
Practice	Madra	Dog	animate
Practice	Máthair	Mother	animate
False start	Athair	Father	animate
TEST	Páiste	Child	animate
TEST	Duine	Person	animate
TEST	Buachaill	Boy	animate
TEST	Cara	Friend	animate
TEST	Iasc	Fish	animate
TEST	Capall	Horse	animate
TEST	Cailín	Girl	animate
TEST	Éan	Bird	animate
TEST	Rí	King	animate
TEST	Deartháir	Brother	animate
TEST	Leanbh	Baby	animate
TEST	Saighdiúir	Soldier	animate
TEST	Dalta	Student	animate

TEST	Deirfiúr	Sister	animate
TEST	Garda	Policeman	animate
TEST	Múinteoir	Teacher	animate
TEST	Sioráf	Giraffe	animate
TEST	Muc	Pig	animate
TEST	Coinín	Rabbit	animate
TEST	Caora	Sheep	animate
Practice	Clog	Clock	inanimate
Practice	Doras	Door	inanimate
Practice	Pictiúr	Picture	inanimate
False start	Bosca	Box	inanimate
TEST	Bóthar	Road	inanimate
TEST	Bord	Table	inanimate
TEST	Leithreas	Toilet	inanimate
TEST	Leabhar	Book	inanimate
TEST	Leathanach	Page	inanimate
TEST	Cloch	Stone	inanimate
TEST	Eitleán	Plane	inanimate
TEST	Airgead	Money	inanimate
TEST	Léarscáil	Map	inanimate
TEST	Leaba	Bed	inanimate
TEST	Liathróid	Ball	inanimate
TEST	Cathaoir	Chair	inanimate
TEST	Fáinne	Ring	inanimate
TEST	Arán	Bread	inanimate
TEST	Bróg	Shoe	inanimate
TEST	Fuinneog	Window	inanimate
TEST	Buidéal	Bottle	inanimate
TEST	Nuachtán	Newspaper	inanimate
TEST	Cáis	Cheese	inanimate
TEST	Rothar	Bycicle	inanimate

Table D.1. *Irish-English items*

Items	*CATALAN*	*SPANISH*	**Type**
Practice	Dofí	Delfín	animate
Practice	Conill	Conejo	animate
Practice	Gavina	Gaviota	animate
False start	Cosí	Primo	animate
TEST**	Gos	Perro	animate
TEST	Guineu	Zorro	animate
TEST	Papallona	Mariposa	animate
TEST	Porc	Cerdo	animate
TEST	Brau	Toro	animate
TEST	Metge	Médico	animate
TEST	Ànec	Pato	animate
TEST	Mico	Mono	animate
TEST	Ocell	Pájaro	animate

TEST	Granota	Rana	animate
TEST	Avi	Abuelo	animate
TEST	Noi	Chico	animate
TEST	Fill	Hijo	animate
TEST	Ruc	Burro	animate
TEST	Germà	Hermano	animate
TEST	Cuiner	Cocinero	animate
TEST	Pagès	Agricultor	animate
TEST	Cambrer	Camarero	animate
TEST	Forner	Padanero	animate
TEST	Fuster	Carpintero	animate
Practice	Teclat	Teclado	inanimate
Practice	Cotxe	Coche	inanimate
Practice	Rellotge	Reloj	inanimate
False start	Roda	Rueda	inanimate
TEST	Paella	Sartén	inanimate
TEST**	Finestra	Ventana	inanimate
TEST	Cadira	Silla	inanimate
TEST**	Formatge	Queso	inanimate
TEST	Clau	Llave	inanimate
TEST**	Ganivet	Cuchillo	inanimate
TEST	Cullera	Cuchara	inanimate
TEST**	Pastanaga	Zanahoria	inanimate
TEST**	Fulla	Hoja	inanimate
TEST	Got	Vaso	inanimate
TEST	Llit	Cama	inanimate
TEST	Ulleres	Gafas	inanimate
TEST	Mirall	Espejo	inanimate
TEST	Estora	Alfombra	inanimate
TEST	Suc	Zumo	inanimate
TEST**	Barret	Sombrero	inanimate
TEST**	Pluja	Lluvia	inanimate
TEST**	Poma	Manzana	inanimate
TEST	Sostre	Techo	inanimate
TEST**	Taula	Mesa	inanimate

*** These words were taken from Costa et al. (2006)*

Table D.2. *Catalan-Spanish items*

Appendix E. *Procedure*

Table E.1. shows the procedure followed in order to counterbalance the tasks across participants and avoid order effects.

INHIBITION		SWITCHING		LANGUAGE		RAVEN
Flanker	MSIT	TMT	GLOB-LOC	GAEL	ENG	
MSIT	Flanker	TMT	GLOB-LOC	ENG	GAEL	
Flanker	MSIT	GLOB-LOC	TMT	GAEL	ENG	
MSIT	Flanker	GLOB-LOC	TMT	ENG	GAEL	
Flanker	MSIT	TMT	GLOB-LOC	ENG	GAEL	
MSIT	Flanker	TMT	GLOB-LOC	GAEL	ENG	
Flanker	MSIT	GLOB-LOC	TMT	ENG	GAEL	
MSIT	Flanker	GLOB-LOC	TMT	GAEL	ENG	

Table E.1.. *Randomisation of the tasks administered.*

Appendix F.1. *Lexical Access Task: tests*

Descriptives					
	Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
LA_L1	Irish monolinguals	13	677,0815	103,83503	28,79866
	Irish bilinguals	35	690,1120	113,54690	19,19293

Table F.1.1. *Descriptives for mean RTs in the lexical access task (English).*

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
LA_L1	**,002**	**,965**	-,361	46	,720	-13,03046	36,08365	-85,66307	59,60215
			-,377	23,398	,710	-13,03046	34,60825	-84,55576	58,49484

Table F.1.2. *Independent t-tests for mean RTs in the lexical access task (English).*

Group Statistics					
	group	N	Mean	Std. Deviation	Std. Error Mean
LA balanced proficiency	Catalan bilinguals	32	70,0487	52,03618	9,19878
	Irish bilinguals	35	74,5933	45,97703	7,77154

Table F.1.3. *Descriptives for balanced proficiency in the lexical access task (Irish vs Catalan bilinguals).*

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
LA balanced proficiency	**1,856**	**,178**	-,38	65	,706	-4,54	11,97	-28,46	19,37
			-,38	62,16	,707	-4,54	12,04	-28,61	19,52

Table F.1.4. *Independent t-tests for balanced proficiency in the lexical access task (Irish vs Catalan bilinguals).*

Correlations				
			LA balanced proficiency	Reported balanced proficiency
Spearman's rho	LA balanced proficiency	Correlation Coefficient	1,000	,256*
		Sig. (2-tailed)	.	,036
		N	67	67
	Reported balanced proficiency	Correlation Coefficient	**,256***	1,000
		Sig. (2-tailed)	,036	.
		N	67	69

*. Correlation is significant at the 0.05 level (2-tailed).

Table F.1.5. *Correlations reported balanced proficiency and balanced proficiency in lexical access task.*

Appendix F.2. *Flanker test*

Type III Tests of Fixed Effects[a]				
Source	Numerator df	Denominator df	F	Sig.
Intercept	1	79,751	2320,455	,000
Group	2	79,696	,255	,776
Congruency	1	111,348	374,739	**,000**
Group *Congruency	2	5005,041	6,284	**,002**
a. Dependent Variable: RTs.				

Table F.2.1. *Linear Mixed Model for RTs in the Flanker test (considering Congruency and Group).*

Estimates of Fixed Effects[a]							
						95% Confidence Interval	
Parameter	Estimate	Std. Error	df	t	Sig.	Lower Bound	Upper Bound
Intercept	437,000029	12,318200	84,905	35,476	,000	412,507749	461,492309
[Congruency=1]	-39,959619	3,004780	381,057	-13,299	**,000**	-45,867645	-34,051593
[Group=1]	-1,319736	17,541473	84,807	-,075	,940	-36,198027	33,558555
[Group=2]	23,124452	23,657469	84,759	,977	,331	-23,914862	70,163766
[Group=1] * [Congruency=1]	6,567663	4,254187	5011,372	1,544	,123	-1,772405	14,907732
[Group=2] * [Congruency=1]	-13,736263	5,711202	4998,731	-2,405	**,016**	-24,932725	-2,539802
a**. Dependent Variable: RTs.**							
b. This parameter is set to zero because it is redundant.							

Table F.2.2. *Estimates of Fixed Effects for RTs in the Flanker test.*

Estimates[a]					
				95% Confidence Interval	
Group	Mean	Std. Error	df	Lower Bound	Upper Bound
Catalan bilinguals	**418,984**	12,303	79,748	394,500	443,469
Irish monolinguals	**433,277**	19,893	79,694	393,687	472,866
Irish bilinguals	**417,020**	12,125	79,734	392,889	441,151
a. Dependent Variable: RTs.					

Table F.2.3. *Descriptives for each Group in the Flanker task.*

The *Group*Congruency* interaction was further analysed by running Bonferroni-adjusted pairwise comparisons.

Pairwise Comparisons[a]								
Group	(I) Congruency	(J) Congruency	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
							Lower Bound	Upper Bound
Catalan bilinguals	congruent	incongruent	-33,392*	3,057	412,926	**,000**	-39,401	-27,383
Irish monolinguals	congruent	incongruent	-53,696*	4,885	1951,378	**,000**	-63,277	-44,115
Irish bilinguals	congruent	incongruent	-39,960*	3,005	381,057	**,000**	-45,868	-34,052
Based on estimated marginal means								
*. The mean difference is significant at the ,05 level.								
a. **Dependent Variable: RTs.**								
c. Adjustment for multiple comparisons: Bonferroni.								

Table F.2.4. *Bonferroni pairwise comparisons for RTs considering Congruency for each Group.*

Pairwise Comparisons[a]								
Congruency	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	df	Sig.[b]	95% Confidence Interval for Difference[b]	
							Lower Bound	Upper Bound
Congruent	Irish monolinguals	Catalan bilinguals	4,140	23,374	79,503	1,000	-53,026	61,306
		Irish bilinguals	9,388	23,280	79,478	1,000	-47,548	66,324
Incongruent	**Irish monolinguals**	**Catalan bilinguals**	**24,444**	23,751	84,752	,919	-33,566	82,454
		Irish bilinguals	**23,124**	23,657	84,759	,993	-34,657	80,906
Based on estimated marginal means								
a. **Dependent Variable: RTs.**								
b. Adjustment for multiple comparisons: Bonferroni.								

Table F.2.5. *Bonferroni pairwise comparisons for RTs considering Group for each condition (congruent vs incongruent).*

Appendix F.3. *Multi-Source Interference Task*

Type III Tests of Fixed Effects[a]					
Group	Source	Numerator df	Denominator df	F	Sig.
Catalan bilinguals	Intercept	1	34,384	1131,312	,000
	Response_Type	2	81,400	2,778	,068
	Congruency	1	78,649	46,529	**,000**
	Response_Type * Congruency	2	81,343	,024	,977
Irish monolinguals	Intercept	1	12,097	426,516	,000
	Response_Type	2	80,321	,391	,678
	Congruency	1	80,243	13,429	**,000**
	Response_Type * Congruency	2	80,317	3,002	,055
Irish bilinguals	Intercept	1	34,261	803,433	,000
	Response_Type	2	78,019	9,082	**,000**
	Congruency	1	78,109	96,436	**,000**
	Response_Type * Congruency	2	78,015	1,122	,331
a. Dependent Variable: RTs.					

Table F.3.1. *Linear Mixed Model for RTs in the MSIT (considering Congruency and Response Type) for each Group.*

Estimates of Fixed Effects[a]								
							95% Confidence Interval	
Group	Parameter	Estimate	Std. Error	df	t	Sig.	Lower Bound	Upper Bound
Catalan bilinguals	Intercept	607,070730	18,712852	46,374	32,441	,000	569,411909	644,729550
	[Response_Type=1]	-12,235381	10,715616	85,806	-1,142	,257	-33,538006	9,067245
	[Response_Type=2]	-10,500158	11,064571	86,918	-,949	,345	-32,492484	11,492168
	[Congruency=1]	-33,405273	8,690396	84,711	-3,844	**,000**	-50,684960	-16,125586
	[Response_Type=1] * [Congruency=1]	-2,250743	12,301947	81,819	-,183	,855	-26,724044	22,222558

	[Response_Type=2] * [Congruency=1]	-2,421457	12,623164	84,108	-,192	,848	-27,523532	22,680618
Irish monolinguals	Intercept	581,843922	29,767049	14,795	19,547	,000	518,320243	645,367600
	[Response_Type=1]	21,964387	13,976596	87,975	1,572	,120	-5,811268	49,740043
	[Response_Type=2]	21,580763	14,123535	79,302	1,528	,130	-6,529767	49,691293
	[Congruency=1]	-2,016373	11,273763	82,208	-,179	**,858**	-24,442630	20,409884
	[Response_Type=1] * [Congruency=1]	-37,459833	16,032214	84,181	-2,337	,022	-69,340644	-5,579021
	[Response_Type=2] * [Congruency=1]	-28,895078	16,142443	77,569	-1,790	,077	-61,035024	3,244867
Irish bilinguals	Intercept	602,873635	20,829111	41,149	28,944	,000	560,813014	644,934256
	[Response_Type=1]	-21,857728	9,460524	81,103	-2,310	,023	-40,680842	-3,034614
	[Response_Type=2]	-30,293262	9,765554	78,763	-3,102	,003	-49,732019	-10,854505
	[Congruency=1]	-53,968689	7,663700	76,829	-7,042	**,000**	-69,229607	-38,707771
	[Response_Type=1] * [Congruency=1]	14,667245	10,902090	78,569	1,345	,182	-7,034675	36,369166
	[Response_Type=2] * [Congruency=1]	13,692446	11,165816	76,922	1,226	,224	-8,541891	35,926784
a. Dependent Variable: RTs.								

Table F.3.2. *Estimates of Fixed Effects for RTs in the MSIT.*

Pairwise Comparisons[a]								
							95% Confidence Interval for Difference[c]	
Group	(I) Congruency	(J) Congruency	Mean Difference (I-J)	Std. Error	df	Sig.[c]	Lower Bound	Upper Bound
Catalan bilinguals	congruent	incongruent	-34,963*	5,126	78,649	**,000**	-45,166	-24,760
Irish monolinguals	congruent	incongruent	-24,135*	6,586	80,243	**,000**	-37,241	-11,029
Irish bilinguals	congruent	incongruent	-44,515*	4,533	78,109	**,000**	-53,540	-35,491
Based on estimated marginal means								
*. The mean difference is significant at the ,05 level.								
a. Dependent Variable: RT_accurateSD.								
c. Adjustment for multiple comparisons: Bonferroni.								

Table F.3.3. *Pairwise comparisons for congruent and incongruent trials (RTs) in the MSIT for each Group.*

Appendix F.4. *Trail-Making Test*

Paired Samples Statistics					
Group		Mean	N	Std. Deviation	Std. Error Mean
Catalan bilinguals	Trail A	53886,8485	33	14689,71694	2557,15149
	Trail B	64327,7576	33	20517,58629	3571,65333
Irish monolinguals	Trail A	54855,9231	13	13610,97209	3775,00444
	Trail B	65065,2308	13	23459,02495	6506,36287
Irish bilinguals	Trail A	54118,8857	35	17043,14889	2880,81796
	Trail B	60646,1143	35	23952,27474	4048,67338

Table F.4.1. *Descriptives for RTs of Trail A and Trail B in the Trail-Making Test for each Group.*

Paired Samples Correlations				
Group		N	Correlation	Sig.
Catalan bilinguals	Trail A & Trail B	33	**,462**	,007
Irish monolinguals	Trail A & Trail B	13	,274	,365
Irish bilinguals	Trail A & Trail B	35	**,593**	,000

Table F.4.2. *Correlations of Trail A and Trail B for each Group.*

Paired Samples Test									
		Paired Differences							
					95% C.I.				
Group		Mean	SD	S.E. Mean	Lower	Upper	t	df	Sig. (2-tailed)
Catalan bilinguals	Trail A - Trail B	-10440,91	18929,13	3295,14	-17152,	-3728,	-3,169	32	**,003**
Irish monolinguals	Trail A - Trail B	-10209,31	23675,13	6566,30	-24516,	4097,	-1,555	12	,146
Irish bilinguals	Trail A - Trail B	-6527,23	19503,69	3296,73	-13226,	172,	-1,980	34	**,056**

Table F.4.3. *Paired samples t-tests for RTs (Trail A – Trail B) for each Group.*

Appendix F.5. *Global-Local Task*

Type III Tests of Fixed Effects[a]					
Group	Source	Numerator df	Denominator df	F	Sig.
Catalan bilinguals	Intercept	1	55,092	387,756	,000
	BLOCK	2	1792,483	267,199	**,000**
	CONGRUENCY	2	1779,562	5,057	**,006**
	SHIFT	1	1768,330	7,332	**,007**
	BLOCK * CONGRUENCY	3	1776,839	3,326	,019
	CONGRUENCY * SHIFT	1	1778,335	,361	,548
Irish monolinguals	Intercept	1	14,072	161,940	,000
	BLOCK	2	666,887	145,657	**,000**
	CONGRUENCY	2	654,246	5,035	**,007**
	SHIFT	1	649,195	17,284	**,000**
	BLOCK * CONGRUENCY	3	649,632	,747	,525
	CONGRUENCY * SHIFT	1	636,942	,249	,618
Irish bilinguals	Intercept	1	54,498	439,534	,000
	BLOCK	2	1819,296	299,274	**,000**
	CONGRUENCY	2	1805,701	5,940	**,003**
	SHIFT	1	1795,229	19,821	**,000**
	BLOCK * CONGRUENCY	3	1804,283	1,890	,129
	CONGRUENCY * SHIFT	1	1797,263	1,331	,249
a. Dependent Variable: RTs.					

Table F.5.1. *Linear Mixed Model for RTs in the Global-Local task (considering Block, Congruency and Shift) for each Group.*

Estimates of Fixed Effects[a]								
							95% Confidence Interval	
group	Parameter	Estimate	Std. Error	df	t	Sig.	Lower Bound	Upper Bound
Catalan bilinguals	Intercept	1121,288461	44,726820	98,105	25,070	,000	1032,530731	1210,046192
	[BLOCK=1]	-513,006180	34,422135	1791,245	-14,903	**,000**	-580,517943	-445,494416

	[BLOCK=2]	-537,137349	33,995907	1784,863	-15,800	**,000**	-603,813317	-470,461380
	[CONGRUENCY=0]	13,891897	36,201451	1772,112	,384	,701	-57,110138	84,893932
	[CONGRUENCY=1]	-102,166136	30,775570	1776,750	-3,320	**,001**	-162,526264	-41,806008
	[SHIFT=0]	-45,999684	33,556327	1771,831	-1,371	,171	-111,813835	19,814467
	[BLOCK=1] * [CONGRUENCY=0]	-37,419899	51,528191	1781,738	-,726	,468	-138,481950	63,642151
	[BLOCK=1] * [CONGRUENCY=1]	109,351809	45,159342	1774,307	2,421	,016	20,780705	197,922912
	[BLOCK=2] * [CONGRUENCY=1]	129,325835	44,950521	1774,390	2,877	,004	41,164297	217,487374
	[CONGRUENCY=1] * [SHIFT=0]	-26,640733	44,314274	1778,335	-,601	,548	-113,554269	60,272803
Irish monolinguals	Intercept	1327,720226	73,817119	22,524	17,987	,000	1174,839167	1480,601285
	[BLOCK=1]	-610,861439	59,477556	658,378	-10,270	**,000**	-727,650004	-494,072874
	[BLOCK=2]	-626,722078	57,370758	646,899	-10,924	**,000**	-739,377472	-514,066685
	[CONGRUENCY=0]	7,980858	58,432460	641,164	,137	,891	-106,761258	122,722973
	[CONGRUENCY=1]	-109,197082	49,251397	640,592	-2,217	**,027**	-205,910776	-12,483387
	[SHIFT=0]	-135,221834	56,065816	644,255	-2,412	**,016**	-245,315641	-25,128027
	[BLOCK=1] * [CONGRUENCY=0]	-70,784187	84,412579	643,906	-,839	,402	-236,541369	94,972995
	[BLOCK=1] * [CONGRUENCY=1]	59,121586	77,140516	661,238	,766	,444	-92,348296	210,591469
	[BLOCK=2] * [CONGRUENCY=1]	101,099562	75,605311	647,608	1,337	,182	-47,361585	249,560710
	[CONGRUENCY=1] * [SHIFT=0]	-36,489007	73,154152	636,942	-,499	,618	-180,141480	107,163467
Irish bilinguals	Intercept	1170,881021	43,911032	98,569	26,665	,000	1083,747294	1258,014749

	[BLOCK=1]	-535,798097	32,487655	1804,615	-16,492	**,000**	-599,515466	-472,080729
	[BLOCK=2]	-515,132178	33,304625	1814,941	-15,467	**,000**	-580,451605	-449,812752
	[CONGRUENCY=0]	-7,633402	35,179476	1800,405	-,217	,828	-76,630293	61,363489
	[CONGRUENCY=1]	-73,454087	30,808039	1793,194	-2,384	**,017**	-133,877518	-13,030656
	[SHIFT=0]	-71,296955	32,721669	1795,128	-2,179	**,029**	-135,473519	-7,120392
	[BLOCK=1] * [CONGRUENCY=0]	2,235397	49,888695	1806,206	,045	,964	-95,610215	100,081009
	[BLOCK=1] * [CONGRUENCY=1]	98,368826	43,977109	1805,778	2,237	,025	12,117466	184,620187
	[BLOCK=2] * [CONGRUENCY=1]	77,798062	43,659048	1803,562	1,782	,075	-7,829563	163,425687
	[CONGRUENCY=1] * [SHIFT=0]	-50,157581	43,479424	1797,263	-1,154	,249	-135,433114	35,117952

a. Dependent Variable: RTs.

Table F.5.2. *Estimates of Fixed Effects for RTs in the Global-Local Task.*

Pairwise Comparisons[a]

group	(I) **BLOCK**	(J) BLOCK	Mean Difference (I-J)	Std. Error	df	Sig.[e]	95% Confidence Interval for Difference[e] Lower Bound	Upper Bound
Catalan bilinguals	Mixed	Global	492,590[b,c,*]	19,069	1787,720	**,000**	446,896	538,285
		Local	497,590[b,c,*]	18,505	1807,051	**,000**	453,249	541,932
Irish monolinguals	Mixed	Global	664,541[b,c,*]	31,785	588,736	**,000**	588,230	740,852
		Local	642,814[b,c,*]	29,938	667,098	**,000**	570,963	714,665
Irish bilinguals	Mixed	Global	532,394[b,c,*]	18,578	1828,711	**,000**	487,878	576,909
		Local	519,330[b,c,*]	18,085	1833,406	**,000**	475,995	562,664

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

a. Dependent Variable: RTs.

e. Adjustment for multiple comparisons: Bonferroni.

Table F.5.3. *Pairwise comparisons for Block (RTs) in the Global-Local task for each Group.*

Pairwise Comparisons[a]								
group	(I) CONGRUENCY	(J) CONGRUENCY	Mean Difference (I-J)	Std. Error	df	Sig.[e]	95% Confidence Interval for Difference[e]	
							Lower Bound	Upper Bound
Catalan bilinguals	Incongruent	Neutral	278,854[*,c,d]	23,201	1792,502	**,000**	223,258	334,450
		Congruent	62,477[*,c,d]	15,863	1776,277	**,000**	24,465	100,490
Irish monolinguals	Incongruent	Neutral	370,613[*,c,d]	38,002	655,912	**,000**	279,404	461,822
		Congruent	96,509[*,c,d]	26,598	662,466	**,001**	32,671	160,346
Irish bilinguals	Incongruent	Neutral	287,073[*,c,d]	22,234	1810,666	**,000**	233,796	340,349
		Congruent	67,031[*,c,d]	15,642	1813,785	**,000**	29,549	104,512

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

a. Dependent Variable: RTs.

c. An estimate of the modified population marginal mean (I).

d. An estimate of the modified population marginal mean (J).

e. Adjustment for multiple comparisons: Bonferroni.

Table F.5.4. *Pairwise comparisons for Congruency (RTs) in the Global-Local task for each Group.*

Pairwise Comparisons[a]								
group	(I) SHIFT	(J) SHIFT	Mean Difference (I-J)	Std. Error	df	Sig.[e]	95% Confidence Interval for Difference[e]	
							Lower Bound	Upper Bound
Catalan bilinguals	switch	repeat	408,393[*,c,d]	18,043	1808,092	**,000**	373,005	443,780
Irish monolinguals	switch	repeat	586,175[*,c,d]	29,295	664,940	**,000**	528,653	643,696
Irish bilinguals	switch	repeat	454,631[*,c,d]	18,004	1829,542	**,000**	419,321	489,942

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

a. Dependent Variable: RTs.

c. An estimate of the modified population marginal mean (I).

d. An estimate of the modified population marginal mean (J).

e. Adjustment for multiple comparisons: Bonferroni.

Table F.5.5. *Pairwise comparisons for Shift (RTs) in the Global-Local task for each Group.*

Appendix G - Analysis of the groups

In case of normality of distribution, parametric tests were run; otherwise, we used non-parametric tests (Kruskal-Willis).

Appendix G.1. *Normality of the experimental tasks*

Tests of Normality							
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
Flanker	Catalan bilinguals	,130	18	,200*	,967	18	,744
	Irish monolinguals	,160	13	,200*	,963	13	,797
	Irish bilinguals	,113	26	,200*	,959	26	,369
MSIT	Catalan bilinguals	,157	18	,200*	,911	18	,089
	Irish monolinguals	,195	13	,191	,883	13	,078
	Irish bilinguals	,119	26	,200*	,952	26	,261
B – A	Catalan bilinguals	,150	16	,200*	,945	16	,409
	Irish monolinguals	,215	13	,101	,876	13	,062
	Irish bilinguals	,146	24	,200*	,924	24	,073
Switch costs	Catalan bilinguals	,199	13	,168	,885	13	,084
	Irish monolinguals	,156	10	,200*	,958	10	,761
	Irish bilinguals	,187	16	,137	,948	16	,457
Mixing costs	Catalan bilinguals	,166	13	,200*	,957	13	,706
	Irish monolinguals	,124	10	,200*	,968	10	,872
	Irish bilinguals	,214	16	,047	,919	16	,165
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

Table G.1.1. *Tests of normality of distribution for RTs in the experimental tasks within each group.*

Appendix G.2. *Comparability between Irish monolinguals and bilinguals*

Descriptive Statistics			
		Group	
		Irish monolinguals N = 13	Irish bilinguals N = 26
Age	Mean	42,77	37,15
	SD	19,018	10,961
Education	Mean	3,38	4,38
	SD	1,193	,852
IQ	Mean	7,62	8,27
	SD	2,873	2,070
SES	Mean	5,92	5,65
	SD	1,256	1,231

Table G.2.1. *Descriptive statistics (M, SD) for background variables (Irish bilinguals and monolinguals).*

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Age is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,720	Retain the null hypothesis.
2	The distribution of Education is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,010	Reject the null hypothesis.
3	The distribution of IQ is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,508	Retain the null hypothesis.
4	The distribution of SES is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,550	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Table G.2.2. *Krushal-Willis Tests between Irish bilinguals and monolinguals for background variables.*

Appendix G.3. *Comparability between Irish and Catalan and bilinguals*

As we can see, the two groups were comparable, except for age of L2 acquisition and therefore also for balanced exposure to the languages (Table G.3.3).

Tests of Normality							
	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Balanced Exposure	Catalan bilinguals	,175	18	,153	,909	18	,082
	Irish bilinguals	,136	26	,200*	,951	26	,240
Language Use	Catalan bilinguals	,156	18	,200*	,944	18	,340
	Irish bilinguals	,139	26	,200*	,948	26	,213
Language Switching	Catalan bilinguals	,173	18	,164	,944	18	,342
	Irish bilinguals	,144	26	,175	,972	26	,685
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

Table G.3.1. *Tests of normality of distribution for exposure, use and switching (Irish and Catalan bilinguals).*

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% C.I. of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	SE Difference	Lower	Upper
Balanced Exposure	1,026	,317	-2,401	42	,021	-7,658	3,190	-14,096	-1,220
			-2,502	41,071	,016	-7,658	3,061	-13,839	-1,478
Language Use	,035	,853	1,958	42	,057	,06459	,03298	-,00197	,13115
			1,930	34,756	,062	,06459	,03347	-,00338	,13256
Language Switching	1,046	,312	1,679	42	,101	2,33333	1,38990	-,47160	5,13827
			1,608	30,909	,118	2,33333	1,45149	-,62736	5,29403

Table G.3.2. *Independent t-tests for exposure, use and switching (Irish and Catalan bilinguals).*

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Age is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,193	Retain the null hypothesis.
2	The distribution of Education is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,370	Retain the null hypothesis.
3	The distribution of IQ is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,803	Retain the null hypothesis.
4	The distribution of SES is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,167	Retain the null hypothesis.
5	The distribution of AO_L1 is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,229	Retain the null hypothesis.
6	The distribution of AO_L2 is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,000	Reject the null hypothesis.
7	The distribution of LA_Balanced_proficiency is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,535	Retain the null hypothesis.
8	The distribution of Summed_lang_switching is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,065	Retain the null hypothesis.
9	The distribution of Balanced_proficiency_reported is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,547	Retain the null hypothesis.
10	The distribution of Proficiency_Mean is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,681	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Table G.3.3. *Krushal-Willis Tests between Irish and Catalan bilinguals for background variables.*

Descriptive Statistics				
	Group			
	Catalan bilinguals (N = 17)		Irish bilinguals (N = 13)	
	Mean	SD	Mean	SD
Age	40,82	12,611	33,85	9,982
Education	4,12	,857	4,00	,707
IQ	8,56	1,861	8,31	1,653
SES	**6,18**	,951	**5,38**	1,261
AO_L1	,18	,728	,00	,000
AO_L2	,76	1,437	2,00	1,826
Balanced Proficiency (LA)	62,9322	45,07806	64,3413	38,26276
Reported Balanced Proficiency	1,59	1,734	2,62	2,468
Proficiency Mean	37,62	1,973	37,38	2,459
Language use	,5353	,11390	,4396	,08939
Language switching	24,5882	5,19686	22,9231	4,29072

Table G.3.4. *Descriptive statistics (M, SD) for background variables (Irish and Catalan simultaneous/early sequential bilinguals).*

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Language_switching is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,102	Retain the null hypothesis.
2	The distribution of Age is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,246	Retain the null hypothesis.
3	The distribution of Education is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,337	Retain the null hypothesis.
4	The distribution of IQ is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,301	Retain the null hypothesis.
5	The distribution of SES is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,019	Reject the null hypothesis.
6	The distribution of AO_L1 is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,433	Retain the null hypothesis.
7	The distribution of AO_L2 is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,278	Retain the null hypothesis.
8	The distribution of LA_Balanced_proficiency is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,828	Retain the null hypothesis.
9	The distribution of Balanced_proficiency_reported is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,089	Retain the null hypothesis.
10	The distribution of Proficiency_Mean is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,633	Retain the null hypothesis.
11	The distribution of Language_Use_computed is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,128	Retain the null hypothesis.
12	The distribution of Balanced_exposure is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	,217	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Table G.3.5. *Krushal-Willis Tests between simultaneous Irish and Catalan bilinguals for background variables after controlling for age of onset for the L2.*

Appendix G.4. *Comparability between Irish simultaneous and sequential bilinguals*

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Age is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	,090	Retain the null hypothesis.
2	The distribution of Education is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	,019	Reject the null hypothesis.
3	The distribution of IQ is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	,774	Retain the null hypothesis.
4	The distribution of SES is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	,303	Retain the null hypothesis.
5	The distribution of Language_switching is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	,817	Retain the null hypothesis.
6	The distribution of LA_Balanced_proficiency is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	,898	Retain the null hypothesis.
7	The distribution of Balanced_proficiency_reported is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	,593	Retain the null hypothesis.
8	The distribution of Language_Use_computed is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	,258	Retain the null hypothesis.
9	The distribution of Balanced_exposure is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	,017	Reject the null hypothesis.
10	The distribution of AO_L1 is the same across categories of SEQUENTIAL_BILINGUALISM.	Independent-Samples Kruskal-Wallis Test	1,000	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Table G.4.1. *Krushal-Willis Tests between Irish simultaneous and sequential bilinguals.*

Descriptive Statistics				
	SEQUENTIAL BILINGUALISM			
	early-sequential (N=13)		late-sequential (N=13)	
	Mean	SD	Mean	SD
Age	**33,85**	9,982	**40,46**	11,267
Education	**4,00**	,707	**4,77**	,832
IQ	8,31	1,653	8,23	2,488
SES	5,38	1,261	5,92	1,188
AO_L1	,00	,000	,00	,000
AO_L2	2,00	1,826	12,08	3,774
Balanced Proficiency (LA)	64,3413	38,26276	76,5582	57,24736
Reported Balanced Proficiency	2,62	2,468	2,92	4,518
Proficiency Mean	37,38	2,459	37,31	4,039
Language Use	,4396	,08939	,4915	,11434
Language switching	22,9231	4,29072	22,0769	3,94676

Table G.4.2. *Descriptive statistics (M, SD) for background variables (Irish early/late sequential bilinguals).*

Appendix H.1. *Correlations*

Correlations								
		FLANKER	Age	AO_L2	Balanced Exposure	Balanced proficiency	Language use	Language switching
FLANKER	Pearson Correlation	1						
	Sig. (2-tailed)							
	N	57						
Age	Pearson Correlation	,194	1					
	Sig. (2-tailed)	,149						
	N	57	57					
AO_L2	Pearson Correlation	,016	,198	1				
	Sig. (2-tailed)	,919	,197					
	N	44	44	44				
Balanced Exposure	Pearson Correlation	**,370****	,085	,287	1			
	Sig. (2-tailed)	,005	,532	,059				
	N	57	57	44	57			
Balanced proficiency	Pearson Correlation	,255	-,143	,077	,063	1		
	Sig. (2-tailed)	,098	,359	,621	,687			
	N	43	43	43	43	43		
Language use	Pearson Correlation	,069	,244	-,194	-,062	-,053	1	
	Sig. (2-tailed)	,657	,111	,206	,688	,734		
	N	44	44	44	44	43	44	
Language switching	Pearson Correlation	-,050	,262	-,156	-,035	-,049	,255	1
	Sig. (2-tailed)	,745	,086	,313	,821	,755	,094	
	N	44	44	44	44	43	44	44

**. Correlation is significant at the 0.01 level (2-tailed).

Table H.1.1. *Correlations between Flanker inhibition scores and background variables.*

Correlations								
		MSIT	Age	AO_L2	Balanced Exposure	Balanced proficiency	Language use	Language switching
MSIT	Pearson Correlation	1	,026	**,327***	-,127	-,153	-,059	**,379***
	Sig. (2-tailed)		,846	,030	,345	,326	,702	,011
	N	57	57	44	57	43	44	44

Table H.1.2. *Correlations between MSIT inhibition scores and background variables.*

Appendix H.2. *Tests for Irish monolinguals and bilinguals*

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
Flanker	Irish monolinguals	13	53,3055	27,07436	7,50908
	Irish bilinguals	26	36,8666	17,92424	3,51523
MSIT	Irish monolinguals	13	24,4990	32,78596	9,09319
	Irish bilinguals	26	34,4876	35,33364	6,92950
B – A	Irish monolinguals	13	10209,3077	23675,13002	6566,29963
	Irish bilinguals	24	8505,7083	19387,16407	3957,38829
Switch costs	Irish monolinguals	10	245,0829	123,60812	39,08832
	Irish bilinguals	15	201,0808	121,14923	31,28060
Mixing costs	Irish monolinguals	8	311,6437	297,52931	105,19250
	Irish bilinguals	12	277,1871	134,66971	38,87580

Table H.2.1. *Descriptives for RTs (Irish bilinguals and monolinguals).*

Independent Samples Test									
	Levene's Test for Equality of Variances		*t*-test for Equality of Means						
								95% C.I. of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Flanker	1,946	,171	2,269	37	,029	16,43883	7,24423	1,76063	31,11703
			1,983	17,434	,063	16,43883	8,29115	-1,02085	33,89852
MSIT	,362	,551	-,852	37	,400	-9,98863	11,72857	-33,75296	13,77571
			-,874	25,807	,390	-9,98863	11,43259	-33,49720	13,51995
B – A	,014	,908	,236	35	,815	1703,59	7216,72	-12947,13	16354,33
			,222	20,864	,826	1703,59	7666,63	-14246,34	17653,54
Switch costs	,031	,862	,883	23	,387	44,00217	49,85418	-59,12906	147,13340
			,879	19,165	,390	44,00217	50,06369	-60,72113	148,72547
Mixing costs	5,531	**,030**	,354	18	,728	34,45666	97,37058	-170,11	239,02
			,307	8,937	,766	34,45666	112,14628	-219,51	288,42

Table H.2.2. *Independent t-tests for RTs (Irish bilinguals and monolinguals).*

We run other tests by taking into account **SES**. We carried out a two-way ANOVA taking *SES* and *Group* as Fixed Factors.

We found significant differences in the Flanker test and in the switch costs in Global-Local test.

Tests of Between-Subjects Effects

Dependent Variable: **Flanker**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3333,888[a]	3	1111,296	2,456	,079	,174
Intercept	69685,109	1	69685,109	154,011	,000	,815
Group	2152,626	1	2152,626	4,758	**,036**	**,120**
SES	609,271	1	609,271	1,347	,254	,037
Group * SES	95,670	1	95,670	,211	,648	,006
Error	15836,364	35	452,468			
Total	89105,194	39				
Corrected Total	19170,252	38				

a. R Squared = ,174 (Adjusted R Squared = ,103)

Table H.2.3. *Two-way ANOVA with Group and SES as between-subjects factors (Flanker scores).*

Estimates

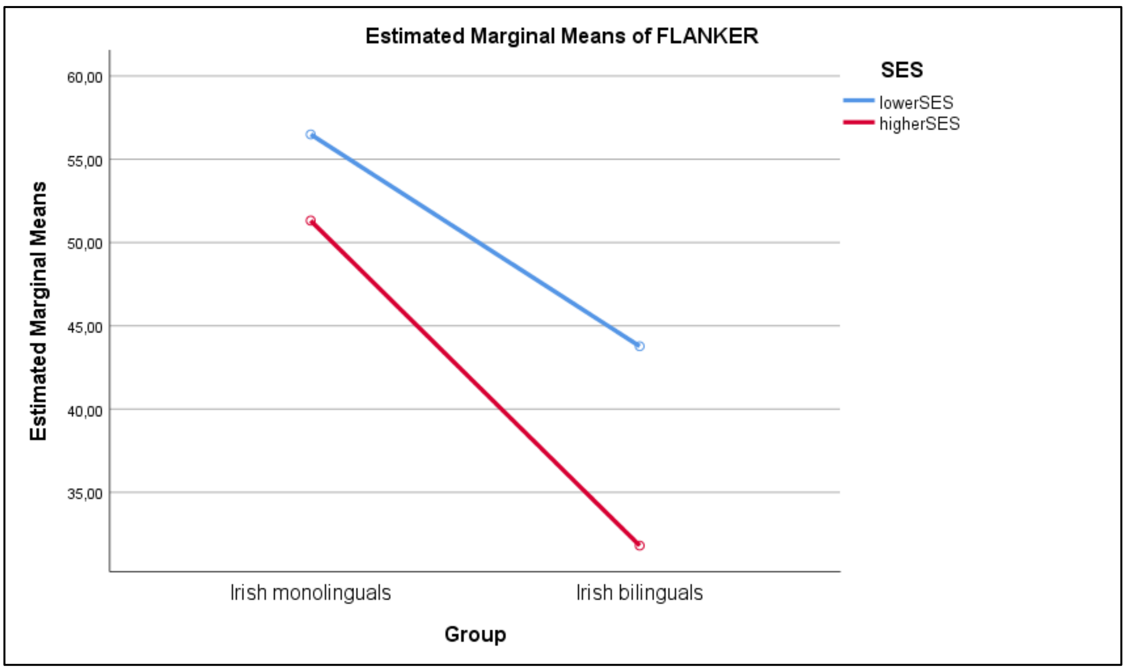
Dependent Variable: **Flanker**

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Irish monolinguals	53,903	6,063	41,594	66,212
Irish bilinguals	37,787	4,222	29,217	46,358

Table H.2.4. *Estimates of the Flanker inhibition scores (Group).*

Pairwise Comparisons							
Dependent Variable: FLANKER							
SES	(I) Group	(J) Group	Mean Difference	SE	Sig.[b]	95% C.I. for Difference[b] Lower B.	Upper B.
Lower-SES	Irish monolinguals	Irish bilinguals	12,718	11,473	,275	-10,573	36,009
Higher-SES	Irish monolinguals	Irish bilinguals	19,513*	9,313	**,043**	,607	38,418
Based on estimated marginal means							
*. The mean difference is significant at the ,05 level.							
b. Adjustment for multiple comparisons: Bonferroni.							

Table H.2.5. *Bonferroni pairwise comparisons for Group (Higher and Lower SES) - Flanker.*



Graph H.2.1. *Line graph for ordinal interaction between Group and SES (Flanker scores).*

Tests of Between-Subjects Effects						
Dependent Variable: **Switch costs**						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	72832,903[a]	3	24277,634	1,864	,165	,203
Intercept	1263467,729	1	1263467,729	97,028	,000	,815
Group	19031,580	1	19031,580	1,462	,240	,062
SES	6836,710	1	6836,710	,525	,476	,023
Group * SES	58467,590	1	58467,590	4,490	**,046**	**,169**
Error	286477,199	22	13021,691			
Total	1572275,755	26				
Corrected Total	359310,102	25				
a. R Squared = ,203 (Adjusted R Squared = ,094)						

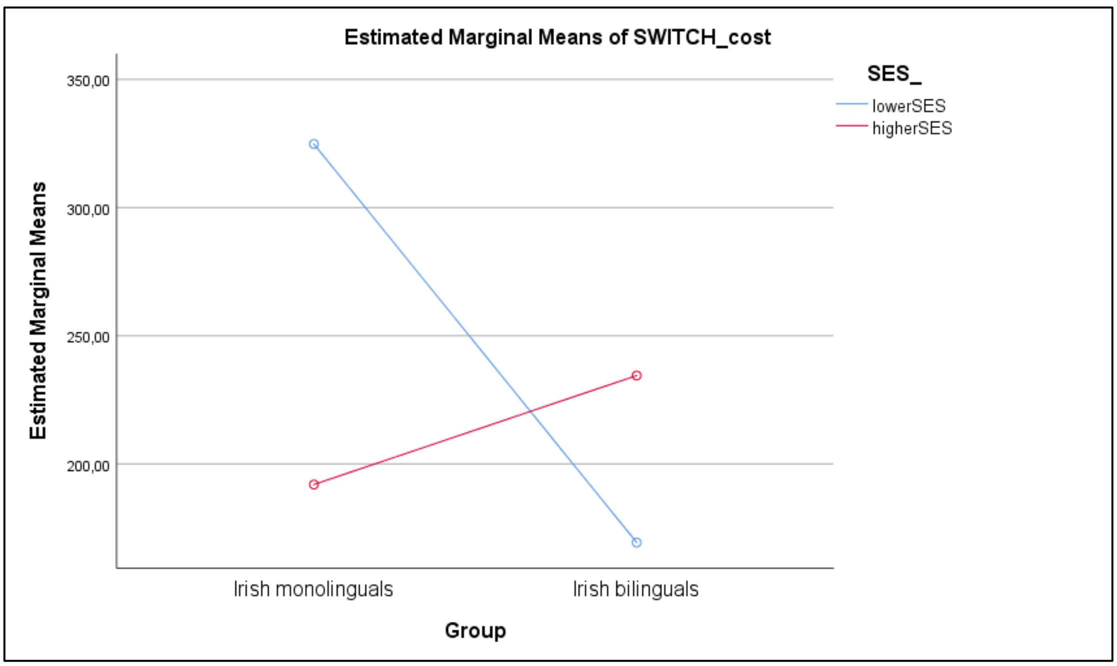
Table H.2.6. *Two-way ANOVA with Group and SES as between-subjects factors (switch costs).*

Estimates					
Dependent Variable: SWITCH costs					
				95% Confidence Interval	
Group	SES	Mean	Std. Error	Lower B.	Upper B.
Irish monolinguals	**Lower-SES**	**324,801**	57,056	206,474	443,129
	Higher-SES	191,937	46,586	95,323	288,551
Irish bilinguals	**Lower-SES**	**169,306**	38,038	90,421	248,191
	Higher-SES	234,458	43,131	145,011	323,905

Table H.2.7. *Estimates of the Flanker inhibition scores (Group).*

Pairwise Comparisons							
Dependent Variable: SWITCH costs							
SES	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower-Bound	Upper Bound
Lower-SES	**Irish monolinguals**	**Irish bilinguals**	155,495*	68,573	**,034**	13,283	297,707
Higher-SES	Irish monolinguals	Irish bilinguals	-42,521	63,486	,510	-174,184	89,142
Based on estimated marginal means							
*. The mean difference is significant at the ,05 level.							
b. Adjustment for multiple comparisons: Bonferroni.							

Table H.2.8. *Bonferroni pairwise comparisons for Group (Higher-SES and Lower-SES SES) - switch costs.*



Graph H.2.2. *Line graph for interaction between Group and SES (switch costs).*

Likewise, we run a second set of analyses to analyse potential effects of *Education*, since the two groups differ significantly on the basis on this variable. Neither main effects nor interactions were significant.

Tests of Between-Subjects Effects						
Dependent Variable: **FLANKER**						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3569,793[a]	3	1189,931	2,670	,063	,186
Intercept	54578,003	1	54578,003	122,447	,000	,778
Group	752,427	1	752,427	1,688	,202	,046
EDUCATION	51,683	1	51,683	,116	,736	,003
Group * EDUCATION_	1196,975	1	1196,975	2,685	,110	,071
Error	15600,459	35	445,727			
Total	89105,194	39				
Corrected Total	19170,252	38				
a. R Squared = ,186 (Adjusted R Squared = ,116)						

Table H.2.9. *Two-way ANOVA with Group and Education as between-subjects factors (Flanker).*

Tests of Between-Subjects Effects						
Dependent Variable: **MSIT**						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1530,879[a]	3	510,293	,411	,746	,034
Intercept	25235,463	1	25235,463	20,330	,000	,367
Group	708,676	1	708,676	,571	,455	,016
EDUCATION	596,755	1	596,755	,481	,493	,014
Group * EDUCATION	89,987	1	89,987	,072	,789	,002
Error	43444,501	35	1241,271			
Total	82837,522	39				
Corrected Total	44975,380	38				
a. R Squared = ,034 (Adjusted R Squared = -,049)						

Table H.2.10. *Two-way ANOVA with Group and Education as between-subjects factors (MSIT).*

Tests of Between-Subjects Effects						
Dependent Variable: **B – A**						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	973388476,472[a]	3	324462825,491	,742	,534	,063
Intercept	1780439217,561	1	1780439217,561	4,074	,052	,110
Group	627452,401	1	627452,401	,001	,970	,000
EDUCATION	495051552,801	1	495051552,801	1,133	,295	,033
Group * EDUCATION	491820287,401	1	491820287,401	1,125	,296	,033
Error	14422054942,82	33	437031967,964			
Total	18462289694,00	37				
Corrected Total	15395443419,29	36				
a. R Squared = ,063 (Adjusted R Squared = -,022)						

Table H.2.11. *Two-way ANOVA with Group and Education as between-subjects factors (B – A).*

Tests of Between-Subjects Effects						
Dependent Variable: Switch costs						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	15433,850[a]	3	5144,617	,329	,804	,043
Intercept	1048851,042	1	1048851,042	67,102	,000	,753
Group	14259,256	1	14259,256	,912	,350	,040
EDUCATION	398,742	1	398,742	,026	,875	,001
Group * EDUCATION	1430,017	1	1430,017	,091	,765	,004
Error	343876,252	22	15630,739			
Total	1572275,755	26				
Corrected Total	359310,102	25				
a. R Squared = ,043 (Adjusted R Squared = -,088)						

Table H.2.12. *Two-way ANOVA with Group and Education as between-subjects factors (switch*

Tests of Between-Subjects Effects						
Dependent Variable: Mixing costs						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	161177,301[a]	3	53725,767	1,303	,304	,178
Intercept	1183531,173	1	1183531,173	28,703	,000	,615
Group	12049,065	1	12049,065	,292	,595	,016
EDUCATION	85337,568	1	85337,568	2,070	,167	,103
Group * EDUCATION	53785,044	1	53785,044	1,304	,268	,068
Error	742206,954	18	41233,720			
Total	2658037,301	22				
Corrected Total	903384,255	21				
a. R Squared = ,178 (Adjusted R Squared = ,041)						

Table H.2.13. *Two-way ANOVA with Group and Education as between-subjects factors (mixing costs).*

Appendix H.3. *Tests for Irish and Catalan simultaneous/early sequential bilinguals*

Tests of Between-Subjects Effects						
Dependent Variable: **FLANKER**						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	254,958[a]	3	84,986	,277	,842	,032
Intercept	29924,766	1	29924,766	97,435	,000	,796
Group	13,746	1	13,746	,045	,834	,002
Switching	174,962	1	174,962	,570	,457	,022
Group * Switching	11,639	1	11,639	,038	,847	,002
Error	7678,121	25	307,125			
Total	41132,937	29				
Corrected Total	7933,079	28				
a. R Squared = ,032 (Adjusted R Squared = -,084)						

Table H.3.1. *Two-way ANOVA with Group and Switching as between-subjects factors (Flanker scores).*

Tests of Between-Subjects Effects						
Dependent Variable: MSIT_inhibition						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7825,610[a]	3	2608,537	2,936	,053	,261
Intercept	21839,131	1	21839,131	24,581	,000	,496
Group	1218,037	1	1218,037	1,371	,253	,052
Switching	3611,042	1	3611,042	4,064	,055	,140
Group * Switching	1096,224	1	1096,224	1,234	,277	,047
Error	22211,629	25	888,465			
Total	56064,370	29				
Corrected Total	30037,239	28				
a. R Squared = ,261 (Adjusted R Squared = ,172)						

Table H.3.2. *Two-way ANOVA with Group and Switching as between-subjects factors (MSIT).*

Tests of Between-Subjects Effects						
Dependent Variable: B – A						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4674117197,575[a]	3	1558039065,858	8,377	,001	,512
Intercept	3535035717,963	1	3535035717,963	19,008	,000	,442
Group	1403600503,856	1	1403600503,856	7,547	**,011**	,239
Switching	2435336246,379	1	2435336246,379	13,095	**,001**	,353
Group * Switching	2577913664,045	1	2577913664,045	13,861	**,001**	,366
Error	4463522427,103	24	185980101,129			
Total	10872360799,000	28				
Corrected Total	9137639624,679	27				
a. R Squared = ,512 (Adjusted R Squared = ,450)						

Table H.3.3. *Two-way ANOVA with Group and Switching as between-subjects factors (B – A).*

The *Group*Switching* interaction was further analysed.

Pairwise Comparisons							
Dependent Variable: B – A							
						95% C.I. for Difference[b]	
Group	(I) Switching	(J) Switching	Mean Difference	Std. Error	Sig.[b]	Lower Bound	Upper Bound
Catalan bilinguals	Non-Switchers	Switchers	564,683	6872,630	,935	-13619,728	14749,093
Irish bilinguals	Non-Switchers	Switchers	-39702,25*	8351,200	**,000**	-56938,279	-22466,221
Based on estimated marginal means							
*. The mean difference is significant at the ,05 level.							
b. Adjustment for multiple comparisons: Bonferroni.							

Table H.3.4. *Bonferroni pairwise comparisons for Switching between Catalan and Irish bilinguals (B – A).*

Pairwise Comparisons							
Dependent Variable: B – A							
						95% Confidence Interval for Difference[b]	
Switchers	(I) Group	(J) Group	Mean Difference (I-J)	S.E.	Sig.[b]	Lower Bound	Upper Bound
Non-Switchers	Catalan bilinguals	Irish bilinguals	5277,321	7058,05	,462	-9289,782	19844,425
Switchers	Catalan bilinguals	Irish bilinguals	-34989,611*	8195,09	**,000**	-51903,443	-18075,779

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Bonferroni.

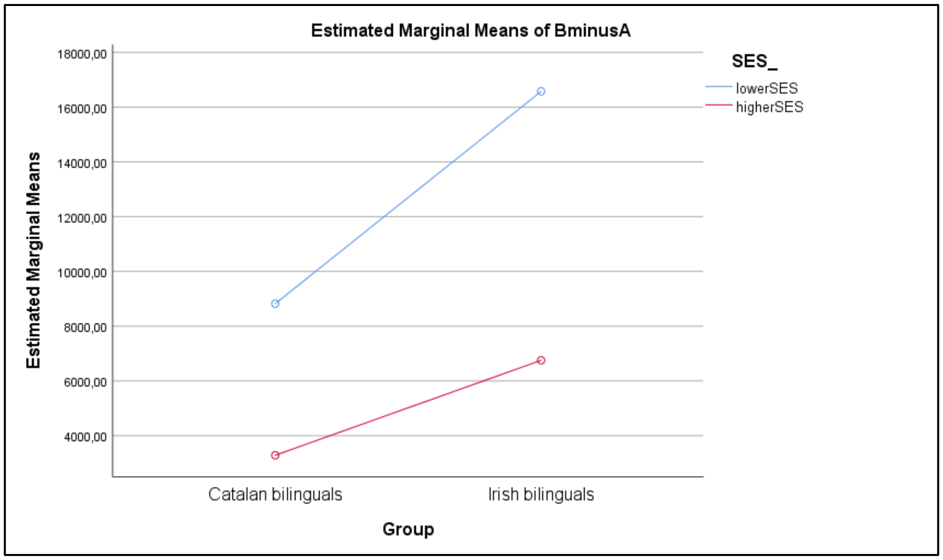
Table H.3.5. *Bonferroni pairwise comparisons for Group between switchers and non-switchers (B – A).*

Since Catalan came from higher SES families, we also performed a two-way ANOVA with *Group* and *SES* as fixed factors.

Tests of Between-Subjects Effects						
Dependent Variable: B – A						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	813715889,219[a]	3	271238629,740	,814	,498	,089
Intercept	1744936104,372	1	1744936104,372	5,237	,031	,173
Group	174861046,879	1	174861046,879	,525	,476	,021
SES_LH	327814293,413	1	327814293,413	,984	,331	,038
Group * SES_LH	25533393,817	1	25533393,817	,077	,784	,003
Error	8330011958,022	25	333200478,321			
Total	10901090399,00	29				
Corrected Total	9143727847,241	28				

a. R Squared = ,089 (Adjusted R Squared = -,020)

Table H.3.6. *Two-way ANOVA with Group and SES as between-subjects factors (B – A).*



Graph H.3.1. *Line graph showing no interaction between Group and SES (B – A).*

We finally analysed the Global-Local task, first taking into account *Switching* and, thereafter, *Group*.

Group Statistics					
	Switching	N	Mean	Std. Deviation	Std. Error Mean
SWITCH costs	non-switchers	10	173,8984	152,54504	48,23898
	switchers	12	201,7119	127,15856	36,70751

Table H.3.7. *Descriptives for switch costs (switchers and non-switchers).*

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	SE Difference	95% C.I. of the Difference Lower	Upper
SWITCH costs	1,007	,328	-,467	20	,646	-27,81	59,58337	-152,10	96,47
			-,459	17,61	,652	-27,81	60,61716	-155,37	99,74

Table H.3.8. *Independent t-tests for switch costs (switchers and non-switchers).*

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
SWITCH costs	Catalan bilinguals	13	207,8215	161,85688	44,89102
	Irish bilinguals	9	161,9829	90,80579	30,26860

Table H.3.9. *Descriptives for switch costs (Catalan and Irish bilinguals).*

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% C.I. of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	S.E. Difference	Lower	Upper
SWITCH costs	8,870	**,007**	,767	20	,452	45,84	59,80	-78,90	170,57
			,847	19,382	,408	45,84	54,14	-67,33	159,01

Table H.3.10. *Independent t-tests for switch costs (Catalan and Irish bilinguals).*

Group Statistics					
	Switching	N	Mean	Std. Deviation	Std. Error Mean
MIXING costs	non-switchers	10	339,0369	239,73244	75,81005
	switchers	6	187,5758	178,81349	73,00030

Table H.3.11. *Descriptives for mixing costs (switchers and non-switchers).*

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% C.I. of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	SE Difference	Lower	Upper
MIXING costs	,224	,644	1,334	14	,204	151,46111	113,56694	-92,11	395,04
			1,439	13,121	,174	151,46111	105,24356	-75,68	378,61

Table H.3.12. *Independent t-tests for mixing costs (switchers and non-switchers).*

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
MIXING costs	Catalan bilinguals	9	287,9483	273,29413	91,09804
	Irish bilinguals	7	274,8985	165,80854	62,66974

Table H.3.13. *Descriptives for mixing costs (Catalan and Irish bilinguals).*

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% C.I. of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	SE Difference	Lower	Upper
MIXING costs	1,489	,242	,111	14	,913	13,05	117,61	-239,19	265,29
			,118	13,37	,908	13,05	110,57	-225,15	251,25

Table H.3.14. *Independent t-tests for mixing costs (Catalan and Irish bilinguals).*

Appendix H.4. *Tests for Irish early-sequential and late-sequential bilinguals*

Tests of Between-Subjects Effects

Dependent Variable: **FLANKER**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	54,141[a]	3	18,047	,050	,985	,007
Intercept	33022,397	1	33022,397	91,064	,000	,805
SEQUENTIAL BILINGUALISM	2,099	1	2,099	,006	,940	,000
Switching	26,547	1	26,547	,073	,789	,003
SEQUENTIAL BILINGUALISM * Switching	20,964	1	20,964	,058	,812	,003
Error	7977,818	22	362,628			
Total	43369,805	26				
Corrected Total	8031,959	25				

a. R Squared = ,007 (Adjusted R Squared = -,129)

Table H.4.1. *Two-way ANOVA with Sequential-Bilingualism and Switching as between-subjects factors (Flanker scores).*

Tests of Between-Subjects Effects

Dependent Variable: **MSIT**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3881,991[a]	3	1293,997	1,042	,394	,124
Intercept	31288,535	1	31288,535	25,187	,000	,534
SEQUENTIAL BILINGUALISM	2058,676	1	2058,676	1,657	,211	,070
Switching	627,179	1	627,179	,505	,485	,022
SEQUENTIAL BILINGUALISM * Switching	537,363	1	537,363	,433	,518	,019
Error	27329,667	22	1242,258			
Total	62135,904	26				
Corrected Total	31211,658	25				

a. R Squared = ,124 (Adjusted R Squared = ,005)

Table H.4.2. *Two-way ANOVA with Sequential-Bilingualism and Switching as between-subjects factors (MSIT scores).*

By running further independent *t*-tests, we noticed that early bilinguals were better at inhibiting in the MSIT, see Table H.4.4.

Group Statistics					
	SEQUENTIAL BILINGUALISM	N	Mean	Std. Deviation	Std. Error Mean
MSIT	late-sequential	13	44,7110	40,71551	11,29245
	early-sequential	13	24,2642	26,77246	7,42535

Table H.4.3. *Descriptives for MSIT inhibition scores (early and late bilinguals).*

Independent Samples Test									
	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	S.E. Difference	Lower	Upper
MSIT	4,135	**,053**	1,513	24	,143	20,44674	13,51500	-7,44685	48,34032
			1,513	20,743	,145	20,44674	13,51500	-7,68050	48,57397

Table H.4.4. *Independent t-tests for MSIT scores (early and late bilinguals).*

Tests of Between-Subjects Effects						
Dependent Variable: **B – A**						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3726444147,6[a]	3	124214849	5,051	,009	,431
Intercept	2165224922,9	1	2165224922	8,805	,008	,306
SEQUENTIAL BILINGUALISM	799555936,3	1	799555936	3,251	,086	,140
Switching	1220035471,2	1	1220035471	4,961	**,038**	,199
SEQUENTIAL BILINGUALISM * Switching	1838359463,2	1	1838359463	7,475	**,013**	,272
Error	4918384859,3	20	245919242			
Total	10381158789,0	24				
Corrected Total	8644829006,9	23				
a. R Squared = ,431 (Adjusted R Squared = ,346)						

Table H.4.5. *Two-way ANOVA with Sequential-Bilingualism and Switching as between-subjects factors (B – A).*

The interaction was analysed through pairwise comparisons.

Pairwise Comparisons							
Dependent Variable: **B – A**							
Switching	(I) SEQUENTIAL BILINGUALISM	(J) SEQUENTIAL BILINGUALISM	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower B.	Upper B.
non-switchers	early-sequential	late-sequential	-6184,893	8116,1	,455	-23114,800	10745,014
switchers	**early-sequential**	**late-sequential**	30142,500*	10519,6	**,010**	8198,833	52086,167
Based on estimated marginal means							
*. The mean difference is significant at the ,05 level.							
b. Adjustment for multiple comparisons: Bonferroni.							

Table H.4.6. *Bonferroni pairwise comparisons for Sequential-Bilingualism between switchers and non-switchers (B – A).*

Pairwise Comparisons							
Dependent Variable: **B – A**							
SEQUENTIAL BILINGUALISM	(I) Switching	(J) Switching	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
early-sequential	**non-switchers**	**switchers**	-32960,750*	8940,009	**,001**	-51609,281	-14312,219
late-sequential	non-switchers	switchers	3366,643	9829,096	,736	-17136,492	23869,778
Based on estimated marginal means							
*. The mean difference is significant at the ,05 level.							
b. Adjustment for multiple comparisons: Bonferroni.							

Table H.4.7. *Bonferroni pairwise comparisons for Switching between early and late bilinguals (B – A).*

Tests of Between-Subjects Effects						
Dependent Variable: **SWITCH costs**						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	41206,237[a]	3	13735,412	,988	,431	,198
Intercept	513311,619	1	513311,619	36,920	,000	,755
Switching	8667,620	1	8667,620	,623	,445	,049
SEQUENTIAL BILINGUALISM	12512,718	1	12512,718	,900	,362	,070
Switching * SEQUENTIAL BILINGUALISM	9347,461	1	9347,461	,672	,428	,053
Error	166841,015	12	13903,418			
Total	834108,580	16				
Corrected Total	208047,251	15				
a. R Squared = ,198 (Adjusted R Squared = -,002)						

Table H.4.8. *Two-way ANOVA with Sequential-Bilingualism and Switching as between-subjects factors (switch costs).*

Tests of Between-Subjects Effects						
Dependent Variable: **MIXING costs**						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	50333,164[a]	3	16777,721	,754	,545	,184
Intercept	918519,269	1	918519,269	41,255	,000	,805
Switching	32117,699	1	32117,699	1,443	,257	,126
SEQUENTIAL BILINGUALISM	236,718	1	236,718	,011	,920	,001
Switching * SEQUENTIAL BILINGUALISM	17033,286	1	17033,286	,765	,402	,071
Error	222643,610	10	22264,361			
Total	1261396,991	14				
Corrected Total	272976,774	13				
a. R Squared = ,184 (Adjusted R Squared = -,060)						

Table H.4.9. *Two-way ANOVA with Sequential-Bilingualism and Switching as between-subjects factors (mixing costs).*