The impact of bilinguism on cognitive aging and dementia

Finding a path through a forest of confounding variables

Running Head: Bilingualism, ageing and dementia: confounding variables.

The impact of bilingualism on cognitive aging and dementia: Finding a path through a forest of confounding variables.

Thomas H Bak

School of Philosophy, Psychology & Language Sciences (PPLS),

Centre for Cognitive Ageing and Cognitive Epidemiology (CCACE)

and

Centre for Clinical Brain Sciences (CCBS)

University of Edinburgh, UK

Correspondence concerning this article should be addressed to:

Thomas H Bak,

School of Philosophy, Psychology and Language Sciences, University of Edinburgh,

7 George Square

Edinburgh EH8 9JZ

E-mail: thomas. bak@ed.ac.uk

Abstract

Within the current debates on cognitive reserve, cognitive aging and dementia, showing increasingly a positive effect of mental, social and physical activities on health in older age, bilingualism remains one of the most controversial issues. Some reasons for it might be social or even ideological. However, one of the most important genuine problems facing bilingualism research is the high number of potential confounding variables. Bilingual communities often differ from monolingual ones in a range of genetic and environmental variables. In addition, within the same population, bilingual individuals could be different from the outset from those who remain monolingual. We discuss the most common confounding variables in the study of bilingualism, aging and dementia, such as group heterogeneity, migration, social factors, differences in general intelligence and the related issue of reverse causality. We describe different ways in which they can be minimized by the choice of the studied populations and the collected data. In this way the emerging picture of the interaction between bilingualism and cognitive aging becomes more complex, but also more convincing.

Keywords: Cognitive ageing, dementia, confounding variables

1. LANGUAGES VERSUS PILLS: WHY BILINGUALISM MATTERS IN CURRENT AGEING AND DEMENTIA RESEARCH

With growing numbers of older people in societies across the world, the effects of ageing are attracting increasing research interest. High among the priorities of this research agenda is the search for both protective and risk factors of cognitive ageing. On average, some cognitive abilities decline with age from early/middle adulthood onwards. However, there are substantial individual differences in age-related cognitive changes and explaining them could contribute to ameliorating age-related cognitive decline. The search for factors that influence cognitive ageing has cast a wide net, and includes genetic, biomedical, and psycho-social factors (Deary et al., 2009) (Plassman, Williams, Burke, Holsinger, & Benjamin, 2010). Different lifestyle factors have been examined, and thus physical, cognitive and social activities have all been explored as possible modifiers of cognitive performance in old age (Gow et al., 2011).

One of the most intriguing and controversial phenomena discussed in this context is bilingualism. Less than 100 years ago, bilingualism was regarded as an impediment to cognitive development, causing delays or even lasting cognitive disadvantages (Saer, 1923). However, from the late 20th Century onwards, a growing body of evidence began to accumulate suggesting that bilingualism is associated with cognitive advantages, not only in the domain of language but also, importantly, on non-linguistic tasks. Advantages on executive tasks and social cognition have been documented in children (Bialystok & Viswanathan, 2009; Kovács & Mehler, 2009). At the other end of the life course, Kavé et al. (Kavé, Eyal, Shorek, & Cohen-Mansfield, 2008) demonstrated that the number of spoken languages correlated positively with performance on a brief cognitive screening test in individuals aged over 75 years.

A seminal paper by Ellen Bialystok and her research group (Bialystok, Craik, & Freedman, 2007) extended this debate into the most extreme and socially most relevant form of age-associated cognitive decline: dementia. The authors found that bilingual patients developed dementia 4 years later than their monolingual counterparts; a finding confirmed by further research from the same group (Bialystok, Craik, Binns, Ossher, & Freedman, 2014; Craik, Bialystok, & Freedman, 2010; Schweizer, Ware, Fischer, Craik, & Bialystok, 2012). This development has brought an entirely new dimension to bilingualism research; if these findings could be confirmed by studies from other research groups, it would make bilingualism one of the most effective tools against dementia: more so than any currently available pharmacological disease-modifying treatment.

However, this new importance has also exposed bilingualism research to a much stricter scrutiny. Are such stunning effects genuine? Could it be that at least some of them could be due to some systematic error or confounding variables? And if such confounding variables can be identified, is it possible to avoid or at least minimise them through a careful selection of the examined populations or a tight experimental design? We will discuss first possible confounds *between bilingual and monolingual populations,* with a particular attention paid to the much discussed topic of immigration. We will then move to *individual differences within populations*, touching the difficult problem of "reverse causality". Given the interdisciplinary character of current research on bilingualism, ageing and dementia, we will then discuss how different traditions within *linguistics and medicine* could influence the approaches taken by different scientists. Finally, we will consider another type of confound, rarely mentioned in the literature and often implicit but at least as important as those discussed above: the *ideological and political attitudes towards bilingualism.* By putting bilingualism research in

historical and social context, we will attempt to answer the question why bilingualism remains much more controversial than almost any other form of the so-called "cognitive reserve".

While we will try to cover as much as possible of the available literature, the present paper is not primarily a literature review but, as the title suggests, a discussion of the most important confounding variables in this field and possible way to tackle them. As such, it will hopefully help in the interpretation not only of past but also of future studies. Accordingly, although the main focus is on ageing and dementia, we have also included discussion of studies dealing with young adults or even children, if they appeared relevant to illustrate the discussed phenomena.

2. IMMIGRANTS, OUTCASTS AND ELITES: DIFFERENCES BETWEEN MONO- AND BILINGUAL POPULATIONS

Ideally, a study comparing a mono- and a bilingual group would like both groups to differ only in terms of their language knowledge and/or use but to be equal in all other respects. In reality, such a situation is extremely difficult to achieve. More often than not, the bilingual group differs from the monolingual one not only in language but also in the immigration status and/or in ethnic, religious, cultural and social background, often connected with considerable differences in lifestyle. The most hotly debated issue in this context is arguably *immigration*. In many studies of cognitive ageing and dementia, particularly those conducted in the USA and Canada, the bilingual groups tend to consist predominantly of immigrants (or their descendants) whereas the monolingual groups are composed mostly from a population, which has been living in the same area for several generations (autochthonous population). The difference between both populations can go far beyond the language they speak and

include different ethnic (including genetic) background as well as differences in lifestyle, such as diet, occupation, leisure activities and/or attitudes to health and health services.

Indeed, Fuller-Thomson & Kuh (Fuller-Thomson & Kuh, 2014) argue that the bilingual advantage might be in large parts due to what they call *healthy migrant effect*: "*a self-selection, such that healthier people are more likely to decide to migrate*" (one could add that they are also more likely to survive the migration, to settle down successfully in a new country and to found families, through which the healthy migrant effect can continue well into the second or even third generation). However, if this were the case, we would expect a relatively straightforward pattern of results: studies in which bilinguals are at the same time immigrants would show a bilingual (or, as Fuller-Thomson & Kuh would argue, healthy immigrant) advantage while those without a difference in immigration status would show the same results in bi- and monolinguals.

In reality, the picture is much more complex. Some of the largest studies showing positive effects of bilingualism in healthy aging (Bak, Nissan, Allerhand, & Deary, 2014) and dementia (Alladi et al., 2013) include practically no immigrants. Others studies confirming benefits of bilingualism were conducted in places like Luxembourg (Perquin et al., 2013) or Belgium (Woumans et al., 2014) where immigration is not the main contributor to bilingualism. On the other hand, many studies cited as evidence against a bilingual advantage (Paap & Greenberg, 2013; Sanders, Hall, Katz, & Lipton, 2012; Yeung, John, Menec, & Tyas, 2014) compared bilinguals with immigration background to non-immigrant monolinguals. So according to the healthy migrant hypothesis, they should find a difference (albeit because of migration rather than bilingualism); but they do not. A particularly complex pattern of results was reported by Chertkow et al (Chertkow et al., 2010). The authors found a later onset of dementia in bilinguals only in the immigrant, but not in the

autochthonous population, which at first glance would confirm the healthy immigrant hypothesis. However, like in an earlier study of Kavé et al (Kavé et al., 2008), which will be discussed in more detail later on, they found an effect of multilingualism (defined as knowledge of three or more languages) in all subgroups, immigrant and non-immigrant (for a thorough up-to-date discussion of the question of the influence of the number of languages see (Freedman et al., 2014).

Apart from the differences between migrants and host population, the migrants themselves are not necessarily a homogenous group either, be it in terms of their origin or the degree they adapt to the host country. Accordingly, different studies examining the onset of dementia in immigrants to the USA came to different conclusions. A group investigating second-generation Japanese migrants on the Oahu island in Hawaii found no influence of either spoken or written Japanese on the age of onset of dementia (Crane et al., 2009; Crane et al., 2010). The authors discuss a wide range of variables, which could have influenced the results, including differences in education, income and lifestyle (e.g. those who both read and spoke Japanese were less likely to smoke). Gollan et al (Gollan, Salmon, Montoya, & Galasko, 2011) found a later age of dementia diagnosis in bilingual Hispanic migrants in California, but only in the low-educated group. Another study from California (Padilla et al., 2014) detected less severe cognitive impairment in bilingual as opposed to monolingual Mexican-born immigrants.

The study of Hispanic migrants in Washington Heights (New York City) by Zahodne et al (Zahodne, Schofield, Farrell, Stern, & Manly, 2014), cited sometimes inaccurately as a straightforward example of a “negative finding”, shows in fact a much more complicated pattern of results. Bilingual participants had significantly better executive functions than monolingual ones and the rate of conversion to dementia decreased with the level of

bilingualism, although this effect did not reach significance compared with the overwhelming (and expected) influence of age. Moreover, since the participants were enrolled into the study at the age of 65 years, some members of community could have developed dementia at a younger age: information not available to the researchers at the time of the study (Yaakov Stern, personal communication). This would have affected particularly patients with Frontotemporal Dementia (FTD): a subtype of dementia with the youngest average age of presentation but also the largest delay in onset attributable to bilingualism (Alladi et al 2013). Moreover, as pointed out by the authors, the population they studied, with predominantly Carribbean roots, might have quite different from the Californian immigrants of Mexican origin examined by Gollan et al (and indeed of Padilla et al). So ethnic, cultural and lifestyle differences could exist even within the Hispanic population.

To make the matters even more complicated, the phenomenon of migration can occur not only between countries and continents but also within the same country. In Spain and Italy, a large number of people migrated in the 20th Century from the economically disadvantaged South to the more industrial North. An opposite movement can be seen in industrialised countries like Britain where well-to-do middle-class families move from industrial areas to relatively unspoiled rural landscapes, such as the West Country, Wales or Scotland. These population movements can be highly relevant for bilingualism research, since some of them are associated with a migration from largely monolingual areas (such as Southern Spain or most of Britain) to a predominantly bilingual one (such as Catalonia, Northern Wales or the Western Isles of Scotland). This produces an opposite pattern of associations to the one discussed above, with the local population being mostly bilingual and the migrant one monolingual. So according to the healthy migrant hypothesis, we should expect here a monolingual/migrant advantage. In comparison, if we assume that both factors, bilingualism and migration, are likely to play an important but independent role, we would expect them to

interact, producing opposite effects. Interestingly, the first results from a set of bilingualism studies in North Wales (Clare et al., 2014) (Martyr et al., 2014) seem to point in this direction. There is a trend towards a better performance in monolinguals, but the few cognitive domains in which bilinguals seem to perform equally as monolinguals or even slightly better are in the area of frontal-executive function, exactly as we would expect from previous bilingualism research.

The examples of North Wales and Catalonia illustrate also another potential confounding variable associated with bilingualism. Irrespective of their immigration status, bilingual communities can have different socio-economic status from monolingual ones. It can be higher (as for middle-class Englishmen buying a house in Wales) or lower (as for Andalusian migrants looking for jobs in Catalonia). From discriminated and marginalised minorities to leading intellectual elites, bilingualism can be associated with almost any position in society. But in each case, it makes a comparison of mono- and bilingual groups difficult. Furthermore, even within the same socio-economic status, differences can exist in customs, cultures and conditions of living. Let's take as an example a recent study from the Basque Country (Duñabeitia et al., 2014), which ambitiously set out to destroy the "myth" of bilingual advantage in inhibitory control. The bilingual group in this study was recruited from bilingual schools in the Basque Country (no further information is provided about their location). About the monolingual group, with which the bilingual group was compared, we can learn only that it was recruited "*from Spanish provinces where Spanish is the only official language*". We don't know whether these areas were urban or rural, agricultural or industrial, wealthy or poor, located in or close to the capital or fairly remote etc. Given the cultural diversity of Spain and its federal system with substantial variation in education, health services, living standards and many other variables between (and sometimes even within) the regions, this lack of characterisation of the control group makes the results of the study

difficult to interpret.

Admittedly, finding an appropriate control group can be difficult, particularly in pervasively bilingual regions of Europe such as Catalonia in Spain or South Tirol in Italy, where most young people are bilingual (and receive bilingual education), forcing researchers studying those areas to recruit their controls in other regions of the country. But the more we know about *both* groups, the bi- *and* the mono-lingual one, the better we can interpret the results. The current emphasis on the details of experimental design, influenced by the strong input of psycholinguists in the field, should not obscure the importance of sociolinguistic factors, which currently tend to be underestimated. Accordingly, future research on bilingualism would benefit from a more intense interdisciplinary dialogue including humanities and social sciences as well as psychology, linguistics and neuroscience.

So far, the studies we have discussed came almost exclusively from the Western World: Western Europe and North America. Unfortunately, this lack of representativity characterises much of modern science. As poignantly formulated for the area of cognitive psychology (Henrich, Heine, & Norenzayan, 2010) and aphasia research (Beveridge & Bak, 2011), but equally true for many other disciplines, findings based on the study of a small and arguably highly atypical subset of world population should not be treated without questioning as universally valid. As demonstrated through previous examples, although bilingualism is often associated with confounding variables, these variables tend to differ from population to population. So the broader we cast our net, the more we are likely to discover.

A good case in point is a study of bilingualism and dementia from Hyderabad in India (Alladi et al., 2013). Like in many other countries outside the Western World, bilingualism in India is common and natural, forming part of every-day life. The population of Hyderabad has been predominantly bilingual for many centuries and bilingualism is not associated with

immigration or membership of a specific ethnic group. The patterns of use of different languages have been extensively studied and are well documented (Vasanta, Suvarna, Sireesha, & Raju, 2010). In terms of clinical research facilities, Nizam's Institute for Medical Studies (NIMS) in Hyderabad has one of the largest and most up-to-date dementia clinics in the country; all patients undergo a multidimensional cognitive assessment, using tests that have been adapted into the major languages spoken in the area and adjusted for literate or illiterate subjects respectively. Thus, NIMS and Hyderabad seem to be an ideal place to study the relationship between bilingualism and dementia. Despite huge differences in population, culture, living conditions and lifestyles, medical services and almost any other conceivable variable, the Hyderabad study found a result tantalisingly similar to that of Bialystok et al (Bialystok et al., 2007): a 4 years delay in the onset of dementia. So whatever factor can account for it, it certainly cannot be immigration.

The other obvious confounding variable, which we shall discuss in greater detail in the next section, is education. But also in this respect Hyderabad offers a unique research opportunity. Since, as mentioned above, languages are usually acquired (and practised) in the natural context of every-day life (rather than at school), a substantial part of the population is illiterate but bilingual. It was, therefore, possible to compare the age of dementia onset in mono- and bilingual illiterates. Stunningly, in this group the difference was even bigger: 6 years. The idea that people from a lower educational background could benefit most from bilingualism is in line with a study by Gollan et al (Gollan et al., 2011), which found an effect of bilingualism in low but not in high education Hispanic immigrants in California. However, as suggested by a recent study from India (Iyer et al., 2014), low education might not play the same role as a risk factor for dementia in Asia as in the Western World: another reason to study the relationship of bilingualism, education and cognition across the whole world.

A cross-cultural perspective could also be helpful in tackling another potential confound, namely non-linguistic intellectual activities. Several studies incorporated questions about leisure activities (Bialystok et al 2014, Perquin et al., 2013) or musical experience, such as playing instruments or singing (Vega-Mendoza, West, Sorace, & Bak, 2015) into their design and found that the bilingualism effects remained significant after controlling for these variables. However, pronounced differences in leisure activities across the world, particularly among the less globalised older generation, require a culturally adjusted approach.

The Hyderabad study provides strongest evidence to date that bilingualism can delay the onset of dementia, independently of immigration and education. But an open question remains: why, in the largely bilingual environment of Hyderabad, some people become bilingual while others stay monolingual? Could this reflect differences in their cognitive abilities *before* the acquisition of a second language? Could language learning be the consequence of rather than the reason for cognitive differences between people? With these questions we are moving from the level of whole population to the level of individual differences within the same population, which will be discussed in the following section.

3. CHICKENS, EGGS AND REVERSE CAUSALITY: INDIVIDUAL DIFFERENCES WITHIN THE SAME POPULATION

In the previous section we have focused on bilingual populations rather than individuals. In most cases, the knowledge of languages was not determined by a personal decision of an individual but by the environment: first parents and family, later neighbours, media and the state-determined language of education. People did not decide to become mono- or bilingual; the decision was made for them. However, as the individuals grow up, they have more and more power to decide which languages they chose to learn and to speak. Traditionally,

research on bilingualism tended to focus on "classical" cases of a simultaneous or early sequential language acquisition within the first few years of life, so we know much less about cognitive effects of later life language learning. So far, it seems that at least late childhood or early adulthood acquisition of new languages leads to a similar cognitive profile as an early acquisition, even if the second language is not acquired to a level of full proficiency (Bak, Vega-Mendoza, & Sorace, 2014; Vega-Mendoza et al., 2015). Given the large number of people worldwide who acquire new languages throughout their lives for personal and social reasons, professional benefits or intellectual curiosity, it is likely that this type of late and imperfect bilingualism will receive more attention in future. Studies of language learning in later life could also provide a link between bilingualism research and recent literature on cognitive training in elderly (Park et al., 2014).

However, studies of language acquisition beyond early childhood are confronted with a fundamental methodological problem, referred to in every-day language as the "*chicken and egg question"* ("*what was first: chicken or egg*?") and in scientific terminology as the "*reverse causality*". Individuals who become bilingual later in life might have different baseline characteristics from those who remain monolingual. In other words, it might not be bilingualism that leads to later-life cognitive differences; it might be that *original cognitive differences lead to bilingualism*.

Such cognitive differences might relate to socio-economic status and/or educational level, but could also reflect the individual's trait intelligence; all three of these variables are correlated (Deary & Johnson, 2010). The potential confound of trait intelligence is particularly difficult to address: whereas it might be possible (although not always easy) to control for socioeconomic status and education, it is exceptionally rare to know the prior level of

intelligence of the individuals who later went on to learn (or not to learn) other languages. In order to explore long-term impact of bilingualism on cognitive ageing one would need to assess children who are now around the age of 10 years and then re-examine them in 60 or 70 years. But would it be possible to have an answer a little bit earlier? For this we would need to know childhood cognitive performance of people who are currently in their 70's or 80's and to have a chance to re-examine them, assuming that some of them will have learned other languages than their native one, others not. Is there any place in the world where we can find such an opportunity?

Scotland is the only country in the world that has tested the intelligence of its entire population of a certain age. In June 1947, all children born in 1936 (hence aged 11 years at the time) underwent a comprehensive and well validated intelligence test, conducted at their respective schools. Crucially, the data of the participants from the Lothian region (the area around the Scottish capital Edinburgh) has been preserved, the current whereabouts of most participants could be determined and in 2004 the Lothian Birth Cohort (LBC) study was established with the aim of following them up longitudinally and investigate their physical and cognitive status in relation to their childhood cognitive performance (Deary, Gow, Pattie, & Starr, 2012; Deary et al., 2007). The LBC has already provided insights into the complex relationship between genetics, childhood intelligence, lifelong habits and physical and mental health in old age (Corley et al., 2010; Luciano, Marioni, Gow, Starr, & Deary, 2009). Could it also contribute to a better understanding of the influence of bilingualism on cognitive aging?

In a questionnaire distributed to 853 participants of the LBC 1936 (all of whom were English native speakers) 255 reported to have learned another language well enough to be able to

communicate in it. Importantly, the vast majority has learned other languages *after* the age of 11 years, in other words, between their first and second assessment. Classifying those individuals as bilinguals (in a very broad sense of the word) Bak et al (2014) compared their cognitive performance to that of the monolinguals, who were not able to communicate in any language other than their native English. However, rather than simply comparing the performance at the age of 73 years (when the participants were re-tested) they compared the relationship between the results in childhood and late adulthood. It is well established that childhood intelligence is one of the main predictors of cognitive performance in old age (Gow et al., 2011). So what the authors determined was whether bilinguals performed differently from what we would expect based on their childhood IQ results. In many cognitive domains, such as memory or complex reasoning not much difference could be discovered. However, as could be expected on the basis of previous bilingualism literature, in areas related to reading and executive functions bilinguals performed significantly better than could be predicted from their childhood IQ. Thirteen participants of the LBC 1936 were born (as children of Scottish parents) outside the UK and moved to the Lothian region before the age of 11 years. Aware of the crucial importance of migration as a confounding variable, the authors conducted their analysis twice: once with this group included and once excluded. The results were practically the same.

Thanks to the availability of the childhood intelligence data the authors were also able to explore another relevant question, namely whether the effects of learning a second language for low and high childhood cognitive ability groups, (at the 5^{th} and 95^{th} percentiles) were different from those with average cognitive performance (50^{th} percentile). Overall, the beneficial effects of bilingualism were similar for all three subgroups. There was a tendency for people at the higher end of the intelligence spectrum to benefit more from early

acquisition of a second language (before the age of 18 years). In contrast, those at the lower end of the spectrum benefited more from a later acquisition (age of 19 years or more). But crucially, no negative effects were observed in any of the analyses and in any of the subgroups, suggesting that second language acquisition does not impede cognitive development, whatever the baseline intelligence. Somewhat to their surprise, the authors found only a small additional benefit among those bilinguals who regularly practised their second language as opposed to those who hardly ever used it in the last decades of their life. Since this question is important in the context of cognitive reserve, it will be discussed in more detail in the following section.

4. COMPETENCE, PERFORMANCE AND EXERCISE: LINGUISTICS MEETS MEDICINE

The recent findings suggesting a possible interaction between bilingualism and the age of onset of dementia made the already interdisciplinary field of bilingualism research relevant also to medical practitioners. Indeed, the present article is written from a perspective of a practising clinician, working regularly with patients with dementia, aphasia and other cognitive disorders. Seen from this angle, one of the most striking characteristics of the bilingualism research up to date is its focus on *knowledge* rather than *practise* of languages. As mentioned previously, the question of the age of acquisition has been at the centre of bilingualism studies for a long time and many studies were confined to the classical cases of a simultaneous acquisition of two or more language in early childhood. Recently, more attention has also been paid to possible effects of proficiency (Abutalebi et al., 2013): a variable, which might interact but not necessarily overlap with the age of acquisition. In contrast, only very few studies examined the influence of the actual pattern of language use on cognitive functions.

Such an attitude might have been influenced by the important linguistic distinction between *competence* and *performance*. Particularly within the tradition of generative grammar, competence has been typically viewed as more important, with performance being often seen as random variation, a kind of "white noise", of little relevance to the fundamental theoretical questions. As formulated clearly by Chomsky at the beginning of the first chapter of his influential book "Aspects of the Theory of Syntax": "*Linguistic theory is concerned primarily with an ideal speaker-listener, in a completely homogeneous speech-community, who knows its (the speech community's) language perfectly and is unaffected by such grammatically irrelevant conditions as memory limitations, distractions, shifts of attention and interest, and errors (random or characteristic) in applying his knowledge of this language in actual performance*" (Chomsky, 1964). Although alternative models incorporating aspects of language use into mental representations of grammatical knowledge have been developed (Bybee, 2006; Hawkins, 2004), the primacy of competence remains influential.

In contrast, in medicine, the extensive literature on risk and protective factors for different diseases is usually interested not so much in the ability of doing something as in the actual behaviour. To put it crudely, the ability to swim is unlikely to have much influence on the risk of a heart attack or stroke; but the regular practice of swimming might. If the positive effect of bilingualism on cognitive functions is mainly due, as suggested by the currently dominant theories, to better developed frontal-executive functions caused by the constant necessity of a bilingual person to monitor, selectively activate, switch and suppress linguistic information (Bialystok, Craik, & Luk, 2012; Costa, Hernández, Costa-Faidella, & Sebastián-

Gallés, 2009; Garbin et al., 2010; Green, 2011), shouldn't we expect that active language use will have a more pervasive effect than passive language knowledge?

Let's return to the already mentioned paper by Kavé et al (Kavé et al., 2008). It is important for many reasons: the large number of participants included (814), the finding of an association between the number of languages and the performance on cognitive screening and the presence of a bilingualism effect also in participants with no formal education. But crucially in this context, the authors also observed that "*those who reported being most fluent in a language other than their mother tongue scored higher on average than did those whose mother tongue was their best language*". A similar association between bilingual practice and cognitive performance (controlling for non-linguistic leisure activities) was described by Perquin et al (Perquin et al., 2013). Also the LBC study (Bak et al., 2014) attempted to determine whether active use of a non-native language can confer more benefits than their passive knowledge. The differences were small, but the interpretation of the results is limited by the fact that there was very little variation in language use between the participants: almost all were using their native English by far most of the time.

A recently completed study from the Scottish islands of Outer and Inner Hebrides (de Bruin, Bak, & Della Sala, 2015) examined three groups of elderly participants. Two groups were English/Gaelic bilinguals from the Outer Hebrides (Lewis and Harris): one of them was using both languages regularly (active bilinguals) while the other spoke almost exclusively English (passive bilinguals). Both groups were compared to English-speaking monolinguals from the geographically and culturally very similar Inner Hebrides (Skye, Mull and Islay). Interestingly, the only significant difference between the groups (on a switching task) was detected between monolinguals and active but not passive bilinguals. These results merit a further investigation: since the pattern of use has rarely been assessed in previous studies,

more evidence is required to determine to what extent it can impact on cognitive performance.

Even within active bilinguals, there can be a variation in the pattern of use of their languages, particularly of switching, e.g., some might always use a specific language with a specific person or in a certain social context (e.g., family, work, shopping etc), others might mix languages even within the same conversation. It has been speculated that such difference could account for a different cognitive effect of the numbers of languages spoken in Toronto, Montreal and Hyderabad (Freedman et al., 2014). Clearly, this is an area requiring a lot more of systematic work.

The other three points in which a medically trained scientist might take a slightly different point of view from that currently predominant in the research on bilingualism and cognition have to do with the type of results to be expected. And, as will be shown below, diverging expectations can easily lead to a completely different appreciation and judgement of the available evidence. The first point has to do with the continuous and gradual character of most physiological variables. Let's take for example the much-studied relationship between physical exercise and stroke. Obviously, there is a continuum between the extremes of complete inactivity and a regular intensive exercise. Accordingly, the risk of stroke is lower in the moderate than in the low activity group and still lower in the high activity one (Do Lee, Folsom, & Blair, 2003). Quantitative differences do matter. In contrast, many papers on bilingualism treat it as a strictly dichotomous variable. In their controversial paper, Paap and Greenberg (2013) attempt to discard the idea of increased cognitive demands in bilinguals due to language monitoring and switching by stating that "*speaking any language appears to require substantial amounts of monitoring, switching, and inhibitory control*" . Surely it does, but there is a substantial difference in degree. Walking to the local market, going for a swim

and running a marathon are all physical activities, but if conducted regularly, might well have a different impact on the health profile. Suppressing an occasional inappropriate word is not quite the same as constantly switching between different phonologies, vocabularies and grammars.

Another important point is the relationship between causes and effects. In medicine, it has been recognised for a long time that in a large population minor changes in a physiological variable can generate substantial differences in outcome. For instance, one of the most widely cited studies of the effects of blood pressure on vascular diseases in 420 000 individuals reported that a minute difference of 5mm Hg in diastolic blood pressure can be associated with 34% more strokes and 21% more cases of coronary heart disease (MacMahon et al., 1990). Applied to the field of bilingualism this means that measurable differences between mono- and bilinguals in health outcomes (such as the onset of dementia) could well be associated with very subtle and barely detectable differences on laboratory cognitive tests. As will be discussed in the following section, much of the current scepticism about the possible effects of bilingualism on cognitive ageing and dementia stems from the disappointment not to have found large and consistent cognitive differences across all studies. Insights from medical epidemiology could help to put such expectations into perspective.

Finally, knowledge of medical literature might be helpful in interpreting possible effects of publication bias in bilingualism literature. Much has been made of a recent study by de Bruin et al (2014) reporting that 63% of 104 examined conference abstracts went on to be published, as opposed to only 36% of those which found null or negative results. Unfortunately, the authors do not provide us with any baseline information about the frequency of publication bias in other areas of science. Accordingly, researchers not familiar with the situation across different scientific disciplines might be tempted to jump to the

conclusion that the publication bias is particular problem of bilingualism research. In reality, the phenomenon of publication bias was identified over 55 years ago by Stirling (1959). He noted that out of 298 articles published in four leading psychological journals of his time and using tests of statistical significance, 286 confirmed the initial hypothesis and only 8 reported negative results. He concluded that similar practices can be observed across most of sciences, including biology, chemistry, medicine and physiology. In a widely cited and exceptionally thorough and systematic study, Easterbook et al examined the fate of 487 projects in medical sciences approved by the Oxford ethics committee (Easterbrook, Gopalan, Berlin, & Matthews, 1991). They found that 68% of projects with statistically significant results were presented at conferences and published. The corresponding percentage for studies with null results was 25%. Indeed, bilingualism researchers might be more aware of the methodological challenges they are facing than those in many other disciplines of science, as illustrated, among others, by recent special issues of "*Applied Psycholinguistics*" and "*Bilingualism: Language and Cognition*" dedicated to theoretical debates about the future of the field with a particular emphasis on methodological issues (Baum & Titone, 2014; Valian, 2015).

5. PRIDE AND PREJUDICE: WHO IS AFRAID OF BILINGUALISM?

As could be seen from the examples given in the previous sections, converging evidence from a wide range of studies, conducted in different countries and populations and using different methodologies speaks in favour of a beneficial effect of bilingualism on cognitive ageing and dementia. Even authors overtly critical of the idea of a "bilingual advantage" (de Bruin, Treccani, et al., 2014) have to admit that while there is conflicting evidence to what extent bilinguals might or might not outperform monolinguals on different cognitive tasks, there are hardly any studies showing the opposite phenomenon: a negative effect of

bilingualism on cognitive variables (the above-mentioned authors found only 4 such examples out of the 104 abstracts they have scrutinised).

Also neuroimaging studies support the idea of an effect of bilingualism on both grey and white matter as discussed in more detail in a different paper in this issue. Importantly, these findings are well in line with the flourishing literature on *cognitive reserve*: an influential idea suggesting that a higher level of premorbid cognitive functioning, to which physical, social and cognitive activity in middle age can all contribute, might counteract to a certain degree the effects of brain pathology, leading to a later manifestation of cognitive disorders such as dementia (Richards & Deary, 2005; Stern, 2002). In principle, the notion of cognitive reserve faces the already mentioned problem of reverse causality: does mental activity lead to a better cognitive function or are people with better cognitive functions simply more likely to be mentally active? A support for the first option comes from intervention studies, in which well documented mental training leads to improved cognitive functions (Lampit, Hallock, & Valenzuela, 2014; Park et al., 2014). If playing video-games (Anguera et al., 2013) or learning digital photography (Park et al., 2014) can lead to a measurable improvement in cognitive functions, why would we not expect at least the same from a highly complex lifelong mental activity, practised daily and involving different sounds, words, concepts, grammatical structures and even social norms (Bak & Alladi, 2014)?

In order to understand the current situation in the field it might be helpful to take a historical perspective. To start with, bilingualism is neither new nor rare. Studies of hunter-gatherer communities around the world suggest that bilingualism or even multilingualism might have been the rule rather than an exception among early human societies (Bak & Alladi, 2014; Evans, 2009; François, 2012). It survived the invention of script (Cooper, 1993) and the

formation of empires in the Ancient World (Mullen & James, 2012). Bilingualism remains a ubiquitous phenomenon across the world today and it is estimated that the majority of the world population at the moment is at least bilingual (Baker & Jones, 1998). However, by the 19th and early 20th century, negative attitudes to bilingualism became more predominant, as illustrated by an influential paper by Saer (1923). Comparing bilingual Welsh-English children with their monolingual English speaking counterparts, he describes a lower performance of bilinguals on Stanford-Binet intelligence test, on rhythmic tapping and logical reasoning and even a confusion between left and right. He attributes the mental difficulties of bilinguals to an unresolved tension between English used at school and Welsh in play. The obvious solution seems to be to abandon Welsh and indeed Saer considers bilingualism as a "*transitory stage*" through which the "*natives*" have to pass, before they abandon their own languages in favour of English. These ideas still persist. In his many travels to the Western Isles of Scotland, as well as in conversations with children of islanders living in Edinburgh, the author of the present article has encountered countless stories of native Gaelic speakers, who were repeatedly told that the best thing they can do for their children is to "*protect*" them from any Gaelic, since speaking Gaelic can only bring them disadvantages and hinder their progress in life.

Feelings of linguistic superiority might also conceal the fear of the "other", which seem to be currently on the rise across the world. In September 2002, in an essay full of references to 9/11, Osama bin Laden and the dangers of terrorism and riots, the British home secretary at that time, David Blunkett, bemoaned that, according to a survey, 30% of British Asian households speak languages other than English at home and describes speaking English with children as the way to "*overcome the schizophrenia which bedevils generational relationships*" (for full text see:

http://www.theguardian.com/world/2002/sep/15/race.thinktanks). Not surprisingly, this deep-rooted bias against bilingualism has consequences for research and its funding. Grants proposing to study cognitive effects of bilingualism can be rejected, despite positive scientific references, with arguments such as: "*it will only be relevant to a small number of people*", "*interesting hypothesis but it would be restricted in application even if it is proved*" or "*it was not clear to me that any relevant findings could be exploited effectively in the wider English speaking world where second language learning is not widespread*".

While the examples given above show to what extent the prejudice against bilingualism is still surviving to this day, the scientific research from the late 20th century onward begun to tell a very different story, that of possible cognitive advantages of bilingualism. Much of this work is discussed in other papers in this special issue/book, so here we would like to confine ourselves to two basic insights. Firstly, one has to acknowledge the pioneering role played in this research by the Toronto group led by Ellen Bialystok: as mentioned earlier, also the first person to have recognised the association between bilingualism and a later onset of dementia (Bialystok et al., 2007). But secondly, and equally importantly, cognitive effects of bilingualism have meanwhile been confirmed by many other research groups, from California (Gollan et al., 2011) through Kentucky (Gold, Kim, Johnson, Kryscio, & Smith, 2013) to Pennsylvania (Kroll, 2015), from Spain (Costa et al., 2009) and Italy (Abutalebi et al., 2011), through the Benelux countries (Perquin et al., 2013; Woumans et al., 2014) to Scotland (Bak et al., 2014) and, more recently, also in countries outside the Western World, such as India (Alladi et al., 2013) and China (Zou et al., 2012).

Given how much these findings seem to contradict the traditional (and still widely prevalent) prejudice against bilingualism, it is not surprising that they have received considerable

interest from the media. Contradiction makes good news. But the media interest can prove to be a double-sided sword. Contradicting old prejudices might easily lead to exaggerated statements. In the months following the publication of the articles about bilingualism and dementia(Alladi et al., 2013) the authors have been frequently confronted with the question: "*Does bilingualism prevent Alzheimer's Disease*?". There is a subtle but fundamentally important distinction between *delaying* something and *preventing* it. This is by no means exclusive to bilingualism. To cite again as an example the well known (and much less controversial) relationship between physical activity and stroke: physically active people are not protected from stroke, but they are less likely to get it or might get it later (Do Lee et al., 2003).

Against this background, Paap & Greenberg (2013) published a paper in which they not only report their failure to find any differences between mono- and bilinguals on executive tasks in their sample of young adults but also call into question the very existence of any effects of bilingualism on cognition. At this point in time, their work was perceived by many as important and inspiring and has stimulated a lively discussion within the field. And, as stated before, contradiction makes good news, so the debate was widely reported. Soon, studies based on a small number of participants and/or with poorly controlled confounding variables started to make sweeping claims about destroying the "myth" of bilingualism effects and setting aside 30 years of solid research. Indeed, some authors seem to have made their living out of inventing 100 ways of saying "no". The first paper questioning bilingual advantage might have been relevant and refreshing; the 20th paper repeating practically the same message is less refreshing and considerably less relevant.

In a recent paper (Paap, Sawi, Dalibar, Darrow, Johnson, 2014) the authors refer to the search for the "*brain mechanisms underlying the cognitive benefits of bilingualism*" as

"*extraordinarily difficult*". In this, we are more than willing to agree: even the short presentation of some confounding variables in bilingualism research offered in this paper makes clear not only how difficult the interpretation of individual studies can be but also that it is not possible for a single study to address all the relevant questions. However, as expressed eloquently by Titone and Baum "*all scientific domains worth studying pose comparable if not greater challenges"* (Titone & Baum, 2014). Almost all areas of clinical neuroscience that really matter are difficult, whether molecular biology, genetics, pathology, pharmacology or, even more, new fields of exploration such as stem cell research. Still, one will hardly hear the argument that research in these fields should be given up because it is "too difficult". In our view, the challenges in studying bilingualism can also be seen as an opportunity for scientific progress. By drawing our attention to potential methodological problems, conflicting evidence can help us to develop better research, diversify approaches, improve instruments, broaden the selection of examined populations and refine the theories. And the large number of potential confounding variables discussed in this paper means that by studying bilingualism we also study the complex relationship between language, human mind and brain and society: one of the most fascinating topics in all of science.

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