3

How Does Bilingualism Sculpt the Brain?

In many parts of the world bilingualism has an inevitable sociological and political dimension because it is often linked to other factors such as emigration and national identity. This leads to interested, and not entirely objective, claims about the dangers or advantages that the bilingual experience can bring. Some say 'bilingualism causes problems for linguistic development and use' or, more extreme yet, some of the great minds of a few decades ago assumed that bilingualism could result in mental illnesses such as schizophrenia. Although today such exaggerated views are not all that frequent, there are still some who warn about the damage that bilingualism can cause. This kind of claim is often used to question models of bilingual education.

On the other hand, some recent studies, which seem to indicate a more efficient development of certain cognitive abilities associated with the use of two languages, have been publicized by the media as evidence that bilingual speakers are more intelligent. This is not an entirely new opinion either, as we have seen in the previous chapter: in the 1960s, the renowned neurosurgeon Wilder Penfield asserted in an interview published in a Canadian newspaper that the bilingual brain was superior. Fifty years later, I was interviewed for a piece for *The New York Times* that made a very strong claim: *Why are bilinguals smarter?* Again, social and political agents that promote national identity in places where two languages coexist use this to promote bilingual education. In Spain, I constantly witness this polarization and the use of bilingual studies as a weapon when I do

media interviews in which there is interest in highlighting one or the other aspect, but not so often both.

The scientific question that interests us here is the effect of bilingual experience on language processing, cognition, and brain development. In this chapter, we will focus primarily on the former, and leave the issue of how the bilingual experience influences other cognitive domains for the next chapter. To analyse the effect of bilingualism on language processing, it is necessary to compare the performance of bilinguals with that of monolinguals and, like any comparison between groups of individuals (different social strata, sexes, countries, and so on), the conclusions drawn are always … delicate. To put it another way, it is not politically correct to discover that women are better at a particular intellectual activity than men, or vice versa.

To avoid confusion, let's start by stating a truism: the bilingual experience does not seem to have dramatic effects on the linguistic capacity or any other cognitive domain of individuals. We all know bilingual speakers who express themselves without apparent difficulties in their native language (and in the non-native language) or who, at least, do not seem to find it any more complicated than monolingual speakers. So we can state that acquiring a second language does not seem to have devastating effects on the use of the first one, unless, as we have seen in the case of the adopted children mentioned in Chapter 2, it is no longer used. On the other hand, bilingual speakers do not appear to be 'smarter' than monolinguals, and there seems to be no remarkable difference between their cognitive abilities. So don't worry about whether your opponent in a chess match is bilingual or not. Having stated the obvious, next we will look at several studies that show certain differences between bilinguals and monolinguals in some cognitive capacities. What is interesting about these differences is that they are useful for understanding how varied cognitive processes interact with each other. Let's start with language and answer the question of whether the bilingual experience involves some kind of difficulty in linguistic processing.

INTERFERENCE

I usually give this example to my students: Juan and David are going to play a tennis match. Juan practises tennis every afternoon for three hours, while David does so for only one and a half hours and the rest of the time he plays squash. Who do you think will win the game? The majority of the students, showing admirable intelligence and prudence, affirm that they do not possess enough information and that, surely, there are many other factors that they would have to know in order to make a sensible prediction. But I don't let them off the hook that easily, and I give them more pieces of information: Juan and David are identical in all other aspects related to tennis: they learned to play at the same age, they are equally tall, and have the same motor coordination, etc. At this point, the students bet on Juan, reasoning that he practises twice as many hours as David and that, all other things being equal, Juan should win. It's true that they also say that David can play two sports and Juan only one, but that's another story.

Chances are you have already noticed the analogy between practising a sport and practising a language. Juan practises a single sport (tennis) every afternoon, that is, one language (Spanish), while David practises two sports (tennis and squash), that is, two languages (Spanish and English). Juan is monolingual and David is bilingual. Therefore, if the analogy were valid, it would be expected that the greater frequency with which monolinguals practise their only language, compared to bilinguals, will result in differences in the efficiency with which they use it. After all, we know that the frequency with which, for example, we use words affects the reliability and speed with which we retrieve them during the speech production and we recognize them during their comprehension. Speakers tend to retrieve with more speed and accuracy words that are frequent (*table*) compared to others less frequent (*cavern*). In addition, we tend to fall into 'tip-of-the-tongue' situations when trying to retrieve low-frequency words (this would never happen to anyone with the

name of their mother). How do we know this? I will try to prove it to you. Can you tell me the name of the mythological creature that is half-man and half-horse? Tic-toc, tic-toc, tic-toc. If you came up with the name, congratulations, you can continue reading peacefully; if you have it on the tip of your tongue, let me be a little ornery and not give you the answer until the end of this section. Well OK, I will give you a clue: it starts with 'ce'.

There are several studies that have shown that certain linguistic abilities are affected by bilingualism. Bilingual speakers have a slower and less reliable access to the lexicon than monolinguals in speech production tasks. We know this thanks to experiments that have used the technique of naming what is presented in drawings: participants are simply asked to say aloud what appears on a computer screen as quickly as possible and try not to make mistakes. How long do you think it takes to start articulating the name of a picture from the time it first appears on the screen? Young speakers are able to perform this task in 600 milliseconds on average. Not bad, right? Especially if we consider that they are choosing the desired word among the thousands stored in their mental lexicon.

Bilingual speakers perform this task more slowly and with more errors than monolingual speakers, as can be seen in Figure 3.1. This would not be too surprising if this happened when we compared bilinguals naming drawings in their second language with monolinguals naming drawings in their only language, since it would not be entirely fair. After all, the fact that bilinguals were less efficient in their second language is not surprising, since we often find differences among the bilinguals themselves with respect to their performance in the first and second language. In addition, we also know from other studies that there is a negative correlation between the age at which words are learned and the speed and accuracy with which they are processed; for earlier ages of acquisition, this is faster and more accurate. What is more surprising is that the difference in efficiency between bilinguals and monolinguals is also observed when they both name drawings

in their first language (the only one in the case of monolinguals). This happens even for highly proficient bilinguals. It is true that the difference between one and the other is not very large (around 30 milliseconds), but the picture-naming exercise is relatively easy. We do not yet know how a difference of this size can be magnified (or reduced) by evaluating the verbal behaviour of speakers in more complex linguistic situations.

To be fair and more precise, it can be said that these differences arise to a greater extent for words that do not resemble their translations in the other language (*table* in English; *mesa* [*table*] in Spanish); they are what we call 'non-cognate words'. However, words that are similar (*guitar* in English; *guitarra* in Spanish) are not as susceptible to the slowdown associated with bilingualism.

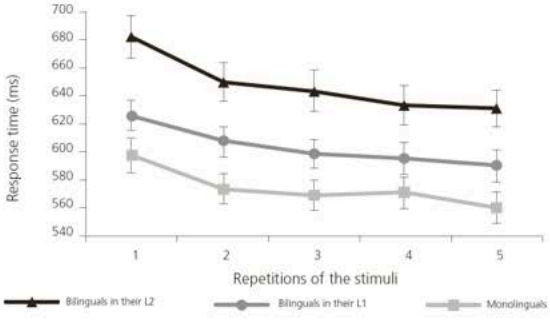

Figure 3.1. Results of bilingual and monolingual speakers naming drawings in the first and second languages. On the vertical axis, the response time is represented in milliseconds: the slower the time, the higher the line is. On the horizontal axis, the various repetitions of the stimuli are represented. As they repeat the task, the response time decreases. However, the difference between the three conditions remains constant.

Other proof that access to the lexicon is less efficient in bilingual speakers comes from the observation that they tend to fall into tip-of-the-tongue states more often than monolinguals. As you can imagine, these studies are complex, because they are difficult to orchestrate. Tamar Gollan from the University of California, San Diego, has found a way to do so by presenting a series of definitions of low-frequency words and asking the participants to say the corresponding term aloud; basically the same thing I did earlier with the name of the mythological animal. In addition, and surprisingly, this tip-of-the-tongue state happens even when bilinguals are allowed to say the corresponding word in either of their two languages. That

is, it does not seem that this difference is due only to one of the languages blocking access to the other.

Some of the activities that are very often used to evaluate the linguistic capacities of a patient with brain damage are those involving verbal fluency. The activity is very simple and you can practise it with anyone (I think there was once a TV game show that did it). Here are the instructions: 'Please name as many animals as you can in a single language in a minute and without repeating any word.' This task requires quick access to the lexicon, as well as control over what has already been said to avoid repetition. It has also been shown that bilingual speakers list fewer examples than monolingual speakers, which would suggest that their access to words is more costly.

These results, among others, would suggest that the bilingual experience affects the efficiency with which lexical access processes work. These effects can be due to the differences in the frequency of use of each language, or also, in some cases, to the interference that a second language can cause during first-language processing. That interference, as we have discussed in the previous chapter, results from the fact that bilingual speakers cannot turn off the language that is not in use. Just look at, for example, the verbal fluency exercise that I have just described: we have to avoid producing words in another language, and to do so the bilingual speaker has to continually block the possible interference that these words could create. Therefore, under a situation of temporary pressure, in which we have to say as many words belonging to a specific category as we can within a limited period of time, it is possible that this interference results in a poorer performance.

There are other examples of this in which it is evident that the use of a language can have negative effects on the recovery of the other language's representations later on. Imagine that we asked a group of bilinguals to name a series of drawings in their second language. After that, we ask them to name those same drawings in addition to new ones, but now in the first language. In principle, one might think that in this second task the reaction would be faster for the drawings

that had already appeared, since, at least, it would be easier to recognize them. Well, as it turns out, it is not. The activity seems to be more costly for the drawings that appeared before than for those that were newly added. It is as if having named something in a second language makes it difficult for us to do so in the first, which would suggest the appearance of interference between them or, if you will, how costly it is to recover from the inhibition exerted during second-language production. We mentioned a similar finding when we talked about asymmetric costs associated with language switching in Chapter 2.

Let us now consider the effects of the tip-of-the-tongue state. As we have seen, when we fall into a state like this, it is usually in situations in which we try to retrieve a word that we do not use often or is of low frequency. It is reasonable to think that the regularity with which the bilingual uses the words in each of their languages is less than that of the monolingual. To put it more simply: all the time I spend using English, I am not using Spanish. Therefore, we could say that for a bilingual, there are more words of low frequency than for a monolingual, and since those are the ones that can make us fall into a tip-of-the-tongue state, a bilingual is more likely to suffer from this phenomenon in both languages.

It must be noted, however, that the magnitude of the effects described above is not dramatic and that there is much variability within each group of speakers. Let's put it another way: we cannot make good predictions about the verbal behaviour of an individual based only on their bilingual status, since there are many other variables that will affect their linguistic performance. The effect that bilingualism can have on linguistic efficiency is only one factor, but there are many more. Returning to the analogy between practising tennis and linguistic competence: my students were smart and cautious in saying that they lacked information when they only knew the number of hours Juan and David practised, and that, therefore, they could not guess who would win the tennis match. Furthermore, we should be cautious when making statements

about the linguistic capacities of specific people, be they bilingual or monolingual. And now I will fulfil my promise and relieve those of you who have fallen into a tip-of-the-tongue state from the question of naming the half-man, half-horse mythological being. It is a centaur.

OUR MENTAL DICTIONARY

Another effect that seems to be associated with being bilingual has to do with a possible reduction in vocabulary size. Do bilinguals really know fewer words than monolinguals? Let's walk through this carefully and start from the beginning.

The ability to learn new words remains open throughout life and, in fact, we never stop doing it. That is, like other language-related skills, such as the acquisition of new sounds, that are dramatically reduced with age (remember the phenomenon of perceptual adaptation discussed in Chapter 1), ageing does not seem to affect learning new lexical items too much. Think about the words added to the Oxford Dictionary in June 2018: antwacky, beerfest, binge-watch, cromulent, Facebook, first-wave, gabster, heteroglossia, hip-pop, impostor syndrome, indica, lab rat, pansexual, piffy, sativa, screed, scrid, scrim, scrum-down, silent generation, spad, twine, ungendered, unween, walkative. Given that it is difficult for dictionaries to add new words unless speakers use them on a daily basis, you may know some of them, but you may also have only learned them recently. I must confess that I did not know several of them, such as *impostor syndrome* and *gabster*, so today I have already learned two. The number of new words that we are acquiring depends on the linguistic richness to which we expose ourselves. In other words, it is difficult to learn new words when language experiences are reduced to sports articles and talk-shows on TV; other types of activities are more stimulating and linguistically – and cognitively – challenging, and I kid you not.

Knowing that this ability is present throughout life, have you ever wondered how many words you know? Two thousand, 10,000, 20,000 … well actually it's quite a bit more. According to

some calculations, a speaker with higher education usually knows about 35,000 words. That's not bad, right? Obviously, this does not mean that we use most of them on a regular basis; in fact, we only use around 1,000 words on a daily basis. (Don't be disappointed: Cervantes is said to have used a total of about 8,000 words in all his works.)

Let's pause for a moment and analyse a recent study that estimated the size of the vocabulary of Spanish speakers, which I think wonderfully exemplifies how we can use new technologies to answer interesting questions. That was the purpose of a study that involved my colleagues Jon Andoni Duñabeitia and Manuel Carreiras at the Basque Centre on Cognition, Brain, and Language (BCBL). Taking advantage of the fact that the vast majority of us have a cellphone, tablet, or computer with an internet connection, the researchers launched a platform where in just four minutes a good estimate of the user's vocabulary level could be elicited. You can check it by searching for the vocabulary test put together by Ghent Univesity. The task proposed is quite simple: a series of strings of letters appear on the screen and the participant must indicate whether each corresponds to a real word in the language being tested or not, a test which we call a *lexical decision task*. It seems easy, but hold on for a second. We all know that *home* is a word and that *hofe* is not. But what about *abstemious*, *ocubavious*, *aplomb*, and *oclomp*? I will not make it that easy by just giving you the answer, for the time being.

One of the virtues of this task is undoubtedly the agility with which it can be completed, since every time a user starts it, the system randomly creates 100 strings of letters drawn from a database of almost 50,000 real words and invented words. If we add to this random sampling the easiness of performing the test on devices that we handle every day, within just a few weeks of launching there can be hundreds of thousands of people taking it. Knowing the percentage of success of each of the participants, we can estimate the average size of the vocabulary of a speaker type, let's say a speaker of Spanish (the way the index is calculated is a little more complicated, but this

is sufficient for our purposes here). As seen in Figure 3.2, the number of words we know increases as we get older (so it might not be a fair match for you to play *Words with Friends* or *Scrabble* with your grandfather). By the way, *abstemious* (referring to moderation in eating or drinking) and *aplomb* (meaning self-confidence) are real words; *ocubavious* and *oclomp* are not.

Now, there are two considerations that we must make before moving on to discussing the effect of bilingualism on vocabulary development. First, there is always time to learn new words and, in fact, we do this continuously, even if we do not realize it. Second, the richness of our vocabulary is related, to a large extent, to the exposure we have to contexts in which the use of new words is more frequent.

Several studies have shown that bilingual individuals have a smaller vocabulary in their two languages than monolinguals. Consider, for example, the studies of Ellen Bialystok and colleagues at York University in Toronto. In one of these studies, the receptive vocabulary of almost 2,000 children between the ages of three and ten was explored. *Receptive vocabulary* refers to words that are recognized when we hear them and from which we can identify the meaning, regardless of whether we use the word habitually. To carry out this experiment the researchers used a standardized test for different ages called the Peabody Picture Vocabulary Test, which they administrated to monolingual children of English and bilingual children of English and various languages. The vocabulary score was higher for monolingual children of all ages. Interestingly, the kind of words in which monolinguals tended to outnumber bilinguals were used mostly in domestic contexts. And when the vocabulary that is used in school was evaluated, the difference between the two groups disappeared. It makes sense, right? After all, in the school context all children were exposed to the same words (at least in this study). This last detail is important, since the size of the school vocabulary is a good predictor of academic performance. The fact that there was no difference in

school vocabulary would suggest that bilingual children would not be affected in their school performance. In any case, this study and other subsequent work have shown that the reduction of the size of the lexicon for bilinguals extends on into adulthood, from twenty to as much as eighty years.

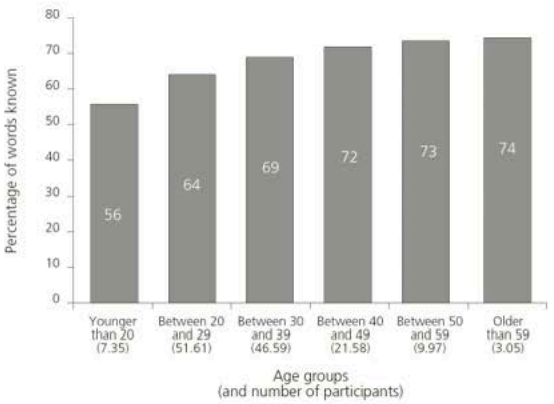

Figure 3.2. Percentage of words known to participants according to age ranges. As you can see, the percentage increases with age. The number of participants for each age group is presented in parentheses.

These findings have to be interpreted with care and, as you can imagine, they are the perfect ammunition for those who are against bilingual education. First, we have to look at how large the difference is in vocabulary for bilinguals and monolinguals, something we call the *magnitude* or *effect size*. Let me explain: imagine that we take a cold medicine that, according to proven studies, shortens the duration of the symptoms. In other words, when we randomly administer this medicine to one group of patients and a placebo to another group, the symptoms of the cold generally disappear earlier in the first group compared to the second. Perfect; we're convinced, let's go buy the medicine. But wait a minute. Ask yourself how much the symptoms are reduced, that is, consider not so much whether the medicine is effective, but *just how* effective. If it turns out that the symptoms will last two days less, you may want to buy the medicine, but if they will only last two hours less, you may want to think again (after all, you will have a cold for almost the same time with or without the medicine). With vocabulary reduction, the same thing happens: the result of the test from the aforementioned study has an average of 100 and a standard deviation of 15. This basically means that the majority of children score between 85 and 115. But what is the average of bilingual children? Between 95 and 100. And that of monolinguals? Be-

tween 103 and 110. That is to say, all are very close to the average of the general population. Therefore, it is true that there is a reduction in the size of the vocabulary associated with bilingualism, but this is relatively modest.

On the other hand, we may be tempted to apply the group norm to particular individuals and think, for example, that if our child grows up in a bilingual environment, his vocabulary will necessarily be smaller than if he grows up in a monolingual environment. Stop right there; applying a group norm to an individual is inappropriate and, in this specific case, even less so. Let's look at Figure 3.3, which shows the distribution of scores for bilingual and monolingual children on a vocabulary test. On the horizontal axis we find the test scores, and on the vertical axis we see the percentage of children who obtained those scores.

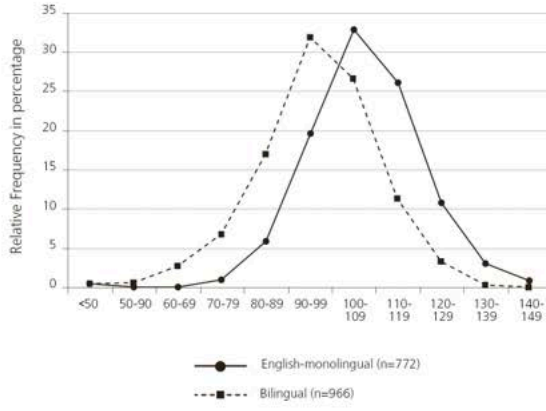

Figure 3.3. Distribution of vocabulary scores for bilingual and monolingual speakers.

The higher the point of each line, the higher percentage of children received the range of vocabulary scores shown on the horizontal axis. For example, we see that there are about 7 per cent of bilingual children who scored between 70 and 79, and that there are only about 1 per cent of monolingual children in that range. We can also observe that the majority of monolingual children scored between 100 and 120, while most bilinguals scored between 90 and 110. Therefore, the average score for each group is different, being higher for monolinguals. In other words, monolinguals generally know more words. But we already knew that. However, what is striking about

this graph is that there is a great overlap in the distribution of scores between the two lines, that is, between the scores of monolingual children and those of bilinguals. This means that there are many bilingual children who score higher than their monolingual counterparts. For example, there are bilinguals who score between 110 and 119 and monolinguals who score between 90 and 99. If we took, then, a random bilingual child, say, my son, it is clear that he should not necessarily have a smaller vocabulary than a monolingual child nor, in fact, than the average monolingual group. And why is that? As we have said before, the size of the vocabulary depends on many other things beyond bilingualism. If our linguistic experience is more focused on sports articles and talk-shows than on *National Geographic* and scholarly works, it is difficult to write like Cervantes or Shakespeare.

But what if it turns out that bilingualism leads to problems in the mechanisms involved in word learning? That is, what if this reduction in vocabulary was not due to the frequency with which the children use words in each of their languages, but rather to some sort of linguistic interference that negatively affects the formation of lexical representations? As we have already noted in Chapter 1 when we were talking about babies, this does not seem to be the case, since basically bilingual individuals know more words than monolinguals if we add together all words in both languages. It makes sense, because for many words the bilingual will also know their translation equivalents, regardless of how different they may be. It seems that bilingualism does not interfere with the formation of lexical representations and, therefore, with the acquisition of words. Most likely, the reduction in the vocabulary associated with bilingualism has more to do with the frequency of use and the likelihood of exposure. The greater these two factors are, the more likely we are to encounter new words that we must learn. It is reasonable to think that, all other variables being constant, bilinguals are less exposed to each of their languages than monolinguals and, therefore, less likely to encounter low-frequency words.

What is not used tends to be either not learned or forgotten. But let me be clear that bilingualism is only one of the variables that can affect vocabulary size and even so, it is likely not the most relevant.

Before moving on to the next section, I would like to highlight one of the practical consequences of these studies. Many tests looking at linguistic development among children and linguistic assessment for patients with brain damage are standardized considering the verbal behaviour of monolingual speakers. That is, the standard with which we compare the performance of a particular person comes from monolingual speakers. Comparing and contrasting a bilingual's capacity to this referential group can lead to confusion and misdiagnosis, since the comparison is not even adequate when evaluating the vocabulary of the bilingual in their first language. So do not worry too much if your bilingual children do not score extremely well on a vocabulary test; maybe they are not having learning problems, but are being measured with the wrong scale. In fact, it is possible that they are learning more words than other monolingual children but, of course, in two different languages.

I believe that up to now I have fulfilled my promise to not give advice, but allow me some liberty here: if you really care about the development of your children's vocabulary, then expose them to a rich, stimulating, and challenging linguistic environment. As the pedagogue and writer Amos Bronson Alcott said, 'a good book [is one] which is opened with expectation, and closed with delight and profit'. Do not worry about which language you read to them in; but if it is in both, all the better.

BILINGUALISM AS A SPRINGBOARD FOR LEARNING OTHER LANGUAGES

Perhaps you have heard before that people who speak two languages have an easier time acquiring a new one. Is this another urban legend? Given my not-so-strong ability to learn languages, I have always been intrigued by this assertion, which, in my view, has an interesting and trivial side. The trivial view is that

if a bilingual speaker is faced with a new language that is in some aspects similar to one he already knows, it might be easier to acquire those similar aspects. I lived for a year in Trieste and, although I never received formal classes, I was able to understand a good number of words in Italian. It was evident that from my knowledge of Spanish and Catalan, learning Italian would be relatively easy for me, and I say this because, as I said, my skills in this regard are quite modest. But of course, most of the words were familiar to me: if I came across one that was not similar to Spanish (*donna* and *tavola* in Italian are *mujer* and *mesa*, respectively, in Spanish), it was very possible that it was similar in Catalan (*donna* and *tavola* in Italian are *dona* and *taula*, respectively, in Catalan), and vice versa. Italian shares many cognate words with Spanish and/or Catalan; that is, words that have a common origin and maintain a formal similarity. It's true that some other Italian words were not similar to any of my languages (e.g. *quindi* in Italian means something like *por tanto* [*therefore*] in Spanish). There were also false cognates, or very similar words that do not mean the same (*gamba* in Italian means *leg*, but in Spanish *gamba* means *shrimp*), but that is another story. In any case, my knowledge of Spanish and Catalan – two languages that were similar to the new one (Italian) – obviously gave me a greater advantage than if I had only known one, either one of them; that is, if I had been monolingual. Notice that here I have focused on word similarity between several languages, but the same argument, or one even more substantiated, can be extended to the acquisition of the phonological repertoire of a new language or its grammatical properties (remember, for example, the problems that English speakers have when learning the grammatical gender of Spanish words). That is, the similarity between languages can help to transfer certain properties from those we know to new ones. Although this can sometimes lead to a certain confusion, in many cases it favours learning. This confusion is often found at times such as when we are faced with false cognates (*terrific* in English has nothing to do with *terrorífico* [*terrifying*] in Spanish) or

when we do things like transfer the grammatical gender from the words of one language to another (*sonne* [*sun*] in German is feminine but *sol* [*sun*] in Spanish is masculine; *mond* [*moon*] in German is masculine but *luna* [*moon*] in Spanish is feminine). In any case, the most interesting aspect derived from the question of whether the knowledge of two languages can favour the learning of a third language has to be separated from the extent to which it comes from the similarities between the languages in question. This is the trivial view; let's now go to the more interesting part of the claim.

Some studies have shown that adult bilingual speakers are better than monolingual speakers at acquiring words from a new *invented* language. In one of these studies, led by Viorica Marian at Northwestern University, researchers taught words from an invented language to three groups of participants: English-Mandarin bilinguals, Spanish-English bilinguals, and English monolinguals, by presenting the invented words paired with their English translations. For example, they had to learn that *cofu* meant *dog* in the new language. Why an invented language? Because this way the researchers could ensure that the similarity between the new words and those in English, Mandarin, and Spanish was minimal. That is, the possible transfer between the properties of the languages of origin and the new language could be controlled. The results showed that both groups of bilinguals were able to learn more words than monolinguals and, in addition, this advantage was maintained at least one week after the learning session. We still have to investigate the mechanism that allows for this advantage. This will help us to know to what extent this occurs in all types of bilinguals or only those who learned their two languages in childhood, as was the case in the study presented here. In any event, what we know so far is that it seems likely that the knowledge of two languages helps to develop certain mechanisms that are put into play during the acquisition of words from a subsequent language.

Similar observations have been obtained in contexts outside the laboratory, such as the English

school performance of bilingual and monolingual children in the writing and the morphological and orthographic knowledge of that foreign language.

We have not yet explored an area where I think it is very likely that we will find differences between bilinguals and monolinguals with respect to the acquisition of a new language: linguistic control. As we saw in Chapter 2, acquiring a second language and being able to use it requires learning how to control it. In this sense, when a bilingual and a monolingual face the acquisition of a new language, it is reasonable to think that the former has already developed some control processes that they can apply or transfer. Let me make the following analogy: when faced with a new language, the bilingual has to learn to juggle with three balls, already knowing how to do so with two, while the monolingual has to learn from the beginning. It is reasonable to think that the bilingual may have an advantage in this case. In fact, some results from the language-switching paradigm presented in the previous chapter would suggest that this is the case.

Remember that switching to the dominant language is more costly than switching to the non-dominant one, although this applies when there is a clear difference between the mastery of languages. In speakers with a good command of both languages, no such asymmetry is observed, and the switching cost is equal for both, which is, to a certain extent, logical. Thus, if we ask a highly proficient bilingual to carry out a language-switching task according to the colour of the border in which the drawings appear, in one of their dominant languages and in a third language that they do not know as well, we should find new asymmetrical switching for these languages. As it turns out, this is not the case: the pattern of switching cost between the dominant language and a third language is exactly the same as when the bilingual performs the task in his or her two dominant languages. It is as if he or she were applying the same linguistic control mechanisms regardless of language dominance. And this could give an advantage in the use of a third language – not so much in learning it, but in how to use it and

control it, which will be reflected in the fluidity with which it is spoken.

EGOCENTRISM AND THE PERSPECTIVE OF THE 'OTHER'

Do you remember the last time you asked someone on the street how to get to a certain place? This is a response that may be familiar: 'Cross this street here, then turn right, when you find the second roundabout, take the third exit, and then turn right on the second street and you have arrived!' Do you ever have the feeling that it would be better to not have asked at all, as expressed in the cartoon below (Figure 3.4)? When someone gives us directions of this kind, the speaker has in his mind a map of the route that we should take. So he has the advantage of being familiar with all the places that you have to pass by. But for you, the question is more complicated, since you lack such a map in your mind and you have to build it according to how the other person describes. A small mistake in your mental map such as a turn to the right instead of the left, and that's it, you are lost.

Figure 3.4

This cartoon exemplifies how difficult it sometimes is to have clear communication, partly because the perspective of the one giving the directions is different from the one who receives them. When we communicate with someone, it is essential to know the perspective that the listener has of the context. We must put ourselves in the place of the other, and try to guess what they know about the subject we are talking about, and to what extent our point of reference is common. Otherwise, communication becomes very difficult. Think, for example, how many times mistakes are made when an appointment is made with someone who is in another time zone. You set a time to talk at six. But is this six o'clock for our interlocutor who is in London or for the other person in Madrid who is an hour ahead? What is the point of reference, ours or the other person's? We

have to establish a common point; if not, we will be lost again. When we hold a conversation, it is as if we were dancing with someone. It is a collaborative activity in which our movements depend on and continually combine with what the other does. Interlocutors do the same when they talk. Well, if they want to be understood.

Being able to put ourselves in the other's place is difficult, and in fact we often do so with what is called 'egocentric bias', or the tendency to think that the other person has the same information and perspective as we do about a specific situation. Basically, if I see it one way, I think that you do too. As it turns out, the bilingual experience seems to help develop the ability to put oneself in someone else's shoes. Let's look at a study carried out by Katherine Kinzler and Boaz Keysar at the University of Chicago, because it will serve as an example of how to study a speaker's perspective. The experiment is simple and ingenious.

Two people participate in the study. One is called 'the director', who is on par with the experimenter in the sense that he knows what the experiment is about and follows the instructions. The director must give directions to the other person, who is the naïve or innocent participant (he does not know the purpose of the experiment). It is precisely the behaviour of the latter that we are interested in studying. The two subjects are separated by a 4 x 4 grid in which there are several objects (see Figure 3.5). Some of the objects that the participant sees, however, are not visible to the director. This information is known by both the director and participant. Therefore, from the participant's perspective, there are objects that he sees and he knows that the director cannot see. We call the stimuli that only the participant can see *distractors* and you will soon find out why. Imagine that the director asks the participant: 'Please, give me the small car.' From the participant's perspective, he can see three cars, one small, one medium, and one large and, therefore, he should give the director the smallest one. However, here is the trick: from the perspective of the director, the small car is covered and, therefore, he cannot see it.

The naïve participant knows that from his perspective, the director cannot see the small car, he can only see the big one and the medium one. Thus, when the director asks for the small car, it is impossible for him to refer to the smallest of the three, since he can only see two, the big one and the medium one. Therefore, the director must be referring to the medium car, which, from his point of view, is the small one. Basically, the idea is that the director sees fewer things than the participant, and he knows this. The question then is: what will the participant do when the director asks him to give him the small car? If he were able to take the director's perspective, he would have to give him the medium car. Something to the effect of the following must be going through his mind: 'The director is asking me to give him the small car. I see that there are three cars and, therefore, I should give him the smallest of the three. Of course, I also know that the director only sees two cars, the big one and the medium one, and therefore, when the director asks me for the small one, he is referring to the one I see as medium.' Easy, right? But if the participant suffers an egocentric bias and does not adopt the perspective of the other, he will give the director the smallest car of the three, because from his point of view (and that is the crucial thing, from *his* point of view) this is what the director is asking for.

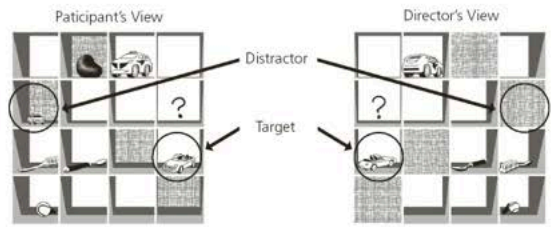

Figure 3.5. Position of objects from the perspective of the researcher and the naïve participant. As can be seen, there are some objects that are only visible to the participant and therefore it is impossible for the director to take them into account. That is, he can never refer to them, because he does not know that they exist.

Children who are naïve participants have problems performing this task. Very often they show egocentric bias and give the object in question from their perspective and not that of their interlocutor. And here comes the interesting discovery: it turns out that monolingual children between four and six years old choose the

wrong object about 50 per cent of the time, whereas those children who have grown up in a bilingual environment do so about 20 per cent of the time. Furthermore, regardless of whether the children performed the task adequately or not (whether they gave the right object to the director from the latter's point of view), the authors evaluated where their gaze was directed right after hearing the instruction. That is, they measured their first reaction. As it turns out, monolingual children tended to look more often at distracting objects. That is, their first evaluation of the situation was egocentric. But there is another surprise yet: better performance by the bilingual children occurred regardless of whether they currently used the two languages or not. It was enough to have grown up in a bilingual context to show this better performance.

These results suggest that children who grow up in contact with two languages develop the ability to put themselves in each other's shoes earlier and change their perspective to that of their partner. So, the next time you ask for directions, let's hope you ask a bilingual person.

The origin of this greater capacity to put oneself in the perspective of the interlocutor may be related to the earlier development of the ability to see the intentions of the other, or what we sometimes call *mind-reading*. Do not panic, this has nothing to do with clairvoyance, fortune-tellers on TV, or other hoaxes like that. We are all reading the minds of others continuously. We know that others have intentions, desires, and knowledge, and that they are private and perhaps different from our own. It is essential to develop, for example, empathy, or the ability to put yourself in the shoes of others. To put it simply: we know that others have minds like ours and that the information in them can be shared or not. The development during childhood of what has been more formally called 'theory of mind' is fundamental. It not only allows the ability to empathize and is crucial for socialization, but also permits, among other things, the ability to lie. As one of my teachers said: rejoice when your son lies to you, but only the first time.

It turns out that there is evidence to suggest that children exposed to two languages show theory of mind development earlier than monolinguals. But how is it possible to explore children's ability to read the minds of others? Let's take a look. In a study conducted in Italy, the false-belief test was used. In this experiment, the researcher explains the following story to the children: 'A boy puts a chocolate bar in a red container in the kitchen and then returns to his room to play. While the boy is playing, the mother enters the kitchen and moves the chocolate bar into a cardboard box.' Then the researcher asks: 'When the boy returns to the kitchen for the chocolate bar, where do you think he will look for it?' The answer for you is clear: in the place where he left it, the red container. In order to answer correctly, the participant must understand that for the child in the story, everything that has happened in the kitchen when he was playing in his room is unknown and, therefore, he would have to look for the chocolate bar in the place where he left it, in the red container, and not where it is at the moment, in the cardboard box. But to respond to this answer, the participant has to put himself in the place of the child in the story, he has to contemplate the perspective of the other. He has to differentiate what he knows from what the child in the story can know. In short, the participant has to be able to separate himself from the content of his own mind in order to read the mind of the other. It turns out that many children up to the age of four fail in this task and believe that the child will look for the chocolate bar where it is actually located at that moment, in the cardboard box. It's as if they thought: 'I know the chocolate bar is in the box and, therefore, the child in the story will also look for it there.' The results of this study showed that at approximately four years old, around 60 per cent of Romanian-Hungarian bilingual children performed the task correctly, whereas only 25 per cent of Romanian monolingual children responded successfully. Surprising, isn't it? Bilingual children seem to develop a 'theory of mind' earlier than monolinguals.

But where does the effect of bilingualism come from in the

development of the capacity to put oneself in the place of the other? Perhaps it is due to the need for the bilingual baby to differentiate between the sounds made by the parents. In other words, if the child has seen his parents speak in different languages from a very young age, maybe that will have helped him to hypothesize that his parents' minds are different to a certain extent. And if his parents' minds are different, then his must also be. It is precisely this that could help the development of theory of mind. But this is only a hypothesis.

Fortunately, as adults we are all able to pass the false-belief test. This does not mean, however, that we all have the same ability to take perspectives different from our own and put ourselves in the place of others. I am sure that I do not have to present any experimental data to convince you that there are more and less empathic people in the world. But I think you will be surprised to learn that in more complex tasks about false beliefs, bilingualism still seems to have an effect in adulthood by reducing the egocentric bias.

BILINGUAL VERSUS MONOLINGUAL BRAINS

This brings us to the evidence we have about how the bilingual experience can sculpt the anatomy and the functioning of some cerebral structures and circuits.

Any learning that we carry out has an effect on our brain. Learning is possible thanks to the plasticity of the brain, which involves the creation of new connections between neurons as a consequence of storing new information. Throughout life we learn factual or declarative information about the world around us: words, phone numbers, land masses, the ingredients of an omelette, our city's streets, the rankings of our favourite teams, the names of the elements of the periodic table, that cod and rice is better if the rice has peas in it, and so on. This type of information is what we often say is *learned by heart*, and we see how, as some neurodegenerative diseases progress, it disappears. But we also learn how to do things: to walk, cycle, swim, drive a car, speak and

read, and so on. This is what we call procedural information, which is what allows us to carry out highly automated activities.

Learning a language involves the absorption of these two different types of information, since on the one hand, we have to acquire the lexical items (vocabulary) and on the other, the grammatical processes to combine them (syntax). But how does the acquisition and use of two languages affect the brain? In other words, is there a difference between the brain of bilinguals and that of monolinguals in terms of the neural network responsible for processing language(s)?

Neuroimaging techniques have been fundamental in answering this question. At the functional level, several studies have shown that there are differences between the activation levels of certain areas of the brain when bilingual and monolingual individuals process their first language. It is important that it is the dominant one, because what interests us here is not so much the processing difference between a first and second language (we already discussed that in Chapter 2), but to what extent the processing of the first language is different among bilinguals and monolinguals. Returning to the analogy of the sports practised by David, squash and tennis, the question is how the learning of two sports affects the cortical representation of the one that was first known, that is, how learning squash affects the cortical representation of tennis.

Perhaps the most complete study on this issue was conducted by Cathy Price and her collaborators at University College London, in which the brain activities of highly proficient Greek-English bilinguals and monolingual English speakers were studied across various linguistic tasks. The results showed that brain activity in language comprehension tasks, such as speech perception, was very similar for both groups. However, those tasks that involved the language production system, such as picture naming or reading aloud, *did* reveal differences. Specifically, bilinguals showed greater activation in five areas of the brain located in the left frontal and temporal lobes. I don't want to bore you with the details

about the specific interpretation the authors make about each area. I will only mention that other studies suggest that these same areas of the brain are related to effects of frequency of use and linguistic control. What is important to note is that, at least in this study, no significant differences were observed in the areas that were activated in bilinguals and monolinguals. To a large extent they were the same, although, yes, with greater intensity for bilinguals. These results were interpreted by the authors as evidence that, either due to the lower use of each of the languages or the need to control interferences (or both reasons), bilingual speakers require a certain overexertion during speech production compared to monolinguals. Other studies carried out with different groups have shown similar patterns and, in fact, are even stronger when second-language proficiency is low. These results suggest that the learning and use of a second language does not radically affect the brain representation of the first language, but it does affect the effort required for its processing, especially when speaking.

However, other studies have shown the existence of certain unique characteristics related to bilingualism. For example, in a study conducted at Jaume I University by César Ávila and colleagues, the brain activity of Spanish-Catalan bilinguals was compared to that of Spanish monolinguals while performing various tasks in Spanish, their first language. Similar to what we saw above, the differences between the groups were very small when the activity involved auditory word comprehension. Yet when participants were asked to name drawings, it was observed that bilinguals tended to use a wider brain network than monolinguals. In other words, bilinguals incorporated areas of the brain that were not deeply related to linguistic processing. This could support the existence of certain areas of the brain, located mainly in prefrontal areas, that only bilinguals use during speech.

These results reveal that the cortical representation of a bilingual's first language is, in general, quite similar to that of the monolingual one. The classic areas where language processing takes place

are involved in both cases. But this does not mean that bilingualism does not affect how those areas are utilized and, as we have seen in this case, it is possible that some of these areas simply have to 'work harder'. So it seems premature to discard the idea that there may be certain areas that are activated more in bilinguals. And it is very possible that these areas have to do with control processes and not so much with the representation of linguistic knowledge.

STRUCTURAL CHANGES

In the previous section we described studies that measure brain activity during different linguistic tasks. Learning and using two languages seems to have not only functional consequences, but also implications for brain structure. By 'brain structure' I am referring to and encompassing the density or volume of basically two kinds of tissue: *grey matter* and *white matter*. Simply defined, the density of grey matter is the number of neuronal bodies and synapses present in a given space of the cerebral cortex. White matter refers to nerve fibres covered with myelin, basically those that include myelinated axons. These fibres are fundamental for transmitting information between neurons, and myelin acts as an insulator that allows nerve impulses to be efficiently transmitted (like the plastic that covers an electric cable). To put it another way (and neurologists, please don't get upset by the analogy): grey matter is that which computes information and white matter is the cable that is responsible for transmitting that information from one place to another.

It turns out that the density of grey and white matter can be altered by learning a new skill. For example, a study published in *Nature* showed that training in juggling resulted in various changes in grey matter of areas of the brain related to the processing and storage of complex visual-motor information. Other studies have shown that such modification occurs after only one week of training. Another more recent study published in *Nature Neuroscience* identified the effects of juggling training on the architecture of white matter. Learning modifies the brain, so in a

way, we could say that knowledge does occupy a place, or at least modifies the structure of that place in terms of brain architecture.

In fact, we also know that it is not necessary to participate in training to alter the structure of our brain, and that daily activities can also result in some modifications. Perhaps the most well-known case of this issue is a study in which the brain structures of a group of taxi drivers in London with an average of fourteen years of experience were compared with those of a control group that, although it shared many other variables, did not have experience of taxi driving. Keep in mind that at the time the study was conducted, the use of technology to help with directions was not as widespread as it is today and, therefore, the drivers needed to learn the London map by heart. The authors observed that, curiously, taxi drivers had a greater volume of grey matter in the area closely related to the storage of spatial representations, the anterior part of the left and right hippocampus. In addition, this greater volume correlated with the years of experience at the wheel: more years, more volume. That is, with more experience, there was more grey matter. These results suggest that activities that we carry out daily have an effect on brain structure. Our behaviour and learning sculpt the brain.

The question is whether the acquisition of two languages affects in some way the cerebral anatomy or, if you will, the brain's *structural architecture*. Notice that I use the term structural architecture to differentiate it from the brain's *functional architecture*, which we discussed in the previous section. In the first study that analysed this question, Andrea Mechelli and her colleagues compared the structure of certain areas of the brains of monolingual and bilingual speakers, and showed that one area in particular, the left inferior parietal lobe, had a greater density of grey matter in bilinguals than in monolinguals. This happened both when the second language had been learned in childhood and when it was learned later on. In addition, bilingual individuals with a more extensive vocabulary in the second language also showed greater density in that area of the brain. These

results led the authors to suggest that learning second-language vocabulary has consequences on the development of the grey matter of that particular area of the brain.

The plasticity of certain areas is not only reflected in the acquisition of new words, but also sounds, as suggested by the observation that multilingual speakers have a greater density of grey matter in the area involved in articulation and phonological processes, namely the left putamen. Thus, a more extensive phonological repertoire and the need to control the articulatory movements of each language would affect the structure of the areas responsible for these representations.

Studies that compare the brain structure of monolinguals and bilinguals face a problem when they try to give a causal interpretation to the results. It's like the chicken or the egg problem. We cannot be sure whether the bilingual experience sculpts the brain in a certain way or whether those individuals with a special type of architecture are the most prepared to learn a language and, therefore, have more facility to be bilingual. If this were so, growing up in a bilingual environment would not affect brain structure, there would simply be a relationship between both variables, but not causal. To explain it in more practical terms: if we compared the average height of basketball players to that of soccer players, we would see that it is different, but that does not mean that practising basketball makes people taller or that playing soccer makes them shorter. It is precisely because they are tall that they play basketball and, continuing with the analogy, given that some individuals show larger grey-matter density in the relevant areas, they are more able to learn a second language successfully and become bilingual.

There are two ways to solve the causal interpretation problem. The first is to evaluate individuals who are bilingual not because they have learned the second language in a regulated manner (e.g. in school) but because they were born or lived in bilingual environments. That is to say, a child born in a family where English and Spanish are spoken will go beyond their brain architecture and learn the two lan-

guages; he will know how to play basketball (if that is what his parents play), regardless of his height. Therefore, if we find differences in the brain structure of this type of bilingual compared to that of monolinguals, we cannot attribute them to bilingualism through regulated acquisition, but to the result of the bilingual experience. Let's discuss a couple of studies.

In a study conducted with Spanish-Catalan bilinguals, whose bilingualism was due simply to the environment where they had grown up, it was observed that the volume of the left Heschl's gyrus was greater than in monolingual speakers, both for grey and white matter. This area of the brain is related to phonological processing and therefore the authors concluded that experience with two languages of relatively different sounds affects the development of the areas responsible for their processing. But this region is not the only one whose volume is increased. In a study focusing on a similar population of Spanish-Catalan bilinguals, it was observed that differences in grey matter occur even in deep areas of the brain, areas that, until not long ago, were thought to have less participation in such complex processes as language production or comprehension. Today we know that these areas, which include the basal ganglia and the thalamus, are involved in the articulation of speech sounds, among other things (see Plate 2). Bilingual individuals make use of these areas to a greater extent since they must learn to produce a greater number of different sounds.

The other way to determine the causal relationship between the bilingual experience and changes in the brain is to conduct studies in which the effect of language learning on brain structure is measured. These studies tend to present their own challenges, since they are ideally longitudinal and, therefore, require analyses of participants at different time points. In one of these studies, the changes experienced by native speakers of English were evaluated during a second-language German immersion experience. The brain measurements related to learning the second language were taken at the beginning

of their stay in a German-speaking environment and once again five months later. A correlation was observed between how much they had learned from the starting point and the change in grey matter density in an area of the brain related to language, the left inferior frontal gyrus. Individuals who learned more German showed a greater change in the density of grey matter in this area. Note that this relationship is independent of the final level of competence acquired in the second language; it points to the difference between the level at which learning was started and the level at which it ended, which suggests that the important thing is *how much* the participants had improved and not *up to what point* they improved. There you have it, then: if you send your child abroad, expect changes not only in their meal times but also in their brain's grey matter.

Other studies have also analysed how the age of acquisition of a second language can affect brain structure. In one of these works, a curious and interesting pattern was observed. Those bilinguals who had learned a second language after childhood showed, compared to monolinguals, more grey matter in the left frontal gyrus and less in the corresponding area of the right hemisphere. In addition, surprisingly, this effect was not found in individuals who learned two languages from birth, who did not show differences from monolinguals.

The bilingual experience also seems to affect the development of white matter, but the results of the various studies regarding this claim are a little less conclusive. Thus, while some experiments show the existence of changes in the corpus callosum (the fibres that connect the two hemispheres), others have found differences in the occipitofrontal fasciculus. There are yet other studies, which we will discuss in the next chapter, that have observed such difference in other brain fibres.

Finally, it is important to note, as some researchers such as Manuel Carreiras at the Basque Centre on Cognition, Brain, and Language have recently pointed out, that the evidence we currently have about how bilingualism sculpts the brain is somewhat inconclusive and con-

fusing. In addition to the fact that the results of the different studies are inconsistent within and among themselves, there are not too many published works that provide a more reliable and accurate view of the areas of the brain affected by bilingualism. This is a problem, it's true, but also an opportunity to continue exploring the interaction between a daily activity such as speaking in two languages and brain plasticity. I have no doubt that in the next few years we will make more progress.