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Abstract

This paper tests for the so-called bilingual advantage, the notion that knowing more than one language improves individuals' other cognitive skills. We use data on children of Latino immigrants in the United States who have been randomly assigned calculation tests in English or Spanish. After controlling for characteristics of children and their parents, we find that bilingual children perform 0.57 standard deviations better than monolingual children, almost equal to learning gains of two additional school years. Applying the Oster test, we find that selection on unobservables would need to be 10 times stronger than selection on observables to explain away our results. Our heterogeneity analysis reveals that the bilingual advantage is particularly strong among boys.

JEL Classification: I2, I24, J15

Key words: bilingualism, cognitive skills, selection on observables and unobservables

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1 Introduction

In the United States, the share of bilingual individuals has doubled over the last 40 years (see Figure A-1 in the Appendix). According to Eurostat, in 2016 around 25% of individuals in Europe, reported to be proficient in at least one foreign language, ranging from 11% in Italy to 66% in Luxembourg. More individuals knowing various languages implies improved communication skills which have been shown to foster trade (Melitz and Toubal [2014]) and migration (Adserà and Pytliková [2016] and Aparicio Fenoll and Kuehn [2016]). However, the individual effects of bilingualism are less clear. In particular, the existence of the so-called bilingual advantage, the notion that knowing more than one language improves individuals' other cognitive skills is still being debated.[1] The current paper contributes to this debate.

We use data on children of Latino immigrants in the Unites States who have been randomly assigned calculation tests in English or Spanish to check whether bilingual children perform better on these tests which are designed to be unaffected by language proficiency (see Aparicio Fenoll [2018]). After controlling for characteristics of children and their parents, we find that bilingual children perform 0.57 standard deviations better than monolingual children, almost equal to learning gains of two additional school years.[2] However, our estimated bilingual advantage could be due to unobservable characteristics such as school or neighborhood quality. Applying the Oster [2019] test, we provide evidence that this is highly unlikely. Selection on unobservables would have to be 10 times larger than selection on observables to explain away our results. This is ten times larger than one, the rule-of-thumb threshold for observational studies.

In the fields of psychology, neuroscience, and education, the idea that bilingualism

[1]Furthermore, if bilingualism improves individuals' cognitive skills, this could help to explain the positive effects of migrants' home country language proficiency on labor market outcomes or social integration (Bleakley and Chin [2004] and [2010]). Bilingualism could then also have an impact on economic growth through improved cognitive skills (Hanushek and Woessmann [2008]).

[2]According to Woessmann [2016], "the rule of thumb [is] that average student learning in a year is equal to about one-quarter to one-third of a standard deviation." (pg. 3) .

can shape individuals' brains beyond language use has been debated for decades. Initially the negative view that additional languages cause confusion dominated, see e.g. Darcy [1953]. As the first to challenge this notion, Pearl and Lambert [1962] reported that bilingual individuals outperformed monolinguals on various cognitive tests. A large and growing number of studies have since provided additional evidence in favor of the bilingual advantage; see for instance Bialystok [1988] or Bialystok et al [2004].[3] However, other authors such as Paap and Greenberg [2013] or Hilchey and Klein [2011] claim that the positive association between bilingualism and cognitive skills is oftentimes the result of flaws in the design of tests, the failure to control for demographic characteristics, different age groups considered, or very small samples.

Among the few works that address these issues and thus closely related to the current paper are Mouw and Xie [1999] who find "no evidence that bilingualism has a positive effect on academic achievement." Looking at a sample of 832 first and second generation Asian Americans from the 1988 National Educational Longitudinal Study, the authors find that speaking a native language with parents has a temporary positive effect on academic achievement which vanishes once immigrant parents achieve a moderate level of English proficiency. Golash-Baza [2005] uses data on more than 3,000 individuals from the 1992-1993 and 1995-1996 Children of Immigrants Longitudinal Study and estimates that bilingualism improves performance on the Stanford Math and Reading tests, but only for individuals in communities with low levels of English proficiency and high levels of resources and networks. Focusing on academic paths, Han [2012] looks at the Early Childhood Longitudinal Study and shows that despite starting with lower math scores in kindergarten, by fifth grade the math gap between bilingual and monolingual children is fully closed.

Different from these three papers the current paper is able to isolate the role of bilingualism from the influence of English proficiency per se, because the random assignment

[3] This positive view has become so widespread that there is even evidence of a publication bias, see De Bruin et al [2015].

of tests in English and Spanish allows us to estimate an effect of being bilingual that is not tied to one particular language. Moreover, we are able to address the role of unobserved characteristics for explaining differences in academic performance between bilingual and monolingual children. We hence contribute to the literature by showing that independently of the language of the test, bilingual individuals perform better on calculation tests and that this difference is hardly explained by unobserved characteristics. Our heterogeneity analysis reveals that the bilingual advantage seems to be particularly strong among boys.

The remainder of this paper is organized as follows: The next section presents our data. In Section 3, we describe the methodology used, and Section 4 presents our results. Section 5 concludes.

2 Data

For our analysis we use data from the New Immigrant Survey (NIS). The NIS was conducted among US immigrants who were granted permanent residence between May and November of 2003, including both new arrival immigrants as well as so called adjustee immigrants who were already living in the US on temporary non-immigrant visas (or, in some cases, illegally). Surveyed individuals were selected based on administrative records from the US Immigration and Naturalization Service (INS) such as for the data to be nationally representative of new arrival and adjustee immigrants. The survey had a response rate of 69 percent, leading to a sample of 12,500 adults and 1,267 children. The survey asked questions about migrants' education, language skills, and employment history, as well as family composition and characteristics. The language of the interview (English or the respondent's native language) was chosen by the respondent.

Two aspects of the NIS are key for our analysis. First, the survey administered various cognitive tests to the children of respondents. Second, for some children of Spanish-

Table 1: Descriptive Statistics

Variable	Mean	Std. Dev.	Min.	Max.
Bilingual	0.681	0.467	0	1
Male	0.512	0.5	0	1
Age	8.908	2.033	6	12
Years in US	3.775	2.406	0	13
Mother age	35.49	5.175	22	53
Father age	37.873	5.337	24	67
Father years of schooling	12.231	3.114	2	30
Mother years of schooling	10.646	3.28	1	21
Father years of schooling in US	0.722	0.817	0	11
Mother years of schooling in US	0.604	1.113	0	11
Father Mexican	0.358	0.48	0	1
Mother Mexican	0.457	0.499	0	1
Standardized calculations score	0.044	0.948	-4.094	6.177
Calculations score 5	15.501	6.859	0	45
Standardized reading score	0.016	0.957	-3.622	3.265
Reading score	19.827	9.045	0	47
Test in English	0.506	0.5	0	1
Understands English very well	0.476	0.5	0	1
Understands English well	0.334	0.472	0	1
Understands English not well	0.147	0.355	0	1
Understands English not at all	0.042	0.201	0	1
Understands Spanish very well	0.439	0.497	0	1
Understands Spanish well	0.431	0.496	0	1
Understands Spanish not well	0.109	0.311	0	1
Understands Spanish not at all	0.021	0.144	0	1

Notes: This table presents averages and standard deviations for the sample used in the estimation. The number of observations is 617.

speaking immigrants the language of these tests was randomized (English or Spanish). This is important because our estimated effect of being bilingual will thus not be tied to one particular language. For our analysis, we use results from one of the four so-called Woodcock-Johnson tests, the numerical reasoning test. This test was taken by children aged 6 to 12. Test scores are normalized to have zero mean and standard deviation equal to one for each age. Children were also asked to assess their Spanish and English proficiency on the following scale: very bad, bad, well, or very well.

Our sample is composed of all children of Spanish-speaking immigrants aged 6 to 12 who speak at least English or Spanish well or very well, whose language of the test was randomly assigned, for whom we know their calculation test score and have information on parental characteristics.[4] This leaves us with 617 children. Table 1 displays the characteristics of children and their parents in our sample. In the spirit of Grosjean [2010], we define bilingual children as those who report to speak English and Spanish either well or very well.[5] According to this definition, 68% of children in our sample are bilingual. Around half of the children are boys, and they are on average around nine years old. Most have been living for approximately four years in the US. Regarding parental variables, on average mothers and fathers are around 35 and 38 years old, respectively. Most fathers in our sample have at least a high-school degree while mothers' average years of education are lower. Most parents have acquired their education outside of the US. Parents of children in our sample are migrants from 10 different countries, but the majority has arrived from Mexico, 36% in the case of fathers and 46% in the case of mothers. Regarding test scores, children perform better on reading than on calculation tests when scores are in absolute values, but the opposite is true when we adjust for different ages of children and use scores that have been standardized by age. Regarding language proficiency, 81% of children understand English well or very well, and 87% understand Spanish well or very well.

Table 2 presents the differences between bilingual and monolingual children in terms of observable characteristics. Differences are insignificant for most variables with the exception of age, years in the US, test taken in English and raw test scores which are all higher or more likely for bilingual children. In line with our main findings, bilinguals perform better on calculation and reading tests, although these differences become statistically insignificant when we use standardized test scores.

[4]We hence exclude from our sample those who report to speak both English and Spanish bad or very bad, given that for these individuals we cannot ensure that they would understand test instructions in any language.

[5]Grosjean [2010] defines bilingual individuals as "those who use two or more languages (or dialects) in their everyday lives," pg. 4. While we do not have information on language use, we think it is reasonable to assume that everyday use entails speaking a language well or very well.

Table 2: Differences between Monolingual and Bilingual Children

Variable	Monolingual	Bilingual	Difference
Standardized calculation score	-0.016	0.072	-0.088
Calculation score	14.350	16.040	-1.690***
Standardized reading score	-0.100	0.071	-0.171
Reading score	18.112	20.631	-2.519***
Male	0.533	0.502	0.031
Age	8.569	9.067	-0.498***
Years in US	2.810	4.227	-1.418***
Mother year of birth	1967.482	1967.523	-0.041
Father year of birth	1965.318	1965.037	0.280
Mother years of schooling	10.615	10.660	-0.045
Father years of schooling	12.462	12.123	0.340
Mother years of schooling in US	0.601	0.606	-0.004
Father years of schooling in US	0.666	0.748	-0.082
Mother is Mexican	0.437	0.467	-0.030
Father is Mexican	0.360	0.357	0.003
Test in English	0.442	0.536	-0.094**

Notes: This table presents the average observable characteristics of monolingual and bilingual children who are part of the sample used in the estimation, separately. The last column includes the differences between the two values. *** p<0.01, ** p<0.05, * p<0.1.

3 Methodology

We estimate the difference in calculation test scores between bilingual and monolingual individuals controlling for English and Spanish language proficiency and demographic characteristics of children and their parents as follows:

$$C_i = \beta_0 + \beta_1 B_i + \beta_2 D(E)_i + \beta_3 D(S)_i + \beta_4 f(R_i) + \beta_5 T(E)_i + \beta_7 X_i + u_i \tag{1}$$

where C_i is the calculation test score standardized by age of child i, and B_i is a dummy variable that takes on value one of the child is bilingual. $D(E)_i$ and $D(S)_i$ are dummies for each of the four language proficiency categories (very well, well, bad, very bad) for English and Spanish respectively. To control for children's innate ability in a flexible manner, we also include $f(R_i)$, a fourth order polynomial of the standardized reading test score. $T(E)_i$ controls for the language of the test, taking on value one if the test was administered in English. Finally, X_i is a vector of children's characteristics (male, age dummies, time in the US dummies and the interaction of age and time in the US dummies) and parental characteristics (age, years of schooling, years of schooling in the US, and country of birth dummies).

Note that our coefficient of interest β_1 may be affected by the presence of certain unobservable characteristics which could lead to different cognitive abilities of bilingual individuals but which should not be attributed to bilingualism per se. For instance, bilingual individuals may be those living in neighborhoods or attending schools which are less segregated and also richer allowing them to acquire better English skills and to receive a better education overall. To address this issue, we employ the methodology proposed by Oster [2019]. In particular, we estimate Equation 2 in two different ways. Once, as proposed above and a second time only retaining two controls necessary for the coefficient β_1 to be meaningful (age dummies and language proficiency controls). We refer to this last specification as uncontrolled (u) while our main specification is the controlled specification (c). Retaining the estimated coefficients of interest β_{1u} and β_{1c} as well as the R-squared R_u^2 and R_c^2 from both estimations respectively allows us to compute the following statistic :

$$\delta = \left(\frac{\beta_{1c}}{\beta_{1u} - \beta_{1c}} \right) \times \left(\frac{R_c^2 - R_u^2}{0.3 * R_c^2} \right). \tag{2}$$

δ indicates how many times larger selection on unobservables would have to be compared to selection on observables in order to fully explain away the estimated coefficient.

4 Results

Table 3 shows the results from estimating Equation 2. Column (1) displays the uncontrolled specification which regresses the standardized calculation test score on a bilingual dummy, dummies for English and Spanish proficiency, and age dummies. In column 2, we add parents' country of birth dummies and children's' years in the US dummies (interacted with age dummies), and finally column 3 presents results from our controlled specification that also includes a fourth order polynomial in the standardized reading test score and variables for parental age and education. Results indicate significant differences in the performance on calculation tests between bilingual and monolingual children. The magnitude of these differences ranges from 0.57 to 0.68 standard deviations. According to Woessmann [2016], the latter difference is more than twice the average student learning in a year.

Table 3: Difference in calculation test scores between bilingual and monolingual children

	(1)	(2)	(3)
Bilingual	0.681	0.594	0.566
	(0.196)***	(0.197)***	(0.205)***
Parental characteristics	No	Yes	Yes
Age by Years in US	No	No	Yes
Obs.	617	617	617
R^2	0.364	0.413	0.457
F statistic	10.43	6.631	3.826

Notes: Data is from the NIS 2003. Our sample is composed of all children of Spanish-speaking immigrants ages 6 to 12 who speak at least English or Spanish well or very well, whose language of the test was randomly assigned and for whom there is information on their calculation test score. Coefficients are the result of estimating Equation 2 by OLS. The dependent variable is the standardized calculation test score. *** p<0.01, ** p<0.05, * p<0.1.

Using results from columns (1) and (3) we calculate parameter δ to be equal to 10. This indicates that for the coefficient 0.57 to be explained entirely by selection on unobservables, such selection needs to be 10 times larger than the selection on the observables that were added between columns (1) and (3). According to Oster [2019], values above one for δ indicate that unobservable characteristics do not explain the estimated differences. This implies that our findings on the bilingual advantage are not driven by unobserved characteristics.

Note that for ease of interpretation we used the standardized calculation test score as our outcome variable. However, one caveat of this measure is that it has been constructed by age group using sample averages and standard deviations instead of population means and standard deviations. The latter information is not available to us, and hence we can only test the robustness of our results to using raw test scores. Results in Table A1 in the Appendix are in line with those from our main specification. The magnitude of the estimate is even larger, around 3.1 equal to 0.45 of a standard deviation.

We further explore our results by performing separate regressions of our controlled specification for boys and girls. Literature finds important gender differences in performance on math or calculation test scores (e.g. Guiso et al. [2010] or Anghel, Rodríguez-Planas, and Sanz-de-Galdeano [2020]) as well as regarding the influence of external factors on cognitive development (Rosselli et al [2009]). In line with these findings, results in Table 4 show clear gender differences. The bilingual advantage seems to be particularly strong and only significant among boys. In our sample, similar to most studies, girls are 2.5 percentage points more likely to be bilingual. Moreover, boys tend to perform worse than girls on language or reading tests (see e.g. OECD [2019]). If the latter is due to the fact that on average for boys language acquisition is more difficult than for girls, then boys who manage to become bilingual could be more selected than bilingual girls. This could explain why only bilingual boys perform significantly better on calculation tests.

Table 4: The bilingual advantage: Heterogeneity by gender

	Standardized test scores		Raw test scores	
	Boys	Girls	Boys	Girls
	(1)	(2)	(3)	(4)
Bilingual	0.758	0.477	3.986	2.309
	(0.356)**	(0.406)	(1.802)**	(2.001)
Obs.	316	301	316	301
R^2	0.495	0.587	0.744	0.816
F statistic	2.49	3.371	7.362	10.524

Notes: Data is from the NIS 2003. Our sample is composed of all children of Spanish-speaking immigrants ages 6 to 12 who speak at least English or Spanish well or very well, whose language of the test was randomly assigned and for whom there is information on their calculation test score. In columns (1) and (3) the sample is restricted to boys and in columns (2) and (4) it is restricted to girls. Coefficients are the result of estimating Equation 2 by OLS. The dependent variable is the standardized calculation test score. All regressions include all controls specified in Equation 2. *** p<0.01, ** p<0.05, * p<0.1.

5 Conclusion

Our findings provide support for the existence of the bilingual advantage. We show that better performance by bilingual children on cognitive test scores, independently of any particular language, is not explained by observables and highly unlikely to be driven by unobserved factors. In particular, among boys, bilingualism seems to improve cognitive skills.

For potential mechanisms behind the bilingual advantage we have to turn to findings from other disciplines. Neuroscience argues that bilingualism alters the functional involvement of certain brain areas in the performance of tasks (see e.g. Garbin et al [2010], or Rodriguez at al. [2013]). Some studies in sociology sustain that bilingual children have access to positive "cultural capital" in their families and ethnic communities (see e.g. Rumberger [1998]), potentially improving academic performance. Others highlight the importance of speaking the same language as one's family, and how this may enhance the parent-child relationship, which in turn, could have great implications for children's motivation to succeed academically (e.g., Fuligini [1997], or Tseng and Fuligini [2000]).

While our data is not rich enough to speak to the mechanisms at work, our findings together with the fact that immigrant children who speak their mothers' tongue are able to bond with older family members and in case of a language as prevalent as Spanish might also increase their labor market opportunities, suggest that raising bilingual children in the US seems to be advisable.[6]

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[6]Currently some researcher are studying how Covid-19 related lockdown measures which have implied more joint time of children and parents have made it easier to raise a bilingual child, see Harach [2020].

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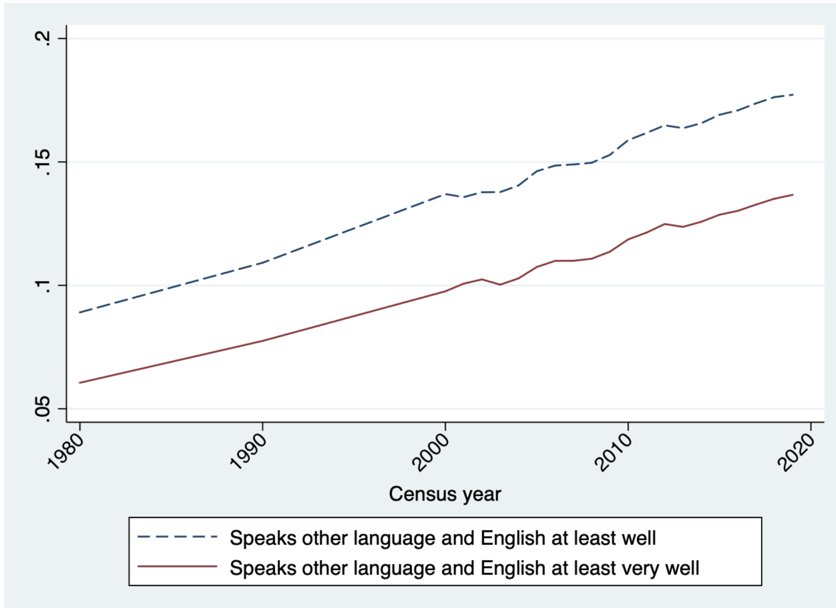
A Appendix

Figure A-1: Share of bilingual individuals in the Unites States



Source: US Census, Ruggles et al.[2021], weighted data

Table A1: Robustness: Using raw test scores instead of standardized test scores

	(1)	(2)	(3)
Bilingual	3.255	3.272	3.106
	(0.975)***	(1.007)***	(1.027)***
Parental characteristics	No	Yes	Yes
Age by Years in US	No	No	Yes
Obs.	641	617	617
R^2	0.679	0.708	0.739
F statistic	40.226	22.865	12.874

Notes: Data is from the NIS 2003. Our sample is composed of all children of Spanish-speaking immigrants ages 6 to 12 who speak at least English or Spanish well or very well, whose language of the test was randomly assigned and for whom there is information on their calculation test score. Coefficients are the result of estimating Equation 2 by OLS. The dependent variable is the raw calculation test score. *** p<0.01, ** p<0.05, * p<0.1.