Title: Twinkle Twinkle Little Estrella: Representative Evidence on a Real-World Bilingual Advantage

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Abstract: This paper tests whether bilingual children have better cognitive skills than comparable monolingual children. A large and increasing number of studies have analyzed differences between bilingual and monolingual children, focusing on specific aspects of the cognitive process and using behavioral tests conducted with groups of voluntary subjects. This study is novel in three ways: (1) it uses a large and representative sample of children of Latino immigrants living in the US; (2) it focuses on standardized test scores that measure a variety of cognitive aspects and are widely used to evaluate students; (3) it compares monolingual and bilingual children, taking into account not only demographic and socioeconomic characteristics, but also home and school inputs. The results show that bilingual children outperform their monolingual counterparts.

One Sentence Summary: Bilingual children outperform their monolingual counterparts on standardized cognitive tests.

Main Text:

More than half of the world's population can speak two or more languages (*1*). According to the American Community Survey, in 2012, 20% of US residents were bilingual. The idea that bilingualism can shape our brain has sparked much research, especially in the fields of psychology, neuroscience, and education. In particular, there has been intense and extended debate on the effect of bilingualism on children's cognitive skills. These skills determine children's future educational attainment and labor market performance. Hence, if bilingualism does, in fact, improve cognitive skills, this would support evidence in the sociological (*2*) and education literature (*3*) of a positive association between bilingualism and academic outcomes, as well as that showing the positive effects of home language proficiency on the labor market outcomes and social integration of immigrants (*4, 5*). Conversely, a negative impact of bilingualism on cognitive skills could help to explain native-immigrant gaps in cognitive skills (*6*).

Experts are far from reaching a definitive agreement as to whether bilingualism has a positive or negative impact on children's cognitive skills. Indeed, while a positive view is now widespread among academics within the discipline of cognitive science (*7*), a number of recent papers (*8*) have challenged this perspective. In line with disagreement among experts, and probably as a consequence of this, parents often face contradictory recommendations as to which language they should speak with their children (*9*, *10*). In response to this debate, in this paper I estimate the magnitude and statistical significance of cognitive differences between bilingual and comparable monolingual children as measured by standardized cognitive tests that have consequences for real-world outcomes.

To this end, I employ information on a representative sample of children of Latino immigrants living in the US provided by the New Immigrant Survey (NIS). Crucial for my analysis, this survey includes information on language proficiency and cognitive test scores obtained from standardized Woodcock Tests administered to children aged 3 to 12. A set of variables on English and Spanish proficiency (speaking, understanding, reading and writing skills) is used to classify children as bilingual, Spanish monolingual, or English monolingual. Children classified as bilingual know Spanish and English either well or very well. Non-bilingual children are classified as English (Spanish) monolingual if they are more proficient in English (Spanish) than Spanish (English). In contrast to previous literature that focuses on specific tasks, here I examine standardized testing: a relevant outcome per se because these tests are an integral component of academic progress and success and are often used to assign students to different educational tracks. Moreover, the NIS also includes a wide set of variables allowing for a comparison of bilingual and monolingual children who are otherwise similar in many dimensions, such as family and individual characteristics, parents' labor market outcomes, home and school inputs, and parenting behaviors. Finally, the design of the NIS includes an experiment in which the language of the test is assigned randomly. I use this feature to both compare the performance of bilingual and Spanish monolingual children on tests in Spanish, and to compare the performance of bilingual and English monolingual children on tests in English. Given that bilingual children typically know fewer words in either of their vocabularies than their monolingual counterparts know in their one vocabulary (although bilingual children know a comparable number of words in total), this comparison provides lower bounds for the bilingual cognitive advantage (*11, 12*).

The bilingual advantage debate

Over the years, academic views of bilingualism have changed drastically. Literature on how bilingualism shapes the brain was initially predominated by the negative view that additional languages can cause confusion (*13*). This perspective was challenged in 1962 with the finding that bilingual individuals outperformed their monolingual counterparts on a battery of cognitive tests (*14*). A large and growing number of studies have since provided additional evidence in favor of the so-called "bilingual advantage", a term used to refer to the greater cognitive outcomes of bilingual individuals. This positive view has become so widespread that there is even evidence of a publication bias (*15*).

The most widespread view currently held is well summarized by Grosjean (*16*). Experts have identified the executive control function as the set of cognitive processes (including attentional control, inhibitory control, working memory, cognitive flexibility, reasoning, problem solving and planning (*17, 18*)) that underlie the differences between bilingual and monolingual individuals in terms of cognitive skills (*19*). Neuroscientists have shown that bilingualism affects brain activity related to language processing, probably as a result of increased language-processing demand. In that sense, bilingualism represents "brain exercise" and hence bilingualism is likely to affect other cognitive processes. Recent studies indicate that the potential mechanism through which this happens is that bilingualism alters the functional involvement of certain brain areas in the performance of tasks (*20-22*). Some bilingual advantages are found in metalinguistic tasks, indicating that bilingual individuals are better at analyzing different aspects of language like sounds, words, syntax, etc. (e.g., recognizing whether sentences are grammatically correct). However, this only occurs when the metalinguistic task involves some conflict solving through inhibitory control. If instead the task requires the analysis of representational structures, monolingual and bilingual subjects obtain similar results. Monolingual and bilingual children are also comparable in language acquisition capacities, such as discriminating between languages and learning phoneme repertoires and words (*23*). The only domain where bilingual children seemingly do less well than their monolingual counterparts are vocabulary tests, such as choosing a picture that illustrates the word spoken by the researcher. However, when bilingual children are evaluated in terms of both of their languages, their results improve significantly.

According to the current literature, what might we expect in terms of the implications of bilingualism for overall cognitive skills as measured by standardized tests? First, the improvement in the executive control system should translate into an advantage for problem solving. In particular, working memory skills are positively associated with skills and knowledge in mathematics and reading comprehension (*24-28*). Given that these aspects play a key role in standardized cognitive tests, we should expect that bilingual individuals do better on those tests. However, serious concerns have been raised about the robustness and reliability of the reported cognitive effects of bilingualism (*29-31*). Some scholars have argued that the positive association between bilingualism and executive control found in the literature is the result of "malpractice" in the design of behavioral tests. In a recent study, Paap, Johnson and Sawi make an exhaustive list of these critiques (*8*). In what follows, I explain in detail how I address these issues so as to compellingly analyze the relationship between bilingualism and cognitive skills.

Methodology: avoiding malpractice in analyzing the bilingual advantage

Following Paap and coauthors malpractice list, I explain how my approach addresses such criticisms so as to avoid estimating bilingual cognitive advantages where none exist or where disadvantages should be found:

1. Paap and coauthors note that positive effects tend to be found in small samples but disappear when large samples are used. I use data from the New Immigrant Survey, which includes information on a large and representative sample of children of Latino immigrants living in the US. While the studies reviewed by Paap and coauthors rarely include more than 100 subjects, my sample size is well above 1,000 children. The characteristics of my sample allow for estimating even small significant differences.

2. Many studies fail to control for demographic factors, which could lead to erroneous estimations of differences between monolingual and bilingual individuals when their demographic characteristics differ. This happened in the case of the replication of a study of Bialystok, Craik, Kelin and Viswanathan (*32*) by Morton and Harper (*33*). The latter replicated the former study, but additionally used information on parent's educational levels, family income, ethnicity and immigrant status to make bilingual and monolingual individuals comparable. Paap and coauthors highlighted immigrant status and cultural differences as particularly important aspects to take into account (*8*). They argue that the identification of bilingualism with immigrant status could explain the results reported in some papers (*34*). The institutional setup in which children reside is another potentially important confounder. In the study by Engel de Abreu and coauthors bilingual children resided in Luxembourg, whereas the monolingual children resided in Portugal (*35*).

The richness of the NIS data allows me to account not only for the demographic (origin, gender, age, etc.) and socioeconomic (parents' labor market status, education level, wages, etc.) characteristics of the children, their parents and siblings, but also for potentially relevant factors that are rarely available to researchers, such as parents' language use and proficiency, home inputs (e.g., parenting style, proxied by behavior towards children: controlling, helping, getting involved,…) and school inputs (e.g., subjects offered, meritocratic vs. egalitarian approach, etc.). The complete list of controls can be found in the Supplementary Material sections. These factors jointly account for a sizeable part of the variation in children's language proficiency (81% as measured by the R-square of an OLS regression of a bilingual child dummy on all these factors). Within the sample, I can clearly distinguish between children born in the US and immigrant children, and although immigrant children are less likely to be monolingual English-speaking, there are sizeable groups of bilingual and monolingual Spanish and English speakers in both groups (see Figure 1). All children reside in the US, hence differences in the institutional context in which bilingual and monolingual subjects live do not drive my results.

3. Bilingual and monolingual individuals often perform differently on tasks that do not have demonstrated convergent validity, i.e., the measures obtained from those tasks do not relate to one another as predicted by the theory. According to Paap and coauthors, "many of the standard measures of inhibition (or monitoring) obtained with nonverbal interference tasks do not correlate with one another." Hence, they "may reflect task-specific mechanisms and not domain-free executive function abilities" (8). Some examples of tasks used in this type of study include: block design (*36*), the Flanker task (*37, 38*), theory of mind tasks (*39, 40*), the Simon task (*41*), task switching (*42*), and attention tasks (*43*).

In this paper, I measure cognitive ability using the results of four Woodcock Johnson Tests: Letter Word Identification measures symbolic learning and reading identification skills, Applied Problems evaluates aptitude in practical problem solving in mathematics, Passage Comprehension assesses reading comprehension and vocabulary, and Calculation determines mathematical and quantitative ability (*44*). The first two tests were administered to children aged 3 to 12 while the latter two were given to children aged 6 to 12. Scores on standardized evaluations like the Woodcock Johnson Tests are considered to provide a comprehensive picture of children's cognitive abilities. Many schools use them to evaluate students, some with the aim of placing those with poor scores in non-honors classes or shifting them to less competitive schools (*45*).

Some of the measurements used in the studies above have the advantage that they are language-free. However, the NIS also includes an experiment that helps overcome the potential influence on the bilingual difference of children with limited proficiency in English (Spanish) taking the test in English (Spanish). Children of Latino immigrants were randomly administered the test in English or in Spanish. I present separate results for children who took the test in English and in Spanish and only compare bilingual children taking the test in English with monolingual English speakers (taking the test in English) and bilingual children taking the test in Spanish with monolingual Spanish speakers (taking the test in Spanish). As bilingual children tend to have lower proficiency in either of their languages compared to monolingual individuals in their one language (*46*), this strategy ensures that any estimated bilingual advantage is not due to the language of the test.

4. Many studies do not use statistical tests to determine whether differences between monolingual and bilingual children are statistically relevant (*47*), other studies use the wrong tests or baselines. The large sample size in this study allows me to test for differences in tests scores between monolingual and bilingual children using standard t-tests where the null hypothesis is that the difference in coefficients is zero.

Data

The NIS provides a nationally representative sample of immigrants granted lawful permanent resident status, drawn from electronic files compiled by the U.S. government (*48*). The sampling frame consists of newly arrived immigrants (i.e., those arriving in the United States with immigrant documents acquired abroad) and adjustee immigrants (i.e., those already in the United States with temporary non-immigrant visas or who were living in the United States illegally, but adjusted to lawful permanent residence). The sampling design includes both a sample of adults that are 18 years or older, and a child sample. The Child Sample covers immigrants with child-of-U.S.-citizen visas who are under 18 years of age.

The first full cohort sampled immigrants from June 2003 to June 2004. Follow-up interviews were conducted from June 2007 to December 2009. The sample consists of 12,500 adults and 1,250 children, of which 810 completed the entire questionnaire and can be used for analysis.

Results

The results of my estimation of average test scores across three subgroups of children (bilingual, Spanish monolingual and English monolingual) are presented in bar graphs. Details on the estimation strategy are presented in the Supplementary Materials section. The vertical lines over the bars represent 10% confidence intervals and t-statistics for the differences of means are reported in the footnotes. Scores are normalized to have a zero mean and a standard deviation of one so that differences are measured in standard deviations.

Figure 2 reports raw average scores for bilingual and English monolingual children on cognitive tests in English. Bilingual children significantly outperform monolingual English-speakers on all four tests. In fact, bilingual children perform above the population average while monolingual English-speakers perform more poorly than the average child in the US. Differences between the scores of bilingual and English monolingual children are all statistically highly significant (p-values lower than 0.003). The observed differences range from one-fourth to one standard deviation score. A similar picture is portrayed in Figure 3 where bilingual children who took the test in Spanish are compared to monolingual Spanish-speakers. Consistent with results in the literature, bilingual children perform worse when tests are administered in Spanish (*45*). However, they still outperform their Spanish monolingual counterparts, with statistically significant differences on the various tests (very significant for Letter-Word Identification and Passage Comprehension and significant at 6.3% for Calculation). The only exception is Applied Problems, where bilingual children perform below the population average and the performances of bilingual and monolingual children are statistically indistinguishable. The magnitude of the observed differences is lower than that for the test in English and ranges from one-fifth to 0.85 standard deviation. However, these differences could be due to differences among the three groups of children in terms of variables other than language proficiency.

To this regard, I then control for the broad set of variables mentioned above. The resulting conditional averages are shown in Figures 4 and 5. Figure 4 shows that bilingual children outperform monolingual English-speaking children, and that all differences are statistically highly significant (p-values below 0.017). The magnitudes of the estimated differences stay stable with respect to those shown in Figure 2. These results mirror those for the test in Spanish presented in Figure 5, although differences in the Applied Problems and Calculation tests are imprecisely estimated for tests in Spanish. The similarity between Figure 4 and Figure 5 is consistent with previous literature showing that the effects of bilingualism on executive control do not depend on the specific languages spoken (*49*). Across all cases, the largest differences are found in Letter-Word Identification and Passage Comprehension (above half standard deviation) as compared to Applied Problems and Calculation (below one-third standard deviation). Overall, results highlight the existence of a significant advantage in being bilingual, as captured by cognitive tests.

Discussion

Many decades after the bilingual advantage was first documented, and in the face of substantial additional evidence in favor of bilingualism, debate over whether bilingualism can enhance aspects of cognitive function continues. Educational and clinical practitioners routinely advise parents to "simplify" their children's linguistic environments when there are signs of academic struggle, and language professionals prescribe optimal timetables (and methods) for introducing languages to children to minimize the inevitable confusion. Some linguistic experts consider that these views are “often based on fear and anecdote” (*9*). This negative perspective on bilingualism has provided support for the English-only movement (*50, 51*), which has thus far not had any proven positive effects on the labor market or the social integration of immigrants (*52*). Moreover, some psychologists embrace the opinion that "bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances" (4).

In contrast, in this study I show that bilingual subjects outperform their monolingual counterparts on comprehensive cognitive tests taken in the language of the monolingual test-takers. This is true even when comparing bilingual to monolingual children with similar individual and family socio-demographic characteristics, as well as similar upbringing and schooling. These findings, together with the fact that speaking a language other than English (especially one as prevalent as Spanish) can allow children to bond with older family members and potentially increases their opportunities in the labor market, make raising bilingual children advisable.

Bilingualism in the United States is often associated with low socioeconomic status. Indeed, legislation referring to bilingual education is included in federal programs for disadvantaged students (*53*). Although I capture differences in socioeconomic status through controls, there may be other unobserved negative features associated with low socioeconomic status such as low self-esteem, behavioral problems, etc. that work against the performance of bilingual subjects on cognitive tests. In this sense, my results represent the lower bounds of the bilingual advantage.

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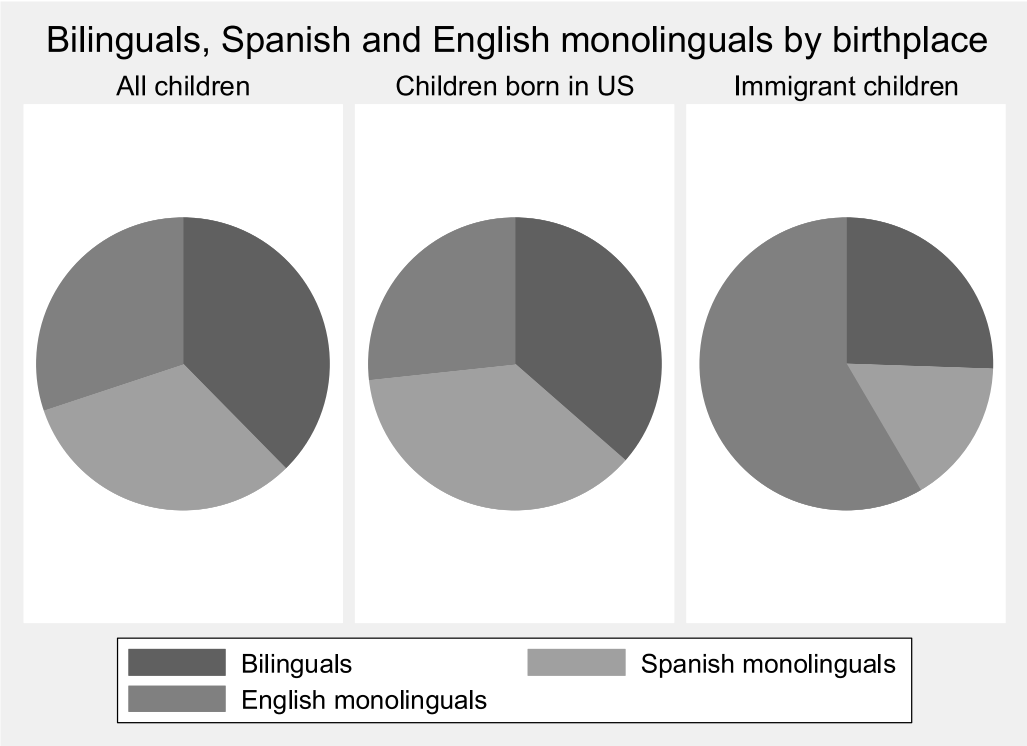

Fig. 1. **Shares of bilingual, Spanish monolingual and English monolingual children by country of birth.** These figures represent the composition of the sample in terms of children that are proficient in English and Spanish, only in Spanish or only in English. Two subgroups are defined according to whether the children were born in the US or abroad.

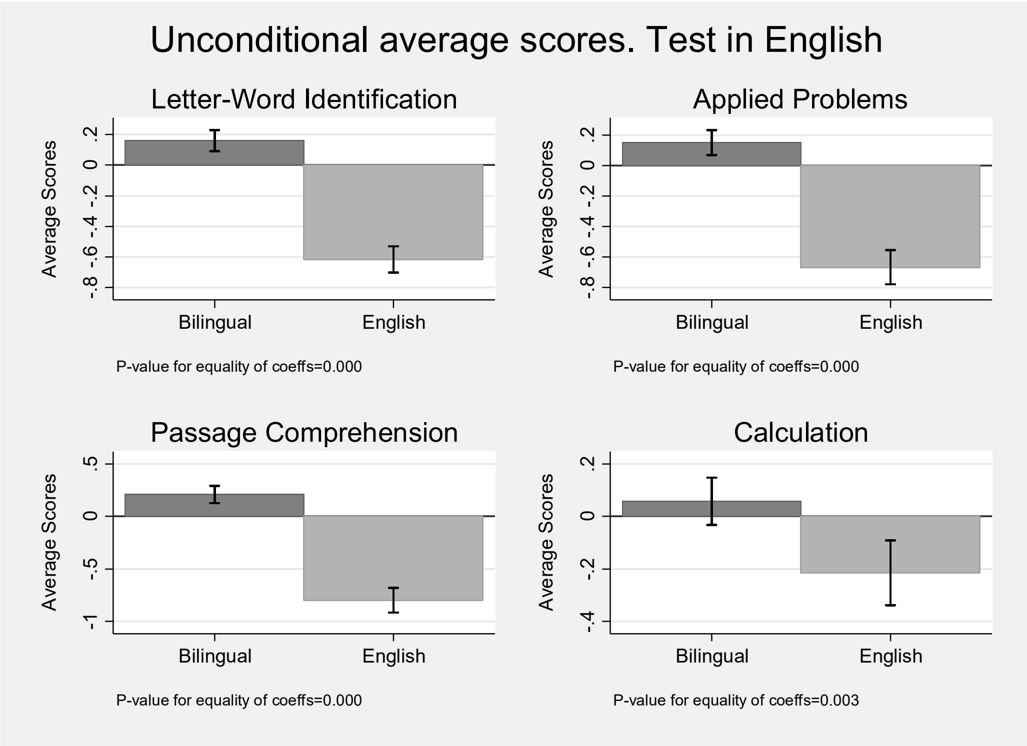

Fig. 2. Unconditional average test scores for bilingual and English monolingual children. The bars represent the average values of test scores obtained by estimating Equation (1) as specified in the Supplementary Materials. The left bar represents bilingual children taking the test in English (coefficient α_1) and the right bar refers to monolingual English-speakers taking the test in English (coefficient α_2).

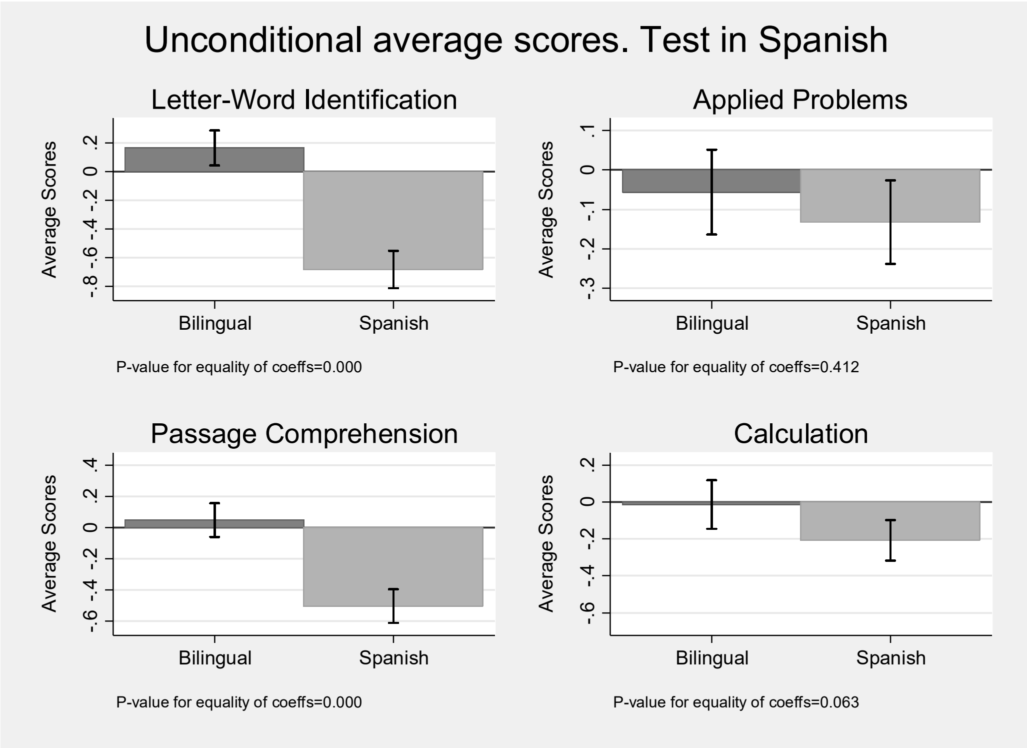

Fig. 3. Unconditional average test scores for bilingual and Spanish monolingual children. The bars represent the average values of test scores obtained by estimating Equation (1) as specified in the Supplementary Materials. The left bar represents bilingual children taking the test in Spanish (coefficient α_4) and the right bar refers to Spanish monolingual children (coefficient α_6).

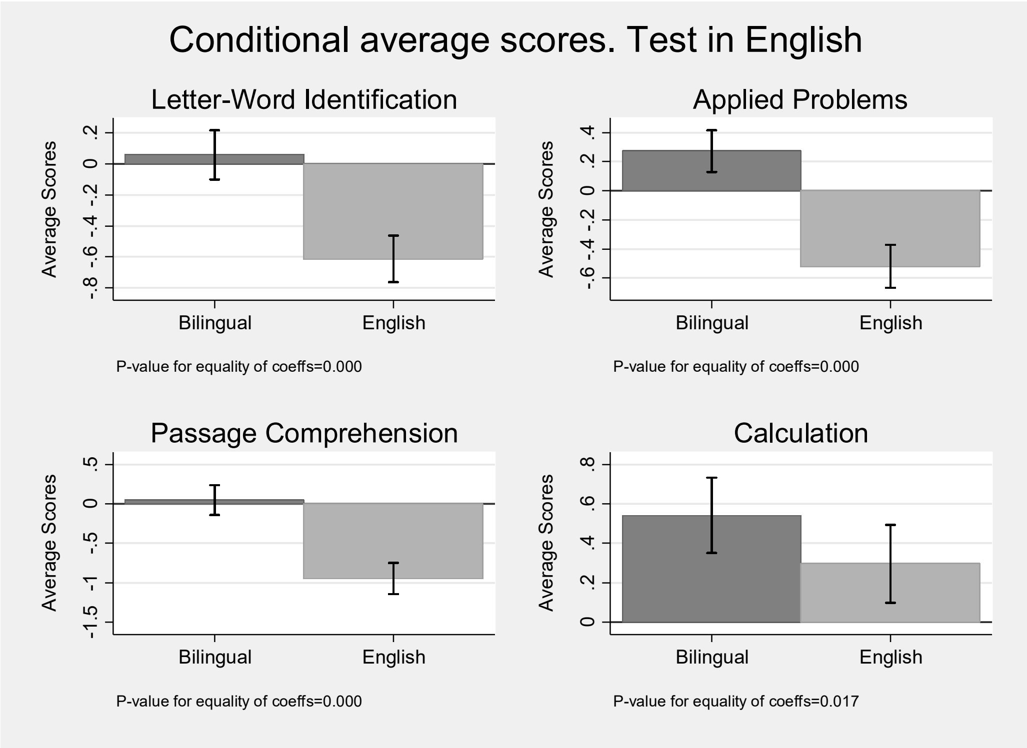

Fig. 4. Conditional average test scores for bilingual and English monolingual children. The bars represent the average values of test scores obtained by estimating Equation (2) as specified in the Supplementary Materials. The left bar represents bilingual children taking the test in English (coefficient β_1) and the right bar refers to English monolingual children taking the test in English (coefficient β_2).

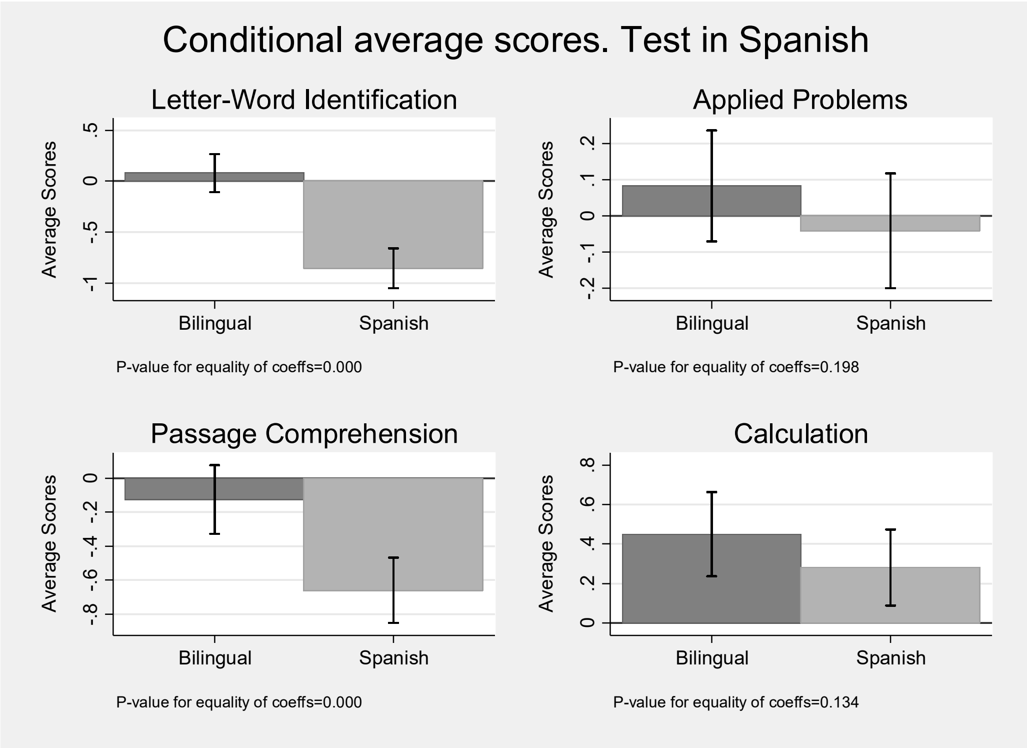

Fig. 5. Conditional average test scores for bilingual and Spanish monolingual children. The bars represent the average values of test scores obtained by estimating Equation (2) as specified in the Supplementary Materials. The left bar represents bilingual children taking the test in Spanish (coefficient β_4) and the right bar refers to Spanish monolingual children (coefficient β_6).

Supplementary Materials:

Materials and Methods:

I obtain the unconditional average test scores of three groups of children (bilingual, Spanish monolingual and English monolingual) by means of the following linear specification that I estimate by Ordinary Least Squares:

$$S_{it} = \alpha_1 \cdot B_{it} \cdot T_{it}^E + \alpha_2 \cdot E_{it} \cdot T_{it}^E + \alpha_3 \cdot S_{it} \cdot T_{it}^E + \alpha_4 \cdot B_{it} \cdot T_{it}^S + \alpha_5 \cdot E_{it} \cdot T_{it}^S + \alpha_6 \cdot S_{it} \cdot T_{it}^S + \varepsilon_{it} \quad (1)$$

where S is one of the four test scores for child i who took the test at time t, B is a binary variable that takes the value one if the child is bilingual, E is an indicator variable equal to one for children who are proficient only in English, S is a dichotomous variable with value one for Spanish monolingual children, T^E is an indicator for the test in English, T^S is the corresponding indicator for the test in Spanish and ε is the error term. Including separated indicators for monolingual Spanish-speakers and English-speakers takes into account that monolingual English-speakers speak the language of the country of residence (and hence the language of instruction at most schools).

In order to estimate cognitive differences among children who are similar in many dimensions except for the language spoken at home, I obtain the conditional mean test scores for the three groups of children. To do this, I expand the equation above as follows:

$$\begin{aligned} S_{it} = {} & \beta_1 \cdot B_{it} \cdot T_{it}^E + \beta_2 \cdot E_{it} \cdot T_{it}^E + \beta_3 \cdot S_{it} \cdot T_{it}^E + \beta_4 \cdot B_{it} \cdot T_{it}^S + \beta_5 \cdot E_{it} \cdot T_{it}^S + \beta_6 \cdot S_{it} \cdot T_{it}^S \\ & + \beta_4 \cdot C_{it} + \beta_5 \cdot I_{it} + \upsilon_{it} \end{aligned} \quad (2)$$

where, in addition to the variables defined above, I control for a vector of individual and family characteristics denoted by C and the set of home inputs I. Finally, υ stands for the resulting error term.

The complete list of control variables is:

- Dummies for age
- Country of birth
- Number of siblings
- Mean age of siblings
- Father's year of birth
- Mother's year of birth
- Dummies for father's country of birth
- Dummies for mother's country of birth
- Parents coming from different country
- US parent
- Father's degree
- Mother's degree
- Father's labor market status dummies (employed, unemployed, and out of labor force)
- Father's salary
- Mother's labor market status dummies (employed, unemployed, and out of labor force)
- Mother's salary
- Parents' languages spoken at age 10

- Parents’ languages spoken at home
- Parents’ languages spoken at work
- Parents’ languages with friends
- Parent understands English
- Parent speaks English
- Father absent
- Mother absent
- Language assistance program
- Calculator and dictionary at home
- Repeated grade
- Technology at home
- Parents show interest in school
- Reading material at home
- Parents impose limits
- Attended school outside US
- Meritocratic school
- School offers language support
- Survey wave dummies