Impact of Music Education on Student Performance

By

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Abstract

It is claimed that music may have many benefits on students, but few empirical analyses have examined the effect that music can have on the academic outcomes of these students. This paper analyzes the impact music education has on the academic outcomes of students, using a subset of the National Longitudinal Survey of Youth. To try and obtain the exact effect of music education, my paper uses OLS regression, an internal instruments estimation, and the addition of a lagged dependent variable, all while bootstrapping the standard errors. These same techniques are then performed again, adding in a critical age, examining if the age at which a child begins the music education is significant. The results are positive and significant correlations for all measurements, except when including critical age and examining the effect on mathematics outcomes.

1. Introduction:

Many individuals play or listen to music for enjoyment; however, many argue that there may also be additional benefits to studying music, including the possibility that music can improve cognitive ability (Altenmüller et al 1997, Holochwost et al. 2017). This begs the question: Does music have a significant impact on the educational outcomes of students? Does this impact suggest an increase or decrease in the requirements and structures for music as well as the level of spending associated with music programs? Though these and other questions are commonly asked, there is still a void of definitive answers which this paper hopes to begin filling.

Currently, the structure and amount of music education can vary significantly from state to state. It even has the potential of significantly varying across different school districts within a single state. Between preschool and fourth grade most students will have had compulsory music education. Sometimes it will be in a formal educational setting, such as a general music class, or sometimes it will be indirectly through learning methods, such as a way to teach and remember the alphabet. Still, in other districts or states, students will have five days of music, at least thirty minutes each day, throughout the year. This variance is due to different standards and benchmarks with states. The absence or presence of these standards will affect the capabilities of different districts and schools to even have the option of changing their organization and offerings of their programs. This paper aims to see whether or not the study of music has an effect on the student outcomes, and if it matters at which age the students were introduced to music. That effect, its strength, and the age of onset will imply whether or not different standards should be instilled or changed at the district, state, or national level.

Previous literature points towards a positive correlation between music and student achievement as measured by ability in both mathematics and language arts. Additionally, individuals that start at an early age may enjoy greater benefits from music education (Anvari et al. 2002). This paper aims to examine this correlation, as well as attempt to discover if and when the critical age to begin music education is for the fullest and longest lasting effect.

This critical age could have significant impacts in deciding when to implement different music programs. For instance, if there is a strong effect of a critical age, and it is an early age, music education programs should be incorporated as a part of the core subjects across the board, particularly in elementary schools. However, if there is not a strong effect of a critical age (and there is a strong effect of music) the implementations of the program should only be required early if allowed by the budget, but otherwise it should be at the discretion of the state or local boards if and when it is most important to include.

I utilize a nationwide panel (National Longitudinal Survey of Youth), to examine the effects of music education on cognitive achievement. This will be done with four sets of analyses. The first two analyses focus on how the math performance of the child is affected by music education. One of the two analyses includes, in addition to the music education, whether the student had begun music education by the critical age. The other two analyses have the same format with music education and the critical age, but now examining the child's reading performance as opposed to the child's math performance. The results of these analyses indicated a highly significant and positive relationship between music and academic achievement, consistent with previous studies on the subject. There was one case where neither of the independent variables had a significant relation with the scores of the children, and that was the when the critical age was being measured with the effect of music education while math was the dependent variable. On the other hand, the remaining three sets of equations showed a significant impact from both critical age and music education on the outcome of the students.

The following will describe the remainder of the paper. First, I discuss the current literature surround the subject matter. Next, I describe the source of my data along with what parts of it I extracted for my study. Then, I expand on the different methods I use in my analysis of that data. Finally, I discuss the results of that study and the conclusions that can be drawn from them.

2. Literature Review:

Some consider music to be a language, due to factors such as its notes having a particular meaning or interpretation. Johnson and Newport (1991) did a study to look at languages. They took a group of twenty-one native Chinese speakers who learned English and moved to the United States of America at an early age. The nine males and twelve females came from the same university, to try to control a multitude of factors (a previous study of theirs showed that after five years of exposure, time does not make a further difference). The recruitment was accomplished through a mixture of letters, voluntary sign-ups, and word-of-mouth. They found that all the groups from ages up to seven did not have a significant difference than from natives in their measurement. All other groups, ages greater than seven, were significantly different, implying that the age which someone begins to study a language is important. For this reason, the age of seven is chosen as the critical age in this study.

Previous studies examined the relationship between music and different academic fields, such as math and reading. Engdahl (1994) analyzed how different pull-out music programs, in this case band and choir, affected the reading score outcomes of sixth graders. In her study, there were two groups of 299 students. The first group, the experimental group, consisted of the students involved in the pull-out programs; the students who were not in a pull-out-program composed the control group. The students in the pull-out program were students already in and only in an instrumental pull-out program, while the control group was in no type of pull-out program. The students in each group were matched one-to-one on the basis of their Normal Curve Equivalent scores (a way to convert multiple standardized test scores to a comparable level) as best as was possible. Though it was not possible for a perfect match, 96% of the students were matched up one-to-one exactly. To perform this analysis, an ANOVA technique was utilized. Engdahl showed that the students in the pull-out programs, while missing more than half of the class time set aside for reading, performed, on average, either equal to or superior to those not in a pull-out program. This implies that music practice time may assist in reading ability, in which case the study of music would have the positive side effect of assisting with reading, or that it may have no effect on reading ability, implying that the study of music may or may not have side effects of assisting with reading. There was a loss of mathematical abilities in both the experimental and the control groups here; however, this loss was only significant in the non-pull-out students group when examining the correlation of their ethnic status and their mathematical performance. Engdahl conducted further analyses drawing significant results comparing program participation and race with math, male versus female benefits, and different impacts of race on reading. My study hopes to show the study of music in lieu of some class time will help with not only language arts ability, but in additional areas such as mathematics.

Research has shown that music activates many different parts of the brain. Altenmüller et al. (1997) performed a study showing a pattern of large activation of different portions of the brain when analyzing, listening to, and sometimes reading music. In general, they wanted to examine the different patterns of cortical auditory activation that occur when engaging in various methods of music learning. For this experiment, they gathered nine different thirteen-year-olds. All of these students were selected to have the same level of general education and the same level of musical aptitude (which was measured with Gordon's Advanced Measures of Music Audiation Test). They set up three different groups: first was a group who received only verbal instructions, second was a group that received interactive musical instruction, and finally there was the control group that had no special type of instruction. To visualize the activation, they employed low frequency direct current (DC) shifts of an electroencephalographic (EEG) scan before the training and at the end of the five-week training. Those that received verbal instruction had a higher activation in the left frontotemporal regions of the brain as compared to the control group. Also, those in the group receiving musical instruction through playing had increased activation both in the right frontal and the bilateral parietal regions of the brain. Thus, Altenmüller et al. were able to conclude that different sections of the brain are able to be activated depending on how musical instruction is provided and administered.

Graziano et al. (1999) analyzed what kind of impact piano-keyboard training has on proportional mathematics. This study was composed of 237 second graders, ranging from six years and eight months to eight years and five months. The selection was not random, but they were all chosen from inner-city schools in hopes of creating a similar base. These children practiced their proportional math skills through a math video game, with one group only playing the game and the other group, the experimental group, both playing the game and receiving piano-keyboard instruction. The math video game had within it an evaluation program that was used to estimate the achievement of the two groups of students. The students who also had the piano-keyboard training more rapidly achieved higher levels of performance.

Looking at reading ability as opposed to mathematical ability, Anvari et al. (2002) examined how music might work to enhance reading abilities. In particular, they wanted to know the relationship between phonological awareness, music perception skills, and early reading skills. In doing this they performed a study on fifty four-year-olds, twenty-nine of which were female and twenty-one of which were male, and fifty five-year-olds, thirty of which were female and twenty of which were male. These subjects were recruited from the Hamilton-Wentworth area’s schools and daycares in Canada. In this study they did not train the students in any way, but examined the correlations that existed between various present abilities. They found that musical perception has a positive correlation with phonological and phonemic perception, where phonemes are the individual sounds that help to make up the sounds of a language and its alphabet. This also held true for reading ability as measured by vocabulary. Similarly, there was also a significant relationship between musical perception, and the digit span (ability to retain and repeat back strings of numbers). All of these results were more significant with the four-year-old students than the five-year-old students. The relationship between music rhythm and reading ability remained unclear.

A recent study by Holochwost et al. (2017) examined if music education was associated with an increase in academic achievement and executive functions. In their study, 265 children participated. These children were in grades one through eight. Fifty-eight percent were female and eighty-six percent were African American. To ensure a random sample, students were chosen with a lottery from those who had expressed interest in the music program being offered. This out-of-school program consisted of training in orchestral instruments, both as individual players and as part of an ensemble. To measure the achievements of the students they looked both at their standardized test scores and at their grades in the subjects of math and English. They used specialized tests to measure executive functions. Holochwost et al. utilized a SAS Mixed Procedure to perform the model estimation. On average, the students in the music program performed higher (with a p-value of 0.07) on the standardized tests than the non-music program students. Additionally, the students in the program had higher math grades (p-value of 0.11) and higher English grades (p-value of less than 0.001) as well. Also, they had higher scores on the executive function and short-term memory tests as well. This positive correlation was strongest between the children for second to third grade.

In summary, all of the measurements of reading ability had positive correlations with music studies, from general reading ability to overall literary skills. While one study was inconclusive regarding the correlation of musical study and math, the others had significant results regarding the effects on number retention and memory, level of mathematical achievement, and the speed in which students reached that level of achievement. Music studies also had varying effects on brain activation, activating different areas depending on the method of study. Also, the age of seven (or second and third graders) was shown as statistically significant for different measurement.

3. Data:

The panel data used in this paper is from The National Longitudinal Survey of Youth (NLSY), which is a nationwide study of men and women that began in 1979. I use a subsection of this study that starts in 1986 and continues until 2014, with surveying occurring every other year. The subjects of this subsection are the children of the women surveyed in NLSY. In collecting the data on these children, the interviewer would directly survey the children themselves, survey the parents, or even survey a mixture of the two, depending on the age of the child in that particular year. I only use the data from the years 1998 through 2006 of the children subsection of the NLSY for the purpose of this study, as within this time period, the types of questions and ranges of available answers in the survey were consistent with each other. This consistency means the data is comparable, thus making the results of the regressions interpretable.

There are four main variables used in my study, two dependent variables and two main independent variables of interest. The two dependent variables are results from the Peabody Individual Achievement Test (PIAT), the first being the student's percentile ranking in math and the second being the student's percentile ranking in reading. The first variable of interest, music education, is represented by whether or not a child has an instrument in his or her home. The second variable of interest is a "critical age" term, meaning the best age for a child to have started their musical education in order for it to have the most beneficial effect. The age chosen for this is seven, which is consistent with previous studies, such as Johnson and Newport (1991). Also, at this age the music education curriculum switches from early childhood theory to elementary theory, or in grade levels, it switches from first grade to second grade.

Tables 1 through 4 contain the descriptive statistics of this data. The Total Sample sections of the Tables are the descriptive statistics for the entire subsection of children. The Math Dependent Variable sections in Tables 1 and 2 contain the descriptive statistics of the data used when the PIAT Math Test is used as the dependent variable, and the Reading Dependent Variable sections in Tables 3 and 4 have the descriptive statistics of the data when the PIAT Reading test is the dependent variable. The number of available observations varied depending on which of these dependent variables were used. When the PIAT math percentile ranking is the dependent variable, there were 7,610 useable observations; however, when using the PIAT reading percentile ranking as the dependent variable, the useable observations dropped to 7,470. The range of the data is representative of a large range of the United States. This means the results can be viewed as representative of the population as a whole. Regardless of which dependent variable is being used, the scores of the children range from the first percentile to the ninety-ninth percentile on both tests. The ages of the children range from six-years-old to fourteen-years-old, because of the scoring standard of the tests. The education levels of the mothers range from no education to up to twenty years of education. And finally, the household income of the children ranges from as low as $0 to as high as $479,980. About 26.8 percent of the children are of African descent, and 19 percent of the children identify as being Hispanic or Latino(a).

4. Empirical Methods:

4.1 Simple Regressions

I use a variety of empirical techniques to examine the effects of music education on the academic outcomes of students. First, to gain a basic understanding of the relationship between the dependent variables (math and reading percentiles scores) and independent variables of interest (having a musical instrument at home and whether or not there is a significant, time sensitive, critical age), I look at a simple bivariate regression. These are two for each dependent variable; one of each has the musical instrument at home and the critical age variables, and the other of each has only the musical instrument at home variable. The simple regression models are:

$$PIAT_{it} = \rho_0 + \rho_1 musiclessons_{it} + \boldsymbol{\varepsilon_{it}} \qquad (1)$$

$$PIAT_{it} = \mu_0 + \mu_1 musiclessons_{it} + \mu_2 critage_i + \boldsymbol{\nu_{it}} \qquad (2)$$

where $PIAT_{it}$ represents the percentile score in either the PIAT reading or PIAT mathematics test of child *i* in year *t*; $musiclessons_{it}$ is dummy variable representing whether child *i* had a musical instrument at home in year *t*; $critage_i$ is a dummy variable representing whether child *i* had musical lessons by the critical age of seven years old, calculated using the data on whether or not the child had had a musical instrument at home; and finally, $\boldsymbol{\varepsilon_{it}}$ and $\boldsymbol{\nu_{it}}$ represent error terms. The ρ's and μ's are all of the coefficients, which represent the magnitude each individual factor has on percentile scores.

4.2 Baseline Models

After establishing the basic relationships, I choose a method to begin to isolate the true effect of these independent variables by controlling for different observable characteristics. The method I select for this is Ordinary Least Squares (OLS). By using this method, I am able to control for variables which are both measurable and observable. This means the effects of the main independent variables will be isolated as the other independent variables are held constant.

My baseline models are:

$$PIAT_{it} = \beta_0 + \beta_1 musiclessons_{it} + \boldsymbol{d'_{it}}\beta_2 + \boldsymbol{p'_{it}}\beta_3 + \boldsymbol{\tau_t} + \boldsymbol{\varepsilon_{it}} \quad (3)$$

$$PIAT_{it} = \delta_0 + \delta_1 musiclessons_{it} + \delta_2 critage_i + \boldsymbol{d'_{it}}\delta_3 + \boldsymbol{p'_{it}}\delta_4 + \boldsymbol{\tau_t} + \boldsymbol{\nu_{it}} \quad (4)$$

where $PIAT_{it}$, $musiclessons_{it}$, $critage_i$, $\boldsymbol{\varepsilon_{it}}$, and $\boldsymbol{\nu_{it}}$ are defined as above. The remaining variables are $\boldsymbol{d_{it}}$ a vector consisting of different demographical data: the race and gender of child *i* and the child's age in year *t*; $\boldsymbol{p_{it}}$ a vector of parental information for each child *i*: their enrollment of the child in afterschool activities and household income for each year *t*, the mother's level of education, and whether or not it is a one or two parent household; and finally, $\boldsymbol{\tau_t}$ the year fixed effects. The β's and δ's are all of the coefficients, which represent the magnitude each individual factor has on percentile scores.

4.3 Internal Instruments

Even after controlling for the other factors which also could affect academic achievement, there are reasons to suspect the estimate might be biased. First and foremost, there is likely an endogeneity issue present. This could be seen in two different manners. On one hand, parents who provide instruments at home for their children may also be more likely to provide other learning opportunities. That is, the parents want their kids to perform better in school so they would subscribe to herd behavior[1] to assist them, whether it be music, sports, drama, clubs, tutoring and preparation type classes, et cetera. On the other hand, the bias could also be having the opposite effect. The parents might instead focus more on the musical aspect of their children's education, causing shortcomings in their reading and math abilities. That is the instrument at home and the critical age variables can both depend on whether or not the parents consider music education to be a critical component to a child's education or success: viewing it as something that is beneficial, something that is detrimental, or even something that has no effect either way. Another possibility is that a child's natural musical ability might be correlated with their abilities in math and/or reading. In this instance, the child would be performing higher on both math and reading tests than the average student while also being naturally inclined to own an instrument.

In order to attempt to address these problems, I employ the method of internal instruments. This method is especially useful in situations with limited or pre-established data where there are no plausible instruments available to correct for the unobserved error. Instead of adding in a new variable as an instrument, all of the other independent variables in the regression are utilized as the instruments instead. This is possible, assuming the other independent variables have no correlation with the present heteroskedastic errors. Instead, these heteroskedastic errors are used to produce external variation. When applied to models which have used "traditional" external instrumental

[1] e.g. the quick adoption of the Mozart effect when that study was first released

variables, in place of those variables, the resulting coefficients were similar. This method is an extrapolation of the Lewbel Approach (Lewbel 2012). The following is a representation of the calculations that were used for this. In the first stage:

$$musiclessons_{it}'' = \zeta_0 + \boldsymbol{d'}_{\boldsymbol{it}}\zeta_1 + \boldsymbol{p'}_{\boldsymbol{it}}\zeta_2 + \boldsymbol{\eta}_{\boldsymbol{it}} \tag{5}$$

$$critage_{it}'' = \gamma_0 + \boldsymbol{d'}_{\boldsymbol{it}}\gamma_1 + \boldsymbol{p'}_{\boldsymbol{it}}\gamma_2 + \boldsymbol{\xi}_{\boldsymbol{it}} \tag{6}$$

where $\boldsymbol{d}_{\boldsymbol{it}}$ and $\boldsymbol{p}_{\boldsymbol{it}}$ are still the vectors of the same control variables. However, there are now two more variables, $\boldsymbol{\eta}_{\boldsymbol{it}}$ and $\boldsymbol{\xi}_{\boldsymbol{it}}$, which are the error terms of their respective equations. The ζ's and γ's are the coefficients, which represent the magnitude each individual factor has on the percentile scores. I estimate values for $\boldsymbol{\eta}_{\boldsymbol{it}}$ and $\boldsymbol{\xi}_{\boldsymbol{it}}$ by predicting the residuals of the above equations. These estimated errors are then combined with the regressors in the forms of $(\boldsymbol{d}_{\boldsymbol{it}} - \bar{d}_{it})\boldsymbol{\eta}_{\boldsymbol{it}}$, $(\boldsymbol{p}_{\boldsymbol{it}} - \bar{p}_{it})\boldsymbol{\eta}_{\boldsymbol{it}}$, etc. Where $\boldsymbol{d}_{\boldsymbol{it}}$ and $\boldsymbol{p}_{\boldsymbol{it}}$ have the same meaning, and $\bar{d}_{it}$ and $\bar{p}_{it}$ are the average values of the vectors. The resulting vectors are the actual instruments used in equations (3) and (4) reducing endogeneity concerns. It has the following form:

$$PIAT_{it} = \beta_0 + \beta_1 musiclessons_{it}'' + \boldsymbol{d'}_{\boldsymbol{it}}\beta_2 + \boldsymbol{p'}_{\boldsymbol{it}}\beta_3 + \boldsymbol{\tau}_{\boldsymbol{t}} + \boldsymbol{\varepsilon}_{\boldsymbol{it}} \tag{7}$$

$$PIAT_{it} = \delta_0 + \delta_1 musiclessons_{it}'' + \delta_2 critage_i'' + \boldsymbol{d'}_{\boldsymbol{it}}\delta_3 + \boldsymbol{p'}_{\boldsymbol{it}}\delta_4 + \boldsymbol{\tau}_{\boldsymbol{t}} + \boldsymbol{\nu}_{\boldsymbol{it}} \tag{8}$$

where these equations are generally the same as the previous, but a "$''$" superscript denotes the different variables representing music lessons and critical age. The variables $musiclessons_{it}''$ and $critage_i''$ are vectors containing those individual instrument calculations. This drastically mitigates the chances that endogeneity remains in the instrumented $musiclessons_{it}$ and $critage_{it}$ variables. From each of the different instrumentations done for these models, the lowest first stage F-stat of excluded instruments is 85.38, indicating that none of the instrumental variables used are weak (Staiger and Stock 1997).

4.4 Lagged Dependent Variable Models

However, even after addressing these endogeneity issues, there is still the potential for unobserved effects which are time invariant. In order to account for this, a lagged value of the dependent variable[2] is included as a control in the regression to encompass these effects. A way to visualize this is modifying the left hand side of the above equations to $P_{it} - P_{it-2}$, where those time invariant factors are the same in both terms. Separating out the time invariant factors out of the other terms modifies the equation to $(p`_{it} + c_i) - (p`_{it-2} + c_i) = p`_{it} + c_i - p`_{it-2} - c_i$. All that remains then is $p`_{it} - p`_{it-2}$ which are the dependent variable and its lag without their time invariant factors. These new equations, implementing the fix for the time invariant effects, are:

$$PIAT_{it} = \theta_0 + \theta_1 musiclessons_{it} + \theta_2 P_{it-2} + \boldsymbol{d_{it}}'\theta_3 + \boldsymbol{p_{it}}'\theta_4 + \boldsymbol{\tau_t} + \boldsymbol{\varepsilon_{it}} \qquad (9)$$

$$PIAT_{it} = \lambda_0 + \lambda_1 musiclessons_{it} + \lambda_2 critage_i + \lambda_3 P_{it-2} + \boldsymbol{d'_{it}}\lambda_4 + \boldsymbol{p'_{it}}\lambda_5 + \boldsymbol{\tau_t} + \boldsymbol{\nu_{it}} \qquad (10)$$

where, because the data is measured every other year, P_{it-2} represents individual i's percentile ranking in the previous period. The θ's and λ's are all of the coefficients, which represent the magnitude each individual factor has on the percentile scores.

Nevertheless, even after accounting for unobserved effects, the equations may still have endogeneity issues. Thus, similar to equations (5) and (6), two new first stage

[2] As the data measurements occur every other year, a lagged value would occur at t-2 instead of t-1.

equations are created to implement a form of Lewbel's internal instrument approach to include the lagged dependent variable. The first stage equations for these are as follows:

$$musiclessons_{it}''' = \phi_0 + \phi_1 P_{it-2} + \boldsymbol{d_{it}}'\phi_2 + \boldsymbol{p_{it}}'\phi_3 + \boldsymbol{\psi_{it}} \quad (11)$$

$$critage_{it}''' = \chi_0 + \chi_1 P_{it-2} + \boldsymbol{d_{it}}'\chi_2 + \boldsymbol{p_{it}}'\chi_3 + \boldsymbol{\omega_{it}} \quad (12)$$

where all variables are defined as before, but with $\boldsymbol{\psi_{it}}$ and $\boldsymbol{\omega_{it}}$ being the error terms. ϕ's and χ's are the coefficients which represent the magnitude each individual factor has on the independent variable. Once again I proceed to estimate the values of $\boldsymbol{\psi_{it}}$ and $\boldsymbol{\omega_{it}}$. Then, as before, the estimated errors, $\boldsymbol{\psi_{it}}$ and $\boldsymbol{\omega_{it}}$, are combined with the regressors to create the instruments. These instrumental variables are incorporated into equations (9) and (10) to create the fully defined models in which I have accounted for all forms of endogeneity. The lowest first stage F-Stat of exclusion for these tests is 3,956.51 indicating that none of these instruments are weak (Staiger and Stock 1997). The resulting equations:

$$PIAT_{it} = \theta_0 + \theta_1 musiclessons_{it}''' + \theta_2 P_{it-2} + \boldsymbol{d_{it}}'\theta_3 + \boldsymbol{p_{it}}'\theta_4 + \boldsymbol{\tau_t} + \boldsymbol{\varepsilon_{it}} \quad (13)$$

$$PIAT_{it} = \lambda_0 + \lambda_1 musiclessons_{it}''' + \lambda_2 critage_i + \lambda_3 P_{it-2} + \boldsymbol{d}_{\boldsymbol{it}}'\lambda_4 + \boldsymbol{p}_{\boldsymbol{it}}'\lambda_5 + \boldsymbol{\tau_t} + \boldsymbol{\nu_{it}} \quad (14)$$

are the most presumably accurate models developed for this study. All of the variables are defined as before, with the superscript of "$'''$" attached to $\boldsymbol{musiclessons}$ and $\boldsymbol{critage}$ signifying the instrumental variables. This is done so that each model may be concisely written.

4.5 Estimation with Bootstrapped Standard Errors

The use of internal instruments does not allow for the use of robust standard errors. Thus, throughout these equations, one more technique is used to assure an accurate measurement, bootstrapped standard errors. The bootstrapped standard errors are obtained through the original regression data. To begin, the data used in the regression is assumed to actually be the population data. Then, from this data, different subsets are randomly obtained by choosing one sample, replacing it, taking a second sample at random, replacing it, and iterating until a new data set is completed. The drawing, replacing, and formation of a new data set is performed a large number of times to attain an estimation of the distribution. From this distribution, the standard errors are able to correct for heteroskedasticity.

5. Results:

An examination of the control variables show that they behave as would be expected, especially in the OLS and internal instruments models. Traditionally, one sees people of Hispanic background, or of African descent performing lower on standardized tests. That is the case with all models in all forms, except for Hispanic in the lagged dependent variable model with math as the dependent variable with no critical age. Involvement in summer activities is always associated with a positive increase on test performance in all models, though this effect loses significance in the lagged dependent variable model for math without critical age. The gender variable behaves differently for the two different dependent variables. In all regressions where the math score is the dependent variable, the effect of being female is correlated with lower test performance. Conversely, being female is associated with an increase in reading performance for both the OLS and internal instruments regressions, but a decrease in performance in the lagged dependent variable models for both regressions. Higher household income and living in a two adult household are correlated with higher achievement on standardized tests, which is present in all models (barring the lagged dependent variable model where math is the dependent variable with critical age not included). Finally, as expected, the educational attainment of the mother is positively correlated with the child's performance on standardized tests in all models, except for a loss of significance in the lagged dependent variable model for math with no critical age.

5.1 Without Critical Age

5.1.1 Math Dependent Variable

Tables 5-20 contain regression results for the different models with different dependent variables. First, I discuss Tables 5 and 6. These are for the first two models without critical age, using the PIAT math percentile ranking as the dependent variable. The first measured relationship, column one in Tables 5 and 6, is a simple regression between if the children had an instrument at home and his/her math percentile ranking. This simple regression shows a highly statistically significant relation between the presence of a musical instrument in the household and the math percentile ranking, showing that having an instrument at home is associated with a 14.04 percentage point increase in the child's percentile ranking.

However, as noted above, the next step was to control for other observable, measureable factors that could affect academic achievement. After including these controls in a multivariate regression with controls, the musical instrument still has a highly statistically significant effect; however, its magnitude declines to a 6.24 percentage point effect.

Next is the first column in Tables 7 and 8. After employing internal instruments as an additional control in the multivariate regression with controls to account for endogeneity, the still highly significant musical instrument at home increases slightly in magnitude to a 6.29 percentage point effect.

The other column of Tables 7 and 8 is all that remains. Once accounting for unobserved effects with the addition of a lagged dependent variable, the instrument at home is significant with a magnitude of 30.27 percentage points. The variable created to encompass the unobserved effects, Lagged Math Score, has a value of 0.52 percentage points, meaning the effect would be the previous period's percentile ranking multiplied by 0.52. This effect is highly significant. For example, a previous 70th percentile score leads to an upward shift of 36.40 percentage points, compared to someone who previously scored in the 10th percentile, causing an upward shift of only 5.2 percentage points.

5.1.2 Reading Dependent Variable

Tables 9 and 10 contain the results for the first two models with the reading percentile score as the dependent variable, but with no critical age included. The first column of Tables 9 and 10 reveal the simple regression between having a musical instrument at home and reading percentile rank yielding a coefficient that implies a significant 12.06 percentage point increase in reading percentile.

After attempting to correct for observable factors that may affect academic achievement with a multivariate regression with controls, the magnitude of the coefficient for having a musical instrument at home dropped to 5.61 percentage points while still remaining highly significant. This is displayed in column two of Tables 9 and 10.

Next, in the first column of Tables 11 and 12, are results from attempting to address the endogeneity issues with the addition of an internal instruments control to the other controls in the multivariate regression. The highly significant coefficient of having a musical instrument at home has a slight magnitude decrease to 5.01 percentage points.

Finally, there is the other column of Tables 11 and 12. After controlling for unobservable effects with the addition of a lagged dependent variable, the value of instrument ownership, while still highly significant, drops to a value of 2.78 percentage points. The newly created Lagged Reading Score has a highly statistically significant coefficient with a value of 0.57 percentage points. This would mean a child who had a percentile ranking of 70^{th} percentile in one period would have an extra gain of 39.9 percentage points in the next period, as compared to someone who previously scored in the 10^{th} percentile, causing an upward shift of only 5.7 percentage points.

5.2 With Critical Age

The remaining Tables, 13 through 20, are similar to Tables 5 through 12, but include Critical Age. Critical Age represents whether a child had had music education by a specific cut off point. In this study, the cut off age used is seven and is measured by the presence of a musical instrument in the home at any point by the age of seven. The value of this variable has few changes, only differing for those whose age crosses seven years old during the sample period used in this study.

5.2.1 Math Dependent Variable

Tables 13 and 14 are very similar to Tables 5 and 6, with the math percentile rankings again, but with critical age included. The results follow a similar pattern to those presented in Tables 5 and 6. The first simple regression contains only having a music instrument at home and critical age as the independent variables. Both having a musical instrument at home and the critical age variable are highly significant, with effects of 12.37 and 4.63 percentage points respectively for the percentile ranking. In other words, if a child has a musical instrument in their home, they would score 12.37 percentage points higher for that concurrent year. Furthermore, if that same child were to have had a musical instrument in the home by the time he or she were seven, regardless of whether or not he or she has one now, the lasting effect of this would be a further gain of 4.63 percentage points on his or her PIAT Math percentile ranking.

As before, after controlling for observable factors that might have an effect on the math percentile rankings with a multivariate regression with controls, both musical instrument ownership and critical age remain significant. These values are in the second column of Tables 13 and 14. The coefficient for musical instrument at home declines to 5.64 percentage points. The effect of having a musical instrument by the critical age falls to 2.17 percentage points.

After attempting to correct for the endogeneity with the addition of an internal instruments control to the other controls in the multivariate regression, the coefficient on musical instrument at home, remains highly significant, but again drops in magnitude to 5.63 percentage points. However, the still highly significant coefficient on Critical Age has a slight increase in magnitude. These values are presented in the first column of Tables 15 and 16.

Finally, there is the other column of Tables 15 and 16. Once all the unobserved effects have been taken into consideration by using a lagged dependent variable, the effect of having a musical instrument at home drops to 1.20 percentage points and critical age to 7.70 percentage points, both losing their significance. The new Lagged Math Score representing these unobserved effects has a highly significant coefficient whose value is 0.58 percentage points, which would be akin to someone having landed in the 70^{th} percentile the previous period having a supposed extra 40.6 percentage points to their percentile ranking this period, as opposed to someone landing in the 10^{th} percentile in the previous period only having a supposed extra 5.8 percentage points.

5.2.2 Reading Dependent Variable

The last tables, Tables 17 through 20, are for the model using the reading percentile ranking with both a musical instrument at home and the critical age being considered. As shown in column 1 of Tables 17 and 18, the simple regression yields highly significant values on both coefficients, with 10.17 percentage points for the musical instrument and 5.48 percentage points for the critical age.

Once implementing a multivariate regression with controls, column 2 of Tables 17 and 18, the value of the coefficient of a musical instrument at home retains its significance, but drops in magnitude to 5.40 percentage points. The coefficient of critical age loses its significance and its magnitude declines to 0.79 percentage points.

Employing internal instruments as an additional control in the multivariate regression, column 1 of Tables 19 and 20, decreases the magnitude of having a musical instrument at home to 4.85 percentage points while retaining significance. On the other hand, the magnitude of the Critical Age's coefficient increases to 0.94 percentage points and results in statistical significance.

Finally, results when including a lagged dependent variable to address unobserved effects, the results may be seen in column 2 of Tables 19 and 20. The effect of a musical instrument at home retains significance with a further decline in magnitude to 2.50 percentage points, while the critical age coefficient is significant with a magnitude of 1.29 percentage points.

6. Conclusion:

6.1 Results

It is argued that music can have neurological benefits, especially in the constantly evolving minds of children. Despite this, empirical analyses of this subject appear to be relatively sparse. I have attempted to address this void by using data from the National Longitudinal Survey of Youth. I find music that education positively impacts students in both math and reading, as measured by their PIAT test performances. The impact on math scores is uncertain in the presumably most accurate model if considering the critical age of having music education by age seven as one of the factors; however, it does retain the same positive correlation that is present at a 1% significant level in all models except for the lagged dependent variable model. The variable for a child with current musical instrument ownership demonstrates a current effect, and the critical age variable demonstrates a lasting effect of musical ownership at any time by the critical age. For reading, the impact of current music education is positive for both current and lasting effects.

After controlling for different factors that may affect the variables of interest, and accounting for endogeneity, I am able to draw conclusions for both models, with and without the critical age, with both dependent variables. When not considering critical age, the simple presence of a musical instrument at home is shown to increase math and reading performance, with both impacts proving highly significant. Including a critical age variable yields different effects depending on whether you are considering math or reading tests as the dependent variable. In the math model, neither the variable for having a musical instrument at home, nor the variable for critical age has a significant effect. However, while looking at the reading model, the effects of the critical age variable and musical instrument at home variable are both highly significant. Though the impact of the critical age and having a musical instrument at home may seem minute, the benefit of having the instrument is greater than the benefit of increased household income. To put this into perspective, the effect from having a musical instrument at home ranges from around 2 percentage points to 5 percentage points. To increase your test scores by 2 to 5 percentage points, you would need to increase your income by $80 thousand to $200 thousand dollars (by estimate of the around 0.025 average value for the effect of thousands of dollars of income) while holding all else constant. This would imply the effect from having a musical instrument at home being equivalent to about an $80 thousand to $200 thousand dollar increase in income.

6.2 Prospects

However, there are some potential shortcomings in my paper which could be addressed in future analyses. First and foremost is the way by which music education is measured. The best way available for this measurement was by assessing whether or not there was an instrument at home. However, there is no way to guarantee whether or not the child uses it. It could simply be an extension of the parents' personality and effect on the lives of the children. Moreover, there can definitely be children who, despite the lack of a musical instrument at home, still receive significant music education. In future studies, the best approaches would include whether or not the student is taking music classes in school, whether the child takes private lessons or studies on their own at home, how often they take those lessons or study, and what the quality of all of these are. This would guarantee which students are for sure actively participating or not participating in music education and can compare across similar levels of that education. Another examination would be to look at different critical age cutoffs, covering most of elementary school if possible, comparing not only the normal music education in the curriculum but also orchestra, band, piano, and/or youth choir participation as well. Other studies could include examinations of the effects occurring purely with middle and high schools, examining student outcomes and if the varying programs are able to decrease the amount of students dropping out and diminish the frequency of absences.

6.3 Summary and Implications

Noting the already well established generalized neural benefits and opening further potentials for students to pursue music for scholarships to pay for college, I have also shown that music may have a positive impact on how students perform on standardized tests. When examining the impact of music education on language arts, I have shown that this benefit may increase when music education starts at a younger age. I would therefore suggest that districts and/or states start implementing more and more uniform music programs in the elementary school. Where this is not possible, I would suggest increasing the availability of school owned instruments which students might be able to borrow, rent, or play in before or after school programs.

Tables

***Table 1**: Descriptive statistics – Math Dependent Variable*

	Total Sample					Math Dependent Variable *7,610 Observations*			
Coefficient	Observations	Mean	Standard Deviation	Min	Max	Mean	Standard Deviation	Min	Max
Math Percentile Score	11,970	56.3899	28.45488	1	99	57.3597	28.5801	1	99
Instrument at Home	12,023	0.5783	0.4939	0	1	0.5927	0.4914	0	1
Critical Age (of 7)	57,605	0.1879	0.3906	0	1	0.3389	0.4734	0	1
Hispanic	57,605	0.1926	0.3943	0	1	0.1920	0.3939	0	1
Black	57,605	0.2770	0.4475	0	1	0.2672	0.4426	0	1
Age	56,786	16.1940	6.6698	0	36	11.3226	2.1671	6	14
Summer Activities	37,273	0.9286	0.2576	0	1	0.7054	0.4559	0	1
Female	57,600	0.4894	0.4999	0	1	0.4949	0.5000	0	1

***Table 2**: Descriptive statistics – Math Dependent Variable Continued*

	Total Sample					Math Dependent Variable *7,610 Observations*			
Coefficient	Observations	Mean	Standard Deviation	Min	Max	Mean	Standard Deviation	Min	Max
Maternal Education Achievement	41,302	12.6327	2.6287	0	20	13.3312	2.6388	0	20
Spouse or Partner Living at Home	41,379	0.6542	0.4756	0	1	0.7130	0.4524	0	1
Income (Thousands of Dollars)	38,280	64.1899	72.7667	0	479.98	77.3753	83.0164	0	479.98

***Table 3**: Descriptive statistics – Reading Dependent Variable*

	Total Sample					Reading Dependent Variable *7,470 Observations*			
Coefficient	Observations	Mean	Standard Deviation	Min	Max	Mean	Standard Deviation	Min	Max
Reading Percentile Score	10,842	53.5917	27.8854	1	99	52.2180	27.8545	1	99
Instrument at Home	12,023	0.5783	0.4939	0	1	0.5951	0.4909	0	1
Critical Age (of 7)	57,605	0.1879	0.3906	0	1	0.3384	0.4732	0	1
Hispanic	57,605	0.1926	0.3943	0	1	0.1901	0.3924	0	1
Black	57,605	0.2770	0.4475	0	1	0.2676	0.4427	0	1
Age	56,786	16.1940	6.6698	0	36	11.3836	2.1111	6	14
Summer Activities	37,273	0.9286	0.2576	0	1	0.7026	0.4572	0	1
Female	57,600	0.4894	0.4999	0	1	0.4978	0.5000	0	1

***Table 4**: Descriptive statistics – Reading Dependent Variable Continued*

	Total Sample					Reading Dependent Variable *7,470 Observations*			
Coefficient	Observations	Mean	Standard Deviation	Min	Max	Mean	Standard Deviation	Min	Max
Maternal Education Achievement	41,302	12.6327	2.6287	0	20	13.3455	2.6288	0	20
Spouse or Partner Living at Home	41,379	0.6542	0.4756	0	1	0.7142	0.4518	0	1
Income (Thousands of Dollars)	38,280	64.1899	72.7667	0	479.98	77.6580	83.1503	0	479.98

Table 5: *Math Test – No Critical Age*

Regression Type	Pooled OLS	Pooled OLS
Instrument at Home	14.0405*** (0.5309)	6.2356*** (0.4977)
Hispanic	…	-8.8433*** (0.6325)
Black	…	-14.7875*** (0.5909)
Year 2000 Dummy	…	-0.5689 (0.8038)
Year 2002 Dummy	…	-0.2128 (0.7088)
Year 2004 Dummy	…	0.4610 (0.7383)
Year 2006 Dummy	…	2.7535*** (0.7700)
Age	…	-0.8126*** (0.1077)
Summer Activities	…	2.1932*** (0.5352)
Female	…	-2.9891*** (0.4498)

***Table 6**: Math Test – No Critical Age Continued*

Regression Type	Pooled OLS	Pooled OLS
Maternal Education Achievement	…	2.1553*** (0.0948)
Spouse or Partner Living at Home	…	3.2257*** (0.5470)
Income (Thousands of Dollars)	…	0.0292*** (0.0027)
Constant	48.3997*** (0.4034)	34.6823*** (1.9947)
F-Stat	699.31	173.85
R^2	0.0601	0.2293
First Stage F-Stat of Excluded Instruments	…	…
Observations	10,942	7,610

Notes: The number in parentheses represents the standard errors for the percentile score. The reference groups are 1998 for the year dummy variables, neither Hispanic nor black for race, and male for gender.
*,**,*** - Significant at the 10%, 5%, and 1% levels respectively

Table 7: *Math Test – No Critical Age Continued*

Regression Type	Internal Instruments	Lagged Dependent Variable
Instrument at Home	6.2916*** (0.5513)	30.2745* (16.4556)
Lagged Math Score	…	0.5239*** (0.0360)
Hispanic	-8.8368*** (0.6417)	0.7546 (2.2598)
Black	-14.7796*** (0.5944)	-2.9755*** (1.9355)
Year 2000 Dummy	-0.5697 (0.7852)	-0.2215 (1.5232)
Year 2002 Dummy	-0.2150 (0.6945)	0.0573 (1.1374)
Year 2004 Dummy	0.4580 (0.7339)	-1.3303*** (0.9263)
Year 2006 Dummy	2.7477*** (0.7848)	…
Age	-0.8135*** (0.1097)	-1.7684*** (0.2283)
Summer Activities	2.1892*** (0.5366)	0.2582 (1.0879)
Female	-2.9920*** (0.4447)	-3.2230*** (1.0440)

Table 8: *Math Test – No Critical Age Continued*

Regression Type	Internal Instruments	Lagged Dependent Variable
Maternal Education Achievement	2.1533***	0.0015
	(0.0972)	(0.5078)
Spouse or Partner Living at Home	3.2204***	-0.0190
	(0.5489)	(1.7148)
Income (Thousands of Dollars)	0.0291***	0.0012
	(0.0027)	(0.0074)
Constant	34.6936***	30.2274***
	(2.0468)	(3.0578)
F-Stat	173.85	182.50
R^2	0.2293	0.3690
First Stage F-Stat of Excluded Instruments	112.96	93.39
Observations	7,610	5,267

Notes: The number in parentheses represents the standard errors for the percentile score. The reference groups are 1998 for the year dummy variables, neither Hispanic nor black for race, and male for gender.
*,**,*** - Significant at the 10%, 5%, and 1% levels respectively

***Table 9**: Reading Test – No Critical Age*

Regression Type	Pooled OLS	Pooled OLS
Instrument at Home	12.0561*** (0.5351)	5.609*** (0.4762)
Hispanic	…	-5.8290*** (0.6115)
Black	…	-14.8529*** (0.5578)
Year 2000 Dummy	…	-1.2980* (0.7770)
Year 2002 Dummy	…	-1.1667* (0.6745)
Year 2004 Dummy	…	-0.9020 (0.6874)
Year 2006 Dummy	…	-0.1654 (0.7365)
Age	…	-3.0067*** (0.1029)
Summer Activities	…	1.4452*** (0.4988)
Female	…	0.7209* (0.4282)

***__Table 10__**: Reading Test – No Critical Age Continued*

Regression Type	Pooled OLS	Pooled OLS
Maternal Education Achievement	…	2.1663*** (0.0926)
Spouse or Partner Living at Home	…	2.7412*** (0.5202)
Income (Thousands of Dollars)	…	0.0219*** (0.0028)
Constant	46.4102*** (0.4083)	54.9853*** (1.9352)
F-Stat	507.61	208.92
R^2	0.0460	0.2670
First Stage F-Stat of Excluded Instruments	…	…
Observations	10,537	7,470

Notes: The number in parentheses represents the standard errors for the percentile score. The reference groups are 1998 for the year dummy variables, neither Hispanic nor black for race, and male for gender.
*,**,*** - Significant at the 10%, 5%, and 1% levels respectively

***__Table 11__**: Reading Test – No Critical Age Continued*

Regression Type	Internal Instruments	Lagged Dependent Variable
Instrument at Home	5.0089*** (0.5076)	2.7803*** (0.4997)
Lagged Reading Score	…	0.5658*** (0.0092)
Hispanic	-5.8975*** (0.6129)	-2.2496*** (0.6503)
Black	-14.9367*** (0.5675)	-7.8776*** (0.5891)
Year 2000 Dummy	-1.2912 (0.7899)	-0.7094 (0.6547)
Year 2002 Dummy	-1.1455* (0.6813)	-1.1268* (0.6035)
Year 2004 Dummy	-0.8726 (0.6973)	-1.1738* (0.6162)
Year 2006 Dummy	-0.1044 (0.7412)	…
Age	-2.9985*** (0.1031)	-1.2712*** (0.1350)
Summer Activities	1.4876*** (0.5026)	1.4186*** (0.5164)
Female	0.7527* (0.4234)	-1.0626** (0.4291)

Table 12: *Reading Test – No Critical Age Continued*

Regression Type	Internal Instruments	Lagged Dependent Variable
Maternal Education Achievement	2.1871***	1.1061***
	(0.0928)	(0.0950)
Spouse or Partner Living at Home	2.8008***	2.3529***
	(0.5251)	(0.5553)
Income (Thousands of Dollars)	0.0222***	0.0098***
	(0.0028)	(0.0028)
Constant	54.8694***	18.4524***
	(1.9311)	(2.2501)
F-Stat	208.82	430.78
R^2	0.2669	0.5139
First Stage F-Stat of Excluded Instruments	112.96	85.38
Observations	7,470	4,771

Notes: The number in parentheses represents the standard errors for the percentile score. The reference groups are 1998 for the year dummy variables, neither Hispanic nor black for race, and male for gender.
*,**,*** - Significant at the 10%, 5%, and 1% levels respectively

***Table 13**: Math Test – With Critical Age*

Regression Type	Pooled OLS	Pooled OLS
Instrument at Home	12.3687*** (0.5714)	5.6409*** (0.5202)
Critical Age	4.6285*** (0.5945)	2.1689*** (0.5052)
Hispanic	…	-8.7401*** (0.6354)
Black	…	-14.6870*** (0.5972)
Year 2000 Dummy	…	-0.5319 (0.7731)
Year 2002 Dummy	…	-0.1465 (0.6944)
Year 2004 Dummy	…	0.5196 (0.7235)
Year 2006 Dummy	…	2.8218*** (0.7657)
Age	…	-0.7521*** (0.1074)
Summer Activities	…	2.2216*** (0.5207)
Female	…	-2.9301*** (0.4402)

Table 14: *Math Test – With Critical Age Continued*

Regression Type	Pooled OLS	Pooled OLS
Maternal Education Achievement	…	2.1227*** (0.0969)
Spouse or Partner Living at Home	…	3.1520*** (0.5408)
Income (Thousands of Dollars)	…	0.0289*** (0.0027)
Constant	47.7771*** (0.4102)	33.9779*** (2.0108)
F-Stat	381.86	162.42
R^2	0.0653	0.2304
Lowest First Stage F-Stat of Excluded Instruments	…	…
Observations	10,942	7,610

Notes: The number in parentheses represents the standard errors for the percentile score. The reference groups are 1998 for the year dummy variables, neither Hispanic nor black for race, and male for gender.
*,**,*** - Significant at the 10%, 5%, and 1% levels respectively

***__Table 15__**: Math Test – With Critical Age Continued*

Regression Type	Internal Instruments	Lagged Dependent Variable
Instrument at Home	5.6324*** (0.5679)	1.2029 (9.2304)
Critical Age	2.1718*** (0.5011)	7.6962 (10.9881)
Lagged Math Score	…	0.5750*** (0.0206)
Hispanic	-8.7408*** (0.6303)	-2.3490* (1.3418)
Black	-14.6879*** (0.5966)	-5.6804*** (1.1141)
Year 2000 Dummy	-0.5318 (0.7778)	-2.5652 (1.0148)
Year 2002 Dummy	-0.1461 (0.6897)	-1.4867* (0.7774)
Year 2004 Dummy	0.5201 (0.7212)	-2.3591*** (0.6989)
Year 2006 Dummy	2.8227*** (0.7607)	…
Age	-0.7519*** (0.1059)	-1.2411*** (0.3548)
Summer Activities	2.2222*** (0.5364)	1.7998** (0.7132)
Female	-2.9296*** (0.4427)	-1.4165* (0.8016)

***<u>Table 16</u>**: Math Test – With Critical Age Continued*

Regression Type	Internal Instruments	Lagged Dependent Variable
Maternal Education Achievement	2.1230*** (0.0979)	0.7050** (0.2902)
Spouse or Partner Living at Home	3.1526*** (0.5447)	2.4157** (0.9985)
Income (Thousands of Dollars)	0.0289*** (0.0027)	0.0123*** (0.0043)
Constant	33.9754*** (1.9946)	28.8027*** (3.8140)
F-Stat	162.42	356.24
R^2	0.2304	0.5014
Lowest First Stage F-Stat of Excluded Instruments	112.96	47.10
Observations	7,610	5,267

Notes: The number in parentheses represents the standard errors for the percentile score. The reference groups are 1998 for the year dummy variables, neither Hispanic nor black for race, and male for gender.
*,**,*** - Significant at the 10%, 5%, and 1% levels respectively

Table 17: *Reading Test – With Critical Age*

Regression Type	Pooled OLS	Pooled OLS
Instrument at Home	10.1680*** (0.5709)	5.3991*** (0.4938)
Critical Age	5.4808*** (0.5940)	0.7921 (0.4827)
Hispanic	…	-5.7939*** (0.6224)
Black	…	-14.8173*** (0.5633)
Year 2000 Dummy	…	-1.2835 (0.7892)
Year 2002 Dummy	…	-1.1411* (0.6775)
Year 2004 Dummy	…	-0.8808 (0.7064)
Year 2006 Dummy	…	-0.1398 (0.7504)
Age	…	-2.9843*** (0.1042)
Summer Activities	…	1.4536** (0.5184)
Female	…	0.7424* (0.4259)

***__Table 18__**: Reading Test – With Critical Age Continued*

Regression Type	Pooled OLS	Pooled OLS
Maternal Education Achievement	…	2.1543*** (0.0934)
Spouse or Partner Living at Home	…	2.7140*** (0.5249)
Income (Thousands of Dollars)	…	0.0218*** (0.0028)
Constant	45.6409*** (0.4151)	54.7237*** (1.9493)
F-Stat	298.39	194.13
R^2	0.0536	0.2671
Lowest First Stage F-Stat of Excluded Instruments	…	…
Observations	10,537	7,470

Notes: The number in parentheses represents the standard errors for the percentile score. The reference groups are 1998 for the year dummy variables, neither Hispanic nor black for race, and male for gender.
*,**,*** - Significant at the 10%, 5%, and 1% levels respectively

__Table 19__: Reading Test – With Critical Age Continued

Regression Type	Internal Instruments	Lagged Dependent Variable
Instrument at Home	4.8502*** (0.8053)	2.5024*** (0.5080)
Critical Age	0.9383* (0.5365)	1.2938*** (0.4820)
Lagged Reading Score	…	0.5661*** (0.0091)
Hispanic	-5.8456*** (0.6016)	-2.1710*** (0.6642)
Black	-14.8819*** (0.5703)	-7.8055*** (0.6064)
Year 2000 Dummy	-1.2750 (0.7894)	-0.7241 (0.6527)
Year 2002 Dummy	-1.1184* (0.6761)	-1.1203* (0.6003)
Year 2004 Dummy	-0.8520 (0.6980)	-1.1700** (0.5968)
Year 2006 Dummy	-0.0833 (0.7338)	…
Age	-2.9732*** (0.1029)	-1.2275*** (0.1346)
Summer Activities	1.4912*** (0.5079)	1.4123*** (0.5133)
Female	0.7734* (0.4275)	-1.0144** (0.4336)

***<u>Table 20</u>**: Reading Test – With Critical Age Continued*

Regression Type	Internal Instruments	Lagged Dependent Variable
Maternal Education Achievement	2.1698*** (0.0924)	1.0806*** (0.0963)
Spouse or Partner Living at Home	2.7596*** (0.5331)	2.3202*** (0.5641)
Income (Thousands of Dollars)	0.0221*** (0.0028)	0.0096*** (0.0029)
Constant	54.5770*** (1.9253)	17.9853*** (2.2570)
F-Stat	194.05	400.35
R^2	0.2671	0.5143
Lowest First Stage F-Stat of Excluded Instruments	112.96	43.46
Observations	7,470	4,771

Notes: The number in parentheses represents the standard errors for the percentile score. The reference groups are 1998 for the year dummy variables, neither Hispanic nor black for race, and male for gender.
*,**,*** - Significant at the 10%, 5%, and 1% levels respectively

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