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PIER Working Paper
22-019

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September, 2022

The impact of the JUNTOS conditional cash transfer programme on foundational cognitive skills: Does age of enrollment matter?

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Abstract

This paper studies the relationship between the age of enrolment in Peru's conditional cash transfer programme, JUNTOS, and the foundational cognitive skills of a sample of children aged between 5 and 12 years old. Using a difference-in-differences approach and exploiting within-household variation, we show that younger siblings in recipient households display significantly higher levels of inhibitory control than their older counterparts (0.11 standard deviations), having benefited from the programme for the first time at a relatively earlier age. In high-income countries, this behavioural trait has been linked to later-life outcomes such as job success, physical health, and even reduced risk of criminality. Conversely, we find little evidence that enrolment age is associated with long-term memory, working memory, or implicit learning. Employing a threshold estimator, we show that relative gains in inhibitory control are most clearly defined where a child benefits from the programme before they reach 80 months of age (6.7 years). In an extension to our main results, we then conduct mediation analysis, demonstrating that a small but meaningful proportion of this benefit (6.5%) operates through changes in the probability of the child's timely entry into primary school.

Keywords: Cognitive skills; JUNTOS; conditional cash transfer; Peru; inhibitory control

JEL Codes: J24, 015, I24

Acknowledgements: This study was funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD R21 HD097576) project entitled "Foundational cognitive skills in low- and middle-income countries: early-life nutritional, climatic and policy determinants and impacts on adolescent education, socio-emotional competencies and risky behaviors." The funder had no role in the design, interpretation or writing-up of the study or in the decision to submit the study for consideration for publication. Thanks also to the UK's Foreign, Commonwealth and Development Office (FCDO) for funding Young Lives at Work and enabling this research. Additional funding was also provided by the Old Dart Foundation. Special thanks to Margaret Sheridan, Marta Favara, Catherine Porter, Richard Freund, Annina Hittmeyer, Nicolás Pazos Navarro and Santiago Cueto for very useful comments and feedback.

Ethical Approval: The Institutional Review Board of the University of Pennsylvania approved this project (protocol #834313).

1. Introduction

Throughout the developing world, conditional cash transfers (CCTs) are one of the most widely implemented policies aimed at addressing intergenerational poverty. CCT programmes typically provide financial payments to recipient households upon the fulfilment of a set of pre-specified conditions, commonly including a requirement to ensure all children receive routine health checks and attend school regularly (at the appropriate ages). Given the prevalence of CCTs, it is unsurprising, therefore, that attempts to verify the impact of these programmes have generated a substantial literature across multiple academic disciplines. The majority of these studies aim to evaluate the direct benefits of programme enrolment by focusing on indicators of childhood nutrition, school enrolment, or (to a lesser extent) cognitive achievement tests (see Manley et al. 2013, and Glewwe & Muralidharan, 2016 for overviews). Evidence of the impact of CCTs on more general cognitive abilities is far more limited, however (two exceptions are Macours et al., 2012 and Barham et al., 2013). As these broader cognitive skills are believed to play determining roles in school readiness and subsequent academic achievement (Blair, 2002; Blair & Razza, 2007), while also being associated with adult outcomes, such as wealth, investment, and even criminal behaviour (Moffitt et al. 2011; Diamond, 2013), this is an important oversight.

This study seeks to establish whether a link exists between the age of enrolment in Peru's JUNTOS CCT programme and the development of foundational cognitive skills (FCS).[1] We use an innovative tablet-based test to measure four distinct cognitive abilities: long-term memory, inhibitory control, working memory, and implicit learning. Our analysis exploits variation in the age at which the child's household was first enrolled in the

[1] We consider foundational cognitive skills to be a set of cognitive abilities that are considered domain-general, rather than skills such as reading, arithmetic, or linguistics, which are domain-specific to certain types of knowledge (Hamoudi & Sheridan, 2015).

JUNTOS programme, utilizing a main, cross-sectional sample of 1,755 children aged 11 and 12 years old, as well as information on a group of 726 younger siblings.

For the initial part of the analysis, we employ a difference-in-differences approach, exploiting within-household variation to establish the likelihood that age at first exposure to the programme influences FCS. As is the case with most CCT programmes, JUNTOS imposes a number of conditionalities, many of which will apply only during a particular stage of a child's life.[2] For this reason, it seems likely that variation in age of enrolment will lead to differential impacts.

We then employ a threshold model to establish the specific age that matters most for maximizing FCS benefits from early receipt of JUNTOS. In an extension to our main results, we also conduct mediation analysis to predict the role played by nutrition and schooling (key targets of the JUNTOS programme) in explaining the cognitive gains achieved by those receiving the programme at relatively earlier ages.

Using within-household variation in FCS and exploiting the earlier exposure ages of the younger siblings (three years, on average), our findings show that the siblings of JUNTOS-recipient children display significantly higher levels of inhibitory control than their older counterparts. This improvement equates to a 0.11 standard deviation increase in our measured test score for this component of FCS.[3] Focusing on inhibitory control, our threshold estimator predicts that the greatest benefits for this specific cognitive ability occur when a household receives JUNTOS for the first time before the child reaches 80 months of age (6.67 years). We find little evidence that relatively earlier enrolment in the

[2] The specific conditionalities associated with JUNTOS are discussed in Section 3.

[3] A 0.11 standard deviation in the inhibitory control score represents a 0.02 second faster response time in our test, which is based on the 'Simon Task' game developed by Simon & Rudell (1967). Further details of the approach used to elicit measures of FCS can be found in Section 4.2 and Appendix B.

programme is associated with improvements in working memory, long-term memory, or implicit learning.

In an extension to our main results, we explore the potential mechanisms which may link early receipt of JUNTOS to improvements in inhibitory control. Mediation analysis suggests that a higher probability of timely enrolment in Grade 1 of primary school explains a small but meaningful proportion of the heterogeneity between younger and older beneficiaries (approximately 6.5%). Although we find a clear positive correlation between improved inhibitory control and height-for-age, there is little evidence that relatively early receipt of JUNTOS influences this outcome, beyond any overall benefits gained (regardless of enrollment age). Similarly, we are unable to find a significant link operating through a reduction in school absenteeism.

The paper provides two key contributions. First, we employ a unique dataset measuring four distinct components of FCS, collected via an innovative tablet-based test: the Rapid Assessment of Cognitive and Emotional Regulation (RACER). Unlike the majority of papers considering the effect of CCTs on cognitive skills, the measures we record are not domain-specific (based on skills in mathematics, vocabulary, or literacy, for example), and should, therefore, be relatively free of bias due to the language of implementation or differences in the child's, caregiver's or community's beliefs in the value of academic knowledge.

Second, we go beyond a general discussion of the impact of CCT enrollment age on cognitive ability, and shed light on the role of specific mechanisms underlying the link between JUNTOS and FCS. Our findings have clear policy implications for the future design and roll-out of the JUNTOS programme in Peru, but also for the numerous other CCTs operating across Latin America, and in many low- and middle-income countries throughout the world.

More generally, this study contributes to the extensive literature evaluating the impact of CCTs (see Fiszbein & Schady, 2009), and the less numerous papers aimed at verifying the impact of Peru's JUNTOS programme specifically (Perova & Vakis, 2012; Sánchez & Jaramillo, 2012; Andersen et al., 2015; Díaz & Saldarriaga, 2019; Sánchez et al., 2020, among others). We also contribute to the growing number of papers addressing the early childhood determinants of cognitive skills (Cunha & Heckman, 2007; Maluccio et al., 2009; Attanasio, 2015; Schady et al., 2015; Grantham-McGregor et al., 2020; Attanasio et al, 2023), and especially those concerned with the benefits of appropriately timed entry into primary education (Glewwe & Jacoby, 1995; Alderman et al., 2001; Glewwe et al., 2001).

The remainder of the paper is organized as follows: The next section briefly describes the relevant literature on the impact of cash transfer programmes on cognitive skills, with a particular focus on studies related to Latin America and those considering domain-general aspects of cognition. Section 3 describes the JUNTOS programme, in terms of coverage, eligibility and conditionalities. Section 4 describes the data used in the analysis, including the measures of the four components of FCS. Section 5 describes the conceptual framework of our study and our empirical strategy. The main results of the paper can be found in Section 6. In Section 7, we extend our analysis to consider the role played by specific mechanisms in linking early receipt of JUNTOS to improvements in cognitive ability. Section 8 discusses the implications of our findings and concludes.

2. Literature

Early evaluations of the impact of CCTs on human capital (including cognition) commonly focus on school attendance and physical health outcomes. However, CCT programmes generally have two main goals: immediate poverty reduction, through cash transfers, and long-term poverty reduction, through the development of human capital and skills (de Janvry & Sadoulet, 2006; Parker & Todd, 2017). As the development of FCS relates primarily to future returns, and few studies in the literature address the link between CCTs and domain-general cognitive skills, there is a considerable knowledge gap regarding the potential benefit of CCTs for these behavioural traits.

Even among the relatively few studies that do consider the impact of CCTs on cognitive skills, cognition is usually assessed through narrowly defined achievement tests, often related to vocabulary, literacy, or mathematics (see Glewwe & Muralidharan, 2016, for a review). Only a few studies explore concepts such as abstract reasoning (usually through the Raven's progressive matrices test) or executive functioning (Baird et al., 2011; Macours et al., 2012; García et al., 2012; Barham et al., 2013). The remainder of this section briefly summarises the relevant literature concerning the effects of CCT programmes on the development of cognitive skills in low- and middle-income countries, with a specific focus on papers considering FCS. Many of these studies relate to Latin America, where CCTs originated and expanded most rapidly.[4]

In Nicaragua, Macours et al. (2012) employ a randomised control trial (RCT) to estimate the impact of a CCT pilot *Atención a crisis*. For children aged 36 months and older, they evaluate the impact of the programme on the development of vocabulary and short-term memory, using the Peabody Picture Vocabulary Test (PPVT) and a test from the McCarthy scales test battery. These tests were repeated two years later, with the inclusion of an associative memory task from the Woodcock-Johnson-Muñoz battery. Overall, they find that *Atención a crisis* led to persistent positive impacts on short-term and associative

[4] Unlike JUNTOS, which remains in operation 17 years after its inception, most studies considered here relate to CCT programmes which were relatively short-lived (a pilot programme, in Macours et al., 2021). The exception is Colombia's *Familias en Acción*, which is still in operation.

memory, while only a short-term impact is found for receptive vocabulary (measured via the PPVT).

Baird et al. (2011) implement an RCT to assess the role of cash transfers provided to adolescent girls in Malawi on school attendance, cognitive test scores, and non-verbal reasoning. The authors separately evaluate the impact of a CCT and an unconditional cash transfer (UCT). The study finds that both the CCT and UCT lead to an improvement in school enrolment, but only the CCT generates improvements in school attendance and test scores (English reading comprehension and mathematics). Notably, only the CCT is associated with an improvement in non-verbal reasoning (measured via the Raven's test).

A small number of papers focus on the impacts of CCT programmes by comparing early versus later treatment. García et al. (2012) use quasi-experimental methods to assess the long-term impact (after ten years) of *Familias en Acción*, a nationwide CCT programme in Colombia. The authors compare the impact of the programme between an early treatment group (which received the nutritional and schooling subsidies), relative to a late treatment group (which only received the schooling subsidy). They find evidence of an impact of the earlier treatment on mathematics test scores, but not on scores for non-verbal reasoning (again, measured using the Raven's test).

Finally, Barham et al. (2013) conduct an RCT evaluation of Nicaragua´s *Red de Protección Social* programme, comparing the impact of the programme on boys, whose families received transfers in the first 1,000 days of the child's life (the early treatment group), to those first exposed to the programme from ages two to five (the late treatment group).[5] The authors use a composite score based on cognitive tests that measure processing speed, short and longer-term memory, visual integration, and receptive

[5] Notably, the assessment took place ten years after the programme's inception (and five years after it had ceased operation).

vocabulary. They find an improvement in both nutrition and cognitive skills for those treated relatively early.

Although, to the best of our knowledge, the impact of the JUNTOS programme on FCS has not been explored prior to this analysis, the programme's impact on health and human capital accumulation has been the subject of numerous studies (see Sánchez & Rodríguez, 2016, for a review). Sánchez & Jaramillo (2012) show that JUNTOS positively impacts the early nutritional status of children, leading to a reduction in severe stunting, while Perova & Vakis (2012) find a positive impact on school attendance, but not on school enrolment. More recently, Sánchez et al. (2020) explore the impact of JUNTOS on both nutritional status and receptive vocabulary (via the PPVT). In a similar approach to this study, the authors consider the impact of younger (relative to older) exposure, concluding that those exposed during the first four years of life benefit relatively more in terms of nutritional status, while improvements in PPVT scores are only observed for this group.

Overall, the literature suggests that CCT programmes have the potential to positively impact general cognitive development, especially (but not only) for those treated early in life. Moreover, the existing studies on the impact of JUNTOS show that there remains a clear knowledge gap related to the programme's impact on FCS. The need to understand this relationship highlights the key contribution of this paper.

3. The JUNTOS programme

The JUNTOS CCT programme has operated in Peru since 2005 and targets poor families with children or pregnant women. In 2005, the programme was piloted in 70 districts, but gradually expanded over time to reach 638 districts by 2007, and 1,306 districts by 2017 (after a hiatus between 2008-2009). The roll-out can roughly be split into two phases: a first expansion between 2005 and 2007, during which poorer districts (mainly rural) in the highlands of Peru were incorporated into the programme; followed by a second expansion between 2010 and 2013, in which (again, mainly rural) districts located in the Amazonian Jungle region became eligible. More recently, changes in the eligibility criteria have allowed for the inclusion of a greater number of urban districts.

Although the precise programme conditionalities have changed somewhat over time, between 2005 and 2011 (the period of interest for our study) these were as follows: (i) all children must have a national ID; (ii) all children aged less than five years old must attend regular health check-ups and all pregnant women must attend regular antenatal services; (iii) all children aged 6 to 14 years old must be enrolled in school and must maintain at least 85% attendance. Since 2013, an additional requirement relating to attendance at preschool was also included (for those aged four and five), while the age requirement for continued school attendance was increased from 14 to 17 years.

The cash transfer amount is fixed, and is equivalent to 100 soles per month for beneficiary families that fulfill all the required conditions (around US$26).[6] In the early years of the programme, this represented approximately 10% of the average consumption of recipient households (Sánchez et al. 2020), although inflation has reduced the real value of the transfer over time.

Selection for eligibility to receive JUNTOS proceeded in two stages. First, the poorest locations within the country were chosen by ranking districts according to a pre-specified set of criteria. This ranking process took into account the satisfaction of basic needs (access to services, including sewage, clean water, and electricity) as well as the extent of monetary poverty. As previously mentioned, approximately 1,306 districts were

[6] Based on an average 2021 exchange rate of 3.88 soles to the US dollar.

incorporated into the programme by 2017.[7] Second, within selected districts, those households deemed to be the poorest were considered eligible to access the programme. To this end, census data on household and family characteristics were collected by the government in order to establish an eligibility threshold for recipient families (akin to a monetary poverty threshold). Once eligible households were identified, community leaders were asked to check if any poor households had been omitted or non-poor households had been selected. More details on the two-stage selection process can be found in Carpio et al. (2019).

4. Data

4.1 The Young Lives longitudinal study

The data used in this analysis come from the Young Lives longitudinal study (also known as *Niños del Milenio* in Peru). Based at the University of Oxford, the study has tracked approximately 12,000 children in Ethiopia, India (Telangana and Andhra Pradesh states), Peru, and Vietnam since 2002. In Peru, the first survey round, led by *Grupo De Análisis Para El Desarrollo* (GRADE) and the *Instituto de Investigación Nutricional* (IIN), collected information on 2,052 children who were born just after the start of the millennium (henceforth, the *index children*).[8] This initial sample was randomly selected from the universe of districts in the country in 2001, excluding the wealthiest 5%. While some locations were omitted, statistical analysis using data from the Peruvian Demographic and Health Survey indicates that the original sample contained households across the entire wealth spectrum (Escobal & Flores, 2008).[9] The RACER test was

[7] Over time, the criteria for district selection have become more flexible to allow for the inclusion of districts with lower overall rates of poverty, but which may still contain some of the poorest families.
[8] This sample represents the younger cohort of children within the study. An older cohort of 714 children (who were approximately eight years old in 2002) was also surveyed in all rounds. However, the RACER test was not administered to this older group. Hence, they are not included in this analysis.
[9] The study has experienced relatively low attrition rates compared to other longitudinal studies in developing countries (Sánchez & Escobal, 2020). The attrition rate in the final sample, relative to the initial

administered to the Young Lives samples in Ethiopia and Peru in 2013, during Round 4 of the study.[10]

The following analysis focuses primarily on the index children who were administered the RACER test when they were 11 or 12 years old. While this group was the target of the sample design, we also incorporate information relating to 726 younger siblings, closest in age to the index child (next born), who ranged between 5 and 11 years old at the time of the 2013 survey (we refer to this group as the *younger siblings*).

The first column of Table 1 presents descriptive statistics for the sample of index children whose households had received JUNTOS at some point prior to 2013. We report these statistics alongside those for the index children who came from households that had never received the programme (the Non-JUNTOS group). The final two columns in Table 1 present similar statistics for the younger siblings.

Panel A reports little difference in the average age or gender between the groups of JUNTOS and Non-JUNTOS index children. However, the siblings of those in the non-recipient group were slightly younger than those who were enrolled in the programme.[11] Table 1 also clearly indicates relatively lower average levels of schooling among the mothers of JUNTOS-recipient children, alongside a higher probability of the child not speaking Spanish as a first language. Both characteristics would be an indication of JUNTOS children coming from relatively poor or more vulnerable households.

2002 survey, is approximately 14.5% (inclusive of observations dropped due to missing information on key variables). A discussion of attrition is presented in Appendix A.

[10] An analysis of the impact of the Ethiopian Productive Safety Net Programme (PSNP) on FCS, measured via the RACER test, is provided by Freund et al. (2022).

[11] The key findings in our empirical analysis are derived from estimations using only the index children. However, our identification strategy also recognizes expected age differences in FCS, via a series of year-of-birth fixed effects (see Section 5.2).

TABLE 1
Descriptive statistics

	Index children		*Younger siblings*	
Variable	JUNTOS (mean)	Non-JUNTOS (mean)	JUNTOS (mean)	Non-JUNTOS (mean)
Panel A				
Female child	0.48	0.51	0.46	0.49
Child's age (years)	11.9	11.9*	9.0	8.5***
Mother has no formal schooling	0.43	0.03***	0.22	0.02***
Mother has primary schooling only	0.59	0.27***	0.64	0.30***
Mother has post-primary schooling	0.18	0.70***	0.14	0.68***
Child's first language is not Spanish	0.43	0.03***	0.45	0.04***
Panel B				
Rural household	0.67	0.11***	0.69	0.14***
Lowest asset wealth quintile (2002)	0.41	0.10***	0.44	0.11***
Highest asset wealth quintile (2002)	0.00	0.30***	0.00	0.25***
Coastal area	0.25	0.53***	0.23	0.55***
Highlands	0.57	0.25***	0.60	0.24***
Jungle	0.18	0.22*	0.17	0.22
Panel C				
Height-for-age z-score (2013)	-1.70	-0.77***		
Child is stunted (2013)	0.36	0.12***		
Height-for-age z-score (2009)	-1.80	-0.90***		
Child is stunted (2009)	0.39	0.13***		
Panel D				
Age > 6 when starting Grade 1	0.18	0.06***		
Absent school for one week (2013)	0.03	0.09***		
Absent school for one week (2009)	0.07	0.15***		
Number of children	459	1,296	267	459
Number of children (Total)	1,755		726	

Notes: Panel A reports a series of characteristics specific to the child, whereas Panel B reports characteristics of the child's households. Panels C and D report potential mediator variables related to health (Panel C) and schooling (Panel D). All variables presented in Table 1 are dichotomous, with the exception of Child's age and Height-for-age z-scores. Wealth terciles are based on the Young Lives Round 1 (2002) wealth index (Briones, 2017). Indications of the results of *t*-tests of the equality of means between JUNTOS and Non-JUNTOS groups are reported. * denotes significance at 10%, ** significance at 5% and *** significance at 1%.

Panel B provides further evidence of the underlying differences between JUNTOS and Non-JUNTOS children at the household-level. Recipient households are more likely to be found in rural areas and the highlands of Peru. As would be expected, the probability of being included in the lowest (2002) wealth quintile is also higher for those enrolled in the programme (no JUNTOS households are included in the highest wealth quintile).

For the index children only, panels C and D provide information on a number of intermediate outcomes potentially linking enrolment in the programme to changes in FCS. In panel C, height-for-age z-scores are based on measures recorded in both 2013 and in 2009 (during Round 3 of the Young Lives study).[12] In both survey rounds, the height disadvantage among JUNTOS children is significant, as is the relative probability of stunting (z-score < 2 standard deviations below the reference mean). Indeed, more than one-in-three JUNTOS children are stunted in both 2013 and 2009. Following the widely accepted interpretation of such severe height deficits, this would be an indication of long-term poor nutrition or increased exposure to disease (Martorell & Habicht 1986; Matorell et al., 1992; Martorell, 1999; Strauss & Thomas, 2007; Victora et al., 2008 & 2010).

The final panel of Table 1 considers a second set of potential intermediate outcomes related to the JUNTOS conditionalities on schooling (see Section 3). In panel D, we compare the share of each group who were enrolled in Grade 1 of primary school after the government-mandated age of six years old. Although a condition required for receipt of JUNTOS, the probability of late school enrollment is far greater for recipient children. This inconsistency likely comes as a result of some children already having passed six years of age before their households were enrolled in the programme.[13] There does, however, exist some difference in the probability of being absent from school for at least one week in the 12 months before the respective survey. We observe that the index children from the JUNTOS group were less likely to be absent in both 2009 and 2013.

[12] The index children would have been between seven and eight years old in 2009. Although this earlier measure provides an additional point of comparison, in the majority of cases measurement post-dates JUNTOS enrollment. Therefore, this should not be seen as a pre-treatment or baseline variable.

[13] Among the 459 index children who came from households that had received JUNTOS before 2013, 35.8% had already passed their seventh birthday before their household was enrolled in the programme.

4.2 The RACER test of foundational cognitive skills (FCS)

The RACER test (Rapid Assessment of Cognitive and Emotional Regulation) is a tablet-based assessment tool used to measure cognitive skills among children and adolescents. The test is composed of several tasks, each of which contains both challenge trials and baseline trials. Challenge trials are designed to measure a specific skill (for example, working memory), whereas baseline trials, while similar, are intended to measure other aspects of a child's ability, including familiarity with the tablet, motor response, and level of concentration. These baseline measures are employed as controls in the following empirical analysis.

Each of the tasks included in RACER is accompanied by instructions and practice trials and the research team adapted the protocols of the RACER test to ensure similar administration conditions across households.[14] For many of the children involved, this was the first time they had used a tablet, so instructions for each task were initially provided by the enumerators using cards that displayed the same information as that which would be shown on the tablet screen. Prior to the test itself, these same instructions were then also provided via the tablet.[15]

We focus on four cognitive skills measured by RACER: inhibitory control, working memory, long-term memory, and implicit learning.[16] Of particular interest, inhibitory control and working memory are considered to be key elements of executive functioning,

[14] For example, all children completed the task in locations that were as quiet as possible, with the tablet resting on their knees, as opposed to a table. This was done to ensure test conditions were as similar as possible among both poor and wealthy households.
[15] Behrman et al. (2022) provide more details of the protocols applied when implementing the RACER tests among the Young Lives sample.
[16] Inhibitory control is the ability to resist an automatic response (or behaviour), in order to exhibit a response that is more appropriate to achieve a goal; Working memory is the capacity to hold in mind and manipulate stimuli that are no longer present in the environment; Long-term memory is the ability to encode and retain new knowledge; Implicit learning relates to the motor system used to recognize and respond to regularities in the environment, even when the person is not aware of these regularities.

a set of skills that facilitate the formulation and achievement of higher-level abstract goals, without allowing the pursuit of these goals to be overridden by lower-level, more immediate wants (Diamond, 2013). In high-income countries, executive functioning has been linked to job success, physical health, reduced risk of alcohol or drug abuse, and even lower risk of violent behavior (Broidy et al, 2003; Bailey, 2007; Crescioni et al., 2011; Miller et al., 2011).

Appendix B provides descriptions of each of the challenge and baseline trials involved in measuring the four FCS.[17] The scores obtained for the working memory task are based on the Euclidian distance (pixels) from a target point on the screen. Scores for implicit learning are based on a reaction time (in seconds). Inhibitory control scores represent an equally weighted (standardized) measure of both reaction time and distance. Finally, for the task aimed at measuring long-term memory, scores are based on a percentage of correctly matched pairs of shapes. For clearer and consistent interpretation, some outcomes are re-scaled, such that, in all cases, a higher score represents a relatively better performance on the task.[18] All scores are standardized, based on the distribution of scores for the Non-JUNTOS, index children.

Panel A of Table 2 reports the standardized score for children in the JUNTOS and Non-JUNTOS groups. A comparison of the index children is shown in the first two columns and a comparison for the younger siblings in columns 3 and 4. As would be expected, JUNTOS children, who generally come from poorer backgrounds (thus, qualifying for the programme), perform consistently worse in all RACER tasks than those from the Non-

[17] For a more comprehensive description of the RACER tasks see Hamoudi & Sheridan (2015).
[18] Scores for the long-term memory task should be positively related to the unobserved ability (a percentage of correct answers) and are, therefore, not re-scaled before standardizing. Scores for working memory (Euclidian distance from a target point on the screen), implicit learning scores (reaction time) and inhibitory control scores (an equally weighted measure of both reaction time and distance) are first expressed as the inverse of the original score (such that more-positive values imply better performance), and then standardized.

JUNTOS group. A similar pattern can also be observed in a comparison of the younger siblings. We would also expect to observe improvements in FCS by age, and Table 2 appears to support this. We also see clear heterogeneity in the baseline measures intended to capture (and control for) underlying differences in the general ability to perform the tasks (motor skills, speed, or level of concentration, for example). In Panel B, we observe differences in all baseline measures, in at least one of the two groups (index children or younger siblings), with the exception of the baseline task for long-term memory.

TABLE 2
RACER measures of Foundational Cognitive Skills (FCS)

	Index children		*Younger siblings*	
Variable	JUNTOS (mean)	Non-JUNTOS (mean)	JUNTOS (mean)	Non-JUNTOS (mean)
Panel A				
Long-term memory	-0.21	0.00***	-0.42	-0.25**
Inhibitory control	-0.49	0.00***	-0.78	-0.54***
Working memory	-0.48	0.00***	-1.08	-0.64***
Implicit learning	-0.33	0.00***	-0.66	-0.58
Panel B				
Long-term memory (baseline)	-0.05	0.00	0.08	0.17
Inhibitory control (baseline)	-0.39	0.00***	-0.87	-0.63***
Working memory (baseline)	-0.33	0.00***	-0.87	-0.43***
Implicit learning (baseline)	-0.32	0.00***	-0.52	-0.50
Number of children	459	1,296	267	459
Number of children (Total)	1,755		726	

Notes: Panel A reports average performance in each of the FCS measured by RACER, whereas Panel B reports average performance in the baseline trials associated with each FCS. Scores are standardized, according to the distribution for the Non-JUNTOS, index children. Indications of the results of *t*-tests of the equality of means between JUNTOS and Non-JUNTOS groups are reported. * denotes significance at 10%, ** significance at 5% and *** significance at 1%.

5. Conceptual framework and methodology

5.1 Conceptual framework

Although CCT programmes are not specifically designed to improve cognitive skills, it is not unreasonable to expect that such impacts might exist. In the case of JUNTOS, an improvement in cognition among recipients could potentially be achieved directly through the programme conditionalities relating to health and schooling.

First, assuming that a child will have more opportunity to improve cognition at school, more time in this environment should imply a relative improvement in cognitive ability. Given the programme conditionalities described in Section 3, one would expect receipt of JUNTOS to imply a higher probability of timely school enrolment, a higher attendance, or both. Even aside from the specific learning taking place, what is likely to be a more structured environment may also provide an opportunity to hone skills such as inhibitory control (Hamoudi & Sheridan, 2015; Brod et al., 2017; McKay et al., 2021). Second, investments in health and nutrition during childhood are likely to have a positive impact on FCS (Maluccio et al., 2009; Barham et al, 2013), for example, if better-nourished children are more likely to explore and learn from their environment (Jukes, 2005). Notably, the current JUNTOS literature already provides evidence for the existence of these two channels (see Section 2). In addition, while both mechanisms may clearly operate directly through the conditionalities of the programme, household investments in childhood health and schooling may also be impacted by the additional resources received via the cash transfers.[19]

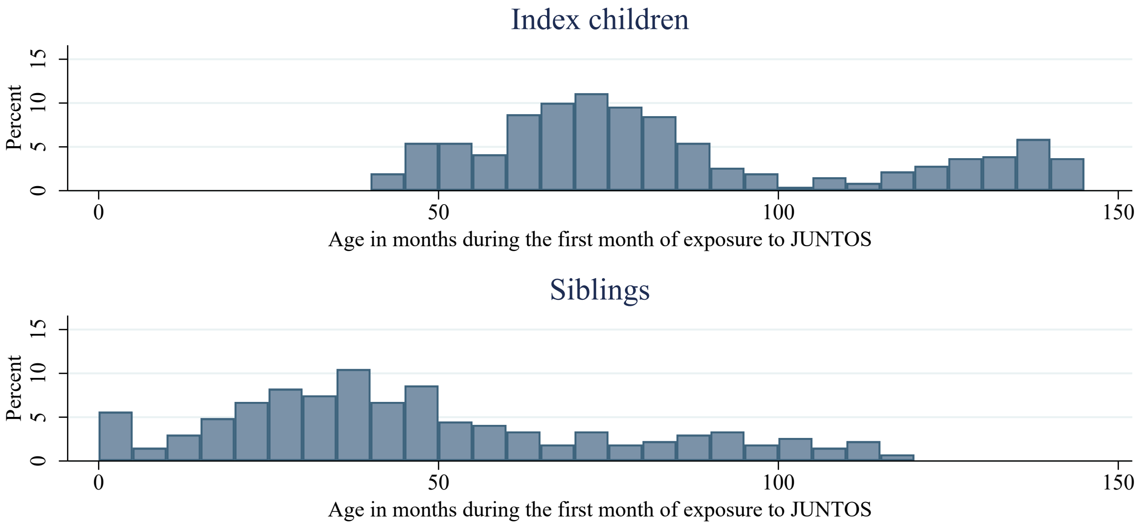
[19] While the impact of the cash transfer on these outcomes may be ambiguous, due to substitution effects in household investment, Perova & Vakis (2012) find that receipt of JUNTOS leads to an increase in food and non-food expenditure among beneficiary households, suggesting the potential impact of the cash transfer on human capital investment is likely to be positive.

5.2 *Empirical strategy*

In formulating the empirical strategy aimed at identifying the impact of JUNTOS on FCS, it is first important to acknowledge the fundamental differences between those who benefit from the programme and those who do not. This should be clear from both the information provided in Table 1 and the description of the targeting of the programme in Section 3. Even were we to incorporate the various (observed) confounding factors in the empirical analysis, it is highly unlikely that the children from non-recipient households would provide a suitable counterfactual for the outcomes of the beneficiary children (in the absence of enrolment). In light of this, we do not attempt to directly estimate the impact of JUNTOS via a comparison of the FCS scores for JUNTOS and non-JUNTOS children. Instead, we focus attention on differences in the age at first enrolment, as a means of establishing whether relatively early enrolment is associated with improvements in measured FCS. Based on the conceptual framework in Section 5.1, we would expect this to be the case.

We begin by exploiting variation in the age at first exposure between the index children and younger siblings within the same household. Figure 1 illustrates the distribution of first exposure ages (in months) for the 459 index children and 267 younger siblings whose households were enrolled in the programme. Among the index children, the age of first exposure ranges between 41 and 144 months, with this group benefitting from JUNTOS for the first time at around 84 months (seven years) old, on average. As the household is enrolled in the programme, and not the child, the younger sibling in each beneficiary household will also have received JUNTOS at the same time, but at a relatively earlier age. This is reflected in the range of sibling first exposure ages (between birth and 120 months) and a lower average age of 47 months (roughly four years old).

Figure 1. The distribution of age at first exposure to JUNTOS



Notes: The figure illustrates the probability of a child being of a given age (in months) when the child's household first received JUNTOS. The figure is based on 459 index children (upper panel) and 267 younger siblings (lower panel) whose households were enrolled in the programme. The mean age at first enrolment is 84 months for the index children and 47 months for the younger siblings.

To establish whether the age of first exposure to the JUNTOS programme is correlated with differences in FCS, we first consider a series of estimations based on equation (1). The model represents a difference-in-differences approach, with the dependent variable Y denoting one of the four measures of FCS, for child i in household h.

$$Y_{ih} = \alpha_h + \beta_1(Sibling_{ih} * JUNTOS_h) + \beta_2 Sibling_{ih} + \boldsymbol{\beta X}_{ih} + \psi_{ih} + \mu_{ih} \qquad (1)$$

On the right side of the equation, the indicator variable $Sibling$ takes the value 1 if the child is a younger sibling, while $JUNTOS$ indicates whether the child comes from a household that reported that they are (or have been) enrolled in the programme. The vector $\boldsymbol{X}$ contains a series of child-level control variables, including gender, baseline measures of FCS (see Table 2, Panel B) and a set of indicator variables capturing the day (week or weekend) and time of the RACER tests (between 9am and 5pm, or between 5pm and 12am). The term α represents a household fixed effect, common to all children in the household (also capturing whether the household was enrolled in JUNTOS or not). Finally, ψ denotes a series of year-of-birth fixed effects, to control for differences in FCS attributable to factors affecting all children born in the same year, while μ represents a mean-zero, idiosyncratic error. In equation (1), the coefficient of interest β_1 captures differences in FCS between younger siblings and index children, while partialling out common effects of age, time-invariant household characteristics and the effect of other underlying individual characteristics contained in $\boldsymbol{X}$.

While equation (1) provides a useful starting point for the analysis, the difference in age at first exposure between two children in the same household may vary substantially.[20] Furthermore, the precise age at which we expect to observe significant benefits from early exposure is not clearly defined, and will likely differ between the various cognitive skills.[21] Given these concerns, we estimate a threshold model to allow the observed data themselves to define which age constitutes early (younger) exposure to the JUNTOS programme (see Hansen, 2000). To ensure that differences in age between the index children and siblings are not responsible for any observed variation in FCS, we begin by estimating this threshold model only on the sample of index children (all of whom were approximately the same age when the RACER tasks were administered).

[20] Among the paired groups of JUNTOS-enrolled younger siblings and index children, the sample mean differences in age at the time of first exposure to the programme is approximately 36 months. However, this figure covers a range between a minimum age difference of 12 months and a maximum difference of 75 months.

[21] In Section 8, we discuss the principle of *developmental plasticity*, a concept that describes how the development of specific cognitive skills is strongly influenced by the environmental conditions during the period where the associated parts of the brain are developing (Nelson & Sheridan, 2011). The implication is that specific skills may be more or less malleable at different ages.

$$Y_{ih} = \beta_0 + \beta_1(Younger_{ih}(\gamma) * JUNTOS_h) + \beta_2 JUNTOS_h + \boldsymbol{\beta X}_{ih} + \boldsymbol{\beta X}_h + \psi_{ih} + \varepsilon_{ih} \quad (2)$$

The dependent variable in equation (2) is, again, a score related to a specific dimension of FCS. As equation (2) is estimated on a cross-section of observations, the $JUNTOS$ indicator is no longer absorbed by the household fixed effect (the case in the previous model) and is included in the equation, as is a vector of household-level controls $\boldsymbol{X}_h$. These controls comprise of an indicator representing the quintile of the 2002 household wealth index, an indicator of rural (as opposed to urban) location, the schooling level of the child's mother, whether the child's first language is other than Spanish, and a series of regional-level fixed effects.[22]

The variable $Younger_{ih}(\gamma)$ in equation (2) represents an indicator variable taking the value 1 if the child's household was first enrolled in the JUNTOS programme before the child reached the age of γ months. With no prior knowledge of the precise value of the threshold parameter γ, we define γ as the age which permits us to split the JUNTOS recipient children into *younger* and *older* initial exposure groups, such that we minimise the residual sum of squares (RSS) from a least-squares estimation of equation (2). We do this consider a range of possible values of the threshold γ (see Hansen, 2000), including all possible first exposure ages between the 10th and 90th percentile of the distribution.[23]

Where equation (2) has the advantage of estimating the difference in the effect of the JUNTOS programme for a sample of children who were approximately the same age at

[22] The regions are defined based on the 24 *departamentos* which represented the different administration areas of Peru in 2001.
[23] This restriction is imposed such that neither the *younger* nor *older* initial exposure group contains less than 10% of the sample of recipient children, ensuring that the coefficient β_1 reflects heterogeneity in the effect of the programme between two groups, each containing a meaningful number of individuals. For the sample of index children, the range of possible values of γ considered is 51 to 134 months.

the time of the RACER test, the error ε in (2) may still contain unobserved household characteristics which are correlated with both the outcome and enrolment (or timing of enrolment) in the JUNTOS programme. To the extent that such characteristics are time-invariant, equation (3) will limit this source of bias by, again, including the younger siblings and incorporating a household fixed effect.

$$Y_{ih} = \alpha_h + \beta_1(Younger_{ih}(\gamma) * JUNTOS_h) + \beta_2 Sibling_{ih} + \boldsymbol{\beta X}_{ih} + \psi_{ih} + \mu_{ih} \quad (3)$$

In equation (3) we control for unobserved (time-invariant) household heterogeneity, under the assumption of no confounding factors related to differences between index children and younger siblings (aside from those already captured by the inclusion of the $Sibling$ indicator or the year-of-birth fixed effects ψ). To be considered a robust estimate of the importance of relatively early enrolment in the JUNTOS programme, we would expect that both the estimate of the threshold γ and the sign (and significance) of the coefficient β_1 should be broadly consistent across models (2) and (3).

6. Results

We begin our discussion of the main results of the analysis by presenting estimations based on equation (1). As discussed in Section 5, this model utilizes within-household variation in age at first enrollment to predict the RACER scores for long-term memory, inhibitory control, working memory and implicit learning.

In the case of long-term memory, working memory and implicit learning, Table 3 predicts no significant difference in the RACER test scores between the younger siblings and the index children (at any of the significance levels considered). However, in the model for inhibitory control (column 2), the younger siblings record scores which are 0.11 standard deviations higher, on average (p-value = 0.045). This change equates to an approximate 0.02 second faster response time in the task (for the same degree of accuracy).[24] One interpretation of this result is that, while we observe an expected lower level of inhibitory control among the younger siblings (evidenced in column 2 by the coefficient on the sibling indicator), this difference is less pronounced within the group of JUNTOS-recipients

TABLE 3
Variation in the effect of JUNTOS between index child and younger sibling

	(1) LTM	(2) IC	(3) WM	(4) IL
Sibling*JUNTOS	-0.025	0.106**	-0.056	-0.027
	(0.097)	(0.053)	(0.096)	(0.058)
Sibling	0.549	-0.419*	-0.094	0.027
	(0.432)	(0.225)	(0.272)	(0.259)
Control variables	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	No	No	No	No
Year-of-birth fixed effects	Yes	Yes	Yes	Yes
Observations	2,481	2,481	2,481	2,481
R^2 (within)	0.104	0.445	0.365	0.586

Notes: Dependent variables: Long-term memory (LTM), Inhibitory control (IC), Working memory (WM), Implicit learning (IL). Child-level control variables: Female child, RACER administration time indicators, RACER administered at the weekend, baseline task score (for associated outcome FCS). Household-level clustered standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Given that only the estimation employing inhibitory control as a dependent variable shows any evidence of differences in FCS between the index children and their younger siblings (potentially reflecting differences in age at first exposure), the remainder of the

[24]As noted in Section 4, scores in the inhibitory control task are an equally weighted function of the inverse of response time (seconds) and the inverse of the Euclidean distance from the centre of the image of the dot displayed (pixels). A standard deviation increase in the final combined score equates to a 0.23 second faster response time (for a given level of accuracy) or a 0.71 pixel (0.19 millimetre) improvement in accuracy (for a given speed of response). While this improvement may appear small, the sample mean response time for the trial task in the RACER test for inhibitory control was 0.89 seconds (median response time of 0.87 seconds).

analysis focuses solely on this outcome. To gain further insight into precisely which age (or ages) matter for early exposure, we now consider the threshold model described in equation (2), utilizing only the sample of index children.

Across a range of potential thresholds (between 51 and 134 months),[25] the RSS from model (2) is minimized at $\gamma = 80$ months (6.7 years), implying that, given our approach, splitting the sample of JUNTOS-recipient children around this age generates estimated parameters for model (2) which most accurately fit the data for the index children.[26] Column 1 of Table 4 reports the estimated difference in the effect of JUNTOS on inhibitory control for those whose household first received the programme before 80 months of age, relative to those who benefited later.

To establish the robustness of the threshold and the effect of early exposure, we re-estimate the relationship between JUNTOS and inhibitory control via equation (3). Here we incorporate all observations from both index children and younger siblings. The RSS in equation (3) is minimized at a threshold of γ=75 months (6.25 years) and column 2 of Table 4 reports the results obtained from model (3) when splitting the sample at this age.

Both models in Table 4 indicate that receiving JUNTOS at a relatively earlier age significantly improves inhibitory control, as reflected by a 0.10 standard deviation improvement in column 1 and a 0.30 standard deviation improvement in column 2. While equation (3) predicts a threshold that is five months earlier, we consider the optimal values of γ to be sufficiently close as to indicate the greatest likelihood of observing a significant

[25]We acknowledge that this range is somewhat limited. In particular, when only considering the possibility of a threshold existing beyond 50 months (4.1 years) we may not detect the relative benefits of early childhood exposure to the programme. We discuss this limitation further in Section 8.
[26]Appendix Figures C1 and C2 provide a representation of the RSS across the range of possible thresholds considered in estimations of equation (2) and equation (3).

difference in the effect of JUNTOS on inhibitory control occurs at around the same first exposure age.

TABLE 4
Variation in the effect of JUNTOS enrolment on inhibitory control by early exposure

	(1)	(2)
Younger(γ)*JUNTOS	0.097**	0.296***
	(0.041)	(0.078)
Sibling		-0.394*
		(0.238)
JUNTOS	-0.149***	
	(0.042)	
Control variables	Yes	Yes
Household fixed effects	No	Yes
Region fixed effects	Yes	No
Year of birth effects	Yes	Yes
Observations	1,755	2,481
R^2	0.397	0.452
Threshold γ	80 months	75 months†

Notes: Dependent variable: Inhibitory control (IC). Child-level control variables: Female child, RACER administration time indicators, RACER administered at the weekend, baseline task score for inhibitory control. Household-level control variables (OLS only): Rural household location, tercile of 2002 wealth index, mother's schooling level, index child first language not Spanish. † Estimated coefficient for Younger(γ)*JUNTOS defined by 312 observations (156 households) with the index child ≥ γ months old and sibling < γ months old at first exposure to JUNTOS. Community-level (column 1) and Household-level (column 2) clustered standard errors in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

The magnitude of the effect clearly differs between the two sets of results in Table 4. A likely explanation for this is the inclusion of the household fixed effect in model (3). By including α in the model, the coefficient of interest will only be defined by households that contain a younger sibling who was first exposed before 80 months of age and an index child who was exposed at 80 months or older. Only 156 households fall within this group (312 children from a possible 726 recipients). While it is reassuring that the direction of the effect and the predicted threshold are broadly equivalent, in light of this limitation, we restrict our sample to only the index children for the remainder of the analysis.

7. Mechanisms

7.1 Decomposing the benefits of earlier enrollment

The previous results suggest a relationship between younger exposure to the JUNTOS programme and improvements in inhibitory control. However, the analysis sheds no light on the mechanisms through which this relationship operates. In this section, we consider the importance of two potential channels which are intrinsically linked to the JUNTOS programme through conditionalities for enrolment: namely, investments in health and schooling. Given the conditions for receipt of the transfer (see Section 3), there should exist variables related to both channels which are causally impacted by JUNTOS enrollment. However, establishing if such factors are affected by *younger* enrolment, specifically, requires a more careful approach.

In what follows, we decompose the overall effect of younger exposure into components operating through the different mediator variables in Table 1 (panels C and D). Following Acharya et al. (2016), we estimate the Average Controlled Direct Effect (ACDE), a measure of the effect of younger exposure on inhibitory control, partialling-out the share of the impact operating through a given mediator variable. A comparison between the ACDE and the total effect (given in column 1 of Table 4) yields an estimate of the share of the impact of younger exposure attributable to the mediator.

Estimation of the ACDE proceeds in two stages. First, we augment model (2) with a single mediator variable, as shown in equation (4a). We use the estimated parameters from this first-stage regression to generate a predicted dependent variable, based on all elements of (4a) other than the mediator variable. This is equivalent to holding the value of the mediator constant for all individuals (at 0) and yields a *de-mediated* outcome variable $\widetilde{IC}$, purged of any variation attributable to the mediator.

$$IC_{ih} = \theta_0 + \theta_1 JUNTOS_h + \theta_2 (Younger_{ih}(\gamma) * JUNTOS_h) + \theta_3 Mediator_{ih} + \theta \boldsymbol{X}_{ih} + \theta \boldsymbol{X}_h + \psi_{ih} + \mu_{ih} \quad \text{(4a)}$$

Yielding the de-mediated outcome variable:

$$\widetilde{IC}_{ih} = \hat{\theta}_0 + \hat{\theta}_1 JUNTOS_h + \hat{\theta}_2 (Younger_{ih}(\gamma) * JUNTOS_h) + \hat{\theta} \boldsymbol{X}_{ih} + \hat{\theta} \boldsymbol{X}_h + \psi_{ih}$$

In the second stage, the newly de-mediated outcome replaces the original dependent variable in equation (2). The coefficient δ_1 in equation (4b) represents the ACDE of early exposure, controlling for any effect operating through the mediator.[27]

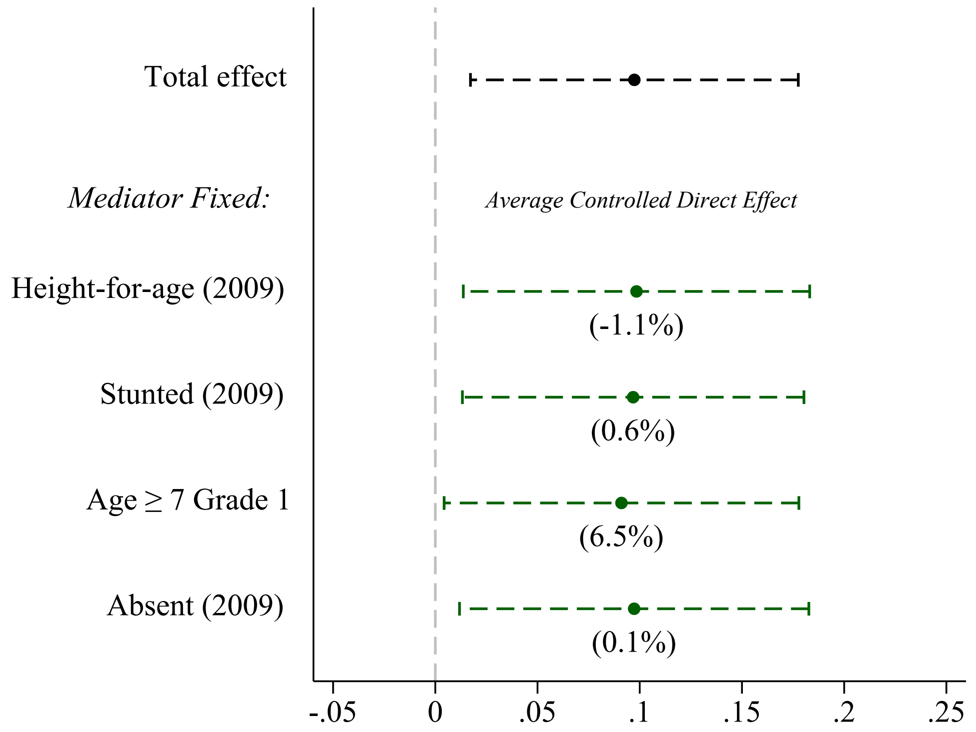
$$\widetilde{IC}_{ih} = \theta_0 + \theta_1 JUNTOS_h + \delta_1 (Younger_{ih}(\gamma) * JUNTOS_h) + \theta \boldsymbol{X}_{ih} + \theta \boldsymbol{X}_h + \psi_{ih} + \mu_{ih} \quad \text{(4b)}$$

Figure 3 provides a representation of the difference between the total effect and the ACDE, where the bracketed terms represent the share (%) of the full impact of younger exposure on inhibitory control explained by the mediator variable (measured as $\frac{\beta_1 - \delta_1}{\beta_1}$). In addition, estimates of the ACDE for all potential mediators are reported in Appendix Table D1, alongside the total effect. As any difference in inhibitory control between the

[27] Due to the two-stage approach, standard errors are bootstrapped in all estimations of the ACDE. We use a cluster (block) bootstrap, with clusters defined as the Young Lives communities, mirroring the community-level clustering in Table 4 (column 1).

younger and older initial exposure group should, arguably, be more pronounced closer to the 80-month threshold, in Figure 3, we report only the effects of the height-for-age, stunting and school absence mediators collected in 2009. However, a similar graphical representation of the 2013 mediator variables can be found in Appendix D.

Figure 3. Comparison of total effect to ACDE when holding potential mediators fixed



Notes: The total effect of younger exposure to JUNTOS on Inhibitory Control is 0.097 (see Table 4). Estimates of the ACDE for all potential mediators are reported in Appendix Table D1. Figures in parentheses represent the share (%) of the full impact of early exposure on inhibitory control explained by the proposed mediator variable ($\frac{\beta_1-\delta_1}{\beta_1}$).

The comparison of the ACDE to the total effect in Figure 3 suggests that we explain 6.5% of the impact of younger receipt of the JUNTOS programme on inhibitory control through differences in the probability of starting primary school by the age of six years old (a condition of the programme). These results suggest this is the most important mediating factor among those considered.

In contrast, the mediator variables related to nutrition and health (height-for-age and stunting) explain little of the effect of younger JUNTOS enrolment. In the case of the 2009 height-for-age z-score, the ACDE even exceeds the total effect (leading to the small negative proportion explained), indicating that, if anything, improvements in height for age are a mediating factor for those receiving JUNTOS at a relatively *later* age. Similarly, differences in the probability of being absent from school for a week or more (during the year preceding the 2009 survey) do not explain a meaningful proportion of the estimated benefit of younger enrolment.

7.2 Robustness

The choice to enroll a child in primary education at the appropriate age will likely be correlated with a number of household decisions regarding schooling. It is, therefore, plausible that the estimated role of late primary enrolment may only be capturing the effect of another (true) mediating variable, such as a lower probability of attending pre-primary education (Diamond et al., 2007). We test this specific hypothesis with the inclusion of a variable measuring the years of pre-primary schooling the child received following their third birthday (see Appendix E). We find that the results illustrated in Figure 3 are fully robust to the inclusion of this additional control.

A further concern is the extent to which our sample is representative of the population of interest. Although households across the full wealth spectrum were included, the initial sampling strategy of the Young Lives study omitted the richest 5% of districts in Peru (see Section 4.1). An analysis of the correlates of attrition in Appendix A also suggests that children in rural areas and those in the lowest 2002 wealth quintile were more likely to have left the sample prior to 2013. To assess the extent of any selection or attrition bias, we re-estimate the total impact of younger JUNTOS enrolment (and the share explained by the mediators) with the inclusion of post-stratification sample weights.[28] We find that the total effect of younger enrolment on inhibitory control is slightly smaller, at 0.085. However, the channel related to starting school at the appropriate age remains the most important mediating factor among those considered, now explaining 9% of the total effect in the weighted sample. These results may be found in Appendix F.

8. Discussion and conclusions

This study provides the first analysis of the relationship between a child's age at the time of household enrolment in Peru's conditional cash transfer programme, JUNTOS, and childhood foundational cognitive skills (FCS). We measure four components of FCS, long-term memory, inhibitory control, working memory and implicit learning, using an innovative tablet-based test. We administer this test to a sample of 1,755 children aged between 11 and 12 years old, alongside 726 younger siblings (aged between 5 and 11 years old).

Exploiting within-household variation, we find that the younger siblings who benefited from the JUNTOS progamme display significantly higher levels of inhibitory control than their older counterparts in an adaptation of a 'Simon Task' game (Simon & Rudell, 1967). This 0.11 standard deviation improvement equates to a 0.02 second faster response time in the task (given the same degree of accuracy). We find no clear evidence of improvements in the other three elements of FCS. This does not imply that these cognitive

[28] Sample weights are derived from gender, location, and the probability of having Spanish as a first language, among 11- and 12-year-olds in Peru's National Censuses 2007: 11th Population Census and 6th Housing Census.

traits are not influenced by enrolment in JUNTOS, only that any effect of the programme does not appear to vary significantly by enrolment age.

We employ a threshold estimator to determine the precise age at which additional benefits from younger exposure are likely to be most pronounced. In splitting our sample of 11- and 12-year-olds at a first exposure age of 80 months (6.7 years), we generate an estimated improvement of 0.10 standard deviations in inhibitory control scores from younger JUNTOS enrolment. We find that the estimated threshold, significance and direction of the effect appear broadly robust to the inclusion of the younger siblings in a household fixed-effects framework, although the estimated magnitude of the effect is notably larger in the later model (see Section 6 for a discussion).

Moving further beyond the current literature, we employ a mediation model to decompose the observed improvement in inhibitory control into components operating through a series of potential mediator variables (related to the conditionalities of the JUNTOS programme). We find that the most likely mediating channel among those considered is the effect of younger exposure to the programme on the age at which a child is enrolled in primary school, with an estimated 6.5% of the total effect operating through this channel. This result is also robust to the inclusion of a variable capturing years of pre-primary schooling and the inclusion of post-stratification sample weights.

An obvious question is why only inhibitory control appears responsive to the age of JUNTOS enrolment. One plausible explanation can be found in cognitive neuroscience and the principle of *developmental plasticity*. This concept states that specific cognitive traits are more responsive to environmental conditions around the time at which the neural system which governs them is developing (Nelson & Sheridan, 2011). Unlike the brain regions associated with implicit learning or long-term memory, those areas associated with executive function (implicit learning and working memory) continue to develop throughout childhood and even adolescence (Best & Miller 2010; Luna et al., 2010). If exposure to a new, more structured environment - such as attending primary school - occurs at an especially sensitive period for the development of inhibitory control, it is, therefore, likely that this particular trait would benefit relatively more from timely school enrolment.

We acknowledge a number of key limitations in our analysis. First, our study does not attempt to quantify the overall benefit of the JUNTOS programme for the development of FCS. This would require a suitable control group that would display similar levels of FCS to the JUNTOS-recipient children, had these children not been enrolled in the programme. Unfortunately, it is unlikely that such a group exists within our sample. Second, the date of the first roll-out of JUNTOS (2005), coupled with the birth years of our index children (2001-2002), implies no child in our sample of 11- and 12-year-olds was exposed to the CCT before 41 months (3.4 years). This means we are limited in our ability to detect any benefits of the programme from younger enrolment before this age.

In spite of the limitations described above, the link between younger enrolment and improved inhibitory control is clearly relevant for the future design and targeting of JUNTOS, and other similar CCT programmes. In considering FCS, we capture some of the less obvious benefits of younger enrolment. While these cognitive abilities are less frequently measured (compared to height-for-age or achievement-test scores, for example), the rapidly growing literature supporting their role as a predictor of future success in both education and the labour market (Blair, 2002; Blair & Razza, 2007; Moffitt et al. 2011) suggests they deserve far more attention in evaluating the full impact of CCTs. The links between younger CCT enrolment, timely entry into primary education, and inhibitory controls is also an important contribution, particularly as changes in FCS, such as inhibitory control (unlike test scores) will not necessarily be a direct function of the material taught, or even the quality of teaching, but may simply respond to the relative structure provided within the school environment (Brod et al., 2017; McKay et al., 2021).

The findings of this study have shown the importance of taking a wider view on the impact of CCTs. The full tangible gains of improved foundational cognitive skills may not be immediately realised, but will accumulate throughout the life cycle, and could well have a profound impact on the lives of those who benefit.

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Appendices

Appendix A. Attrition analysis

Table A1 presents a brief analysis of the characteristics of attrition between the initial sample interviewed in 2002 and the final analytical sample employed in the study. An indication of the significance of differences between variable means is shown in the second column.

TABLE A1
Correlates of attrition between the initial survey round and analytical sample

Variable	Non-attrited	Attrited
Panel A		
Female child	0.50	0.52
Child's age in 2002 (months)	11.5	11.6
Mother has no formal schooling	0.07	0.13***
Mother has primary schooling only	0.36	0.41*
Mother has post-primary schooling	0.57	0.46***
Caregiver first language not Spanish	0.14	0.20***
Panel B		
Rural household	0.30	0.38***
Lowest asset wealth quintile (2002)	0.19	0.26***
Highest asset wealth quintile (2002)	0.21	0.16*
Coastal area	0.36	0.28***
Highlands	0.49	0.59***
Jungle	0.15	0.13
Observations by attrition status	1,755	297
Total observations (% attrited)	2,052	14.5%

Notes: Attrition includes all sources of attrition from the final analytical sample including observations omitted due to missing values on key variables. Indications of the results of *t*-tests of the equality of means between Attrited and Non-attrited groups are reported. * denotes significance at 10%, ** significance at 5% and *** significance at 1%.

In general, Table A1 suggests a pattern whereby what would be considered relatively poorer households in the more rural highlands area are more likely to have either left the survey (in the 11 years between 2002 and 2013) or provided incomplete information on key variables required in the empirical analysis. This relationship is evidenced directly in the wealth quintile variables (Panel B) but is also likely to underlie the negative relationship between attrition and mother's schooling. This geographical difference may also account for higher attrition for non-Spanish-speaking households and those in rural areas (again, more commonly found in the highlands).

As much of the early part of the analysis includes estimations exploiting within-household variation (see Table 3), attrition bias would only influence these findings in a meaningful way under the (unlikely) conditions that attrition was systematically correlated with *differences* in FCS between pairs of index and sibling children.

In the latter part of the analysis, however, where only the sample of index children is used in estimations, it is possible that the relatively higher probability of attrition among poorer households would influence our findings. To this end, all variables reported as correlated with attrition in Table A1 are included as controls throughout. In the case of the geographical location (coastal, highlands, jungle), this is achieved through the inclusion of the Region fixed effects, which cover the 24 *departamentos* of Peru (as of 2001). As a further check on attrition and selection bias, we report estimates of key results using post-stratification sample weights, based on a sample of 11- and 12-year-olds from Peru's National Censuses 2007: 11th Population Census and 6th Housing Census (these results may be found in Appendix F).

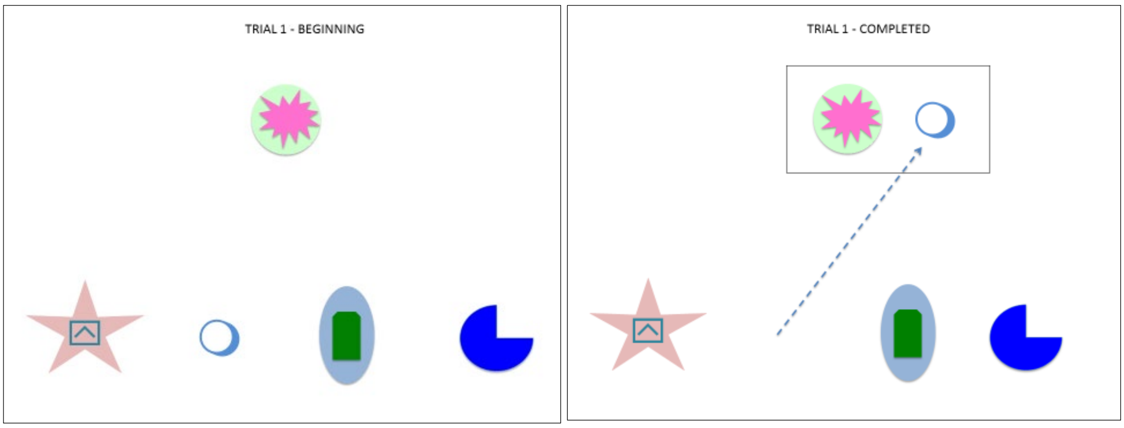
Appendix B. An overview of the RACER tasks

Here we provide a brief introduction to the four RACER tasks used to measure foundational cognitive skills (FCS). In each case, the figure shown is intended to represent the information shown to the child on the tablet screen during the test. More comprehensive information on these tasks is available in the Young Lives technical note (Behrman et al., 2022).

Memory game: measuring long-term memory

This game is adapted from a Paired Associate Learning Task (Gabrieli 1993; Hannula et al. 2006), where the objective of the game is to match six pairs of shapes. Initially, the respondent completes six baseline trials, in which they see each of the shapes for the first time. As shown in Figure B1, each shape will be presented with its correct match and three incorrect matches (lures). In this initial task, they should have no knowledge of which shapes form pairs (and will guess). Following an incorrect guess, they will be asked to choose again.

Figure B1. Measuring long-term memory

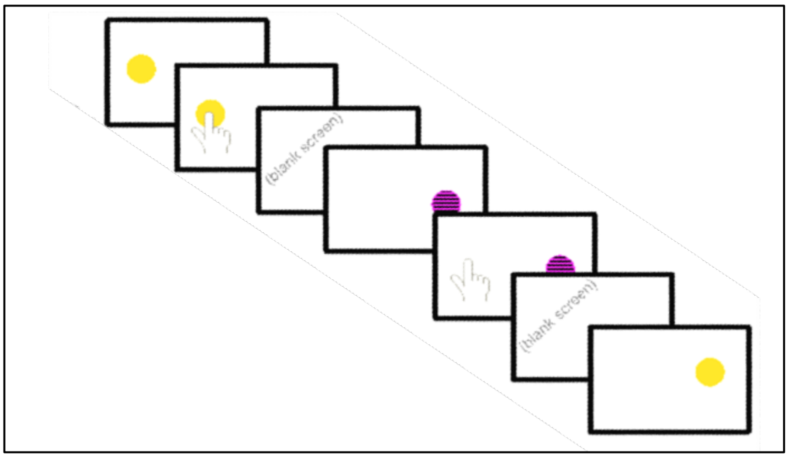


After an 18-20-minute delay (while they complete the other RACER tasks), the child will then see the same shapes again in a second set of six trials. The intention is that the child should remember which shapes form pairs from the first (baseline trial). The score obtained from the RACER task represents the percentage of correct pairs identified at the first attempt (see Section 4.2 for a description of how all initial RACER scores are re-scaled and standardized before conducting the empirical analysis).

Sides game: measuring inhibitory control

The game is based on an original 'Simon Task' game designed by Simon & Rudell (1967). In each of a series of 60 trials, the child is presented with a yellow or striped, pink dot on either the left or the right side of the screen. If the child sees a yellow dot, they should aim to touch the centre of the dot as quickly and accurately as possible. If. Instead, the child sees a striped, pink dot, they should touch the opposite side of the screen, as close as possible to where the dot's mirror image would be. Figure B2 shows a visual representation of the tablet screen and the actions required for a series of three trials.

Figure B2. Measuring inhibitory control



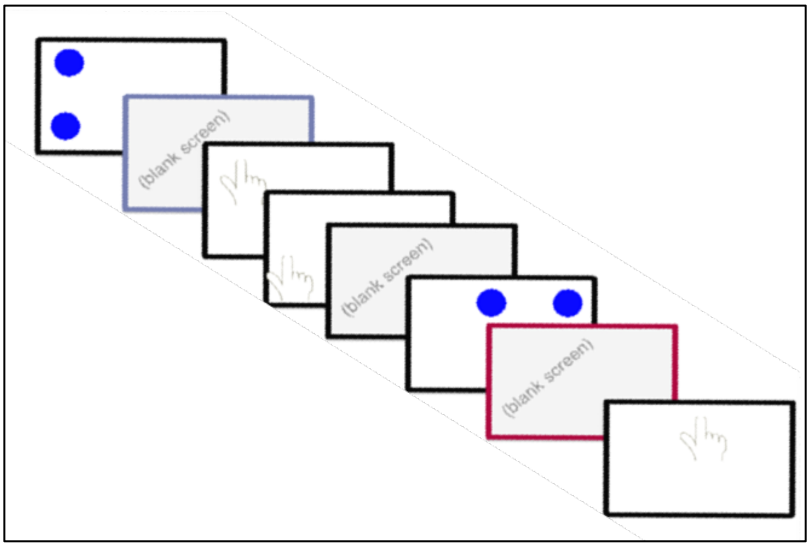
In total, the child completes 30 *same side* and 30 *opposite side* trials in a randomized order. The initial score obtained from the task is an equally weighted measure of the standardized values of distance (pixels) from the centre of the dot, or it's mirror image, and standardized response time (seconds). The scores on the *same side* trials provide the baseline score for this task and the scores for the *opposite side* trials provides the basis for the measure of inhibitory control.

Finding the dots game: measuring working memory

Assessment of working memory is based on a 'dots task' (Thomason et al., 2009). In each of a series of 42 trials, the child is shown a series of up to three dots at different positions on the screen. After a delay of two seconds, the dots disappear and the child is required to wait for a (short or long) period of time, before touching the screen as closely as possible to where the dots used to be. The time delay is either 0.1 seconds (short delay) or 3 seconds (long delay). The test also consists of trials with a single dot (low-stimuli) and two or three dots (high-stimuli). Overall, the respondent completes 21 short delay trials and 21 long delay trials (with 7 low-stimuli and 14 high-stimuli trials for each delay). Figure B3 shows a representation of what the child would see on the tablet screen and the actions required during two high-stimuli trials.

The RACER scores in the working memory task are based on the average Euclidean distance (pixels) from where the child touches the screen to where the dots originally appeared. For this analysis, we use the short delay, low-stimuli (single dot) trials as the baseline measure and the long delay, high-stimuli (multiple dots) trials to represent our measure of working memory.

Figure B3. Measuring working memory

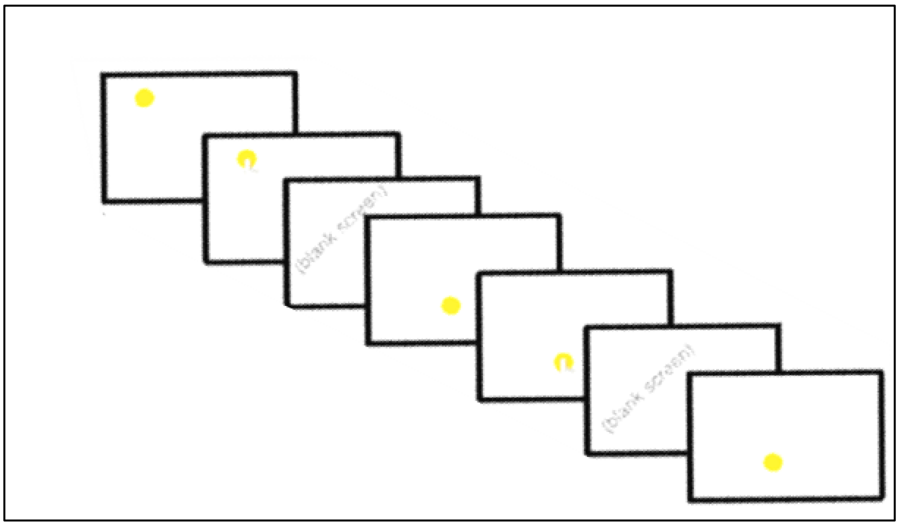


'Catching chickens game: measuring implicit learning

The RACER task for implicit learning measures serial reaction time (Nissen & Bullemer, 1987) and is presented to the children as a game called 'catching chickens' or 'chasing dots'. In total, 175 small yellow dots appear on the tablet screen individually, in four possible locations but in rapid succession (see Figure B4). The child is instructed to try and touch each dot as quickly as they can, as soon as it appears. Each of the 175 dots represents a single trial.

For the first 35 trials (block 1) the dots follow a random pattern, however, in the next 70 trials (blocks 2 and 3) the dots appear in ten repeated cycles of seven locations. The next 35 trials (block 4), again, appear randomly, before the final 35 trials return to the same repeated pattern as blocks 2 and 3. There is no delay between the different blocks and the child would be unlikely to consciously recognize the movement from patterned to un-patterned blocks. Overall, the test comprises of 105 patterned trials and 70 un-patterned trials. The expectation is that individuals will respond more quickly to the position of the dots where they follow a pattern, even where the pattern recognition is unconscious (Pasupathy & Miller 2005).

Figure B4. Measuring implicit learning



The initial scores obtained for the RACER task on implicit learning are based on reaction time between the dot appearing and the child touching the screen (seconds). The average reaction time scores for the un-patterned trials provide the baseline measure, while response time in the patterned trials is used to generate the measure of implicit learning.

Appendix C. Predicting the threshold age

The full range of possible values considered for the threshold γ in equation (2) is illustrated in Figure C1. A series of least-squares estimates of equation (2), considering the range of potential threshold, yields a set of values for the residual sum of squares (RSS) derived from splitting the sample at each given first exposure age.

Figure C1. Threshold age at first exposure based on equation (2) – Index children only

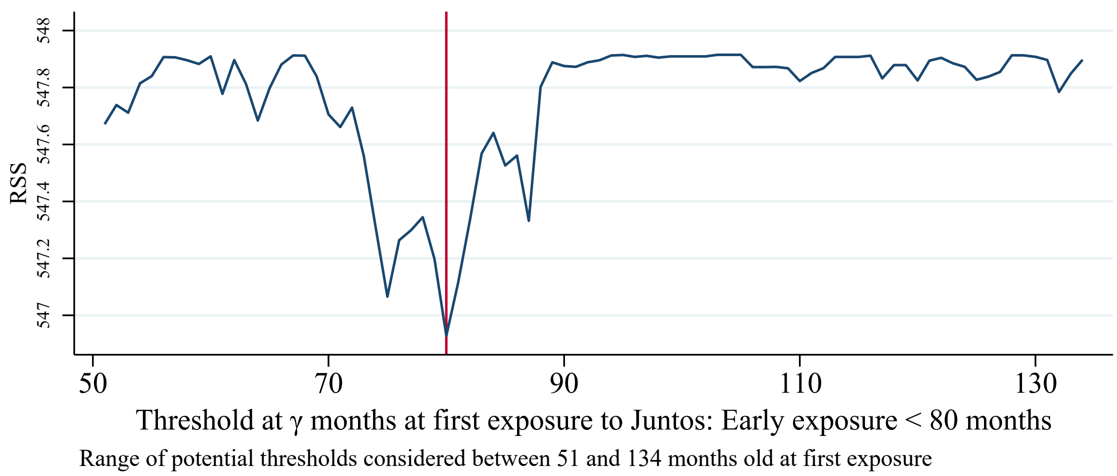
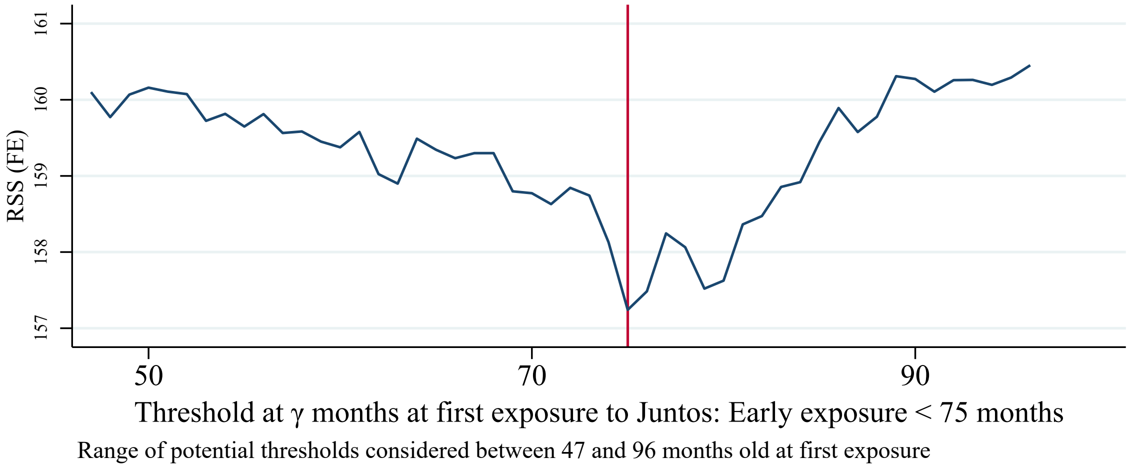


Figure C2 reports an alternative estimation of the threshold. In contrast to Figure C.1, the residual sum of squares (RSS) is estimated across a range of values of γ within the household fixed effects model (3) and both index children and younger siblings are included in the estimations

It is important to note that the coefficient β_1 in (3) will only be defined by recipient households containing both index children and younger siblings and, therefore, we are restricted in our choice of potential threshold γ by the minimum age at first exposure of the index children (41 months) and the maximum first exposure age of the younger siblings (120 months). Having imposed this restriction, as before, we only consider values of γ which lie between the 10^{th} and 90^{th} percentiles, representing potential threshold values between 47 and 96 months.

Figure C2. Threshold age at first exposure based on equation (3)



While Figure C1 indicates the RSS are minimized at a value of 80 months old at first exposure, Figure C2 suggests a slightly earlier threshold at 75 months. Although these two estimates differ slightly, we believe them to be sufficiently close to be an indication of the same process governing improvements in inhibitory control.

Appendix D. Comparing the total effect to the ACDE

Table D1 provides a comparison of the difference between the total effect of younger exposure to JUNTOS on inhibitory control and the Average Controlled Direct Effect (ACDE) holding a specific mediator variable fixed. In all cases, the ADCE remains significant, suggesting that partialling out the effect of younger exposure operating through the mediator is not sufficient to negate all benefits of early enrolment. In line with Figure 3, the greatest mediating effect (total effect – ACDE) is found when holding the indicator of late enrolment in Grade 1 fixed (in column 6).

TABLE D1
Estimated ACDE holding potential mediators fixed

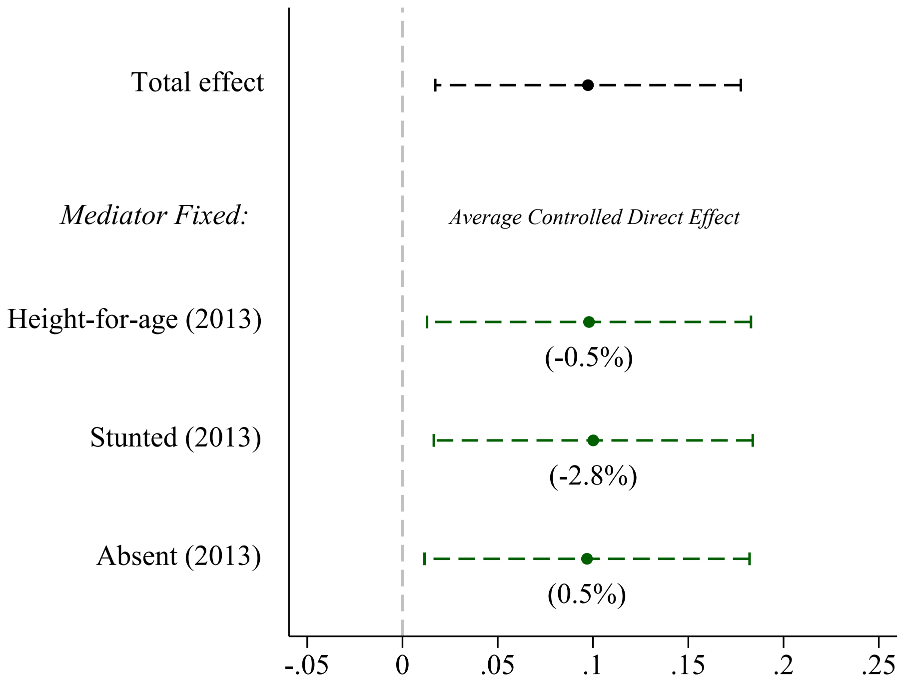
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Potential mediator variables ACDE						
Coefficient	Total effect	Height-for-age (2013)	Stunted (2013)	Height-for-age (2009)	Stunted (2009)	Age ≥ 7 Grade 1	Absent (2013)	Absent (2009)
Early (γ)*JUNTOS	0.097**	0.098**	0.100**	0.098**	0.097**	0.091**	0.097**	0.097**
	(0.041)	(0.043)	(0.043)	(0.043)	(0.043)	(0.044)	(0.044)	(0.044)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of birth effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,755	1,755	1,755	1,755	1,755	1,755	1,755	1,755
Bootstrap replications	n/a	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Threshold γ (months)	80	80	80	80	80	80	80	80

Notes: Dependent variable: Inhibitory control (IC) (column 1), De-mediated inhibitory control ($\widetilde{IC}$) (columns 2-8). Child-level control variables: Female child, RACER administration time indicators, RACER administered at the weekend, baseline task score for inhibitory control. Household-level control variables: Rural household location, tercile of 2002 wealth index, mother's schooling level, index child first language not Spanish. Community-level clustered (column 1) and cluster bootstrap (columns 2-8) standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

In Figure 3 of the paper, we focus on the earlier (2009) measures of height-for-age, stunting and absenteeism. In Figure D1 below, we report the percentage of the total effect attributable to the 2013 measures of these variables.

The figure suggests little of the effect of younger enrolment can be determined by shutting down the potential channels represented by the mediators in Figure D1. As in Figure 3, improvements in height-for-age may even be a mediating factor for those receiving JUNTOS at a relatively *later* age.

Figure D1. Comparison of total effect to ACDE holding 2013 mediators fixed



Notes: The total effect of early exposure to JUNTOS on Inhibitory Control is 0.097 (see Table 4). Estimates of the ACDE for all potential mediators are reported in Appendix Table D1. Figures in parentheses represent the share (%) of the full impact of younger exposure on inhibitory control explained by the proposed mediator variable ($\frac{\beta_1-\delta_1}{\beta_1}$).

Appendix E. Controlling for years of pre-primary schooling

As noted in Section 7, if late enrolment in primary school is highly correlated with the number of years a child spends in pre-primary schooling, we may misinterpret the FCS benefits of early years schooling, as being the result of enrolment in primary school at the appropriate age.

Table E1 reports the total effect and ACDE for an estimation of the mediation model (equations 6a and 6b), holding the indicator *age ≥ 7 Grade 1* fixed. In Table E1, however, we also include a variable measuring the number of years (after age 3) the child attended pre-primary schooling or nursery (1.4 years on average). While we do observe some small difference in the magnitude of both the total effect and the ACDE, we are still able to explain approximately 6.8% of the total effect via the late primary school enrolment mediator.

TABLE E1
Estimated ACDE holding potential mediators fixed

	(1)	(2)
		Potential mediator variable ACDE
Coefficient	Total effect	Age ≥ 7 Grade 1
Early (γ)*JUNTOS	0.098**	0.092**
	(0.041)	(0.044)
Control variables	Yes	Yes
Region fixed effects	Yes	Yes
Year of birth effects	Yes	Yes
Observations	1,755	1,755
Bootstrap replications	n/a	1,000
Threshold γ	80 months	80 months

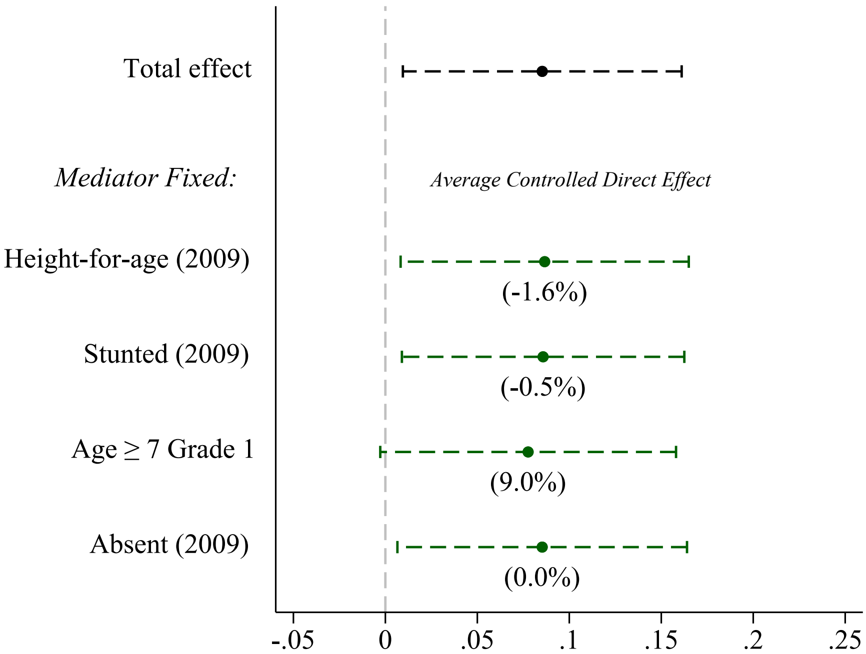
Notes: Dependent variable: Inhibitory control (IC) (column 1), De-mediated inhibitory control ($\widetilde{IC}$) (columns 2). Child-level control variables: Female child, RACER administration time indicators, RACER administered at the weekend, baseline task score for inhibitory control. Household-level control variables: Rural household location, tercile of 2002 wealth index, mother's schooling level, index child first language not Spanish. Community-level clustered (column 1) and cluster bootstrap (columns 2) standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix F. Post-stratification weights to correct for selection and attrition bias

The following figures represent the total effect and ACDE for each mediator, having applied post-stratification sample weights to the sample. Weights are calculated from a sample of 11- and 12-year-olds from the National Censuses 2007: 11th Population Census and 6th Housing Census. Final sample weights are constructed using the Stata module *ipfweights* (Bergmann, 2011), such that the sample shares of males/females, urban/rural, coastal/highlands/jungle geographical regions, and Spanish/non-Spanish speaking match those of the census data.

Figure F1 shows the 2009 mediators, alongside the mediator for timely enrolment. The total effect estimated using the weighted data is 0.085 ($p < 0.05$) and the timely enrolment mediator remains the most important mediating factor among those considered.

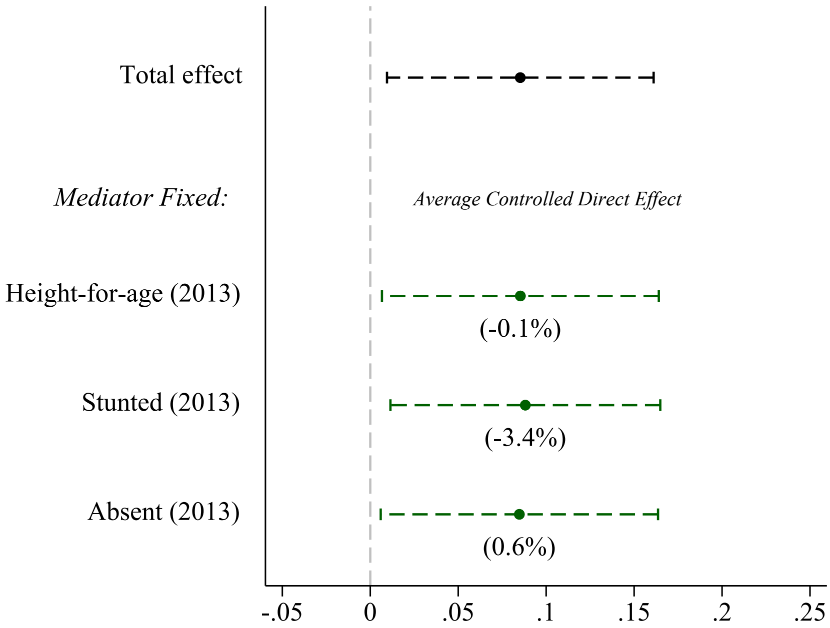
Figure F1. Comparison of total effect to ACDE holding 2009 mediators fixed (weighted)



Notes: The total effect of early exposure to JUNTOS on Inhibitory Control is 0.085. Figures in parentheses represent the share (%) of the full impact of early exposure on inhibitory control explained by the proposed mediator variable ($\frac{\beta_1-\delta_1}{\beta_1}$).

Figure F2 reports a comparison of the ACDE and the total effect holding the 2013 mediators fixed. As in Figure D1, little of the effect of younger JUNTOS enrolment can be determined by shutting down the potential channels represented by the 2013 mediators.

Figure F2. Comparison of total effect to ACDE holding 2013 mediators fixed (weighted)



Notes: The total effect of early exposure to JUNTOS on Inhibitory Control is 0.085. Figures in parentheses represent the share (%) of the full impact of early exposure on inhibitory control explained by the proposed mediator variable ($\frac{\beta_1-\delta_1}{\beta_1}$).

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