# Cognitive Skills and Early Life Conditions in a Developing Country Context

## How do innovations in measurement enhance the picture?

Santiago Cueto
GRADE Peru

Amar Hamoudi
Duke Population Research Institute

Sofya Krutikova
Oxvord University

Alan Sanchez
GRADE Peru

Margaret Sheridan
Children's Hospital Boston

**Abstract**

"Executive functioning" (EF) is likely to be an important form of human capital; it comprises cognitive skills that underlie an individual's capacity to direct resources in pursuit of a goal. In recent years, technological change has presented a valuable opportunity for innovation in the measurement of these skills in large population representative samples. We developed a suite of laboratory-validated cognitive skills assessments administered on touchscreen tablet PCs. We are deploying them on a population-based sample of over 2000 Peruvian children aged 12-14 and over 700 of their younger siblings, as part of wave 4 of an ongoing panel survey called the Young Lives study (YL). We will link participants' performance on the cognitive assessments to the rich set of socioeconomic and developmental measures available from 10 years of YL survey data. Using these data, we examine novel questions around early-life conditions and child development.

In recent years, models of human capital in the social sciences have grown increasingly nuanced, expanding beyond general constructs like generalized health status or IQ into more specific traits and skills like self-control, goal-orientation, and organization (Heckman, 2007). "Executive functions" (EF) comprise a set of specific cognitive skills that underlie an individual's capacity to direct resources in pursuit of a goal; these skills are likely to be an important form of human capital. The term "EF" itself comes from the field of neuroscience, but closely related concepts have been studied in the social sciences—including time inconsistency in economics (O'Donoghue and Rabin, 1999) and self-regulation in social psychology (De Ridder, Lensvelt-Mulders, and others, 2012). This study involves the incorporation of laboratory-validated measures of EF skills as part of a large population based panel survey.

Executive function comprises three core sets of skills—working memory, which is the ability to hold in mind and manipulate information or concepts (as one does, for example, when adding a pair of two-digit numbers without using a pencil); inhibitory control, which is the capacity to control attention or behavior and override a counterproductive impulse (as one sometimes must do, for example, when immediate demands distract attention from longer-run goals); and cognitive flexibility, which involves the ability to switch fluently between tasks, perspectives, or approaches (as one sometimes must do, for example, to adjust productively to new circumstances). Together, these skills facilitate effective planning and goal-orientation; in convenience samples in the United States and Europe, they have been observed to correlate with initial school readiness, academic success, alcohol and drug abuse in adolescence and adulthood, and the risk of becoming incarcerated for crimes that involve impulsive behavior.

In order to measure executive functioning skills specifically and precisely, neuroscientists have developed tasks that use simplified paradigms requiring each skill. Separate tasks are designed to be specific to separate skills. The more effectively a respondent can complete each specific task, the more skilled he or she is assessed to be in that specific cognitive function. These tools have allowed neuroscientists to identify the physiology of the brain that underlies executive function. Until recently, incorporating specific measures like these into field studies on large samples in the context of broader socioeconomic surveys was not cost-effective. Laborious and error-prone paper and pencil tests were required—sometimes taking many minutes or more—just to assess a single specific cognitive skill. In recent years, technological change—including for example the spread of relatively

cheap touchscreen tablet computers and of operating systems specifically designed to ease the development of specialized applications—has presented a valuable opportunity for innovation in the demographic measurement of EF and other specific cognitive skills. This study takes advantage of that opportunity.

We developed a platform-independent software application that administers a suite of laboratory-validated cognitive skills assessments on touchscreen tablet computers. The application includes assessments of six specific cognitive skills, including those involved in EF; it is tailored for use in children aged 5-15. We are deploying these assessments on a population-based sample of over 2000 Peruvian children aged 12-14 and over 700 of their younger siblings, as part of wave 4 of the Young Lives survey (YL). YL is an ongoing longitudinal socioeconomic panel survey aimed at identifying long run effects of material deprivation in early life. We will link participants' performance on the cognitive assessments to the rich set of socioeconomic and development measures available from all four waves (10 years) of YL survey data; these include detailed economic data on income, consumption, and asset wealth, as well as household demographics, children's time allocation, anthropometrics, and traditional measures of generalized cognitive skills like standardized tests in reading or mathematics. We assess skills that are not EF as well as the EF skills in order to identify specific associations between early life conditions and these different types of skills; the different types of skills are amenable to different interventions, at different points in the life course. The preliminary results described below are based on analysis of data for about 15% of the sample; the full dataset is expected by the end of 2013.

By incorporating specific, laboratory-validated assessments of cognitive skills into an ongoing socioeconomic panel survey, we aim to address important lacunae in knowledge both in the population sciences and in the neuroscience of child development. In empirical social science, analysis of human capital—including questions around how it is produced, how its production is impacted by early-life conditions, and what affects the returns it can generate—has been limited in part by considerations of measurement. In the same way that advances in biodemography have shed light on mechanisms linking physical health to the social and economic environment, advances in "cognitive demography" may shed light on mechanisms linking brain, behavior, and society. Does early life poverty delay the development of fundamental, pluripotent cognitive skills like those involved in EF? Does it have a stronger impact EF skills than non-EF skills? Does a delay in the

development of these skills affect acquisition of content knowledge, and thereby academic success? In what specific respects—if any—do interventions that improve EF skills improve long-run socioeconomic welfare? Are the economic and social welfare returns to EF enhanced or attenuated if quality schooling is less available? A necessary but not sufficient condition to answering questions like these is specific measurement in large, population representative samples, in the context of broad socioeconomic surveys. This study represents a first step in that direction.

**Analyses and Preliminary Results**

Our main analyses will explore three sets of questions. The first relates performance on standardized tests to performance on the cognitive skills assessments. Do specific measures of cognitive skill provide information beyond traditional approaches, which often combine many different cognitive skills as well as specific content knowledge? We will examine associations between children's performance on our cognitive assessments on one hand, and on the other their performance on a Peabody Picture Vocabulary Test, an early grade reading assessment, and a mathematics test. In preliminary analyses, we find that after controlling for age, sex, and household economic resources, long term memory (which is not an EF skill) is a strong predictor of performance on the vocabulary and reading tests, but not the mathematics test. Working memory, by contrast—which is an EF skill—is associated with mathematics performance and not performance in the vocabulary or reading tests. The key difference between working memory and long term memory is that the former involves *holding* information or concepts in mind while manipulating them (a function one employs when solving arithmetic problems), whereas the latter involves *recalling* information that was presented a relatively longer time ago, and has not been a focus of continued attention since. Inhibitory control is strongly associated with all three test results—reading, vocabulary, and mathematics. Taken together, these results will illustrate how information on specific cognitive skills can complement and extend more traditional (and general) measures of knowledge and cognition that have been employed in the social sciences.

Next, we will turn attention to relationships between each specific cognitive skill on the one hand, and early life nutrition and health status on the other. Early life nutrition and health will be measured by birthweight and also standardized height-for-age in the second round of the YL survey (when respondent children were aged 5 years). Does early life health and nutrition provide different

information about some cognitive skills than about others? In preliminary analyses, we find that after controlling for age, sex, and household economic resources, both birthweight and height-for-age at age 5 are strong predictors of long-term memory skills at age 12-14. In fact, if *both* birthweight and height-for-age are included as covariates in the *same* regression, birthweight remains a strong predictor of long-term memory performance. This suggests that catch-up growth in terms of body size during early childhood may not correlate with a closing of skill gaps with regard to long-term memory. By contrast, after controlling for household economic resources, age, and sex, we observe no residual relationship between early life nutrition and the EF skills of inhibitory control or working memory. Taken together, these results will provide a more nuanced picture on relationships between specific measures of material deprivation and specific measures of cognitive development.

Finally, we will take advantage of the fact that YL will include information on over 700 sibling pairs, in order to explore a hypothesis that has been of central interest in family demography in recent decades (Frijters, Johnston, and others, 2013; Hsin, 2012; Torche, 2010; Rangel, 2008; Behrman, Pollak, and Taubman, 1982)—do parental and household inputs compensate for, or reinforce, early life differences in human capital? Overall across the population of Peru, birthweight and other measures of early-life health and nutrition are observed to predict cognitive skills—especially long-term memory. Is the same true when the comparison is restricted to *within sibling pairs*? In preliminary analyses, we find that the answer is a qualified "no"—overall within sibling pairs, the sibling who was behind in terms of height for age at age 5 is no more or less likely to also be behind in terms of acquired cognitive skills. This may indicate that parents "compensate" for the effects of early-life poor health or nutritional deprivation, for example by investing more time or attention on the worse-off sibling, thereby equalizing outcomes. However, there is a socioeconomic gradient in this pattern. For sibling pairs whose parents have more resources, differences in terms of height for age correlate relatively weakly with differences in terms of cognitive skills; for siblings whose parents are poorer, the association is much stronger. This pattern is consistent with patterns reported elsewhere in family economics and family sociology (Hsin, 2012; Torche, 2010; Rangel, 2008), and would be consistent with a hypothesis that parents are generally inequality averse over outcomes among their children. Therefore, those who can afford to equalize outcomes among their offspring might do so, while those who are relatively poorer might opt to direct their human capital investments where they will be most productive. As the rest of the data come in, we will repeat these

analyses using birthweights in place of height-for-age (since the latter is itself arguably more affected by the intrafamily distribution of resources). We will also investigate the extent to which these patterns vary with other child characteristics (e.g., do parents appear to "compensate" among sons but "reinforce" among daughters? Do patterns vary depending on whether grandparents are present in the household? And so on.)