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Risk preferences of children and adolescents in relation to gender, cognitive skills, soft skills, and executive functions

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ABSTRACT

We conduct experiments eliciting risk preferences with over 1,400 children and adolescents aged 3–15 years old. We complement our data with an assessment of cognitive and executive function skills. First, we find that adolescent girls display significantly greater risk aversion than adolescent boys. This pattern is not observed among young children, suggesting that the gender gap in risk preferences emerges in early adolescence. Second, we find that at all ages in our study, cognitive skills (specifically math ability) are positively associated with risk taking. Executive functions among children, and soft skills among adolescents, are negatively associated with risk taking. Third, we find that greater risk-tolerance is associated with higher likelihood of disciplinary referrals, which provides evidence that our task is equipped to measure a relevant behavioral outcome. For academics, our research provides a deeper understanding of the developmental origins of risk preferences and highlights the important role of cognitive and executive function skills to better understand the association between risk preferences and cognitive abilities over the studied age range.

1. Introduction

A large literature in experimental economics has focused on the role of risk preferences in explaining life outcomes.[1] For example, some research shows that women are less risk averse than men, which could partly explain the gender gap in competitiveness and in labor market earnings (Niederle and Vesterlund, 2011; Azmat and Petrongolo, 2014). It is important to document when differences in risk preferences begin to emerge and when these differences start to make a difference in the behaviors or skills of boys and girls. Such knowledge may inform policies to address differences in educational performance that may, perhaps lead to a wage gap later in life. Despite the great potential value of such understanding, surprisingly little

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[1] Examples include Bertrand, 2011; Dohmen et al., 2011; Insler et al., 2016; Khwaja et al., 2006; and Sutter et al., 2013.

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is known about differences in risk preferences at an early age or how these may interact with cognitive skills and executive functions, and thereby alter the life paths of students.

To explore this question, we conduct experiments using a risk preference elicitation task that we developed with over 1400 children and adolescents ages 3–15. We find that by age 13–15 years old, adolescent girls display significantly greater risk aversion than adolescent boys. We do not find the same gender gap among children ages 3–12, suggesting that the gap in risk taking emerges in adolescence. We complement our data on risk preference with an assessment of cognitive and executive function skills. The cognitive skills we refer to in this study are reading, writing and math ability. Executive functions refer to planning skills, maintaining focus and attention, following instructions, resisting distraction and temptation, and coordinating multiple tasks. The executive functions that we measure are working memory, inhibitory control, attention shifting, grit, self-control, conscientiousness and openness to experience. We find that cognitive skills and executive functions are significantly related to risk preferences. Children and adolescents with higher cognitive skills (specifically math skills) are more willing to take risks. Children with higher executive functions, and adolescents with more grit, self-control or soft skills, tend to be less willing to take risks. These results are robust to the inclusion of socio-economic and demographic controls.

Our first contribution is to evaluate the gender gap in risk preferences. Documenting gender disparities in risk preferences is important since this disparity can lead to many differential life outcomes.[2] A handful of papers find that adult women are more risk averse than adult men (Borghans et al., 2009; Charness and Gneezy, 2012; Croson and Gneezy, 2009; Dohmen et al., 2011; Eckel and Grossman, 2002; 2008).[3] A few studies (discussed in Section 2) have considered the emergence of a gender gap in risk preferences in children and adolescents, but they have either had relatively small sample sizes or have not included cognitive controls.

Our second contribution is to establish a connection between risk aversion and both cognitive skills and executive functions across childhood and adolescence. It is important to include controls for these two skills when assessing the developmental origins of risk preferences, since there is a rapid change in these as children mature. While some related work on risk preferences has included cognitive controls, the related work focuses on adolescents or adults and excludes children (e.g., Eckel et al., 2012; Benjamin et al., 2013; Burks et al., 2009; Dohmen et al., 2010; Frederick, 2005; Insler et al., 2016). Moreover, no related work that we know of also explores the associations of executive functions with risk preferences, despite its obvious relevance.

In what follows, Section 2 summarizes the related literature. Section 3 describes our experimental design. Section 4 summarizes our results. Section 5 provides a discussion and concludes.

2. Related literature

2.1. Gender gap in risk preferences of children and adolescents

Harbaugh et al. (2002) were the first to explore risk preferences of young children using an incentivized risk elicitation task. Potentially due to relatively small sample sizes,[4] the authors did not find a gender gap in risk preferences in their child, adolescent, or adult subjects.

Sutter et al. (2019) provide a summary of economic preference experiments conducted with children and adolescents since the original Harbaugh et al. (2002) paper. Their survey concludes that the majority of studies find that girls are more risk averse (less risk tolerant) than boys (studies include Levin and Hart, 2003; Borghans et al., 2009; Moreira et al., 2010; Booth and Nolen, 2012; Cárdenas et al., 2012; Eckel et al., 2012; Sutter et al., 2013; Alan et al., 2017; Deckers et al., 2016; Glätzle-Rützler et al., 2015; Khachatryan et al., 2015; Castillo, 2017). However, some studies do not find the gender effect (for example, Angerer et al., 2015 do not report on a gender effect; Tymula et al., 2012; Munro and Tanaka, 2014; Deckers et al., 2017; Castillo et al., 2018 do not find a gender effect). Since many of the above studies span short age ranges and risk elicitation tasks vary widely across studies, it is also difficult to know at what age the gender gap emerges.

The evidence on risk preference development across age is quite mixed, but there is some evidence that the gender gap emerges during adolescence. Säve-Söderbergh and Lindquist (2017) found that while adults on the TV show Jeopardy display gender gaps in risk taking, children ages 10–11 years old do not do so. Khachatryan et al. (2015) studied children ages 7–16 in Armenia and found an emergence of gender-disparate risk preferences for children in grade 7 or higher as compared to younger children. One suggested reason for the emergence of the gap around adolescence is the hormonal change that occurs during puberty (Smith et al., 2013).

[2] We also propose that measures with children can be considered a ‘purer’ measure of time preference than most of the literature presents with their subject pools. This contribution can be thought of in terms of measuring risk posture. Conventional expected utility theory recognizes the important effects of background risk on risk attitudes measured on the current choice. Harrison et al. (2007) show that background risk is important empirically. Specifically, they find their subjects are substantially more risk averse when background risk is introduced. These results suggest the importance of understanding the complete portfolio of risk the agent holds when making choices. As far as we are aware however, the literature has not provided estimates of how background temporal profiles affect current choices.

[3] Note that surveys of the literature conclude that the gender gap in risk aversion is not apparent in all contexts (Filippin and Crosetto, 2016). Moreover, the gender gap in risk preferences is not as robust as the observed gender gap in competitiveness (Byrnes et al., 1999; Niederle and Vesterlund, 2011).

[4] 64 subjects ages 5-8 years old, 65 subjects ages 9-13 years old, 58 subjects ages 14-20 years old, and 47 subjects ages 21-64.

Related studies suggest that social environment influences a person's tendency to take risks. Gardner and Steinberg (2005) found that being surrounded by peers influenced subjects to make riskier decisions. Booth and Nolen (2012) found that girls who attend mixed-gender schools may be more risk averse than girls who attend all-girls schools. Cárdenas et al. (2012) found that the gender gap in risk-taking varies across Columbia and Sweden. Andersen et al. (2013) found the emergence of gender-disparate competitiveness in puberty in patriarchal but not matriarchal societies. Brown and ven der Pol (2015) used survey questions measuring risk preferences and found that adolescents' risk preferences are associated with parental risk preferences.

An improvement our study over related work is that we control for other age-related changes (i.e. cognitive skills and executive functions). A second important improvement is that we use the same task to study children and adolescents, which allows us to understand risk preferences in both groups. A third improvement is that we study risk preferences at a younger age than most studies (for example, in the summary by Sutter et al. (2019), the youngest children studied are 4 years old in Moreira et al. (2010) and 5 years old in Harbaugh et al. (2002), Levin and Hart (2003), and Castillo (2017).).

2.2. Relationship of risk preferences with cognitive skills, executive functions and soft skills

Related work also documents relationships between risk taking, cognitive skills, executive functions and soft skills. We might expect a relationship of cognitive skills (specifically math skills) with risk aversion since these skills may affect the processing of information related to probability. We might also expect a relationship of executive functions with risk aversion since inhibitory control or self-control might affect ability to regulate the prepotent response. That is, if a child's prepotent response is to take many pencils (i.e., take a higher risk), self-control ability may allow him or her to inhibit this response and take fewer pencils. Further, the literature from developmental science described later in this section provides theories about links between working memory and risk taking behavior.

Among adults, some work has found that greater cognitive skills are associated with lower risk aversion (Burks et al., 2009; Dohmen et al., 2010; Frederick, 2005; Insler et al., 2016). Among adolescents, risk taking and cognitive skills were assessed in Eckel et al. (2012) and Benjamin et al. (2013). Eckel et al. (2012) did not find an association of risk preferences with cognitive skills, as proxied by math ability. However, Benjamin et al. (2013) did find an association of risk preferences with cognitive skills, whereby higher cognitive ability – especially in math – was predictive of lower levels of risk aversion. To the best of our knowledge, researchers have not assessed risk preferences and cognitive skills of children. If children are similar to adults and adolescents, we might expect that children with higher levels of cognitive ability would also display lower levels of risk aversion. On the other hand, if the link between risk preferences and cognitive ability develops later in life, we may find no such association.

Some limited related work in economics has also evaluated the association of executive functions and soft skills with risk preferences. Eckel et al. (2012) found that high planning ability was negatively associated with risk taking, but only among 9th grade students. Becker et al. (2012) reviewed the role that personality has on economic preferences. The authors found a low association between personality and economic preferences, but concluded that the two are complementary in predicting life outcomes and behavior.

Developmental psychologists have also been interested in exploring associations of executive functions with risk-taking (see Boyer, 2006, for a review). This literature has focused on adolescents, which is an age group that is known for taking higher amounts of risk generally (e.g., reckless driving, smoking) (Steinberg, 2008). Boyer (2006) emphasized that emotional instability and impulsivity may be the main explanation of adolescent risk-loving preferences. Additional related work includes Rosenbaum et al. (2017), who found some evidence that training adolescents in working memory decreased their risk taking behavior in a hypothetical gambling task. A potential explanation for the link between working memory and risk taking is that improved working memory accelerates executive function development and therefore reduces risk taking. Finally, Romer et al. (2011) found association of risk taking (as measured by surveys) with executive functions and the tendency to act without thinking.

A limitation of the related work is that it does not include young children, since it focuses mostly on adolescents and adults. Our study is the first to document associations of risk preferences with cognitive skills at an early age. Another limitation is that related work does not include measures of executive functions and related skills together with cognitive skills as we do. Importantly, we find that cognitive skills and executive functions matter for risk taking at all age ranges in our study, including for children as young as age 3.

3. Experimental design

3.1. The pencil task

The risk preference task we use is a simplification of a task developed by Andreoni and Harbaugh (2009, 2018). We here provide a simple model that illustrates the point that risk neutrality predicts always choosing the midpoint on the budget, no matter the price. In their task, adult subjects choose both a probability p, $0 \le p \le 1$, of winning a prize x if they win, where p and x lie on a budget constraint, such as $rp+x=100$. In this problem, r is a price that can be any positive number. For instance, if $r=100$, and an individual is risk neutral, the person will solve:

$$Max_{p,x}\ px \quad s.t.\, 100p + x = 100$$

that is, the subject will maximize expected value, choosing $p=.5$ and $x=50$. Risk averse subjects will prefer a higher p and lower x relative to this, while a risk loving person would prefer a lower p. Thus, the degree of risk aversion can be measured simply by distance of the chosen p from the expected-value-maximizing p. In this example, values of p increasingly above ½ indicate greater risk aversion, and values of p increasingly below ½ indicate greater risk loving.

The modification we employ in this study relies on the same principles, but is greatly simplified. Participants were shown a fixed number of pencils in a jar (five pencils for children, ten pencils for adolescents).[5] One pencil had a red mark on the bottom. Participants were told that they could choose to take as many pencils as they wanted from the jar. They could keep any pencils they took out of the jar, as long as none of the pencils that they took had a red mark on the bottom. But if any pencil had a red mark on the bottom, they had to give up all the pencils. Children made the decision only once and then proceeded to take out the number of pencils they specified (i.e., the choice of pencils was not sequential). At the end of the experiment, children kept all the pencils taken out, while adolescents could trade their pencils for U.S. dollars at the rate of 1 pencil = 25 cents.[6] The analogy to the Andreoni-Harbaugh mechanism is clear. The number of pencils taken out is the prize x, while the proportion of pencils still left in the jar indicates the probability of winning, p percent. Since the price is 1, risk neutrality occurs at half of the pencils. Taking fewer than half of the pencils indicates risk aversion and taking more than half indicates risk loving.

Our task is similar to Edwards and Slovic (1965). In their task, children were seated in front of 10 switches and chose how many switches to pull, whereby nine switches were "safe" and one switch was the "disaster switch." The more "safe" switches the child pulled, the more candies he/she received. However, pulling of a "disaster" switch resulted in loss of all candies. Our task differs from Edwards and Slovic (1965) in that children first decide how many pencils to take out of the box, whereas in Edwards and Slovic (1965) children are continuing to pull switches until they stop *or* pull the "disaster switch."

Other tasks that are related to ours include the Balloon Analogue Risk Task (BART) (Lejuez et al., 2003) and the Bomb Risk Elicitation Task (BRET) (Crosetto and Filippin, 2013).

In the BART, children choose continuously whether to keep pumping a balloon that has an unknown probability of popping. More pumping is associated with increasing rewards, and popping the balloon is associated with no reward. In the BRET, subjects decide how many boxes to collect out of 100, one of which contains a bomb. More boxes collected is associated with linearly increasing rewards, but collecting a box with a bomb results in loss of all rewards. The BRET task and Edwards-Slovic task are formally equivalent.

Our pencil task has several improvements over the BART and BRET that may be helpful for economists conducting risk elicitation experiments in the field with children. It is simple, easily understood by children, and can be conducted without a computer. A limitation of the pencil task is that different from a multiple price list (e.g., Holt and Laury, 2002), we are not able to study inconsistency of choices. This is because children make only one choice, and not many choices. Inconsistency of choices has been documented among both adults and children, which can cast doubt on the reliability of risk preference measures (Loomes et al., 1991; Brocas et al., 2018). Solutions for the inconsistency problem include simply dropping individuals who are inconsistent (Harbaugh et al., 2002) or constructing structural estimates to correct for measurement errors and improve estimation (Castillo et al., 2018). Brocas et al. (2018) suggest that inconsistency among children may be due to several factors, including task difficulty, lack of ability to focus or irrational behavior. Our pencil task addresses the first two factors since it is simple and short.

3.2. Experimental setting

Children were recruited from the Chicago Heights Early Childhood Center (CHECC) program. CHECC is a large-scale intervention study on the role of different early education programs on schooling outcomes conducted in 2010–14 (Fryer et al., 2015). Adolescents were recruited from the UProgram, a separate ongoing intervention study on the role of cognitive skills and non-cognitive skills interventions on schooling outcomes of 7th and 8th graders.

Table 1 (column 1) provides a summary of the background characteristics of the CHECC sample. The CHECC sample is drawn from Chicago Heights, IL and the surrounding area. This is a predominantly low-income and high minority area. The UProgram sample is drawn from similarly low-income and high-minority suburbs in Illinois - Harvey, Matteson and University Park. Table 1 (column 2) provides a description of the UProgram sample. The CHECC and UProgram samples were similar along the dimensions of gender and census block variables.[7] They differed by race, with relatively more Hispanic students in the CHECC sample and relatively more Black students in the UProgram sample.

[5] Simplifying tasks slightly for younger children is common in related work. For example, in Alan et al. (2017), children had fewer than half as many balls as their mothers in a risk elicitation task.

[6] We have successfully used similar non-monetary prizes for young children in related work (e.g., Andreoni et al., 2019; Samak, 2013). The pencils were chosen to have patterns that appeal to this age group. Adolescents are motivated by relatively small monetary payments. For comparison, a school lunch or breakfast costs between $2.00 and $3.00 and students can buy other snacks at their school for under $1.00.

[7] We match census block variables on address to include these controls: fraction of residents aged 25+ with HS diploma only, 25+ with college degree only, and 25+ with more than college, and fraction of households below twice the poverty line.

Table 1
Sample summary characteristics.

	Children	Adolescents
Female	0.47	0.47
Age at risk assessment	5.60	13.56
Black	0.33	0.71
Hispanic	0.54	0.19
White	0.13	0.14
Other race	0.00	0.21
25+ HS diploma only	0.28	0.25
25+ college only	0.09	0.15
25+ more than college	0.06	0.10
Below twice pov. line	0.47	0.34
All demographics available	181	922
All SES available	213	1174
N	231	1295

This table shows the average value for several demographic variables. Of 2208 total children in CHECC, 177 children and 54 siblings participated in this task. Compared to the total CHECC population, our sub-sample has fewer black participants (main study = 0.46) and more Hispanic participants (main study = 0.42). Of 1481 total adolescents in UProgram, 1295 participated in this task. Compared to the total population of UProgram, our population is very similar.

3.3. Child experiment

Children participated about a month after the programs started, which is likely before any potential impact of the programs on risk preference could be observed.[8] Participating children (ages 3–5) and their older siblings (ages 6–12) completed the experiment in 2010–2011. Younger children participated one-on-one with a trained experimenter, while older children participated in a group with several trained experimenters who walked around to assist. The experimenter read the instructions out loud to the child (see Appendix I). The risk preference elicitation was part of a larger set of assessments, including time preferences, which we report on in a separate paper (Andreoni et al., 2019).[9]

All CHECC children also participated in a comprehensive assessment of cognitive skills and executive functions (See Appendix II).[10] These were conducted one-on-one with an assessor trained in these tasks. The cognitive skills tests were nationally normed sub-tests of the Woodcock-Johnson III Test of Achievement (Woodcock-Johnson III, 2007), including measuring literacy (letter-word and spelling) and math ability (applied problems and quantitative concepts). These were supplemented with the Peabody Picture Vocabulary Test (measuring receptive vocabulary).

The executive function tests were taken from Blair and Willoughby (2006a; 2006b; 2006c), and include tests of working memory, inhibitory control and attention shifting. They were supplemented with the Preschool Self-Regulation Assessment, a survey that assessors completed after the assessment about the child's regulation skills during the assessment (Smith-Donald et al., 2007).

For children, we create a "cognitive skills index" by averaging standardized scores in the cognitive skills sub-tests, and an "executive functions index" by averaging the scores in the executive function tasks.

3.4. Adolescent experiment

The adolescent experiment was conducted in a group, whereby the experimenter read the instructions out loud while the students followed along (see Appendix I). Adolescents were seated such that they were each doing their own work and could not copy from each other. Three experimenters walked around to assure that children were on task and not discussing any of the questions together. The risk elicitation task was conducted 4–6 weeks after the one-quarter program started and was part of a larger assessment of risk, time and social preferences.[11]

All adolescents also participated in comprehensive assessments of cognitive skills and executive functions (See Appendix II). The cognitive skill scores are taken from the Measures of Academic Progress (MAP) test that is administered annually by the school, and are split into math and reading scores.[12] The executive function scores are taken from the National Institutes of Health (NIH) Toolbox application that we administered, including four sub-test instruments: Dimensional Card Sort Test,

[8] Including controls for treatment assignment does not result in significant coefficients and does not affect our main results.

[9] A related series of papers have reported on other characteristics of the CHECC sample which are different from what is reported here, most notably social preferences (Cappelen et al., 2016; Ben-Ner et al., 2017; List and Samak, 2013; List et al., 2018) and competitiveness (Samak, 2013). This work also includes studies of the associations of economic preferences, cognitive abilities and executive functions at an early age with disciplinary referrals later in life (Castillo et al., 2018) and the development of Theory of Mind (Cowell et al., 2015; Charness et al., 2019).

[10] Note: We do not have cognitive skills and executive function scores for CHECC siblings (n = 54).

[11] Including controls for UProgram treatment assignment does not affect our main results.

[12] https://www.nwea.org/map-growth/

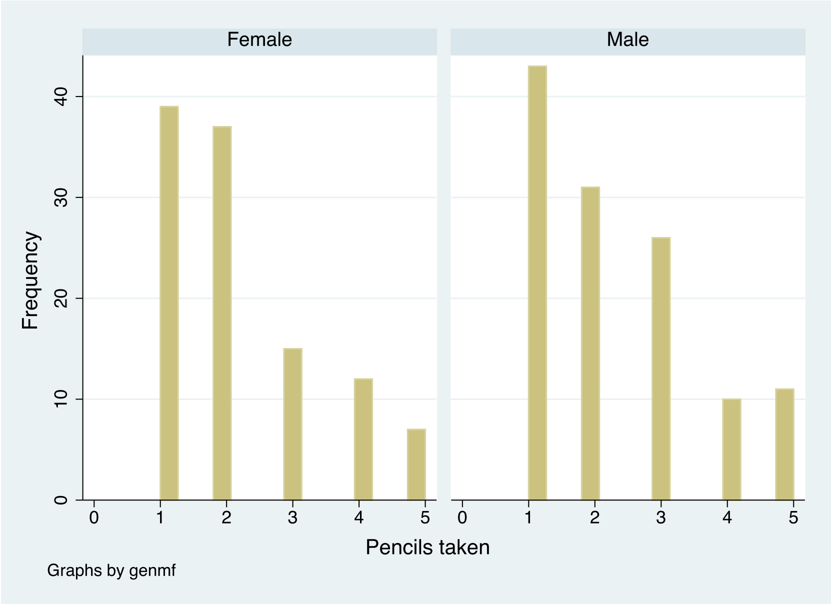

Fig. 1. Histogram of child risk preferences.

Flanker Inhibitory Control and Attention Test, List Sorting Working Memory Test, and Picture Sequence Memory Test.[13] We also collected survey data from adolescents on grit (Duckworth and Quinn, 2009), self-control and two components of the Big Five personality index: conscientiousness and openness to experience (John et al., 1991; John et al., 2008).

For adolescents, we create a “cognitive skills index” by averaging standardized math and reading scores from the MAP and an “executive function index” by averaging the scores in the executive function tasks (NIH Toolbox). This most closely aligns the executive functions measured for adolescents with those measured for children. We complement this data with an aggregate measure from the adolescent survey for “soft skills” (grit, self-control, conscientiousness and openness to experience).

Note that although both children and adolescents participated in comprehensive tests of cognitive and executive function ability, none of the tests conducted with children are the same as the tests conducted with adolescents. Therefore, it is not possible to directly compare the performance of children and adolescents on the tests.

4. Results

4.1. Summary of results

Figs. 1 and 2 provide histograms of the number of pencils taken out of the jar, by gender, for the child and adolescent experiments. It is apparent that some children and adolescents make mistakes by choosing zero pencils or choosing the maximum number of pencils, and therefore having no chance at a reward. None of the 231 children chose zero pencils and 5 (7.8%) chose 5 pencils. Two of 1295 adolescents (0.15%) chose zero pencils, and 5 (0.39%) chose 10 pencils.[14] Dropping children and adolescents from the regressions who made these mistakes does not affect our main results (see Appendix III, Tables A1 and A2).

Table 2 provides a calculation of the expected payoff for participants picking each possible number of pencils from the jar. Expected payoff is calculated by multiplying the number of pencils taken by the probability that none of the pencils is the one with the mark, which would lead to a zero payoff. For example, a child who picks 3 pencils has an expected payoff of $6/5=(3)(2/5)+(0)(3/5)$. An adolescent who picks 7 pencils has an expected payoff of $21/10=(7)(3/10)+(0)(7/10)$. From this table, it can be seen that choosing more pencils in the pencil task is related to greater risk-seeking behavior.

[13] http://www.healthmeasures.net/explore-measurement-systems/nih-toolbox

[14] In total, only 0.54% of observations were lost in the Andreoni-Harbaugh elicitation because of end-point choices. By comparison, the popular Holt and Laury (2002) multiple price list task often loses 10% of observations because of multiple switching. See a discussion and broader comparison in Andreoni and Kuhn (2019).

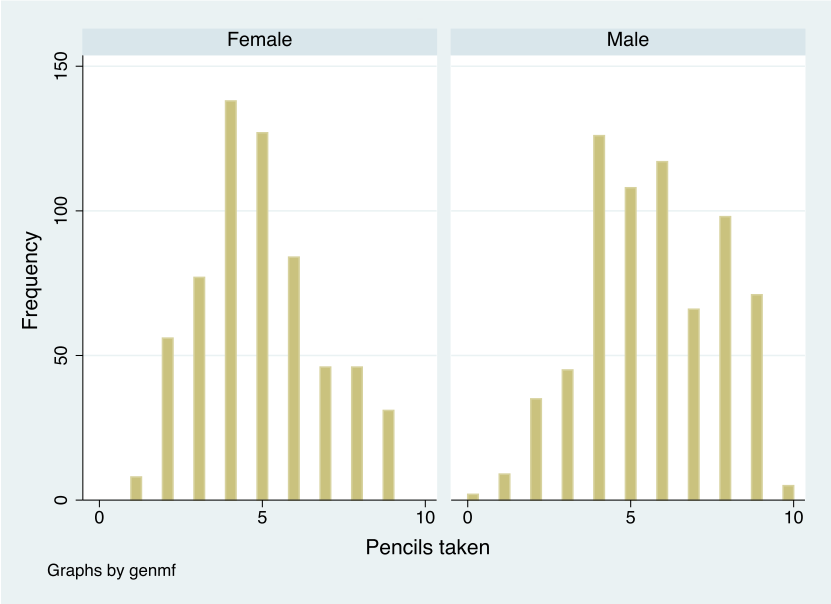

Fig. 2. Histogram of adolescent risk preferences.

Table 2
Expected values.

	Children	Adolescents
EV(1)	4/5	9/10
EV(2)	6/5	16/10
EV(3)	6/5	21/10
EV(4)	4/5	24/10
EV(5)	0	25/10
EV(6)	–	24/10
EV(7)	–	21/10
EV(8)	–	16/10
EV(9)	–	9/10
EV(10)	–	0

This table shows the expected value pay-off from each possible number of pencils a participant could draw from the jar. Chil-dren could pick 1–5 pencils, while adolesc- ents could pick 1–10 pencils. For example, an adolescent who picks 4 pencils has an expected value of $(6/10) * (4) + (4/10) * (0) = 24/10$.

4.2. Gender gap in risk preferences

We now turn to understanding the gender gap in risk preferences. Patterns in Figs. 1 and 2 indicate higher degrees of risk taking in adolescent boys versus adolescent girls, with no apparent differences in younger girls and boys. Table 3 provides summary statistics for children and adolescents, including a p-value for the t-test comparing results by gender. While we do not observe a gender gap in risk taking among children (ages 3–12) (The Wilcoxon Rank Sum test of equality of distribution between male and female is not statistically significant, $p = .48$), we do observe a gender gap in risk taking among adolescents (ages 13–15) (The Wilcoxon Rank Sum test of equality of distributions between male and female is statistically significant, $p < .01$). As shown in Table 3, on average adolescent girls take 4.91 pencils (s.e.=0.08) while adolescent boys take 5.71 pencils (s.e.=0.08).

The gender result is further confirmed in Tables 4 and 5, which provide Ordinary Least Squares (OLS) regressions with number of pencils taken as the dependent variable and gender as the independent variable for children and adolescents, respectively. Child regressions cluster at the family level. Adolescent regressions include school-level controls (the program was run in three middle schools) and cluster on the unit of randomization at UProgram (quarter-school-class). Column 2 adds controls for demographic and socioeconomic status (including the variables summarized in Table 1), and column 3 adds controls for cognitive skills and executive functions. Including all controls, Table 5 (column 3) shows the coefficient on *Female* for adolescents is −0.81 (p-value < 0.01). We do not observe a statistically significant coefficient of *Female* in the child sample, as shown in Table 4 (column 3) where the coefficient on *Female* is −0.12 and is insignificant (p-value 0.62).

Table 3
Summary across age and gender.

	Children			Adolescents		
	Male	Female	p-value	Male	Female	p-value
Pencils taken	2.30	2.19	0.52	5.71	4.91	0.00
	(0.12)	(0.12)		(0.08)	(0.08)	
Cognitive index	−0.20	−0.18	0.80	0.05	0.20	0.00
	(0.09)	(0.09)		(0.03)	(0.03)	
Executive functioning index	0.41	0.35	0.54	0.08	0.10	0.54
	(0.09)	(0.09)		(0.02)	(0.00)	
Self control, grit and personality				−0.02	0.02	0.23
				(0.02)	(0.00)	
N	121	110		682	613	

This table shows a summary of indices for each age group by gender. Reported p-value is for a *t*-test of equality by gender. Standard errors in parentheses. The number of pencils taken for children ranges from 1–5. The Cognitive Index for children is composed of standardized scores on Peabody Picture Vocab, Woodcock Johnson Applied Problems, Woodcock Johnson Letter-Word Problems, Woodcock Johnson Spelling Problems, and Woodcock Johnson Qqrytitative Concepts. The Executive Functioning Index for children is composed of standardized scores of Operation Span Task, Preschool Self-Regulation Assessment, and Spatial Conflict Task. The number of pencils taken for adolescents ranges from 1–10. The Cognitive Index for adolescents is composed of standardized scores on MAP math and reading. The Executive Functioning Index for adolescents is composed of standardized scores on NIH Toolbox Dimensional Change Card Sort Test, Flanker Inhibitory Control and Attention Test, List Sorting Working Memory Test, and Picture Sequence Memory Test. Self Control, Grit and Personality Index for adolescents is com-posed of self-report Grit, Self-Control, Openness (Big Five), and Conscientiousness (Big Five).

Table 4
Children.

	1	2	3
Female	−0.11	−0.07	−0.12
	(0.16)	(0.16)	(0.18)
Cognitive index			0.33***
			(0.12)
Executive functioning index			−0.31**
			(0.13)
Constant	2.25***	2.73***	−0.51
	(0.22)	(0.43)	(0.93)
Demo & SES		√	√
Observations	231	231	177
R^2	0.00	0.10	0.19
Adjusted R^2	−0.01	0.05	0.12

This table shows coefficients from OLS regressions where the dependent variable is the number of pencils taken. Standard errors are in parentheses (clustered at the family level).
$* p < .1$, $** p < .05$, $*** p < .01$.

Table 5
Adolescents.

	1	2	3
Female	−0.80***	−0.77***	−0.81***
	(0.12)	(0.12)	(0.12)
Cognitive index			0.24***
			(0.08)
Executive functioning index			0.22*
			(0.12)
Self control, grit and personality			−0.24**
			(0.10)
Constant	5.71***	7.35***	7.42***
	(0.09)	(0.87)	(0.87)
Demo & SES		√	√
Observations	1295	1295	1295
R^2	0.04	0.06	0.07
Adjusted R^2	0.04	0.04	0.06

This table shows coefficients from OLS regressions where the dependent variable is the number of pencils taken. Standard errors are in parentheses (clustered at the quarter-school-class level).
$* p < .1$, $** p < .05$, $*** p < .01$.

Table 6
Children, individual components.

	1
Female	−0.24
	(0.20)
WJ applied problems	0.55
	(0.58)
WJ quantitative concepts	−0.15
	(0.59)
WJ letter-word	0.07
	(0.43)
WJ spelling	0.90*
	(0.49)
PPVT receptive vocabulary	0.31
	(0.57)
Working memory (Operation Span)	−0.38
	(0.39)
Inhibitory control (Spatial Conflict)	−0.64
	(0.61)
Self regulation survey	−1.10*
	(0.62)
Constant	2.77
	(1.71)
Demo & SES	√
Observations	177
R^2	0.23
Adjusted R^2	0.10

This table shows coefficients from OLS regressions where the dependent variable is the number of pencils taken. Standard errors are in parentheses (clustered at the family level).
$* p < .1$, $** p < .05$, $*** p < .01$.

Multiple hypothesis testing (MHT) is a concern in any experiment that attempts to compare sub-groups (List et al., 2019). Using Holm's adjustment for multiple hypothesis testing (with 7 hypotheses: comparing by gender for each age group, cognitive and executive functioning for each age group, and soft skills for adolescents) our results for the gender gap among adolescents remain significant at the 5% level.

4.3. Association with cognitive skills and executive functions

The regressions in Tables 4 and 5 illuminate another interesting finding: cognitive skills are significantly positively associated with risk preferences, even when controlling for gender, age, socio-economic, and other demographic characteristics. In Table 4, which provides the results from the child experiment, the coefficient on the standardized cognitive ability index is positive (0.33) and statistically significant (p-value $<$ 0.01). In Table 5, which provides the results from the adolescent experiment, the coefficient on standardized cognitive ability index is again positive (0.24) and also statistically significant (p-value $<$ 0.01). Using Holm's adjustment for MHT, these results remain significant at the 5% level.

Among adolescents, the impact of cognitive ability seems to be driven by math ability. In Tables 6 and 7, we separate out the different components of the indices for children and adolescents, respectively. As shown in Table 7, for adolescents the coefficient on standardized math scores is positive (0.39) and statistically significant (p-value $<$ 0.01). These results are remarkable in light of the fact that in our sample of adolescents, girls have higher cognitive test scores than boys (see Table 3) — that is, cognitive ability is not the primary driver of our main result of a gender gap in risk preferences in adolescents. This result is in line with the previous studies where higher cognitive skills are associated with a preference for risk taking (Burks et al., 2009; Benjamin et al., 2013; Dohmen et al., 2010; Frederick, 2005).

The relationship between executive function and risk taking is also interesting. Among children, risk taking is associated with statistically significantly lower executive functions (see Table 4 (column 3), coefficient = −0.31, p-value = 0.01). For adolescents, we split non-cognitive skills into executive functions (the executive functions index includes the average standardized components of the NIH Toolbox) and soft skills (soft skills include the average measures of personality traits, grit and self-control measured by a survey). Among adolescents, risk taking is associated with somewhat higher executive functions, but the result is statistically significant only at the 10% level and not robust to Holm's adjustment for multiple hypotheses. Soft skills are statistically significantly negatively associated with risk taking among adolescents (coefficient = −0.24, p-value= 0.02). As displayed in Table 7, this seems driven in large part by self-reported self-control (coefficient = −0.15, p-value<0.05). Using Holm's adjustment for multiple hypotheses, the result for soft skills remains significant at the 10% level.

Table 7
Adolescents, individual components.

	1
Female	−0.80***
	(0.13)
Math cog comp.	0.39***
	(0.11)
Reading cog comp.	−0.14
	(0.11)
NIH Card Sort	0.04
	(0.07)
NIH Flanker	0.04
	(0.09)
NIH List Sort	−0.00
	(0.08)
NIH Picture Sequence	0.04
	(0.07)
Openness	−0.05
	(0.08)
Conscientiousness	0.04
	(0.07)
Grit	−0.02
	(0.07)
Self control	−0.15**
	(0.07)
Constant	6.80***
	(1.32)
Demo & SES	√
Observations	1295
R^2	0.09
Adjusted R^2	0.07

This table shows coefficients from OLS regressions where the dependent variable is the number of pencils taken. Standard errors are in parentheses (clustered at the quarter-school-class level). $* \ p < .1$, $** \ p < .05$, $*** \ p < .01$.

As a robustness check for our econometric analysis, and the way we have grouped variables between cognitive skills and executive functions, we conduct an exploratory factor analysis. We then re-run the OLS regressions reported in Tables 4 and 5 using the indices constructed by factor analysis (see Appendix III, Tables A3 and A4. The results we find are similar to those we get using the indexes constructed by standardized averages.

4.4. Further analysis

We also have access to disciplinary referral data for the adolescent sample. Disciplinary referrals are an important outcome variable in young-adult samples because disciplinary referrals are a predictor of school drop-out rates, which influence educational attainment and labor market outcomes. We use this data to verify the usefulness of our new simple risk measure at capturing a field-relevant behavior.

Tables 8 and 9 provide OLS regressions that use number of disciplinary referrals as the outcome variable. In Table 8, we evaluate the binary outcome variable – any disciplinary referral versus no disciplinary referral. We find a small and statistically insignificant coefficient on our risk measure (coefficient = 0.01, p-value = 0.105 (see column 2)). In Table 9, we evaluate the number of disciplinary referrals conditional on having at least one disciplinary referral. We find that among adolescents with at least one disciplinary referral, higher risk-taking is associated with statistically significant increases in the number of disciplinary referrals, (coefficient = 0.21, p-value = 0.02 (see column 2). This association holds even when controlling for cognitive skills and executive functions (see Table 9, column 2), suggesting that risk preferences play a role beyond that which is captured in standard measures of cognitive skills. In Tables 8 and 9 we also see that as expected, cognitive skills, executive functions and soft skills are statistically significantly negatively associated with disciplinary referrals.

Related work has shown that time preferences are associated with disciplinary referrals, with more impatient adolescents exhibiting more disciplinary referrals (Castillo et al., 2018). Our work complements this finding by showing that risk preferences can be similarly predictive of field behavior. Castillo et al. (2018) also use a risk preference elicitation (consisting of choosing between 5 lotteries) in their study, but do not find an association with disciplinary referrals. We propose that this could be because of the smaller sample in their study or because their task is more difficult for younger populations to understand than our task.

Finally, we need to take into account two differences between the child and adolescent experiments. First, the adolescent sample is much larger than the child sample, which could explain why we find a statistically significant gender gap among

Table 8
Adolescents, discipline binary.

	1	2
Pencils taken	0.01	0.01
	(0.01)	(0.01)
Female		−0.09***
		(0.02)
Cognitive index		−0.08***
		(0.02)
Executive functioning index		−0.05**
		(0.02)
Self control, grit and personality		−0.10***
		(0.02)
Constant	0.30***	0.14
	(0.04)	(0.30)
Demo & SES		√
Observations	1295	1295
R^2	0.00	0.18
Adjusted R^2	0.00	0.16

This table shows coefficients from OLS regressions where the dependent variable is an indicator of any vs. no disciplinary referrals. Standard errors are in parentheses (clustered at the quarter-school-class level). ∗ $p < .1$, ∗∗ $p < .05$, ∗∗∗ $p < .01$.

Table 9
Adolescents, discipline count (conditional).

	1	2
Pencils taken	0.14*	0.21**
	(0.08)	(0.09)
Female		−0.04
		(0.38)
Cognitive index		−1.13***
		(0.29)
Executive functioning index		−0.41
		(0.40)
Self control, grit and personality		−0.00
		(0.34)
Constant	2.54***	−6.41***
	(0.44)	(1.82)
Demo & SES		√
Observations	469	469
R^2	0.01	0.14
Adjusted R^2	0.00	0.10

This table shows coefficients from OLS regressions where the dependent variable is a count of disciplinary referrals (conditional on having at least one disciplinary referral). Standard errors are in parentheses (clustered at the quarter-school-class level).
∗ $p < .1$, ∗∗ $p < .05$, ∗∗∗ $p < .01$.

adolescents but not among children. To address this concern, in Appendix III, Table A5 we conduct a bootstrap analysis on the adolescent sample, limiting the sample size to 231. We continue to observe a statistically significant gender gap. Second, the adolescent sample includes choices of pencils from 0–10, while the child sample includes choices of pencils from 0–5. To address this concern, in Appendix III, Tables A6-A9 we rescale the adolescent sample by setting all choices of pencils 5–10 to 5 or setting all choices of pencils 0–5 to 5, with and without bootstrapping. The results are unchanged qualitatively, and we continue to observe a statistically significant gender gap in all tables.

5. Discussion and conclusion

Our findings inform our understanding of the development of risk preferences as children grow up and have implications for policy and practice. First, we find that a gender gap emerges around adolescence, with girls displaying more risk averse behavior than boys. This gender gap could be explained by nature, that underlying differences between male and female individuals emerge during puberty. It could also be explained by nurture, that environment plays a role in risky behavior—from upbringing in a single sex school to presence of peers. This result is in line with related work.

Our second main finding is that cognitive skills and executive functions are associated with risk taking at all ages in our sample. This points to the importance for future work to control for these skills when measuring changes in risk preferences over time or across sub-groups. Cognitive skills are positively associated with risk taking in both children and adolescents.

Executive functions are negatively associated with risk taking in children, and somewhat positively associated with risk taking in adolescents. Soft skills in adolescents are negatively associated with risk taking.

Our research finds that while there is no gender gap among young children, a gender gap in risk taking does emerge during adolescence. Since risk taking is associated with competitiveness, our results could have policy implications for decreasing the gender gap in competitiveness Potential policy interventions could focus on increasing willingness for women to take risks prior to adulthood, when preferences may already be ingrained. Adolescents make many choices—for example, choice of coursework—that affect their educational and labor market outcomes. Related work shows that women tend to avoid more competitive fields (Buser et al., 2014). We find that cognitive ability is associated with increased risk taking, yet girls in our sample already display higher cognitive ability than boys, so it is unclear whether interventions that improve math skills could lead to reductions in the gender gap. Finally, we find that extreme risk taking preferences are associated with poorer outcomes, such as increased disciplinary referrals. Therefore, caution should be taken when prescribing policies to increase risk taking.

More generally, we provide a description and evaluation of a simple task that allows us to measure risk preferences quickly and easily of a wide age range of children. The task can be used for children as young as age 3, does not require a computer, and is associated with an expected behavioral outcome (disciplinary referrals). We hope future researchers use this task when evaluating preferences of young or low-literacy populations, or when time to administer the task is limited.

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Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2019.05.002.

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