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Financial literacy, cognitive abilities and gender gap

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ABSTRACT

This paper examines how cognitive abilities explain variation in financial literacy among teenagers. We consider three dimensions of cognition: cognitive reflection, fluid intelligence, and approximate numeracy. Together, these measures account for nearly half of the variance in financial literacy scores and help explain the observed gender gap. While we find that the gender gap in financial literacy is entirely accounted for by differences in cognitive reflection, we do not find a similar result for approximate numeracy or fluid intelligence. These findings suggest that the gap is not driven by general cognitive differences across gender but by specific features that are shared by the Cognitive Reflection Test (CRT) and the financial literacy test and that disproportionately penalize girls.

1. Introduction

Understanding financial literacy among teenagers is crucial, as early financial education potentially influences long-term economic outcomes (Brown et al., 2016; Fan, 2021; Henager & Cude, 2019; Lusardi & Mitchell, 2014). Adolescents form spending and saving habits that persist in adulthood and shape their financial stability and decision-making processes. Inadequate financial literacy can lead to poor credit management, excessive debt, and reduced wealth accumulation, ultimately impacting economic growth and social mobility.

Studies on the determinants of teenagers' financial literacy have typically focused on either formal financial education (e.g., Becchetti et al., 2013; Gray et al., 2021; Lührmann et al., 2015) or on socialization processes (e.g. Agnew & Cameron-Agnew, 2015; Gudmunson & Danes, 2011; Jorgensen & Savla, 2010; LeBaron & Kelley, 2021). In this paper, we investigate the importance of cognitive abilities in explaining differences in financial literacy across individuals and across gender. Individuals differ in how they approach decisions, handle quantitative information and solve problems, which affect how well they understand and use financial information. Eber et al. (2024) report that cognitive abilities significantly influence key preferences and financial behaviors, including risk aversion, time preferences, susceptibility to behavioral biases, and engagement in financial markets. It is therefore likely that financial literacy is influenced by cognitive abilities as well.

Our analysis is based on a sample of 353 students from different high schools in New Zealand. We assess financial literacy using ten

questions drawn from various tests in the literature (Fernandes et al., 2014; Lusardi & Mitchell, 2011; Ranyard et al., 2020). To measure cognitive abilities, we focus on three dimensions largely independent of knowledge and culture, namely cognitive reflection, fluid intelligence and approximate numeracy. We used three well-known tasks to measure these dimensions; an adapted version of the extended Cognitive Reflection Test (CRT) (Toplak et al., 2014), a shortened version of the Raven Progressive Matrices test (SRPM) (Bilker et al., 2012; Raven, 1941; Raven et al., 1989) to test fluid intelligence, and the Number Line Estimation (NLE) task used by Booth and Siegler (2006), Siegler and Booth (2004), Roger et al. (2022), and Sobkow et al. (2020) to assess approximate numeracy.

Our findings are twofold. First, we provide evidence that cognitive abilities, measured along three different dimensions (cognitive reflection, fluid intelligence, and approximate numeracy), account for a substantial share of the heterogeneity in financial literacy among teenagers. Second, we show that the observed gender gap in financial literacy is entirely explained by differences in cognitive reflection but not by differences in fluid intelligence or approximate numeracy.

We interpret our results in light of a growing body of research that questions the validity of the Cognitive Reflection Test (CRT) as a pure measure of cognitive ability, particularly in the context of gender comparisons. Most studies on the CRT document persistent gender differences in CRT performance, with women scoring lower on average than men (Brañas-Garza et al., 2019; Cueva et al., 2016; Frederick,

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2005; Hoppe & Kusterer, 2011; Oechssler et al., 2009). However, these differences may not reflect actual disparities in cognitive ability, but rather test-specific features that disproportionately penalize female respondents. The Cognitive Reflection Test (CRT) shares several features with standard financial literacy assessments, notably in format and content. Both place strong emphasis on numeracy and involve problem-solving tasks that require logical reasoning and quantitative thinking. In contrast, the Raven Progressive Matrices (RPM) test and the Number Line Estimation (NLE) task primarily engage visual reasoning. The RPM assesses abstract pattern recognition by asking participants to identify the missing element in a series of visual matrices. The NLE task involves placing numbers on an unmarked number line, requiring a spatial representation of numerical magnitude rather than verbal or symbolic computation.

Our study presents several methodological strengths. First, unlike most existing research, data were not collected via an online questionnaire. Instead, high school students completed the survey in class, on an electronic platform but under teacher supervision, ensuring that responses were provided individually and without external assistance, such as internet searches or AI tools (e.g., ChatGPT). Second, the tests were selected and designed to ensure sufficient reliability. We employed a 10-item financial literacy test, addressing concerns raised by Huston (2010) and Gignac and Ooi (2022) about low internal consistency in studies that use too few items. Similarly, we used the 7-item version of the Cognitive Reflection Test (CRT) rather than the 3-item version, and we modified the wording to mitigate potential familiarity effects. Finally, our measures of cognitive ability show good test-retest reliability. CRT performance is known to be stable over time, with correlations up to 80% between repeated administrations (Stagnaro et al., 2018). The shortened form of the Raven's Progressive Matrices (RPM) test we use (Bilker et al., 2012) has a reliability comparable to the original versions (Raven, 1941; Raven et al., 1989). Finally, our approximate numeracy measure also displays strong test-retest properties (Chan & Mazzocco, 2024).

Our article contributes to the literature on financial literacy by showing the important role played by cognitive abilities. Overall, prior research documents a positive relationship between cognitive abilities and financial literacy (e.g., Lin & Bates, 2022; Muñoz-Murillo et al., 2020). However, as noted by Callis et al. (2023) and Gignac and Stevens (2024), many existing studies rely on measures of cognitive abilities and/or financial literacy that raise concerns about reliability or validity, often due to a limited number of test items or insufficient sample sizes. While some studies (e.g., Muñoz-Murillo et al., 2020) examine the relationship between financial literacy and cognitive abilities among students, our paper is the first to do so using a sample of teenagers.

Another, if not the most important contribution of our paper relates to the gender gap in financial literacy. Most studies on financial literacy report the existence of such a gap, both for adults and young people (e.g., Driva et al., 2016; Fonseca et al., 2012; Lusardi & Mitchell, 2008; Potrich et al., 2018; Preston & Wright, 2024; Rink et al., 2021). We show, however, that the gender gap in financial literacy is entirely explained or confounded by differences in CRT scores. Interestingly, a similar result was found by Muñoz-Murillo et al. (2020). The authors note: "In contrast to previous studies, we find no role for gender in explaining financial literacy once we control for cognitive abilities [measured by the CRT]". However, Muñoz-Murillo et al. (2020) did not investigate further this exploratory result. We find, however, that the effect of cognitive abilities on the gender gap in financial literacy is restricted to the CRT. We do not find the same result when we consider fluid intelligence and/or approximate numeracy instead of cognitive reflection.

This result suggests that the gender gap in financial literacy may share a common underlying cause with the gender gap in cognitive reflection. Some researchers attribute these differences to intrinsic cognitive or biological differences between males and females (the so-called "nature argument") while others emphasize the role of socialization

and societal expectations (referred to as the "nurture argument").¹ Another line of research posits that the observed gender gap in cognitive abilities partly arises from methodological issues, particularly test design. In particular, several studies argue that math anxiety may partially explain lower CRT scores among female respondents (Juanchich et al., 2020; Maloney & Retanal, 2020; Morsanyi et al., 2014; Primi et al., 2018). Under this interpretation, the gender gap in financial literacy could stem from the same source, reflecting the negative effects of math anxiety rather than actual differences in cognitive abilities, especially since the wording and the type of questions in the financial literacy test share similarities with those in the CRT. Our findings support this view. The gender gap in financial literacy persists when we use alternative measures of cognitive ability such as the Raven Progressive Matrices (RPM) or the Number Line Estimation (NLE) task, which rely more on visual-spatial reasoning and are less likely to be influenced by math-related anxiety or test-taking conditions.

Given the complex interplay between cognitive abilities, financial literacy, and gender, future research should aim to disentangle these effects more clearly. Experimental designs that manipulate test formats or control for anxiety-related factors would help determine whether observed gender differences arise from genuine cognitive disparities or contextual influences, such as math anxiety or stereotype threat. Furthermore, examining cross-cultural differences could reveal the extent to which societal norms and educational systems contribute to the gender gap in financial literacy. By exploring these avenues, future studies can deepen our understanding of the underlying mechanisms driving the gender gap in financial literacy and inform more effective educational interventions.

2. Data and survey instruments

2.1. Questionnaire and data

We designed and distributed the questionnaire using Qualtrics, with the main questions reported in Appendix. High school students completed the questionnaire under direct teacher supervision, ensuring individual responses. The questionnaire began with an informed consent section, followed by self-assessments of patience and risk tolerance (following Falk et al., 2018, 2023), as well as evaluations of financial knowledge and math ability relative to peers. It then proceeded with sections on financial literacy, financial socialization, and cognitive abilities. A final section covered standard socio-demographic characteristics (e.g., age, gender, parental occupation). A detailed presentation of the questionnaire is provided in Appendix.

The sample consists of high-school students in New Zealand. The questionnaire, which took approximately 20 min to complete, was administered with the approval of each school's principal. We retained only participants who completed the questionnaire in full, excluding those who provided careless responses (e.g., straightlining, implausible or repetitive answers in the CRT test), those with self-reported ages outside the expected range (below 15 or above 19) and those who did not terminate the survey before the end of class. We also removed the 5% of participants who spent the least time on the survey to account for insufficient attention. The final sample consists of 353 respondents.

2.2. Cognitive abilities

2.2.1. Cognitive reflection test (CRT)

The Cognitive Reflection Test (CRT) was introduced to the economic literature by Frederick (2005) as a measure of cognitive reflection, which the author defines as "the ability or disposition to resist reporting the response that first comes to mind". This definition aligns with

¹ See Kheloui et al. (2023) for a review on sex/gender differences in cognitive abilities.

the dual-system theory of cognition, initially proposed by [Wason and Evans \(1974\)](#) and later popularized by [Stanovich and West \(2000\)](#) and [Kahneman \(2011\)](#). According to this framework, the brain relies on two systems to make decisions: System 1 and System 2.

System 1 is intuitive, automatic, fast, and effortless. In many instances, decisions based on System 1 are correct, but this quick, intuitive process can also lead to errors. In contrast, System 2 is slow, effortful, reflective, and produces deliberative decisions that help individuals avoid the mistakes associated with System 1. In the CRT, the test items are designed to elicit an incorrect, intuitive response from System 1. Thus, a correct answer is interpreted as an ability to engage System 2 and resist intuitive biases. As such, a high CRT score is seen as indicative of strong System 2 cognition, characteristic of individuals who are more analytical and less intuitive in their decision-making.

The original three-item version of the test gained widespread popularity due to its simplicity and the strong empirical evidence showing that the CRT is an effective measure of cognitive reflection. Moreover, it has been found to predict the performance of students in economics ([Orlov & Roufagalas, 2012](#)). The three items are as follows:

- A bat and a ball together cost \$1.10. The bat costs 1 dollar more than the ball. How much does the ball cost?
- If it takes five machines 5 min to make 5 widgets, how long would it take 100 machines to make 100 widgets?
- In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

For each of the three items in the CRT, respondents are typically drawn to an intuitive but incorrect answer. Consequently, cognitive reflection is usually assessed by counting the number of correct responses. To provide context on typical performance (in large samples), [Campitelli and Gerrans \(2014\)](#) found that 31.35% of respondents in a sample of 2019 adults answered the questions correctly, while [Azevedo et al. \(2023\)](#) reported 37% of correct answers from a sample of 43,974 respondents across 69 countries.

However, the success of the 3-item CRT has become a limitation over time, as many students – especially those studying economics or management – are familiar with the test and know the correct answers. Additionally, answering correctly to the CRT items requires a minimum level of numeracy skills. While familiarity with the CRT may bias responses among adults, it is unlikely to affect our teenage sample. The second issue, however, is highly relevant, as discussed in the introduction. In addition, [Peters et al. \(2006\)](#) demonstrate that the distribution of scores on the original three-item CRT is right-skewed, with a significant proportion of respondents scoring zero. To mitigate these concerns in our sample, we use the more comprehensive seven-item version of the CRT, as outlined in the Appendix and developed by [Toplak et al. \(2014\)](#). In addition, we modified the wording of the items to prevent respondents from easily finding answers online.

2.2.2. Raven's progressive matrices (RPM)

The Raven Progressive Matrices (RPM) test was first introduced by [Raven \(1941\)](#) with the goal of measuring fluid intelligence, a cognitive ability independent of prior knowledge.² RPM is a non-verbal logical test, originally consisting of five sequences, each containing twelve items. It is termed “progressive” because the difficulty of the items increases both from one sequence to the next and within a given sequence. A typical item presents a visual geometric design with a missing piece. The task is to identify the missing piece from a set of six or eight options. This test is designed to assess the educative and reproductive abilities of individuals, which are two key components

of fluid intelligence. Given that the original 60-item version is time-consuming, several shortened versions of the test have been developed. In this study, we use the 9-item version from [Bilker et al. \(2012\)](#) because the scores on this version exhibit a correlation of 0.98 with scores from the complete RPM test. The different items can be found in [Appendix](#).

2.3. Approximate numeracy

Economic and financial decision-making most often require number manipulation, and more generally numerical and probabilistic computations. These abilities are often summarized in a single word, “numeracy”, which is the ability to understand the use of numbers and process numerical concepts and basic probabilities ([Peters et al., 2008](#)). The two most common tests of numeracy are the 11-item test proposed by [Lipkus et al. \(2001\)](#) and the Berlin Numerical Test of [Cokely et al. \(2012\)](#).³ However, numeracy skills are also strongly linked to the approximate number system (ANS), which allows humans to evaluate quantities without using exact calculations ([Peters et al., 2008](#)). According to [Sobkow et al. \(2020\)](#), approximate numeracy, evaluated through the symbolic number mapping described below, is the most robust predictor of performance (compared to other numeracy tests) in various economic decisions like maximizing an expected monetary outcome or avoiding decisions with negative consequences. Moreover, the authors show that a combination of cognitive abilities contributes to a better understanding of different decision outcomes than using a single measure of cognitive ability. Adapting measures from the psychology literature ([Booth & Siegler, 2006](#); [Siegler & Booth, 2004](#); [Siegler & Opfer, 2003](#)), [Roger et al. \(2022\)](#) use a Number Line Estimation (NLE) task to elicit the acuity of the ANS of subjects participating in experimental markets. In such a task, subjects are facing an empty number line on a computer screen. The left end is marked with number 0 and the right end is marked with number 100. A randomly selected number between 0 and 100 (with possibly two decimals) appears on the subjects' screen. Participants are asked to locate this number on the empty number line using a slider initially positioned at the left end (i.e., 0). At the end of the 10 trials, an indicator of the subjects' accuracy is computed and interpreted as a measure of approximate numeracy, and therefore a proxy for numeracy skills.

To evaluate student performance on the NLE task, we follow [Siegler and Booth \(2004\)](#) and [Booth and Siegler \(2006\)](#). For each trial, we calculate the Percent Absolute Error (PAE), defined as:

$$PAE_{i,j} = \left| \frac{Estimate_{i,j} - Value_j}{100} \right|, \quad (1)$$

where $Value_j$ denotes the target number that subject i is instructed to locate on the number line in trial j , and $Estimate_{i,j}$ is the number indicated by subject i using the slider. The denominator is fixed at 100, which corresponds to the length of the number line ranging from 0 to 100. The approximate numeracy score (NLE_i) for respondent i is computed as the average accuracy across the ten trials:

$$NLE_i = \frac{1}{10} \sum_{j=1}^{10} (1 - PAE_{i,j}). \quad (2)$$

2.4. Control variables

In addition to cognitive abilities, we gathered information about other potential drivers of financial literacy and/or confounding factors, such as financial socialization, individual preferences, socio-demographic characteristics, etc. To measure (parental) financial socialization, we used the validated Parent Financial Socialization Scale ([LeBaron-Black et al., 2022](#)).⁴ Financial socialization explains how

² See also [Raven et al. \(1989\)](#).

³ See [Eber et al. \(2024\)](#) for details about these numeracy tests.

family and social environments shape individuals' financial attitudes, knowledge, and behaviors. Research highlights three key mechanisms – parental discussions, modeling, and experiential learning – that influence financial literacy, with studies showing that conversations about finance matters, observed parental behavior, and hands-on financial experiences (such as receiving pocket money) all contribute to financial competence.

Socio-demographics include age, gender and job category of respondents' parents. We also asked participants how many books they have in their home. The number of books at home is a widely used proxy for socioeconomic status and the intellectual environment (Hanushek & Woessmann, 2011). As noted by Heppt et al. (2022), it is associated to student achievement, particularly in reading comprehension (Eriksson et al., 2021; Park, 2008) and academic language proficiency (Heppt & Stanat, 2020; Volodina et al., 2020). It is also used in many surveys such as PISA (Programme for International Student Assessment), PIRLS (Progress in International Reading Literacy Study), and TIMSS (Trends in International Mathematics and Science Study) (Agasisti et al., 2021; Eriksson et al., 2022; Luyten, 2017). We also assessed respondents' interest for business/finance by asking whether they often read about it either in the press or online. Individual preferences comprise risk tolerance and patience. Following Falk et al. (2018, 2023), we asked respondents to self-assess their level of risk tolerance and patience.

3. Descriptive statistics

Table 1 reports summary statistics for the main variables used in the analysis. Panel A shows that respondents are aged between 15 and 19, and that the sample is nearly perfectly balanced by gender. Panels B through E present statistics for the four key variables of interest: financial literacy (number of correct responses out of 10), CRT score (correct answers out of 7), RPM score (correct answers out of 9), and the score on the NLE task, measured as average performance over 10 trials and used as a proxy for approximate numeracy. For these four key variables, we also present in Table 2 the results of univariate t-tests that assess differences in mean values between boys and girls. The t-tests suggest the presence of a gender gap in financial literacy and in CRT performance, while no significant difference emerges for the RPM scores or the NLE task.

In Table 1, we focus on distributions rather than moments (such as the mean or standard deviation), as this approach provides richer information and better captures potential gender differences. It also helps distinguish aggregate differences, such as mean gaps, from disparities occurring across the full distribution or in the tails. To formally test for gender differences, we compare distributions between boys and girls for each variable. For categorical variables, we report the χ^2 statistic. For continuous variables, we use both the Mann–Whitney U test and the Kolmogorov–Smirnov statistic. These nonparametric tests are more appropriate given that the distributions under study are not expected to follow a normal distribution.

Panels B and C (financial literacy and CRT) reveal clear gender differences. The cumulative distribution function (CDF) for boys lies consistently below that of girls, indicating first-order stochastic dominance of boys' scores over girls'. In contrast, first-order stochastic dominance is not observed in Panel D (RPM scores), suggesting weaker differences (in line with the results presented in Table 2). For instance, 73% of girls score at least 6 on the RPM test, compared to 77% of boys.

⁴ Although the subscales of the Parent Financial Socialization Scale align with the modes of influence on children proposed by Bussey and Bandura (1999), we acknowledge that Bussey and Bandura (1999) did not limit influences solely to parents. They also consider the impact of peers, something we do not address in the present paper to keep the analysis simple. To date, studies on children's financial socialization have predominantly focused on the home as a source, rather than peers, except for Agnew et al. (2025).

However, at the upper end of the distribution, 39% of boys score either 8 or 9, compared to only 21% of girls. Panel E shows that approximate numeracy (NLE score) is generally higher among boys across the entire distribution, except at the first quantile (which includes only three students). The median NLE score is 0.9689 for boys versus 0.9627 for girls. These statistics also show that the three cognitive measures capture distinct dimensions of cognitive ability (see also Table A.1 in the Appendix).

Parental socialization (Panel F) is measured by the average score on the 20-item scale developed by LeBaron-Black et al. (2022). In our sample, we find no evidence of a gender-based difference in financial socialization. Panel G illustrates a well-established finding in the literature: boys are more risk tolerant than girls. About 28% of boys choose a score greater than or equal to 8, compared to 15% of girls. The χ^2 test confirms that this difference is statistically significant at the 5% level (See Eber et al., 2024, for a review, and Barber & Odean, 2001; Byrnes et al., 1999; Lemaster & Strough, 2014; Neelakantan, 2010; Powell & Ansic, 1997).⁵

In contrast, Panel H shows no significant gender difference in patience. This result is consistent with previous studies. For example, Nofsinger and Varma (2009) report marginally significant differences on a sample of finance professionals, with women appearing more patient. Other studies, such as Falk and Hermle (2018), find no significant difference or mixed evidence, showing that gender differences in patience may vary with economic development levels. In our data, self-assessed patience does not differ by gender.

A question on reading business or economics news (Panel I) reveals a marginally significant gender difference: 62.5% of girls report not reading such material regularly, compared to 51.35% of boys. Conversely, 8.11% of boys report regular reading, compared to only 3.57% of girls.

Unsurprisingly, Panel J shows no significant gender difference in the number of books at home. Similarly, Panels K and L indicate that the distribution of parental occupations is balanced across genders.

Table 3 presents the Spearman correlations between the main variables used in our analysis. The key finding is that financial literacy is strongly associated with the three dimensions of cognitive ability, with correlation coefficients ranging from 0.42 for the RPM score to 0.59 for the CRT score. Other notable correlations involve control variables such as financial socialization, the intellectual environment at home (proxied by the number of books), and gender.

4. Results and discussion

4.1. Drivers of financial literacy

Table 4 reports the regression results. We estimate five specifications. Model (1) includes all control variables but excludes cognitive ability measures. Model (2) introduces the full set of cognitive ability variables: the score from the Cognitive Reflection Test (CRT score), the score from the Raven Progressive Matrices (RPM score) test, and the score from the NLE task (NLE score). Models (3) to (5) each include only one cognitive ability measure to assess its distinct contribution.

In Model (1), which excludes cognitive abilities, we find that financial socialization, measured using the scale developed by LeBaron-Black et al. (2022), exhibits a positive and statistically significant association with financial literacy (t-stat = 3.37). This result aligns with prior evidence on the role of parental influence (Agnew & Cameron-Agnew, 2015; LeBaron & Kelley, 2021). We also observe a significant gender gap: the coefficient on the girl dummy is negative and statistically significant at the 5% level. Additional controls, including patience and

⁵ This formulation is consistent with Nelson (2015), who notes, however, that this result does not allow one to conclude that “women are on average more risk averse than men”.

the number of books at home, are also significantly associated with financial literacy scores.

In the full specification (Model 2), all three cognitive measures are positively and significantly related to financial literacy. The coefficients of the CRT score and the NLE score are significant at the 1% level, while the RPM score is significant at the 5% level. The inclusion of cognitive abilities substantially increases explanatory power. The R^2 rises from 19.70% in Model (1) to 44.96% in Model (2), indicating that cognitive ability is a key driver of financial literacy in this sample.

Interestingly, introducing cognitive abilities into the regression has an impact on the girl dummy. In Model (1), the gender gap is large and statistically significant, consistent with findings in Barboza et al. (2016). However, the inclusion of cognitive variables in Model (2) makes the girl dummy coefficient small and statistically insignificant. This finding suggests that gender differences in cognitive abilities account for much of the observed gap in financial literacy.

To examine this further, we also estimate regression specifications in which cognitive abilities are introduced individually (Models 3 to 5). The gender coefficient becomes insignificant only when the CRT is included. When either RPM score or NLE score is included without the CRT score, the gender gap remains. This result implies that differences in cognitive reflection, in particular, account for the observed gender disparity in financial literacy.

4.2. The gender gap in financial literacy

Consistent with prior research, we find a substantial gender gap in financial literacy, with girls scoring approximately one point lower than boys on a ten-question test. This gap persists after controlling for standard covariates, including financial socialization, patience, risk tolerance, interest in financial matters, and socio-demographic characteristics. However, the gap disappears once CRT scores are included in the regression model.

To further explore the gender gap in financial literacy and the moderating role of cognitive abilities, we apply the Oaxaca–Blinder decomposition (Blinder, 1973; Oaxaca, 1973). This econometric method, already used in the past to analyze the gender gap in financial literacy (Fonseca et al., 2012; Preston et al., 2024; Preston & Wright, 2024), is commonly employed to analyze gender disparities (e.g., in wages). It separates observed differences into explained and unexplained components. Specifically, it attributes part of the gap to observable factors, such as financial socialization, cognitive abilities, patience, or risk tolerance, while the remainder is due to unobservable factors. In our context, the approach allows us to investigate whether the gender gap in financial literacy arises from differences in these observable characteristics between boys and girls or whether it reflects inherent disparities in financial literacy performance.

Table 5 provides the results of the Oaxaca–Blinder decomposition. Boys score an average of 6.47 while girls respond correctly to approximately 5.35 questions. The statistics, presented in Panel B of Table 1 showed that the advantage of boys over girls is not only true on average, but stem over the whole distribution. As a consequence, the difference in financial literacy between boys and girls is highly significant. We provide the decomposition into explained and unexplained components for our first two regression models (the full model and the model that excludes cognitive abilities) as well as for a third model where we exclude the CRT score. When cognitive abilities are excluded, the unexplained component is highly significant, which indicates that the gender gap is caused either by intrinsic differences or by differences in unobservable characteristics. In contrast, in Model (2), where we include all three measures of cognitive abilities, the unexplained component is no longer statistically significant, while the explained

component becomes significant at the 10% level. When we examine the coefficients of the variables that contribute to the explained component, we find that the CRT score is the primary driver of the difference in financial literacy between boys and girls. To further examine the role of the CRT score, we also estimate Model (3), which includes all variables except the CRT score. The results are similar to those of Model (1): the coefficient of the unexplained component remains large and statistically significant (though slightly smaller than in Model 1), while the explained component is not significant.

These results suggest that the gender gap in financial literacy either reflects actual differences in cognitive abilities or stems from a common underlying factor shared with the gender gap in cognitive reflection. The fact that the gender gap disappears only when the CRT score is included in the model, and not when the RPM or NLE scores are included, combined with prior research showing that the CRT tends to penalize female respondents, leads us to consider the possibility that part of the gender gap in financial literacy may arise from methodological issues (e.g., test design). In particular, Morsanyi et al. (2014), Primi et al. (2018), Juanchich et al. (2020), and Maloney and Retanal (2020) argue that math anxiety may contribute to lower CRT performance among females. If this interpretation holds, the gender gap in financial literacy may share the same origin, reflecting the negative effects of math anxiety rather than genuine differences in ability.

5. Conclusion

This study highlights the critical role of cognitive abilities in explaining heterogeneity in financial literacy among teenagers. By examining three distinct dimensions (cognitive reflection, fluid intelligence, and approximate numeracy), we demonstrate that a substantial portion of variation in financial literacy scores can be attributed to these cognitive factors. Notably, the observed gender gap in financial literacy disappears once cognitive reflection, as measured by the Cognitive Reflection Test (CRT), is taken into account. The gap remains when considering fluid intelligence or approximate numeracy alone.

This finding suggests that gender differences in financial literacy may not necessarily reflect intrinsic cognitive disparities but could instead stem from measurement biases associated with the CRT. Prior research points to math anxiety as a plausible factor disproportionately affecting female respondents' CRT performance, thereby indirectly influencing financial literacy scores that rely on similar question formats and cognitive demands. The persistence of the gender gap when using alternative cognitive measures that emphasize visual-spatial reasoning and are less prone to math anxiety supports this interpretation.

Our findings highlight the need to improve financial literacy assessments by ensuring they are free from biases related to test design and math anxiety. Future research should focus on identifying specific factors that contribute to the gender gap, such as anxiety related to numerical tasks and societal stereotypes. These insights are essential to designing targeted educational interventions that not only enhance cognitive skills but also address psychological barriers affecting financial learning among teenagers. Such an approach can help reduce gender disparities and promote more equitable financial knowledge acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1
Descriptive statistics – Distributions.

Panel A: Age and gender											
	Age						Gender				
	Mean	Min	Max	Boys	Girls						
	16.31	15.00	19.00	52.41%	47.59%						
Panel B: Financial literacy (in %)											
	Low financial literacy ←			$\chi^2 = 30.54^{***}$			→ High financial literacy				
	0	1	2	3	4	5	6	7	8	9	10
All	2.27	2.55	5.10	9.07	11.33	12.18	10.48	15.58	12.75	13.03	5.67
Girls	3.57	2.98	5.95	11.31	11.90	16.67	13.69	14.88	5.95	8.93	4.17
Boys	1.08	2.16	4.32	7.03	10.81	8.11	7.57	16.22	18.92	16.76	7.03
Panel C: CRT score (in %)											
	Low score ←			$\chi^2 = 45.84^{***}$			→ High score				
	0	1	2	3	4	5	6	7	8	9	
All	7.37	18.41	19.83	15.01	14.45	11.61	6.52	6.80			
Girls	12.50	25.00	22.62	16.67	9.52	6.55	5.36	1.79			
Boys	2.70	12.43	17.30	13.51	18.92	16.22	7.57	11.35			
Panel D: RPM score (in %)											
	Low score ←			$\chi^2 = 20.55^{***}$			→ High score				
	0	1	2	3	4	5	6	7	8	9	
All	0.00	0.28	0.85	2.83	6.23	14.73	24.93	19.55	16.43	14.16	
Girls	0.00	0.00	0.60	1.79	5.95	18.45	27.38	24.40	9.52	11.90	
Boys	0.00	0.54	1.08	3.78	6.49	11.35	22.70	15.14	22.70	16.22	
Panel E: NLE score											
	1%	5%	25%	50%	75%	95%	99%				
All	0.8784	0.9236	0.9548	0.9655	0.9744	0.9827	0.9881				
Girls	0.8998	0.9216	0.9492	0.9627	0.9713	0.9819	0.9861	MW test= -3.3***			
Boys	0.8753	0.9243	0.9583	0.9689	0.9759	0.9835	0.9890	KS test= 0.19***			
Panel F: Financial socialization											
	1%	5%	25%	50%	75%	95%	99%				
All	44.06	70	88	102	117.25	129	135.97				
Girls	53.54	70	87	102	116	129.1	135	MW test= -0.43			
Boys	30.35	67.5	88	102	118	127.5	137.65	KS test= 0.08			
Panel G: Risk tolerance (in %)											
	Low risk tolerance ←			$\chi^2 = 18.25^{**}$			→ High risk tolerance				
	0	1	2	3	4	5	6	7	8	9	10
All	0.00	0.57	2.27	6.80	13.88	16.15	16.71	21.81	10.20	4.53	7.08
Girls	0.00	1.19	1.79	7.74	14.29	22.02	17.26	20.83	8.33	2.38	4.17
Boys	0.00	0.00	2.70	5.95	13.51	10.81	16.22	22.70	11.89	6.49	9.73
Panel H: Patience (in %)											
	Low patience ←			$\chi^2 = 11.33$			→ High patience				
	0	1	2	3	4	5	6	7	8	9	10
All	0.28	0.57	1.42	2.27	5.38	13.03	13.60	22.38	19.26	11.05	10.76
Girls	0.00	1.19	1.19	1.19	4.76	13.69	16.67	23.21	20.83	9.52	7.74
Boys	0.54	0.00	1.62	3.24	5.95	12.43	10.81	21.62	17.84	12.43	13.51
Panel I: Read about business or finance (in %)											
	Never	Rarely	Occasionally	Regularly							
All	56.66	23.51	13.88	5.95							
Girls	62.50	22.62	11.31	3.57							
Boys	51.35	24.32	16.22	8.11	$\chi^2 = 6.61^*$						

(continued on next page)

Table 1 (continued).

Panel J: Number of books at home (in %)						
	0–10	11–25	26–100	101–200	201–500	500+
All	14.73	11.61	23.51	21.81	19.55	8.78
Girls	14.29	9.52	21.43	22.02	22.02	10.71
Boys	15.14	13.51	25.41	21.62	17.30	7.03
$\chi^2 = 4.22$						

Panel K: Father's occupation (in %)					
	Category A	Category B	Category C	Category D	Category E
All	22.66	30.88	18.70	20.96	6.80
Girls	19.05	34.52	17.26	22.02	7.14
Boys	25.95	27.57	20.00	20.00	6.49
$\chi^2 = 3.81$					

Panel L: Mother's occupation (in %)					
	Category A	Category B	Category C	Category D	Category E
All	19.26	25.78	23.80	19.26	11.90
Girls	20.24	26.19	22.62	19.64	11.31
Boys	18.38	25.41	24.86	18.92	12.43
$\chi^2 = 0.48$					

This table provides descriptive statistics for the sample used in the study. Panel A displays the distribution of age and gender among respondents. Panels B to E show the main variables of interest, including financial literacy, Cognitive Reflection Test (CRT) score, Raven Progressive Matrices (RPM) score, and NLE score (approximate numeracy). The statistics are presented for the full sample and separately for boys and girls. Chi-square (χ^2) statistics are reported for categorical variables to test gender differences, while Mann–Whitney U and Kolmogorov–Smirnov tests are used for continuous variables. Panels M and N detail parental occupations categorized as follows. Category A: Senior management in large organizations, government administration and defense, and qualified professionals. Category B: Other business managers/owners, arts/media/sports persons and associate professionals. Category C: Tradesmen/women, clerks and skilled office, sales and service staff. Category D: Machine operators, hospitality staff, assistants, labourers and related workers. Category E: Has not been in paid work in the past 12 months. Chi-square statistics are used to test differences in occupational categories by gender.

Table 2
Gender differences in financial literacy and cognitive abilities.

	Boys	Girls	Difference	t-statistic
Financial literacy	6.4703	5.3571	1.1131	4.2195***
CRT score	3.6919	2.3571	1.3347	6.7399***
RPM score	6.6649	6.4107	0.2542	1.4542
NLE score	0.9621	0.9576	0.0045	1.5810

This table presents average values of financial literacy and cognitive ability measures for boys and girls, along with the difference in means and the corresponding univariate t-statistics.

Appendix. Measures used in the survey

Financial literacy test

- Do you think that the following statement is true or false? "If you were to invest \$1000 in a stock mutual fund, it would be possible to have less than \$1000 when you withdraw your money."
 - True
 - False
 - Do not know
- When an investor spreads his money among different assets, does the risk of losing a lot of money:
 - Increase
 - Decrease
 - Stay the same
 - Do not know
- Typically, if you buy things (mobile-phones, TVs, etc.) using credit you will pay...
 - ... more than paying cash
 - ... the same amount of paying cash
 - ... less than paying cash

- Do not know
- Suppose you had \$100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow?
 - More than \$102
 - Exactly \$102
 - Less than \$102
 - Do not know
 - Suppose you had \$100 in a savings account and the interest rate was 10% per year. After 2 years, how much do you think you would have in the account if you left the money to grow?
 - \$110
 - \$120
 - \$121
 - Do not know
 - Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?
 - More than today
 - Exactly the same as today
 - Less than today
 - Do not know
 - Imagine depositing \$100 in your savings account. If after 1 year the balance on your account (included the interest) is \$104 and the inflation rate during the last year was 5%, How rich do you think you would be compared 1 year before?
 - More rich
 - Exactly as rich
 - Less rich
 - Do not know
 - You have an "overdraft" in your bank account if...
 - You use more money than is in your account

Table 3
Spearman correlation matrix.

	Financial literacy	CRT score	RPM score	NLE score	Financial socialization	Gender	Age	Read Business/Finance	Number of books at home	Patience
Financial literacy	1.0000									
CRT score	0.5880	1.0000								
RPM score	0.4890	0.4997	1.0000							
NLE score	0.4066	0.4602	0.3710	1.0000						
Financial socialization	0.1864	0.0066	0.1705	0.0886	1.0000					
Gender (girl dummy)	-0.2278	-0.3396	-0.1022	-0.1758	-0.0229	1.0000				
Age	0.0902	0.0696	0.1002	0.0288	0.0510	0.0178	1.0000			
Read Business/Finance	0.0829	-0.0041	-0.0291	0.0083	0.1837	0.1291	0.0219	1.0000		
Number of books at home	0.2345	0.2343	0.1733	0.1998	0.0463	-0.0920	0.0554	-0.0542	1.0000	
Patience	0.1698	0.1338	0.1628	0.1193	0.2320	0.0577	0.0235	0.1649	-0.0604	1.0000
Risk tolerance	-0.0655	-0.0248	0.0342	-0.0636	0.1938	0.1583	0.0247	0.1051	0.0149	0.2427

This table presents the Spearman correlation coefficients between financial literacy and key explanatory variables, including CRT score, RPM score, NLE score (approximate numeracy), financial socialization, gender, age, reading habits, number of books at home, patience, and risk tolerance.

Table 4
Multivariate analysis.

	(1)	(2)	(3)	(4)	(5)
CRT score		0.4689*** (7.21)	0.6546*** (12.25)		
RPM score		0.2990** (5.54)		0.6085*** (17.37)	
Approximate numeracy		13.9162*** (6.38)			28.2627** (4.11)
Financial socialization	0.0187** (3.37)	0.0162* (2.79)	0.0213** (4.31)	0.0120 (1.93)	0.0165* (2.72)
Girl dummy	-1.3053** (3.90)	-0.4041 (1.59)	-0.3213 (1.19)	-1.0984** (4.48)	-1.1129** (3.96)
Age	0.1495 (0.41)	0.0828 (0.30)	0.0390 (0.11)	0.0357 (0.12)	0.2882 (1.10)
Read Business/finance	0.0912 (0.99)	0.2425* (2.94)	0.1742 (2.00)	0.2008* (2.72)	0.1684 (1.77)
Number of books at home	0.4497** (4.79)	0.1803* (3.11)	0.2169** (3.56)	0.3320** (3.82)	0.3587** (4.31)
Patience	0.2391** (5.30)	0.0796 (1.71)	0.1155 (1.79)	0.1540*** (6.43)	0.1800** (3.87)
Risk tolerance	-0.2196 (-2.13)	-0.1311 (-1.41)	-0.1370 (-1.54)	-0.2025 (-1.93)	-0.1773 (-1.74)
Intercept	-1.1084 (-0.17)	-14.8029 (-1.99)	-0.0349 (-0.01)	-1.7451 (-0.32)	-29.8470* (-2.65)
<i>N</i>	353	353	353	353	353
<i>R</i> ²	19.70%	44.96%	39.65%	33.75%	27.96%

This table reports the results from multivariate regressions examining the determinants of financial literacy. Five models are presented: (1) a model excluding cognitive abilities (2) a model including all explanatory and control variables, and (3) to (5) models using a single cognitive ability measure at a time. Coefficients are shown with *t*-statistics in parentheses. Standard errors are clustered at the high school level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. Read Business/Finance and Number of books at home are entered linearly in the model for presentation sake. However, results are unchanged if we include them in the model as dummies. For the sake of space, we exclude father's and mother's job categories from the regressions. However, including them does not affect the results.

- You receive interest on your deposit from the bank
- You pay by cheques
- Do not know

- \$110 after 2 months
- Do not know

(Fernandes et al., 2014; Lusardi & Mitchell, 2011; Ranyard et al., 2020)

9. Everything else equal, if the maturity of a mortgage is longer the instalments will be...

- The same
- Smaller
- Bigger
- Do not know

Number line estimation

Indicate the position of number 12.20 on the line below using the slider. Note that the boundaries of the interval are 0 and 100 and that the slider is initially at 0.

10. Which of the following pay back options for a \$100 debt shows the highest APR?

- \$102 after 1 week
- \$105 after 1 month



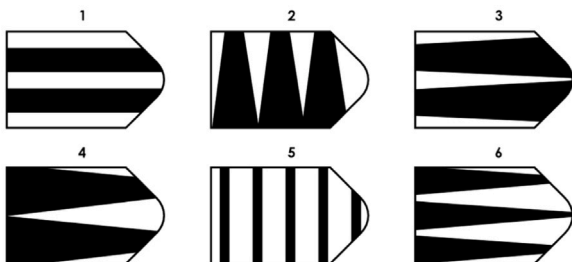
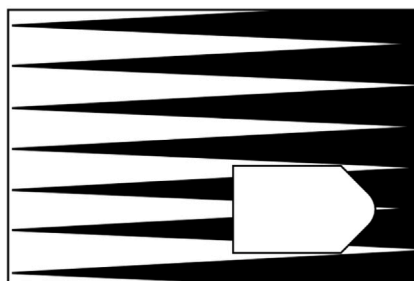
Table 5
Gender gap in financial literacy – Oaxaca–Blinder decomposition.

Gender gap in financial literacy			
FL score for boys	6.4703		
FL score for girls	5.3571		
Difference	1.1131*** (4.22)		
	Model 1: without cognitive abilities	Model 2: with cognitive abilities	Model 3: without CRT
Explained	0.1922 (0.20)	-0.7091* (0.37)	-0.1137 (0.30)
Unexplained	-1.3053*** (0.33)	-0.4041 (0.25)	-0.9995*** (0.23)
Explained component			
CRT score		-0.6259*** (0.19)	
RPM Score		-0.0760 (0.07)	-0.1312 (0.12)
NLE score		-0.0632 (0.04)	-0.0870 (0.05)
Financial socialization	0.0019 (0.01)	0.0016 (0.01)	0.0012 (0.01)
Age	-0.0040 (0.02)	-0.0022 (0.01)	-0.0039 (0.01)
Read Business/Finance	-0.0229 (0.02)	-0.0609** (0.03)	-0.0594** (0.03)
Number of books at home	0.1197 (0.14)	0.0480 (0.06)	0.0767 (0.09)
Patience	-0.0429 (0.04)	-0.0143 (0.02)	-0.0228 (0.02)
Risk tolerance	0.1405* (0.07)	0.0839 (0.06)	0.1128 (0.07)

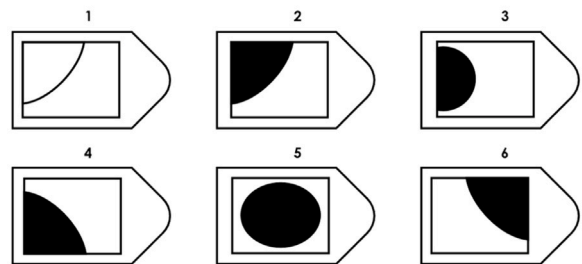
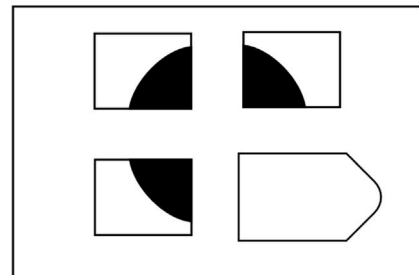
This table analyzes the gender gap in financial literacy using the Oaxaca–Blinder decomposition method. It separates the observed gap into explained and unexplained components, showing results for models with and without cognitive abilities. The explained component represents the portion attributed to observable factors (e.g., CRT score, RPM score, NLE score, financial socialization...), while the unexplained component captures differences due to unobserved factors. Coefficients and *t*-statistics are reported for each model. Standard errors are clustered at the high school level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. Read Business/Finance and Number of books at home are entered linearly in the model for presentation sake. However, results are unchanged if we include them in the model as dummies.

Raven progressive matrices

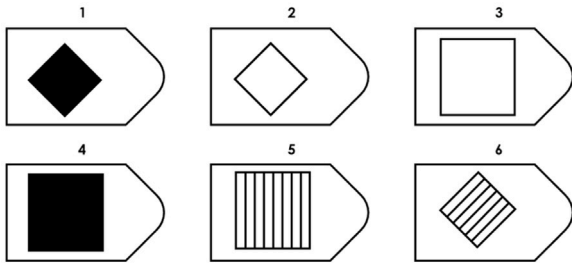
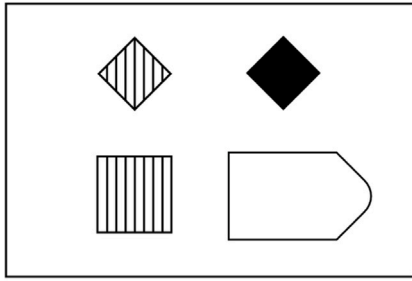
1. Which is the missing piece?



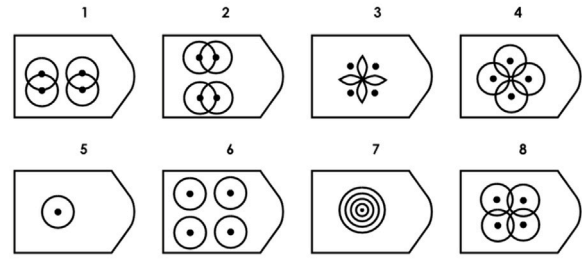
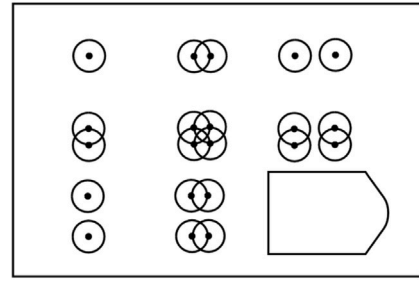
2. Which is the missing piece?



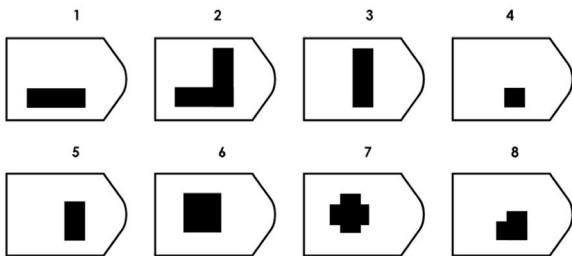
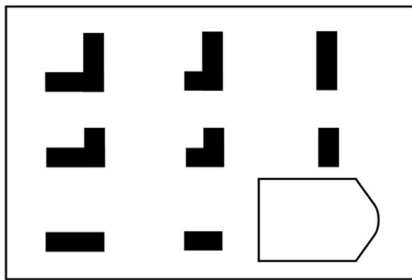
3. Which is the missing piece?



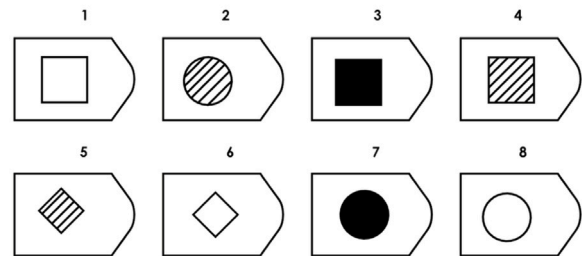
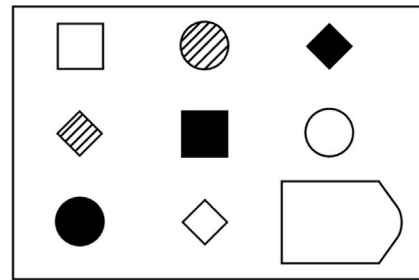
5. Which is the missing piece?



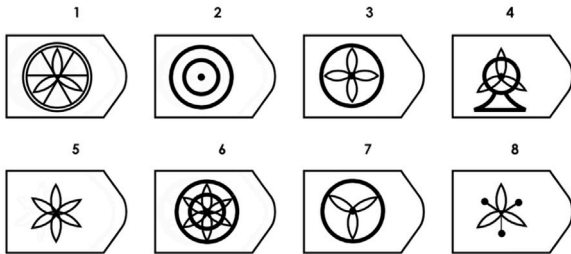
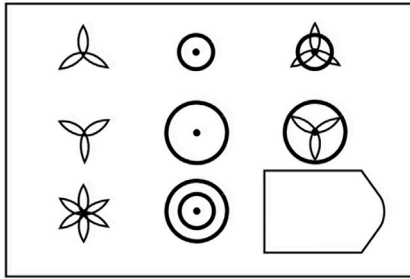
4. Which is the missing piece?



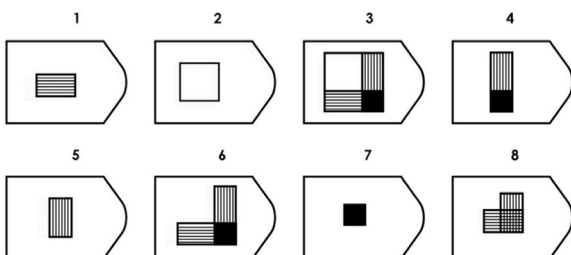
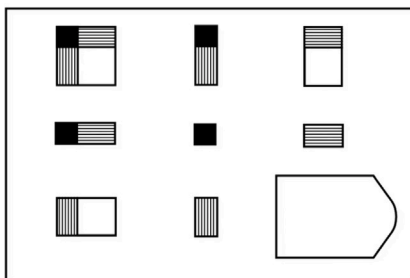
6. Which is the missing piece?



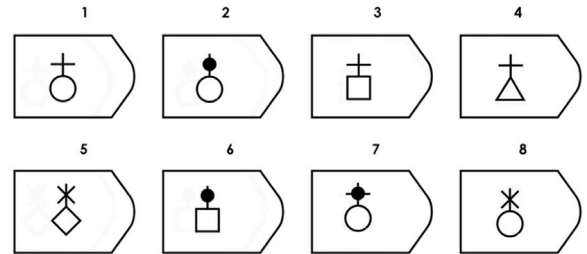
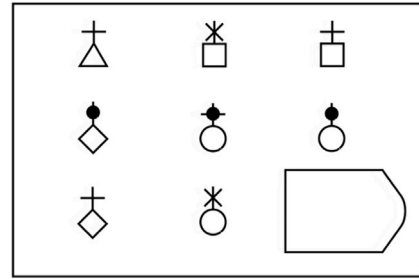
7. Which is the missing piece?



8. Which is the missing piece?



9. Which is the missing piece?



Cognitive reflection test

1. A rose and a tulip cost \$13. The rose costs \$10 more than the tulip. How much does the tulip cost (in \$)?
2. It takes 5 cooks 5 min to make 5 cakes. How long would it take 20 cooks to make 20 cakes (in minutes)?
3. In a bay, there is an oil spill. Every day, the oil spill doubles in size. If it takes 24 days for the oil spill to spread to the whole bay, how long would it take the oil spill to cover half the bay (in days)?
4. If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days, how long would it take them to drink one barrel of water together (in days)?
5. Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class?
6. If you are running a race and you pass the person in second place (2), what place are you in?
7. A farmer had 15 sheep and all but 8 died. How many are left?

Items of the full parent financial socialization (FPSS) scale

Parent financial modeling scale

1. Growing up, I learned how to manage money by observing how my parents' managed. money.
2. While I was growing up, my parents were good examples of how to manage money.
3. When it came to managing money while I was growing up, I looked to my parents as my role models.
4. Growing up, I often made financial decisions based on what my parents had done in similar situations.
5. Growing up, I sometimes saw my parents use a budget to manage their money.
6. Growing up, I knew that my parents regularly tracked their expenses.
7. While I was growing up, my parents prioritized saving money.
8. While I was growing up, my parents preferred to save up for most purchases rather than go into debt.

Table A.1
Reliability statistics for the cognitive ability measures.

Item	Number of observations	Sign	Item-test correlation	Item-rest correlation	Average interitem correlation	Alpha
CRT score	353	+	0.7961	0.5147	0.3308	0.4971
RPM score	353	+	0.7899	0.5034	0.3450	0.5130
NLE score	353	+	0.7251	0.3908	0.4948	0.6620
Test scale					0.3902	0.6575

This table reports reliability statistics for the three cognitive ability measures. The columns display the number of observations, the sign of the item-test correlation, the item-test and item-rest correlations, the average interitem correlation, and Cronbach's alpha for each measure and for the combined scale.

Parent-child financial discussion scale

1. I learned how to manage my money through conversations with my parents while I was growing up.
2. My parents talked with me about money while I was growing up.
3. While I was growing up, my parents told me about their past financial experiences.
4. While I was growing up, my parents were open with me about their budget (or, if they did not have a budget, were open with me about that).
5. My parents would teach me about money during day-to-day activities, such as at the bank, at the store, etc. while I was growing up.
6. While I was growing up, my parents talked to me about financial concepts when I was ready for them.
7. Growing up, I knew I could go to my parents when I had questions about money.
8. Growing up, I asked my parents questions about money.
9. While I was growing up, my parents would answer my questions about money.

Experiential learning of finances scale

1. My parents gave me opportunities to practice money management while I was growing up.
2. My parents gave me hands-on experiences with money while I was growing up.
3. While I was growing up, my parents encouraged me to put a certain percentage of my money away for something like savings or donations.

(LeBaron-Black et al., 2022)

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