PNAS Nexus, 2026, , 1–10
DOI added during production
Published: Date added during production
Paper

PNAS NEXUS

Developmental asymmetries in equilibrium selection

Pablo Brañas-Garza[1,*] **Diego Jorrat**[2] **and Pablo Lomas**[1]

[1]LoyolaBehLab & Department of Finance, Universidad Loyola Andalucía, Escritor Castilla Aguayo 4, 14004, Córdoba, Spain
[2]Department of Applied Economics I, Universidad de Sevilla, Avda. Ramón y Cajal 1, 41018, Seville, Spain
*To whom correspondence should be addressed: branasgarza@gmail.com

Abstract

Coordination problems are central to social and economic life and often involve multiple equilibria. Classical theories identify two canonical principles for equilibrium selection: maximizing payoffs and minimizing strategic risk. These principles differ in what they demand of a decision-maker: payoff-based coordination can be reached by recognizing that one equilibrium pays more, whereas risk-based coordination requires reasoning about what happens when coordination fails. Yet little is known about how the use of these principles varies from late childhood to early adulthood. Using a large sample of more than 2,000 participants aged 10 to 20, who played two coordination games and then stated the reason for each choice, we construct measures that pair each choice with a congruent stated reason and document an asymmetry in their age profiles. Payoff-based coordination is already high at the earliest ages studied and shows at most a weak age gradient. In contrast, risk-based coordination shows a modest but consistent increase with age. The difference between the two age gradients is statistically significant; the risk-based gradient also appears within the study using a common protocol across ages and in the risk-dominant choice itself. Cognitive ability shifts the level of both measures but does not alter their age profiles. These findings show that payoff-based and risk-based coordination vary differently with age, while similar observed choices can be accompanied by different stated reasons.

Keywords Payoff dominance, Risk dominance, Coordination, Age

Significance statement

Coordination underlies many social interactions, yet little is known about how the use of alternative equilibrium-selection principles varies from late childhood to early adulthood. In more than 2,000 participants aged 10 to 20, we pair choices in two coordination games with congruent stated reasons. Payoff-based coordination is already common at the youngest ages and shows at most a weak age gradient. Risk-based coordination, which requires attending to outcomes under miscoordination, increases modestly but consistently with age. The difference between these age gradients is statistically significant and is also visible in the risk-dominant choice itself. These findings show that payoff-based and risk-based coordination have different age profiles, while similar observed choices can be accompanied by different stated reasons.

Introduction

Classical theories of coordination characterize payoff dominance and risk dominance as alternative principles of equilibrium selection (28; 24; 14). When multiple equilibria exist, individuals may coordinate on the outcome that maximizes joint payoffs or on the option that minimizes potential losses under miscoordination. Yet little is known about how reliance on these two principles varies with age. Our question is therefore simple: how does the use of payoff-based and risk-based coordination vary from late childhood to early adulthood?

Coordination problems pervade social and economic life—from adopting technologies and social norms to organizing collective action (28; 11). In such environments, success does not only depend on incentives but also on shared expectations about others' behavior. Canonical coordination models formalize payoff dominance and risk dominance as coexisting selection principles (24; 14). Empirical work has rarely examined how reliance on these principles varies with age, in part because observed choices do not always reveal the rationale accompanying a decision.

Understanding how coordination develops is particularly important given the growing literature on economic behavior in childhood and adolescence. Experimental evidence shows that preferences, beliefs, and decision-making abilities evolve substantially over this period (5; 9; 29; 32; 22). A large body of work documents systematic age patterns in risk taking (23; 31), patience (31; 13), social preferences (19; 2; 20; 30; 4), and strategic reasoning (16; 8; 6), suggesting that adult economic behavior reflects a process of gradual development rather than a fully formed set of capabilities from early ages.

Received: Date Month Year. **Revised received:** Date Month Year. **Accepted:** Date Month Year
© The Author(s) 2026. Copyright and licence statements to be updated by the publisher during production.

However, the evidence on coordination itself remains limited and inconclusive. Recent experimental studies with children and adolescents find little or no robust age gradient in equilibrium selection in one-shot coordination games, despite clear sensitivity to incentives and beliefs (22). The picture is more nuanced once interaction is repeated: Brocas and Carrillo (10) document that older adolescents are better able to converge on the efficient equilibrium in a repeated coordination setting, suggesting that learning may drive part of the developmental gap. Broader work on strategic reasoning likewise reports that strategic decision-making is already well developed by age 10 and changes little thereafter (16). This raises a puzzle: if aggregate coordination behavior appears stable over this age range, does it reflect stable reliance on the same selection principles, or can similar choices be accompanied by different stated rationales at different ages?

The two coordination principles differ in the reasoning made salient by our games. Payoff-based coordination can be reached through a relatively simple comparison of equilibrium payoffs, together with the expectation that the partner recognizes the same feature. Risk-based coordination, by contrast, requires attending to counterfactual outcomes under miscoordination and to strategic uncertainty (12; 25; 17). In the settings studied here, applying the risk-based principle is therefore more cognitively demanding and more closely related to strategic sophistication (1; 5; 7; 9). We therefore expect risk-based coordination to display a stronger age gradient than payoff-based coordination.

To test this idea, we study coordination behavior in a large sample of more than 2,000 participants aged 10 to 20, spanning late childhood, adolescence, and early adulthood. Participants play two coordination games: one makes differences in equilibrium payoffs salient, whereas the other makes outcomes under miscoordination salient. Crucially, we go beyond observed choices: after each choice, participants select the reason for it from a short list—see Methods and section 1B of the Supporting Information (SI) Appendix. We use these responses to define strict measures that pair each choice with a congruent stated reason (PayD and RiskD), distinguishing these action–reason combinations from choices accompanied by a color-based or random-choice reason (15; 27). In a subsample, we additionally elicit what participants expect their partner to do and the reason they attribute to the partner, which allows us to pair each measure with its belief counterpart.

We document an asymmetry in the age profiles of payoff-based and risk-based coordination. Payoff-based coordination is already high at the earliest ages in our sample and shows at most a weak age gradient. In contrast, risk-based coordination shows a modest but consistent increase with age. The difference between the two age gradients is statistically significant, and the increase in risk-based coordination is also visible in the risk-dominant action itself. By pairing choices with congruent stated reasons, our approach helps explain why earlier choice-only studies may find weak age gradients in coordination: similar actions can be accompanied by different stated rationales, and modest changes may be difficult to detect over narrow age ranges or in smaller samples.

The two games also differ in difficulty, so we examine whether the stronger age gradient in the risk-dominance game could simply reflect age-related differences in task confusion. Non-strategic justifications are more frequent in the risk-dominance game than in the payoff-dominance game, consistent with the former being harder, but we find no evidence that this within-participant difficulty gap narrows with age. A stacked specification shows that the age gradient is steeper in the risk-dominance game, while within-age cognitive ability predicts the strict measures similarly across the two games. These checks do not eliminate all differences between the tasks, but they suggest that the observed asymmetry is not accounted for by the difficulty proxies available in our data.

Results

We begin by documenting the developmental pattern of payoff-based coordination. Figure 1 shows the proportion of participants choosing the payoff-dominant action (P) and meeting the strict criterion for payoff-based coordination (PayD), defined as choosing the payoff-dominant action and selecting the congruent reason ("Because I earned more") across age. Overall, 76.0% of participants select the payoff-dominant action, and 60.7% meet the strict criterion for PayD, against a descriptive benchmark of 0.125 under independent random choice of action and reason.

Payoff-based coordination shows at most a weak age gradient. The correlation between age and PayD is small and statistically insignificant ($r = 0.032$, $p = 0.136$), and remains negligible after excluding the idiosyncratic dip at age 13 ($r = 0.018$, $p = 0.441$). In the regressions below, the age coefficient for PayD is positive but only marginally significant, and not robust across samples; we therefore describe the gradient as weak rather than absent. Strict payoff-based coordination is thus already high at the earliest ages in our sample and broadly flat thereafter.

This pattern holds across subgroups. As shown in Figure 1B, high-ability individuals display higher levels of PayD than low-ability individuals (66.5% vs. 51.5%; $t = 7.011$, $p < 0.001$), in line with the well-established link between cognitive skill and strategic sophistication (27; 21; 18). The age profile is broadly flat within both groups ($r = 0.024$, $p = 0.380$ for high-ability; $r = 0.029$, $p = 0.412$ for low-ability), so cognitive ability shifts the level of PayD without steepening the age profile. Similarly, Figure 1C shows a modest gender difference in levels (males: 63.1% vs. females: 58.0%; $t = 2.411$, $p = 0.016$), with no systematic age trend for either group (female: $r = -0.003$, $p = 0.929$; male: $r = 0.064$, $p = 0.032$); the significant correlation for males disappears once age 13 is excluded ($r = 0.049$, $p = 0.133$). Taken together, payoff-based coordination is already high at the earliest ages in our sample and remains broadly flat thereafter. Cognitive ability and gender shift overall levels, but neither meaningfully alters the age profile.

Figure 2 reveals a different developmental pattern for risk-based coordination. Figure 2A displays the proportion of participants choosing the risk-dominant action (R) and meeting the strict criterion for risk-based coordination (RiskD), defined as choosing the risk-dominant action and selecting the congruent reason ("Because it was less risky"), across age. Overall, 52.8% of participants chose the risk-dominant action and 29.1% met the strict criterion for RiskD, against a descriptive benchmark of 0.125 under independent random

choice of action and reason. In contrast to PayD, RiskD shows a modest but consistent increase with age—from 22.2% at age 10 to 39.6% at age 19—and the correlation with age is positive and significant ($r = 0.108$, $p < 0.001$). This pattern contrasts with the much weaker age gradient observed for payoff-based coordination. It is consistent with participants relying increasingly on the risk-based criterion across the age range we study, without implying that the stated reason identifies the mental process that generated the choice.

This pattern is shaped by cognitive ability. As shown in Figure 2B, high-ability individuals display higher levels of RiskD than low-ability individuals (34.8% vs. 20.0%; $t = 7.351$, $p < 0.001$). Cognitive ability shifts the level of RiskD rather than the slope of its age profile: the estimated age slopes are nearly identical in the two groups (0.022 among low-ability and 0.026 among high-ability participants), and the interaction between age and cognitive ability is not significant whether ability enters continuously or as a median split ($F_{1,2089} = 1.74$, $p = 0.19$ and $F_{1,2089} = 0.30$, $p = 0.59$; SI Appendix, section 3). What is non-linear is the relationship between RiskD and cognitive ability itself, which is flat below the sample mean and rises above it (SI Appendix, Figure S2). Cognitive ability therefore shifts the level of risk-based coordination without materially altering its age profile.

Figure 2C shows the age profile of RiskD by gender. Overall levels differ, with females showing lower RiskD than males (males: 31.8% vs. females: 26.1%; $t = 2.900$, $p = 0.004$). We do not interpret the age profiles as differing by gender: the age-by-gender interaction is significant only at the 10% level in the linear probability model and loses significance in the logit specification (SI Appendix, Table S21). We therefore treat the difference as one of levels, and Figure 2C as descriptive. The age-specific estimates are reported descriptively in SI Appendix, Figure S3; because the underlying Age $\times$ Female interaction is not robust across specifications, we do not interpret their pattern as evidence of different age trajectories by gender.

We now turn to the regression estimates, which quantify these descriptive patterns. Table 1 reports OLS estimates of strict coordination on age, cognitive ability, and gender, including school fixed effects and baseline controls. Columns 1–4 examine PayD and columns 5–8 examine RiskD.

The results show an asymmetry between payoff-based and risk-based coordination. For payoff-based coordination (columns 1–4), the age coefficient is positive and similar in magnitude across the four columns (0.019–0.021); it is marginally significant in three of them and reaches the 5% level only in the age-by-gender specification (column 3). It does not survive within Study 1 alone, where the age variation comes from a single protocol (0.012, $p = 0.22$), nor in the raw age correlation reported above, suggesting a weak gradient rather than a flat one. Cognitive ability is a strong predictor of PayD levels (0.067–0.070, all $p < 0.01$). None of the interactions reshapes this picture. The interaction between age and cognitive ability is negative and marginally significant (-0.006, $p = 0.08$), but we do not interpret it: neither ability group displays a substantial age gradient for such an interaction to describe. The interaction between age and gender is not significant, and the quadratic term in cognitive ability is small and insignificant. Cognitive ability and gender shift the level of PayD, leaving broadly parallel and linear age profiles across groups.

For risk-based coordination (RiskD; columns 5–8), the regression results extend the descriptive patterns. The age coefficient is positive and significant across all specifications (0.024, rising to 0.030 in the specification with the age-by-gender interaction; all $p < 0.01$), indicating a modest but consistent developmental increase in risk-based coordination. Cognitive ability is also a strong positive predictor of RiskD levels (0.071–0.079, all $p < 0.01$). Its interaction with age is small and not statistically significant (-0.004, $p = 0.19$), indicating that cognitive ability does not alter the rate of increase in RiskD with age. Instead, the role of cognitive ability is non-linear in ability itself: the coefficient on $CogAb(r)^2$ is positive and significant (0.019, $p = 0.01$), so higher RiskD is concentrated among participants with above-average cognitive ability (SI Appendix, Figure S2). The age-by-gender interaction is negative but significant only at the 10% level (-0.012, $p = 0.07$), and it loses significance in the logit specification (SI Appendix, Table S21). We therefore do not interpret the age profile of RiskD as differing by gender, and report the gender difference in levels instead.

To assess whether the developmental difference between the two games reflects their difference in difficulty rather than age, we pool the two games in a stacked specification with two observations per participant, interacting age, cognitive ability, and gender with a Game 2 indicator (SI Appendix, Panel A of Table S9). The Age $\times$ Game 2 interaction is positive and significant (0.011, $p = 0.011$), showing that the age gradient is steeper in the risk-dominance game. The CogAb(r) $\times$ Game 2 interaction, by contrast, is essentially zero (0.004, $p = 0.77$). A simple difficulty account might predict a stronger within-age cognitive-ability gradient in Game 2, but we do not detect such a difference. Together with the significant Age $\times$ Game 2 interaction, this suggests that the stronger age gradient in the risk-dominance game is not explained by the cognitive-ability differences captured by our measure.

A remaining possibility is that younger participants are more confused by the risk-dominance game and that this confusion declines with age. We examine this using a proxy for non-strategic engagement based on reasons that do not depend on the action chosen: "I liked the color" or "I chose one randomly". These reasons are more frequent in Game 2 than in Game 1 (44.5% vs. 30.4%), consistent with greater difficulty in the risk-dominance game. However, we find no evidence that the within-participant excess declines with age (-0.004, $p = 0.73$). The same is true for a broader proxy that also includes action–reason pairs in which the stated reason contradicts the chosen action (-0.015, $p = 0.21$; SI Appendix, Panel B of Table S9). Thus, the available difficulty proxies do not display the age pattern that would be expected if declining confusion alone generated the RiskD gradient.

Finally, we ask how the two principles combine across participants and age. We classify each participant into one of three mutually exclusive types—satisfying neither criterion, exactly one, or both—and estimate how each type varies with age (SI Appendix, Table S10 and Figure S4). Participants who satisfy exactly one criterion almost always satisfy PayD rather than RiskD: 85.1% of that category has PayD $= 1$ and RiskD $= 0$. Development operates at the extremes: the share satisfying neither criterion declines with age (-0.025, $p = 0.006$), the share satisfying both increases (0.018, $p = 0.029$),

and the intermediate category is flat (0.008, $p = 0.44$). This pattern suggests that higher use of the risk-based criterion with age tends to occur among participants who also satisfy the payoff-based criterion, rather than replacing it.

Taken together, the regression results show different age profiles for payoff-based and risk-based coordination. Payoff-based coordination is already high at the earliest ages and remains broadly flat thereafter: cognitive ability shifts overall levels, but neither cognitive ability nor gender steepens the age profile. Risk-based coordination, by contrast, shows a modest but consistent increase with age. Cognitive ability shifts its level and is non-linear in ability itself, while females show lower levels overall; neither reflects a difference in the age profile by group.

The stated reason is chosen from a closed list after the action, so it could register comprehension of the response option rather than the reasoning behind the choice. That account carries a testable implication, which we test in SI Appendix, section 3C: internally inconsistent pairs—where the stated reason contradicts the action taken, such as choosing the payoff-dominant action while reporting "I earned less"—should grow rarer as participants become more fluent with the wording. Such pairs are about three times as common in Game 2 as in Game 1 (21.0% vs. 7.5%), but they show no significant decline with age in either game (0.000, $p = 0.96$ in Game 1; -0.011, $p = 0.17$ in Game 2); in Game 1 inconsistency declines with cognitive ability instead (-0.020, $p = 0.001$), suggesting that task processing, rather than age-related changes in vocabulary alone, may contribute to these inconsistencies (SI Appendix, Table S11).

Splitting the Game 2 inconsistencies by the action they follow speaks to the more specific concern that RiskD tracks familiarity with the word "risk". Among participants who did *not* choose the risk-dominant action, 32.7% nonetheless report "because it was less risky", with no age trend (-0.012, $p = 0.40$). The mirror error is less frequent but equally flat: among those who *did* choose the risk-dominant action, 10.6% report "because it was more risky", again with no age trend (-0.001, $p = 0.91$) (SI Appendix, Table S12). If age-related changes in comprehension of the risk vocabulary were driving the RiskD gradient, we would expect these misuse rates to decline with age; we find no evidence that either does. Importantly, the age gradient is also visible in the action margin alone, which involves no language: the probability of choosing the risk-dominant action rises with age (0.027, $p = 0.007$; SI Appendix, Table S13).

A subsample of participants also reported what they expected their partner to do and why, which lets us pair each measure with its belief counterpart (six schools in Study 1; $N = 403$ in Game 1 and $N = 394$ in Game 2; SI Appendix, section 3D). Choices and stated reasons are strongly associated with these beliefs: participants expecting the partner to take the relevant action are substantially more likely to take it themselves (0.327 in Game 1, 0.400 in Game 2, both $p < 0.001$), and those who both expect that action and attribute the congruent reason to the partner are more likely to satisfy the strict measure themselves (0.577 for PayD, 0.475 for RiskD, both $p < 0.001$). The order of the own-choice and belief blocks was randomized at the participant level, and a belief stated before the decision cannot rationalize a choice not yet made; the association is of similar magnitude under both orders. We read this as beliefs and behavior lining up rather than as evidence that beliefs cause choices, since participants who choose an action may simply assume their partner will do the same. The subsample is small and covers only part of the age range, so we use it to validate the measures rather than to characterize how beliefs themselves develop (SI Appendix, Table S14).

Because our sample combines a school-based study with a laboratory study of older participants, age is partly confounded with study context, so we ask where the identifying variation comes from (SI Appendix, section 3E). The age gradient in RiskD is present within Study 1 alone, which uses a single protocol and spans ages 10 to 20 through its vocational-training and university-pilot participants (0.021, $p = 0.020$; for the risk-dominant action alone, 0.031, $p = 0.003$), while PayD remains flat (0.012, $p = 0.22$; SI Appendix, Table S15, Panel A). In the pooled sample, the Age $\times$ Study 2 interaction is not significant for either outcome (RiskD 0.050, $p = 0.20$; PayD 0.040, $p = 0.29$), and the age coefficient remains positive and significant (0.022, $p = 0.015$; Panel B). Re-estimating the baseline specification on progressively broader school-based samples gives RiskD age coefficients of 0.015, 0.021, and 0.021, against 0.024 in the full sample (SI Appendix, Tables S16–S18); the estimate moves within a narrow band relative to its standard error, and what changes across samples is mainly age support and precision. Were the pooling of the two studies manufacturing the gradient, adding the older subsamples should inflate it.

A developmental claim also requires that the linear age term not conceal structure (SI Appendix, section 3F). Adding a full set of age indicators to the linear specification does not improve fit for either outcome (RiskD $F_{9,2081} = 0.68$, $p = 0.73$; PayD $F_{9,2094} = 1.46$, $p = 0.16$). A linear spline with a knot at 16, the end of compulsory secondary education in Spain, yields a positive and significant slope for RiskD below the knot (0.022, $p = 0.018$) and a larger but imprecise slope above it (0.040, $p = 0.15$), with equality of the two slopes not rejected ($p = 0.54$); a quadratic in age is insignificant for both outcomes (SI Appendix, Table S19, Panels A and B). The age trajectory is therefore well summarized by a linear term, and the non-linearity documented above concerns cognitive ability rather than age. Three further checks leave the main estimates unchanged (SI Appendix, section 3G): a triple interaction between age, gender, and cognitive ability is negligible for both outcomes (Table S20), logit specifications with average marginal effects reproduce the linear probability estimates (Table S21), and replacing the CRT$\times$3 rescaling for Study 2 participants with multiple imputation (MICE-PMM, $M = 20$) yields the same pattern (Table S22).

Taken together, these checks address three ways in which the asymmetry could be an artifact rather than a finding. It could come from the measure, if the stated reason tracked familiarity with the wording rather than reasoning. It could come from the sample, if the age gradient were produced by combining two studies. It could come from the specification, if a linear age term concealed structure. Across these checks, the estimated age profiles remain qualitatively similar to those reported in Table 1, providing no evidence that the main pattern is driven by any of these specific concerns.

Table 1. OLS regressions of strict coordination on age, cognitive ability, and gender.

	Dependent variable: PayD				Dependent variable: RiskD			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Age	0.019*	0.019*	0.021**	0.019*	0.024***	0.024***	0.030***	0.024***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
CogAb(r)	0.068***	0.162***	0.067***	0.070***	0.072***	0.138***	0.071***	0.079***
	(0.010)	(0.054)	(0.010)	(0.011)	(0.010)	(0.050)	(0.010)	(0.010)
Female	−0.046**	−0.048**	0.031	−0.045**	−0.053***	−0.054***	0.129	−0.049**
	(0.021)	(0.021)	(0.108)	(0.021)	(0.019)	(0.019)	(0.099)	(0.019)
Age × CogAb(r)		−0.006*				−0.004		
		(0.003)				(0.003)		
Age × Female			−0.005				−0.012*	
			(0.007)				(0.007)	
CogAb(r)^2				0.007				0.019**
				(0.008)				(0.007)
Constant	0.581***	0.584***	0.545***	0.575***	0.128	0.130	0.043	0.112
	(0.149)	(0.149)	(0.158)	(0.150)	(0.139)	(0.139)	(0.146)	(0.139)
Observations	2,131	2,131	2,131	2,131	2,118	2,118	2,118	2,118
R-squared	0.078	0.080	0.079	0.079	0.065	0.066	0.066	0.068
BIC	3034.3	3038.8	3041.5	3041.1	2739.2	2745.0	2743.4	2739.5
School FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y

Note: The dependent variable is strict payoff-based coordination (PayD; columns 1–4) or strict risk-based coordination (RiskD; columns 5–8). Age is measured in years. CogAb(r) denotes age-residualized cognitive ability. Columns 2 and 6 include an interaction between age and CogAb(r) to test whether the age gradient differs by cognitive ability; in these columns the CogAb(r) coefficient is evaluated at age zero and is therefore not comparable to the other columns. Columns 3 and 7 include an interaction between age and gender to test whether the age gradient differs by gender. Columns 4 and 8 add a quadratic term CogAb(r)^2 to account for the non-linear relationship between cognitive ability and RiskD documented in SI Appendix, Figure S2. The number of observations is lower for RiskD because 13 participants did not record an action in Game 2. Among the 2,118 participants with a recorded Game 2 action, eight did not record a justification; these cases are coded as RiskD $= 0$. All specifications include school fixed effects and baseline controls (repeater status, class size, and incentive condition). Robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Discussion

We document different age profiles for two canonical principles of equilibrium selection. In a sample spanning ages 10 to 20, payoff-based coordination is already high at the earliest ages studied and shows at most a weak age gradient, whereas risk-based coordination shows a modest but consistent increase from late childhood to early adulthood. The two principles differ in cognitive demand in the settings studied here: coordinating on the payoff-dominant equilibrium can be reached by recognizing that one equilibrium pays more, while coordinating on the risk-dominant equilibrium requires attending to what happens when coordination fails. Our contribution is not that these demands differ, but that reliance on the risk-based criterion increases more strongly with age over this range, while payoff-based coordination changes comparatively little.

Two individual characteristics shift the level of coordination without materially reshaping its age profile. Cognitive ability is associated with markedly higher rates of both measures, and by a similar amount in the two games—about 15 percentage points in each. Females show lower levels of both measures (5.1 and 5.7 percentage points), a difference that holds across specifications. In neither case do we find robust evidence that the age profile differs by group, so we describe these primarily as differences in levels rather than in trajectories.

Pairing each choice with a stated reason lets us distinguish choices accompanied by the corresponding rationale from choices accompanied by color preference or admitted randomness. This distinction matters in a developmental setting because the same action can be accompanied by different stated rationales at different ages. It should not be over-read. The reason is selected after the choice from a closed list, so it records what participants endorse as their reason rather than the process that produced the choice; what we observe is choice plus congruent stated reason. We preferred a closed list to open-ended explanations because, in brief classroom sessions with ten-year-olds, free text would introduce a stronger age-dependent verbal component than the list itself, and we asked for the choice before the reason so that the options would not prime the strategic dimension of the task. The validation reported above—including inconsistent pairs and misuse of the risk vocabulary—provides no evidence that these measures improve mechanically with age, and the difficulty gap between games likewise shows no detectable decline across the age range. These checks weigh against a purely wording-driven account of the RiskD gradient, but they do not turn stated reasons into process evidence.

These results also bear on why earlier studies report little or no age gradient in equilibrium selection in one-shot coordination games (22). Part of the answer is statistical. The association we estimate is modest ($r = 0.108$ for RiskD), and designs built around narrow age windows may have limited power to detect it: a study of 114 children aged 9 to 11 finds no age effect on strategic performance and cautions explicitly that this should not be read as an absence of development over that range (26).

Part of the answer is conceptual. In our data the risk-dominant action itself becomes more frequent with age, so aggregate choice is not static; what choice alone cannot reveal is how those actions are distributed across different stated rationales. Non-strategic reasons—color preference or admitted randomness—account for 44.5% of responses in the risk-dominance game, and among participants who do not choose the risk-dominant action, roughly a third nonetheless describe the alternative as less risky. A choice-only design therefore measures an outcome whose movement is real but whose interpretation is ambiguous. Eliciting the reason does not necessarily yield a steeper gradient; it helps identify which action–reason combinations are changing.

Our findings speak to canonical models of equilibrium selection. Payoff dominance and risk dominance are usually treated as alternative criteria for selecting among equilibria (28; 24; 14), and in games such as the Stag Hunt they are properties of a single strategic situation. Our design makes the two criteria separately observable across two games and shows that their age profiles differ. Payoff-based coordination is already common at age 10 and changes comparatively little thereafter. Risk-based coordination, which requires attending to outcomes under miscoordination and hence to strategic uncertainty (12; 25; 17), increases more strongly with age. This pattern is consistent with evidence that strategic reasoning about others changes across childhood and adolescence (29; 5; 7; 9), while remaining agnostic about the specific cognitive process generating each individual choice.

Several limitations bound this interpretation. First, the design is cross-sectional. The age gradients therefore describe differences across participants of different ages rather than within-person developmental change; longitudinal evidence would be required to establish individual acquisition of the two forms of coordination. Second, risk dominance is behaviorally meaningful only under uncertainty about the partner. Participants were paired within their classroom or experimental-session context and faced the same payoff structure, so the age gradient may reflect both participants' own reasoning and their beliefs about the people with whom they expected to interact. The belief subsample is consistent with this reading, since choices and stated reasons are strongly associated with expectations about the partner, but part of that association may reflect projection, and the subsample is too small and too narrow in age to characterize how beliefs themselves vary with age. Third, we do not measure strategic experience. Exposure to environments involving strategic uncertainty could contribute to the age pattern we observe, but age is not experience and our design neither manipulates nor measures it; we therefore leave this as a conjecture for future work rather than as a result.

Materials and Methods

Participants

The final analytical sample consists of 2,131 participants aged 10 to 20, spanning late childhood, adolescence, and early adulthood. The data combine two studies that implement the same two-game coordination design and the same elicitation of post-choice justifications. Study 1 is a large lab-in-the-field classroom experiment conducted in Spanish schools, covering participants from late primary school to early adulthood (33). Study 2 is a laboratory experiment conducted at Universidad Loyola Andalucía with older participants, including high-school visitors and university students (3). Detailed information on recruitment, design features, incentive schemes, and sample composition is provided in the SI Appendix, sections 1 (Design) and 2 (Sample).

All experimental procedures were approved by the Ethical Committee of Universidad Loyola Andalucía (protocol nos. 20190318, 20200709, and 20230301). In both studies, participants were informed about the study on an initial consent screen and gave their informed consent before beginning the experiment. Participation was voluntary and anonymous. In Study 1, the experiment was integrated into the schools' curriculum and conducted as a regular class activity with the approval of each school's headmaster, under an opt-out consent procedure approved by the committee. For participants under 16, parental consent was covered by the consent parents had previously given to the school for curricular activities. In Study 2, all participants were aged 17 or older, so parental consent was not required. All participants provided informed consent in accordance with the approved procedures.

Experimental design

Participants played two one-shot coordination games, one with unequal equilibrium payoffs and one in which the equilibria differ in their outcomes under miscoordination. In both games, two players simultaneously chose between two actions. Participants were told that they would be paired with a random partner and that they could not communicate with that person. The pairing pool consisted of classmates from the same classroom context in Study 1 and participants from the same experimental session in Study 2. Both players faced the same instructions and the same payoff matrix. Payoffs were highest under successful coordination, whereas miscoordination yielded lower or zero payoffs. The games were implemented using colored buttons rather than abstract labels. The mapping between colors and actions was held constant across participants, so that the salience structure was identical for everyone; the left–right position of the two buttons was randomized independently for each participant to prevent positional bias. Payoff magnitudes differed across studies: in Study 1, payoffs were scaled up by a factor of ten relative to Study 2. This rescaling does not affect the ordinal structure of the games or the equilibrium predictions. Table 2 reports the payoff matrices for the two games.

In the payoff-based coordination game, one equilibrium strictly Pareto-dominated the alternative, making payoff maximization the salient coordination principle. In the risk-based coordination game, both equilibria yielded identical payoffs under successful coordination but differed in their robustness to unilateral deviations, giving rise to a unique risk-dominant equilibrium. Full experimental instructions and additional details are provided in the SI Appendix.

Actions and stated reasoning

After choosing an action in each game, participants were asked to state the main reason for their decision by selecting one option from a predefined list presented in random order. In Game 1, the options were:

Table 2. Payoff matrices of the coordination games.

Game	Own action	Partner's action (A)	Partner's action (B)
Game 1: payoff-dominant	Yellow (A)	**1, 1**	0, 0
	Red (B)	0, 0	0.5, 0.5
Game 2: risk-dominant	White (A)	**1, 1**	0.5, 0
	Blue (B)	0, 0.5	1, 1

Note: Rows give the participant's own action and columns the partner's action, labeled (A) and (B) within each game; entries are the participant's and the partner's payoff, in that order. In Game 1, (A, A) is the payoff-dominant equilibrium. In Game 2, both equilibria yield identical payoffs under coordination, but (A, A) is the unique risk-dominant equilibrium. Payoffs shown on the Study 2 scale; Study 1 amounts are ten times larger.

(a) "Because I earned more"
(b) "Because I earned less"
(c) "Because I liked the color"
(d) "I chose one randomly"

In Game 2, the corresponding options were:

(a) "Because it was less risky"
(b) "Because it was more risky"
(c) "Because I liked the color"
(d) "I chose one randomly"

Participants chose an action and only then saw the list of reasons, so that the response options could not prime the strategic dimension of the task. We used a closed list rather than free-form justifications coded ex post to limit age-related differences in measurement arising from written expression, which itself develops over the ages we study. The justification was not incentivized.

We define strict payoff-based coordination (PayD) as selecting the payoff-dominant action (A) and reporting the congruent justification ("Because I earned more"), and strict risk-based coordination (RiskD) as selecting the risk-dominant action (A) and reporting the congruent justification ("Because it was less risky"). Both measures are conjunctions of a choice and a congruent stated reason; because the reason is elicited after the choice from a closed list, they identify choices accompanied by the relevant reason rather than the mental process that produced them. Under independent random selection of action and reason, each conjunction would arise with probability 0.125. We use this figure throughout as a descriptive reference point only, not as evidence that participants applied the corresponding principle. See SI Appendix 1B for details.

In six schools of Study 1, participants additionally reported which button they believed their partner would press and the reason they attributed to the partner. The order of the own-choice and partner-belief blocks was randomized at the participant level (SI Appendix, section 1B).

Measuring cognitive ability

Cognitive ability was measured using a composite index constructed as the sum of three components: the Cognitive Reflection Test (CRT; 0–3), financial abilities (0–3), and probabilistic reasoning ability (0–3), yielding a total score ranging from 0 to 9 (see SI Appendix, Table S3, for tasks details). For the Study 2 participants—university students and high-school students attending the university as part of school-organized whole-class visits—only CRT scores were available; to preserve comparability with the 0–9 scale used in the rest of the sample, these scores were rescaled by multiplying them by three.

To isolate within-age differences in cognitive performance from general developmental and sample-composition differences, we residualized the cognitive index with respect to age, gender, repeater status, class size, school fixed effects, and educational-stage fixed effects. We then standardized the resulting residuals to mean zero and unit variance. This standardized residualized measure, denoted $CogAb(r)$, is used in the main analyses.

Statistical analysis

We begin with unadjusted descriptive evidence: proportions satisfying each measure by age, with Pearson correlations and two-sample t-tests comparing levels across cognitive-ability and gender groups. Non-parametric (LOWESS) smoothing is reported in SI Appendix, Figure S2. For the main analysis, we estimate linear probability models in which the dependent variable is either strict payoff-based coordination (PayD) or strict risk-based coordination (RiskD). The baseline specification includes age in years, the standardized residualized measure of cognitive ability ($CogAb(r)$), gender, and a set of controls, including repeater status, class size, incentive condition, and school fixed effects.

To examine whether these associations differ across groups, we augment the baseline specification with interaction terms between age and cognitive ability ($Age \times CogAb(r)$) and between age and gender ($Age \times Female$). To capture the non-linear relationship between cognitive ability and RiskD documented in SI Appendix, Figure S2, we also estimate specifications including a quadratic term in $CogAb(r)$. We check the linear age specification with jointly tested age indicators, a spline with a knot at 16, and a quadratic in age.

All models are estimated using ordinary least squares with robust standard errors. These specifications correspond to the models reported in Table 1. The remaining analyses are reported in the SI Appendix. A first group assesses what the stated-reason component captures: non-strategic and internally inconsistent action–reason pairs, misuse of the risk vocabulary, a decomposition of each measure into its action and conditional-reason margins, and, in a subsample, the association between choices and elicited beliefs about the partner; the margin and misuse estimates are descriptive, since they condition on endogenously selected subsamples. A second tests the difference between the age gradients directly, pooling the two games with two observations per participant, all covariates interacted with a Game 2 indicator and standard errors clustered at the participant level, and classifying participants by the number of strict criteria they satisfy. A third reports robustness: progressively broader school-based subsamples and an $Age \times Study\ 2$ test, a triple interaction between age, gender, and cognitive ability, logit average marginal effects, and a replication of Table 1 using multiple imputation (MICE-PMM, $M = 20$) in place of the CRT $\times$ 3 rescaling.

Acknowledgments

We would like to thank Àlex Izquierdo and Daniel Montolio for their help on data collection and Cesar Mantilla for his comments. In addition, we are very grateful to all the schools that participated and were always proactive in collaborating. This manuscript was posted on a preprint: https://pablolomas.github.io/assets/papers/asymmetric-development-strategic-coordination.pdf.

Funding

This research was supported by the Spanish Ministry of Economy and Competitiveness (PID2024-156629NB-100).

Author contributions

P.B.-G. designed research; P.L. conducted the experiments in schools and constructed the dataset; D.J. performed the data analysis; P.B.-G., D.J., and P.L. wrote the paper. P.B.-G., D.J., and P.L. contributed equally to this work.

Competing interest

The authors declare no competing interests.

Data availability

The data and replication code supporting the findings of this study are publicly available in the Zenodo repository (https://doi.org/10.5281/zenodo.19610263).

References

1. Larbi Alaoui and Antonio Penta. Endogenous depth of reasoning. *The Review of Economic Studies*, 83(4):1297–1333, 2016.
2. Ingvild Almås, Alexander W Cappelen, Erik Ø Sørensen, and Bertil Tungodden. Fairness and the development of inequality acceptance. *Science*, 328(5982):1176–1178, 2010.
3. Pablo Brañas-Garza, Diego Jorrat, and Pablo Lomas. Coordination with and without incentives. SSRN 5560849, 2025.
4. Pablo Brañas-Garza. Young teens at play: Girls are egalitarian, boys are generous. *Personality and Individual Differences*, 226:112703, 2024.
5. Isabelle Brocas and Juan D. Carrillo. The determinants of strategic thinking in preschool children. *PLoS ONE*, 13(5):e0195456, 2018.
6. Isabelle Brocas and Juan D. Carrillo. The evolution of choice and learning in the two-person beauty contest game from kindergarten to adulthood. *Games and Economic Behavior*, 120:132–143, 2020.
7. Isabelle Brocas and Juan D Carrillo. Introduction to special issue "understanding cognition and decision making by children." studying decision-making in children: Challenges and opportunities. *Journal of Economic Behavior & Organization*, 179:777–783, 2020.
8. Isabelle Brocas and Juan D Carrillo. Iterative dominance in young children: Experimental evidence in simple two-person games. *Journal of Economic Behavior & Organization*, 179:623–637, 2020.
9. Isabelle Brocas and Juan D. Carrillo. Steps of reasoning in children and adolescents. *Journal of Political Economy*, 129(7):2067–2111, 2021.
10. Isabelle Brocas and Juan D Carrillo. Dynamic coordination in efficient and fair outcomes: a developmental perspective. *Economic Theory*, 80(3):827–861, 2025.
11. Colin F. Camerer. *Behavioral Game Theory: Experiments in Strategic Interaction*. The Roundtable Series in Behavioral Economics. Princeton University Press, Princeton, NJ, 2003.
12. Hans Carlsson and Eric Van Damme. Global games and equilibrium selection. *Econometrica*, 61(5):989–1018, 1993.
13. Marco Castillo, Paul J Ferraro, Jeffrey L Jordan, and Ragan Petrie. The today and tomorrow of kids: Time preferences and educational outcomes of children. *Journal of Public Economics*, 95(11-12):1377–1385, 2011.
14. Russell W. Cooper, Douglas V. DeJong, Robert Forsythe, and Thomas W. Ross. Selection criteria in coordination games: Some experimental results. *American Economic Review*, 80(1):218–233, 1990.
15. Miguel Costa-Gomes, Vincent P Crawford, and Bruno Broseta. Cognition and behavior in normal-form games: An experimental study. *Econometrica*, 69(5):1193–1235, 2001.
16. Simon Czermak, Francesco Feri, Daniela Glätzle-Rützler, and Matthias Sutter. How strategic are children and adolescents? experimental evidence from normal-form games. *Journal of Economic Behavior & Organization*, 128:265–285, 2016.
17. Pedro Dal Bó, Guillaume R Fréchette, and Jeongbin Kim. The determinants of efficient behavior in coordination games. *Games and Economic Behavior*, 130:352–368, 2021.
18. Eduardo Fe, David Gill, and Victoria Prowse. Cognitive skills, strategic sophistication, and life outcomes. *Journal of Political Economy*, 130(10):2643–2704, 2022.
19. Ernst Fehr, Helen Bernhard, and Bettina Rockenbach. Egalitarianism in young children. *Nature*, 454(7208):1079–1083, 2008.
20. Ernst Fehr, Daniela Glätzle-Rützler, and Matthias Sutter. The development of egalitarianism, altruism, spite and parochialism in childhood and adolescence. *European Economic Review*, 64:369–383, 2013.
21. David Gill and Victoria Prowse. Cognitive ability, character skills, and learning to play equilibrium: A level-k analysis. *Journal of Political Economy*, 124(6):1619–1676, 2016.
22. Daniela Glätzle-Rützler, Matthias Sutter, and Claudia Zoller. Coordination games played by children and teenagers: On the influence of age, group size, and incentives. *Experimental Economics*, 28(2):217–236, 2025.
23. William T Harbaugh, Kate Krause, and Lise Vesterlund. Risk attitudes of children and adults: Choices over small and large probability gains and losses. *Experimental Economics*, 5(1):53–84, 2002.
24. John C. Harsanyi and Reinhard Selten. *A General Theory of Equilibrium Selection in Games*. The MIT Press, Cambridge, MA, 1988.
25. Frank Heinemann, Rosemarie Nagel, and Peter Ockenfels. Measuring strategic uncertainty in coordination games. *The*

Review of Economic Studies, 76(1):181–221, 2009.
26. Henning Hermes and Daniel Schunk. If you could read my mind–an experimental beauty-contest game with children. *Experimental Economics*, 25(1):229–253, 2022.
27. Eric J Johnson, Colin Camerer, Sankar Sen, and Talia Rymon. Detecting failures of backward induction: Monitoring information search in sequential bargaining. *Journal of Economic Theory*, 104(1):16–47, 2002.
28. Thomas C. Schelling. *The Strategy of Conflict*. Harvard University Press, Cambridge, MA, 1960.
29. Itai Sher, Melissa Koenig, and Aldo Rustichini. Children's strategic theory of mind. *Proceedings of the National Academy of Sciences*, 111(37):13307–13312, 2014.
30. Matthias Sutter and Martin G Kocher. Trust and trustworthiness across different age groups. *Games and Economic Behavior*, 59(2):364–382, 2007.
31. Matthias Sutter, Martin G Kocher, Daniela Glätzle-Rützler, and Stefan T Trautmann. Impatience and uncertainty: Experimental decisions predict adolescents' field behavior. *American Economic Review*, 103(1):510–531, 2013.
32. Matthias Sutter, Claudia Zoller, and Daniela Glätzle-Rützler. Economic behavior of children and adolescents–a first survey of experimental economics results. *European Economic Review*, 111:98–121, 2019.
33. Mónica Vasco, Antonio Alfonso, Andreu Arenas, Antonio Cabrales, José A Cuesta, Antonio M Espín, María Paz Espinosa, Teresa García-Muñoz, Àlex Izquierdo Nofuentes, Diego Jorrat, et al. Economic preferences and cognitive abilities among teenagers in spain. *Scientific Data*, 12(1):7, 2025.

Figure Legends

Fig. 1. Payoff-based coordination from late childhood to early adulthood. (A) Proportion of participants choosing the payoff-dominant action (P) and meeting the strict criterion for payoff-based coordination (PayD) across age. PayD is defined as selecting the payoff-dominant action and reporting the congruent reason ("Because I earned more"). Payoff-based coordination is already high at early ages and remains broadly flat throughout adolescence and into adulthood. **(B)** PayD by cognitive ability (high vs. low, split at the median within each age group). Higher cognitive ability is associated with higher overall levels of PayD, but the age profile remains largely parallel across groups. **(C)** PayD by gender. No systematic gender differences in the age profile are observed. Error bars indicate 95% confidence intervals. Dashed lines represent the descriptive random-choice benchmarks (0.50 for P; 0.125 for PayD).

Fig. 2. Risk-based coordination increases from late childhood to early adulthood. (A) Proportion of participants choosing the risk-dominant action (R) and meeting the strict criterion for risk-based coordination (RiskD) across age. RiskD is defined as selecting the risk-dominant action and reporting the congruent reason ("Because it was less risky"). Both measures increase with age. **(B)** RiskD by cognitive ability (high vs. low, split at the median within each age group). Higher cognitive ability is associated with greater overall use of risk-based coordination; the age profile is similar across ability groups. **(C)** RiskD by gender. Females show lower levels of risk-based coordination overall; we present the age profiles as descriptive, since the underlying age-by-gender interaction is not robust across specifications. Error bars indicate 95% confidence intervals. Dashed lines represent the descriptive random-choice benchmarks (0.50 for R; 0.125 for RiskD).