Academic achievement helps coordination on mutually advantageous outcomes *

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Abstract

This study examines the relationship between academic achievement and strategic ability to coordinate among middle school students. We designed an experimental framework using repeated asymmetric Battle of the Sexes and Hawk-Dove games, to explore how cognitive and social skills related to academic success influence behavior. A total of 132 students participated, divided into groups of high and low academic achievers based on their performance at school. Our results show that, on average, high achievers coordinate better on equilibrium outcomes with simple but effective strategies and obtain higher payoffs compared to low achievers. This indicates that academic success may reflect broader cognitive abilities–such as strategic thinking, anticipation of others' choices, and cooperation–crucial for navigating real-world interactions. However, we notice also substantial heterogeneity within groups. Finally, performance in pairs with one high and one low achiever is intermediate but closer to the level of high achievers, suggesting potential peer learning effects and the educational value of mixed groups to promote guidance and joint improvements. These findings emphasize the role of long-term learning in developing cognitive skills that facilitate cooperation and strategic interaction in complex environments.

Keywords: developmental game theory, coordination, repeated games.

Significance Statement

This study explores how academic achievement relates to strategic coordination among middle school students. Using classical coordination games, we examined how cognitive and social skills linked to academic success impact behavior. We divided our 132 participants into high and low achievers. Results showed that high achievers coordinate better, using simple strategies and earning higher payoffs than low achievers. This suggests that academic success reflects broader cognitive abilities, such as strategic thinking and cooperation. Additionally, mixed pairs (with one high and one low achiever) performed closer to high achievers, hinting at peer learning effects and the value of diverse groupings for skill development.

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1 Introduction

In game theory, coordination refers to the process by which players align their strategies to achieve a mutually beneficial outcome. This is especially important in games with multiple equilibria—situations where different outcomes are possible where no player has an incentive to change their strategy on their own [1, 2].

Coordination games are highly relevant for modeling real-world challenges such as compromise in relationships, decision-making in team projects, dynamic partnerships, and conflicts over shared resources. A substantial body of experimental research has highlighted differences in the complexity of coordination mechanisms, often linked to variations in personality traits [3], cultural backgrounds [4, 5] and identity of the peers involved [6, 7]. However, developmental aspects of these abilities, particularly during adolescence—a critical period for acquiring cognitive and social skills—remain under-explored.

Recent research from our group indicates that the ability to coordinate develops throughout childhood and adolescence [8]. Adolescence is widely recognized as a pivotal period for developing decision-making styles that often persist into adulthood. Differences in coordination mechanisms seen in adults may stem from variations in intellectual ability, emotional intelligence, or the capacity to read social cues—skills that mature during adolescence and blend into a sophisticated composite ability essential for strategic interaction. Does academic achievement during this formative stage serve as a reflection of this multifaceted skill? Can it reliably predict performance in complex coordination tasks? Despite its relevance, little research has explored how long-term learning ability, captured by academic success, influences adolescents' ability to navigate strategic environments.

In this study, we investigate the link between academic achievement and strategic coordination abilities in adolescents, focusing on middle school students (ages 11 to 14). Academic success, as a composite measure of cognitive and social skills developed through formal education, may reflect broader abilities crucial for strategic interactions. We hypothesize that high academic achievers are better equipped to anticipate others' actions, employ effective strategies, and obtain higher payoffs in repeated coordination games. Also, pairs involving one high and one low achiever may demonstrate intermediate outcomes, suggesting potential peer learning effects. Finally, low achievers may struggle with these tasks, reflecting challenges in problem-solving, attention, and cooperative behaviors. To explore this idea, we design a cooperative experimental paradigm and test the behavior of adolescents with varying levels of academic success.

A main factor in coordination is whether the game is played once or repeatedly. In a one-shot game without communication, coordination can be challenging. In many real-world scenarios, however, individuals often interact multiple times with the same people. Repeated play allows them to learn from past experiences and signal their intentions to try and resolve potential miscoordinations. Overall, while one-shot games are useful for studying how norms influence coordination, repeated interactions involve identification of patterns from previous play and strategic signaling—factors we believe are more closely linked to academic accomplishments. For this reason, we focus on a repeated coordination framework.

A key finding in related studies is the remarkable ability of adults to achieve long-term coordination on fair and Pareto-efficient equilibria in games like the Stag Hunt and the symmetric Battle of the Sexes, where coordination in one-shot versions is rare [9, 10]. This pattern of behavior develops gradually during childhood and solidifies in adolescence [8]. In both cases, adolescents and adults alike often recognize the benefits of a cooperative approach. Intuitive ideas of fairness and efficiency are less effective in the Hawk-Dove (or chicken) game, which involves balancing aggression and avoidance, and in asymmetric versions of the Battle of the Sexes, where long-term fairness requires more complex turn-taking strategies. We decided to employ these two arguably more nuanced and complex games because we anticipated that differences in academic performance would more strongly reflect variations in behavior.

This study contributes to the literature in three ways. First, it addresses unanswered questions about how cognitive and social skills related to academic achievement influence coordination performance. Second, it provides empirical evidence linking academic success to broader strategic abilities, such as forward-thinking and cooperation. Third, it opens new avenues for research by emphasizing the need to disentangle the specific mechanisms underlying coordination, such as problem-solving, attention, and social reasoning.

2 Methods

Population. We recruited 132 children from 6th, 7th and 8th grade in Thomas Starr King Middle School (KING), a public school in Los Angeles. The study was conducted with the University of Southern California IRB approval UP-12-00528. We distributed consent forms to parents through the school administration with an opt-out option. Students' main ethnicities at KING are Latino (55%), White (20%) and Asian (12%). Families are of very low socioeconomic status, with 75% living at or below the national poverty level. Only a minority of these students go to college. Students in the school are divided in four tracks: honors, regular, at risk, and special education. "Honors students" are high academic achievers as identified by the school. They are grouped in advanced classes whenever possible, and pooled with "regular students" otherwise. "Special education students" are individuals with special needs such as dyslexia or attention deficit. They typically have low academic performance due to their difficulty to follow the standard curriculum combined with the school's inability to give personalized education (despite their different needs, all special education students are grouped together due to budget shortages). Finally, "at risk students" are individuals with low academic performance and sometimes in-class problems of discipline. They are usually in the same class as regular students but occasionally they are pooled with special education ones. For power considerations, we grouped students in 2 tracks: 'honors' and 'regular' students are pooled in the *High* academic performance track (28, 35 and 8 students in 6th, 7th and 8th grade, respectively) whereas 'at risk' and 'special education' students are pooled in the *Low* academic performance track (21, 19 and 21 students in 6th, 7th and 8th grade, respectively).

Games. Participants were anonymously paired. In half the sessions, participants were assigned a color (red or green) and played the same asymmetric battle-of-the-sexes game (**aBS**) with the same partner for 18 rounds (which, following [11], we call a "supergame"). They then changed partners and colors and played the same 18-round supergame again. After that, they were assigned new colors (blue or yellow) and played two hawk-dove (**HD**) supergames, again with a fixed 18-round termination rule, and with change of partners and colors between the two supergames. In the other half of sessions, rules were identical except that the order was reversed (two **HD** supergames followed by two **aBS** supergames). Table 1 describes the payoff matrix of each stage game with the points used in the experiment (labels and notations will become clear later).

aBS

		green player	
		red (Y_g)	green (M_g)
red	red (M_r)	(6,2)	(1,1)
player	green (Y_r)	(1,1)	(2,4)

HD

		yellow player	
		in (R_y)	out (S_y)
blue	in (R_b)	(2,2)	(5,3)
player	out (S_b)	(3,5)	(3,3)

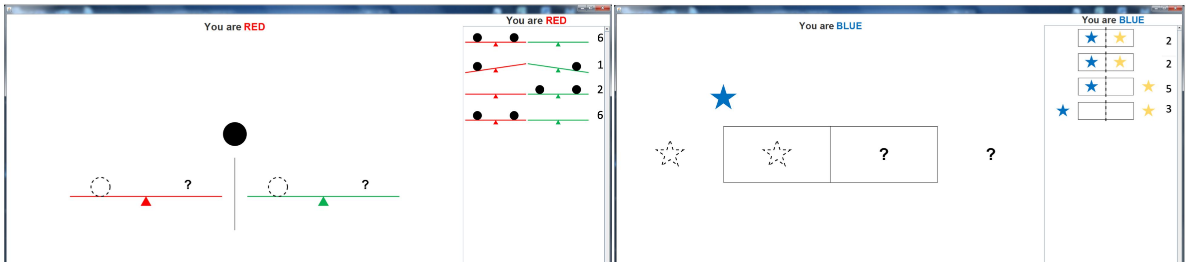
Table 1: Payoff matrix of asymmetric battle of the sexes **aBS** and hawk-dove **HD** games

Grouping. For logistics reasons related to the availability of classrooms, teacher schedules, and students, we could not exclusively form homogeneous pairs. The experiment thus consists predominantly of pairs with two *High* (47%) or two *Low* (40%) academic achievers, but there is also a small fraction of *Mixed* pairs (13%). All pairs consist of participants in the same grade.

Presentation. It was of paramount importance to provide a simple, graphical representation of the game that all participants could easily understand, independently of their intellectual ability. This way, differences in behavior cannot be attributed to misunderstanding or confusion. Figure 1 presents screenshots of the two games with the narrative used in the experiment.

Duration and payments. The experiment consisted of two games: a short lying game analyzed in a different paper [12] and the present study. To avoid cross-contamination, we did not communicate the results of the first game until the end of the second. The experiment never exceeded one school period (50 minutes) including instructions and payments. Participants accumulated points that were converted into money at the rate of 3 cents per point. Since the school does not allow cash on premises, participants were paid immediately after the experiment with an Amazon e-giftcard sent to their school email. Incentives were high: average payment over the two games was $11.90, which is significantly more than typical experiments with school children. A copy of the instructions is included in Appendix A1. The data, full instructions, oTree software and its code are all available in our GitHub page `https://github.com/labelinstitute/dev_DM` under the folder "Coordination & Academic Achievement".

Theory. Repeated coordination games with multiple equilibria of the stage game are particularly interesting to study empirically because theory has very limited predictive power. Indeed, according



(a) aBS screenshot

(b) HD screenshot

Figure 1: Experimental design. **(a) aBS** "Find the Balance" game. Players have a role, red or green (here, red). They each possess a scale with their own color and a ball, which they simultaneously place on one of the scales (dotted circles for own choice and "?" for the partner's choice). If both participants place their balls on the same scale, the scale is balanced and both earn 2 points. Furthermore, the owner of the scale gets an additional 2 points (if green) or additional 4 points (if red), thus generating an asymmetry in the coordination payoff. If players place their balls on different scales, the scales are unbalanced, yielding only 1 point to each. **(b) HD** "Risky Stars" game. A blue and a yellow player (here, blue) possess a star and simultaneously decide whether to place it on or outside a common carpet (dotted stars). Placing the star outside the carpet gives 3 points for sure. Placing it on the carpet gives 2 points if the other player also places their star on the carpet and 5 points if the other player places their star outside the carpet. For both games, the right column populates the past choices of both players. It allows participants to easily track the history of outcomes and their payoffs in the supergame (here, the first four rounds).

to the limit perfect "folk theorem", any feasible and individually rational payoff vector of the stage game is achievable in the finitely repeated game as the finite time horizon gets sufficiently large [13].[1] At the same time, some strategies are more natural and intuitive, and may lead to higher payoffs than others.

For the **aBS** stage-game, we call M_i the choice by player $i \in \{r, g\}$ (red or green) of 'My' favorite action (red scale for red player and green scale for green player) and Y_i the choice of 'Your' favorite action (green scale for red player and red scale for green player). For the **HD** stage-game, we call R_i and S_i the choice by player $i \in \{b, y\}$ (blue or yellow) of the 'Risky' and 'Safe' actions, respectively (see Table 1). Both are two-player coordination games with two pure strategy Nash equilibria–(M_r, Y_g) and (Y_r, M_g) in **aBS** and (R_b, S_y) and (S_b, R_y) in **HD**– and one mixed-strategy Nash equilibrium. Each player prefers a different equilibrium, and their payoff in the mixed strategy one is strictly (**aBS**) or weakly (**HD**) lower than in either of the pure strategy.

aBS captures situations where players have a common goal (a research joint venture, a new legislation) but conflicting preferences on how to achieve it (who invests the most, which provision to compromise). **HD** captures situations where countries at war, competing firms and parties in a negotiation can adopt aggressive or accomodating strategies, with the former yielding highest payoffs only if the rival adopts the latter.

For the repeated game version, we call *Simple Efficient Outcome (SEO)* the strict alternation

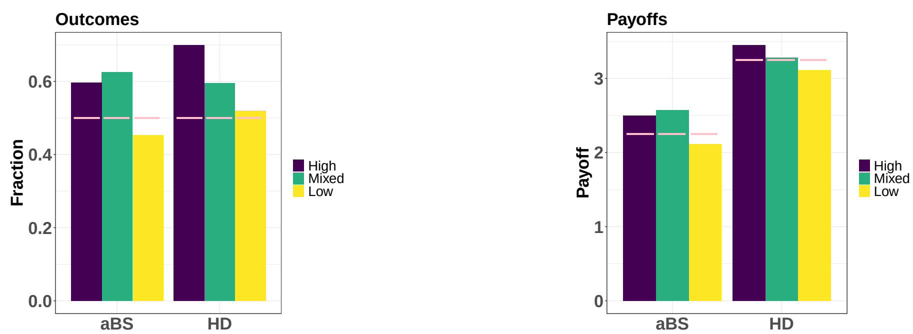
[1]This contrasts with stage games that have a unique equilibrium (such as the prisoner's dilemma) where indefinite repetition is necessary to apply the folk theorem.

between the two equilibria of the stage game: (M_r, Y_g), (Y_r, M_g), (M_r, Y_g), ... in **aBS** and (R_b, S_y), (S_b, R_y), (R_b, S_y), ... in **HD**. The idea can be summarized as "let's choose first your favorite outcome and then mine". Achieving tacit coordination has added difficulties in these games, compared to the more commonly studied symmetric battle of the sexes and stag-hunt games [8]. Indeed, the red and green players in **aBS** obtain different average payoffs under pure alternation (4 and 3, respectively). This is likely to be perceived as unfair, and make the outcome non-focal. Similarly, by choosing always S_i, a player in **HD** can avoid risks and secure a payoff of 3 that does not depend on the willingness or ability of the rival to cooperate.[2]

3 Results

3.1 Aggregate outcomes and payoffs

To study the performance of our participants, we present in Figure 2 the proportion of *equilibrium outcomes* (likelihood of playing one of the pure strategy Nash Equilibria) and the resulting average *payoffs* for each track and game, combining both supergames.[3] The first measure identifies whether individuals succeed in dynamically coordinating their actions. The second measure allows us to quantify the monetary cost of miscoordinations. In what follows, and unless otherwise stated, we perform simple two-sided t-tests for mean comparisons.



(a) Fraction of equilibrium outcomes

(b) Average payoffs

Figure 2: **(a)** Proportion of equilibrium outcomes in **aBS** ((M_r, Y_g) and (Y_r, M_g)) and in **HD** ((R_b, S_y) and (S_b, R_y)) for each track (*High* achievers, *Mixed* pairs and *Low* achievers). **(b)** Average per-round payoff in **aBS** and **HD** for each track. In both figures, behavior of a random player is represented in pink.

These games prove challenging for our middle school participants. Under random behavior, we would observe 50% equilibrium outcomes with average payoffs of 2.25 in **aBS** and 3.25 in **HD**

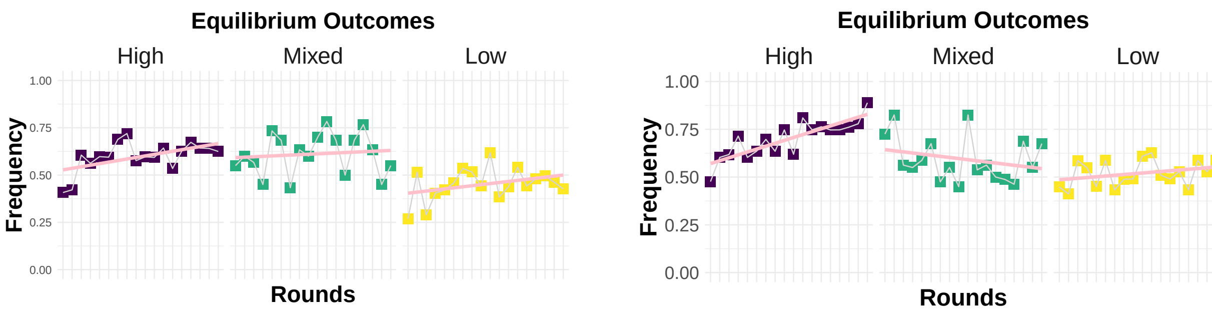
[2]By construction, any outcome where individuals play one of the pure strategy Nash equilibria in every stage is efficient and yields average payoffs in the Pareto frontier. SEO is only a natural outcome on which participants are likely to coordinate. If players wanted to reach the efficient *and fair* outcome in **aBS** (same average payoff for both players), they would need to play (Y_r, M_g) twice as often as (M_r, Y_g).

[3]As the regression analysis will demonstrate, there are no significant differences between both supergames so we combine them to increase statistical power.

(pink horizontal lines). Conversely, perfect coordination on SEO would result in 100% equilibrium outcomes, with average payoffs of 3.5 and 4, respectively. Participants in the *High* track perform significantly better than random in both games, with equilibrium probabilities of 0.60 in **aBS** and 0.70 in **HD** ($p < 0.01$), though far from SEO. Their payoff is very significantly higher than random in **aBS**, but only by a small margin (2.50 vs. 2.25, p = 0.008). Meanwhile, the *Low* track is not statistically different from random performance, in terms of either outcomes or payoffs.[4]

We generally observe highly significant differences between *High* and *Low* tracks in both equilibrium outcomes (0.60 vs. 0.45 in **aBS**, p = 0.006, and 0.70 vs. 0.52 in **HD**, p = 0.001) and payoffs (2.50 vs. 2.11 in **aBS**, p = 0.003, and 3.45 vs. 3.11 in **HD**, p = 0.002). This provides our first indication that academic achievement is a strong predictor of performance in coordination games.

We next examine the outcome dynamics. Figure 3 illustrates the evolution from round 1 to round 18, in the proportion of groups that successfully coordinate on an equilibrium, again combining data from both supergames.



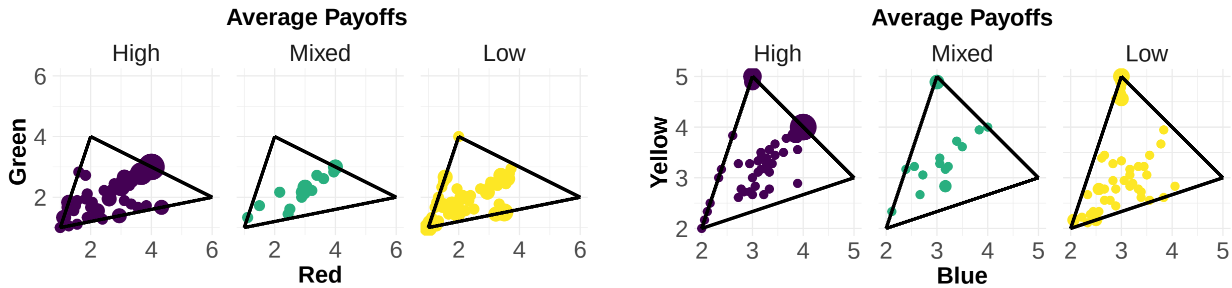
(a) aBS **(b) HD**

Figure 3: Evolution in average proportion of equilibrium outcomes from round 1 to round 18 of a supergame in **(a) aBS** and **(b) HD** separated by track. The best fit trend is represented in pink.

Consistent with Figure 2a, equilibrium play is more prevalent in the *High* track than in the *Low* track, with the *Mixed* track falling somewhere in between. Additionally, the slope β of the coordination trend across rounds within a supergame is positive and significant in the *High* track ($\hat{\beta}^1_H = 0.008$, p = 0.019 in **aBS** and $\hat{\beta}^2_H = 0.015$, $p < 0.001$ in **HD**). This corresponds to an estimated increase in coordination of 14.4% in **aBS** and 27.0% in **HD** between the first and last round of a supergame. In contrast, the *Low* track exhibits greater variability and no significant trends ($\hat{\beta}^1_L = 0.006$, p = 0.15 in **aBS** and $\hat{\beta}^2_L = 0.004$, p = 0.21 in **HD**). To compare the slopes between *High* and *Low* in each game, we combined the datasets and ran a regression with an interaction term between the round number and a dummy variable indicating the track. The significance of the interaction term tests whether the difference in coefficients is statistically significant. We found that it was different at $p < 0.001$ in both **aBS** and **HD**. Finally, inferences in the *Mixed* track are challenging due to the limited number of observations.

[4]The behavior of the *Mixed* track looks comparable to *High* but statistical inferences are difficult to make due to the low number of observations (16 or 18 depending on the game).

Figure 4 extends the analysis of average payoffs by examining the earnings of each pair of players in the game.



(a) aBS **(b) HD**

Figure 4: Average payoffs over all rounds of a supergame in **(a) aBS** and **(b) HD** by track. Dots correspond to pairs of players. Size of a dot is proportional to number of pairs with that payoff combination. The area inside the black lines represents the set of achievable expected payoffs in the game, with the rightmost segment (from (2,4) to (6,2) in **aBS** and from (3,5) to (5,3) in **HD**) marking the Pareto frontier.

Again consistent with Figure 2b, there is a significant difference in payoffs between the *High* and *Low* tracks. Let's define MIN as the vector of payoffs that can be easily secured by the players: (2,2) in **aBS** (achieved by each player coordinating on the rival's preferred outcome) and (3,3) in **HD** (achieved by consistently choosing the safe action). The proportion of outcomes where both players in the pair fall below MIN is 0.22 in **aBS** and 0.17 in **HD** for the *High* track, compared to 0.38 in **aBS** and 0.35 in **HD** for the *Low* track. These proportions are marginally statistically different (test of comparison of proportions, $p = 0.08$ in **aBS** and $p = 0.05$ in **HD**). Conversely, let's define MAX as the vector representing 90% of the payoff under SEO: (3.7, 2.8) in **aBS** and (3.8, 3.8) in **HD**. The proportion of outcomes where both players in the pair weakly exceed MAX is 0.17 in **aBS** and 0.29 in **HD** for the *High* track, compared to only 0.02 in **aBS** and 0.02 in **HD** for the *Low* track. These proportions are significantly different (test of comparison of proportions, $p = 0.02$ in **aBS** and $p < 0.001$ in **HD**). Overall, while there is large heterogeneity in behavior within each track, the payoff gap between the *High* and *Low* tracks is considerable.

Notice that no pair of players in **aBS** achieves or approaches the efficient and fair outcome, as described in footnote 2 $(10/3, 10/3)$. Achieving such coordination likely demands both very high sophistication and a strong belief that the partner is also very sophisticated. By contrast, 13% of pairs in **HD** coordinate on or near the equilibrium preferred by one player. Such acceptance of an inequitable outcome is unusual in the literature.

Last, in Table 2, we conduct OLS regressions to analyze the determinants of performance.

As previously documented, *High* achievers (and to a lesser extent, *Mixed* pairs) tend to play at equilibrium more frequently and obtain higher payoffs than *Low* achievers, the reference group in the regression. There is no significant behavioral difference between the first and second supergame

	Eq. outcomes		Total payoffs	
	aBS	**HD**	**aBS**	**HD**
(const.)	10.1***	11.5***	-1.60	42.66**
	(1.00)	(1.05)	(13.89)	(14.63)
Mixed	2.39°	0.54	8.35**	1.84
	(1.38)	(1.38)	(2.93)	(3.40)
High	1.64°	2.30*	6.70**	4.54°
	(0.93)	(0.97)	(2.12)	(2.38)
HD1st	-2.90**	-2.80**	-5.69**	-5.15**
	(0.88)	(0.91)	(1.96)	(1.97)
Second	0.28	-0.21	0.40	-0.88
	(0.83)	(0.86)	(1.63)	(1.09)
Red	—	—	9.43***	—
			(1.61)	
Age	—	—	0.25**	0.12
			(0.09)	(0.10)
Male	—	—	1.36	-2.73
			(1.88)	(2.08)
Siblings	—	—	-1.23	0.24
			(2.53)	(4.23)
Adj. R^2	0.12	0.12	0.21	0.09
Num. obs.	132	132	262	262

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{\circ}p < 0.1$

Table 2: OLS regressions to determine the effect of track (*Low* is the reference), order of play (*HD1st* is a dummy for participants who start with the **HD** game), supergame (*Second* is a dummy for the second time they play the same supergame), role (*Red* is a dummy for red players in **aBS**) and demographics (age, gender, siblings) on the outcome and payoff of players in **aBS** and **HD**.

of either game (variable *Second*), validating our decision to pool the supergames for the aggregate analysis. Also, given the payoff asymmetry in the battle of the sexes and the lack of coordination on fair equilibria, players in the red role earn significantly higher payoffs than those in the green role (variable *Red*). Age shows a significant effect only in **aBS**, which could be due to the narrow age range in our sample. Gender and having one or more siblings do not appear to impact performance.

The most puzzling finding is the negative effect of starting with **HD** on performance and earnings in both games. While the reason for this outcome is not immediately clear, it could be that starting with **HD** leads to increased complexity or strategic confusion that carries over into subsequent gameplay.

3.2 Individual analysis

We next analyze behavior at the individual level. We consider a very extensive range of strategies that players could plausibly employ, and retain those that are empirically most frequent. A detailed explanation of our classification method can be found in Appendix A2.

The strategies most commonly used by our participants are the same across both games and are among the simplest we considered. (i) Tit-for-tat (TFT): replicate the action of the partner in the previous round; (ii) Alternate (ALT): alternate between the two actions; and (iii) Favorite (FAV): always choose the action that yields highest payoff provided the partner accommodates (M_i in **aBS**, R_i in **HD**). After categorizing players' strategies separately for the first and second supergames to account for potential behavioral changes across games, we show that, with only these three strategies, we classify 74% of decisions in **aBS** and 66% in **HD**. Each additional strategy contributes only marginally to the classification, so we do not include any other. Instead, we group the remaining 26% and 34% of players in the OTHER category.

Identifying a player's strategy within a single supergame is challenging, as we lack the counterfactual of what the player would have done if the partner had played differently. Fortunately, the overlapping of strategies is, in that respect, highly revealing. Indeed, an individual classified as both ALT and TFT (ALT&TFT) is someone who alternates between actions but also plays the action opposite to their rival in every round. Such a person achieves the SEO. In contrast, someone who is only ALT or only TFT is strategic but fails to reach the SEO. On the other hand, an individual classified as both FAV and TFT (FAV&TFT) indicates that both they and their partner consistently choose their favorite action, which leads to miscoordination and low payoffs. By contrast, someone classified only as FAV might be coordinating sometimes (or often) on their favorite outcome.

Table 3 displays the number of participants classified under each strategy (including the overlapping ones) together with their average fraction of equilibrium behavior and their average payoff.

		ALT&TFT *Efficient*	TFT *Strategic*	ALT	FAV *Inferior*	FAV&TFT	OTHER *Unclassified*	*SEO*	*random*
aBS	# obs.	41	42	21	64	27	69	–	–
	% eq.	0.92	0.70	0.73	0.36	0.12	0.51	1.0	0.50
	ave. payoff	3.26	2.74	2.72	2.16	1.22	2.11	3.5	2.25
HD	# obs.	49	21	23	60	20	91		
	% eq.	0.96	0.64	0.66	0.47	0.34	0.57	1.0	0.50
	ave. payoff	3.93	3.44	3.48	2.82	2.68	3.31	4	3.25

Table 3: Number of individuals, average proportion of equilibrium choices and average payoffs under each strategy (including overlapping ones) in **aBS** and **HD**. Equilibrium and payoffs under the SEO and random choice are provided for reference.

The distribution of behavior is similar across games. Participants employ either strategies that are forward-looking and conducive to high average payoffs (*Efficient* and *Strategic*) or strategies that are mostly myopic and conducive to low average payoffs (*Inferior* and *Unclassified*).

Of the 264 observations in each game, around 15%-20% fall under ALT&TFT, an *Efficient* strategy that yields a very high fraction of equilibrium outcomes and an expected payoff close to SEO. Approximately 20%-25% of choices are classified as either ALT or TFT, which are *Strategic* choices. These strategies result in high payoffs, but below SEO due to systematic deviations by players. Then, there are 30%-35% of self-centered choices, classified as either FAV or FAV&TFT.

These strategies rarely achieve coordination (especially the latter one). They lead to *Inferior* outcomes, with payoffs below the random benchmark. For the remaining 25%-35% of choices, a clear strategy is hard to discern, so we categorize them as *Unclassified*. These individuals obtain payoffs around the random outcome. They incur notable losses, though not as severe as those employing self-centered strategies.

Figure 5 presents the distribution of these four types of strategies by game and track.

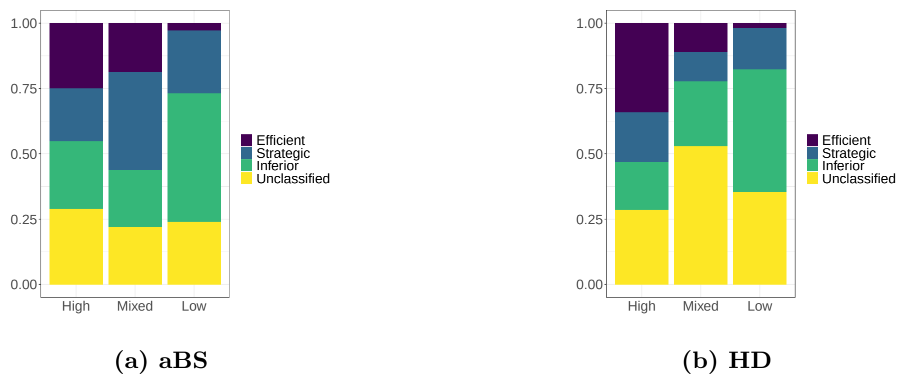


Figure 5: Distribution of individual strategies, *Efficient* (ALT&TFT), *Strategic* (ALT or TFT), *Inferior* (FAV or FAV&TFT) and *Unclassified* (OTHER) by game (**aBS** and **HD**) and track (*High*, *Mixed*, *Low*).

Consistent with previous findings, we observe a sharp overrepresentation of *Efficient* choices among *High* achievers and *Inferior* choices among *Low* achievers in both games. Strategies are more challenging to classify in the *Mixed* track, and in **HD** compared to **aBS**.

Overall, performance is highly heterogeneous, sometimes suboptimal, but typically better in the *High* and *Mixed* tracks than in the *Low* track, with choices closer to equilibrium and higher payoffs. We performed Probit regressions to study in more detail the determinants of individual strategy choices. The results are presented in Appendix A3, and they support the findings of Figure 5. *High* achievers and *Mixed* groups are significantly more likely to adopt the *Efficient* strategy and significantly less likely to choose the *Inferior* strategy compared to *Low* achievers.

4 Discussion

This study contributes to the literature on coordination games by examining how academic achievement influences strategic behavior and coordination among middle schoolers in complex repeated-game settings, such as the asymmetric Battle of the Sexes (**aBS**) and the Hawk-Dove (**HD**) games.

Academic achievement and coordination. A central finding of the study is the strong positive link between academic achievement and performance. On average, *High* achievers outperform *Low* achievers. They are more likely to obtain superior outcomes from the outset and they also improve their coordination over the course of the supergame. This implies that academic achievement may reflect not only domain-specific knowledge but also broader cognitive skills, such as problem-solving, anticipation, and the ability to model others' behaviors—skills that are crucial not only for successful coordination in the game, but also for navigating through life. Conversely, *Low* achievers struggle with coordination which results in significant payoff losses. They do not exhibit significant trends over the course of the supergame. This gap in performance between *High* and *Low* achievers aligns with previous research suggesting that individuals with stronger cognitive skills tend to perform better in tasks requiring forward-thinking and strategic interaction [3, 14, 15]. A major strength of this study is its ecological validity in evaluating cognitive skills, as it avoids reliance on abstract tasks testing narrow abilities. Instead, it uses a single measure—academic achievement—that reflects the cumulative effect of skills developed through long-term learning. However, we recognize that this choice also presents a limitation: academic achievement is a composite measure that aggregates multiple underlying skills, such as problem-solving, anticipation, and social reasoning. This breadth makes it challenging to isolate the specific mechanisms responsible for the observed differences in coordination ability. Despite this limitation, our findings emphasize the broader relevance of academic success in understanding strategic coordination and underscore its value as an ecologically valid predictor of performance in complex environments.

Strategy selection and behavior. The most successful participants use *simple yet effective* strategies that allow for efficient coordination: tit-for-tat and alternation of actions. These strategies are particularly prevalent among *High* achievers, who demonstrate a stronger ability to adopt them. In contrast, the prevalence of self-centered strategies, such as consistently choosing one's favorite action, is much higher among *Low* achievers, resulting in miscoordination and low payoffs. Relying on these uncooperative strategies suggests a difficulty to adapt to the strategic environment, further exacerbating the performance gap. It is also consistent with the existing literature which shows that poor performers in strategic games are typically individuals who focus primarily on salient, self-centered information [16–18]. Future research should explore the link between academic performance and limited attention to better understand the causes of the observed performance gap.

Heterogeneity. A second key finding of the study is the substantial heterogeneity within tracks, thus providing a nuanced view of how academic achievement influences strategic behavior. While *High* achievers generally outperform *Low* achievers, not all consistently play optimally, and some *Low* achievers occasionally demonstrate sophisticated thinking abilities that lead to efficient outcomes. This highlights the complexity of decision-making, where factors beyond academic performance—such as experience, risk-attitudes, social preferences and theory of mind—play a role. This heterogeneity has been observed in young children and has been shown to persist over time in other strategic contexts [19]. *High* achievers may benefit from more challenging tasks that deepen strategic thinking, while *Low* achievers might need foundational support in trust-building and cooperation. Tailored interventions and opportunities could help improve outcomes for those who struggle with coordination tasks.

Performance in mixed pairs. An intriguing aspect of the study is the performance of the

Mixed group. These pairs show intermediate performance (closer to *High* than to *Low* achievers), suggesting that *Low* achievers benefit from interacting with *High* achievers, who likely provide guidance that improves coordination. This aligns with research on peer learning, where exposure to more advanced peers promotes cognitive development [20]. Although it is based on a small sample, this finding suggests that pairing *Low* achievers with *High* achievers can enhance performance in educational settings. Further research is needed to explore the dynamics of these interactions and optimize their benefits.

Inequity. One surprising finding is the prevalence of inequitable outcomes by participants, particularly in **HD**, where around 13% consistently coordinate on outcomes favoring their partner at their own expense but also in **aBS**, where coordination on efficient and fair outcomes is non-existent. This contrasts with the common expectation of inequity aversion, with people typically resisting unequal payoffs, even at personal cost [21]. Several factors could explain this behavior. Younger individuals may be less sensitive to inequity or prioritize maintaining cooperation over fairness. The dynamics of **HD**, where one strategy involves a smaller but safe payoff, might also lead players to view these outcomes as acceptable, even if inequitable. An alternative explanation could be that our participants are inequity averse but find it difficult to identify a way to achieve outcomes that are both efficient and fair. Further research could explore how factors like communication, stakes or environmental complexity influence inequity tolerance and whether this behavior persists into adulthood.

Order of games and behavior. Starting with the Hawk-dove game negatively impacts performance in both games. One possible explanation is psychological priming: **HD** involves conflict, which may prime participants for competitive behavior. Risk-aversion may also play a role, as **HD** encourages safe, cautious strategies that do not translate well into **aBS**. Finally, emotional responses from the conflict in **HD**—such as frustration or distrust—could linger, impairing trust and cooperation in subsequent games. In summary, the observed order effect likely arises from a mix of cognitive, emotional, and strategic factors. Further research could explore how these elements interact to affect performance.

Education. A natural question would be to investigate how interventions aimed at improving strategic thinking and coordination skills might mitigate the documented performance gap. Understanding whether targeted training can improve outcomes of *Low* achievers could have important implications for educational practices. Also, *Mixed* groups generally outperform *Low* groups. This suggests that offering opportunities for collaborative learning and problem-solving may be a way for educators to help support students who struggle with strategic thinking.

Limitations. While this study provides valuable insights into the relationship between academic achievement and coordination performance, there are several limitations worth noting. First, the study is restricted to middle school students, which may limit the generalizability of the findings to other age groups. Additionally, the study does not explore the specific cognitive or social factors that drive the performance differences between *High* and *Low* achievers. Future research could benefit from examining the role of specific cognitive abilities, such as working memory, cognitive flexibility, or theory of mind, in shaping coordination behavior to provide a clearer understanding of the processes at play.

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