Intelligence, Personality, and Gains from Cooperation in Repeated Interactions

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We study how intelligence and personality affect the outcomes of groups, focusing on repeated interactions that provide the opportunity for profitable cooperation. Our experimental method creates two groups of subjects who have different levels of certain traits, such as higher or lower levels of Intelligence, Conscientiousness, and Agreeableness, but who are very similar otherwise. Intelligence has a large and positive long-run effect on cooperative behavior. The effect is strong when at the equilibrium of the repeated game there is a trade-off between short-run gains and long-run losses. Conscientiousness and Agreeableness have a natural, significant but transitory effect on cooperation rates.

I. Introduction

The effect of intelligence and personality and outcomes in single-agent decision problems is straightforward. For example, the relationship be-

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tween intelligence and outcomes for a single individual is natural and clear. Higher intelligence functions as a technological factor; it allows larger, faster, and better levels of production. This prediction is natural and is also supported by extensive research in psychology and economics (Heckman, Stixrud, and Urzua 2006; Jones and Schneider 2010). Similarly, when the task requires consistent application of effort, we can expect higher consistency in subjects with a higher Conscientiousness score. When the interaction is strategic instead, the link may be complex. This is what we study here.

A possible conceptual link between intelligence and behavior in social situations follows if we view choice in economic and social interactions as a cognitive task; the link follows as a corollary. This view produces the general idea that intelligence reduces behavioral biases (e.g., Frederick 2005; Dohmen et al. 2010; Benjamin, Brown, and Shapiro 2013). For example, higher intelligence may reduce violations of transitivity; or, in choice under uncertainty, the behavior of subjects with higher intelligence is better described by expected subjective utility. When we apply this intuition to behavior in strategic environments, we are led to the conjecture that more intelligent individuals in real life—and in an experiment—will exhibit a behavior closer to the game theoretic predictions. When refinements of the Nash concept, such as subgame perfection, are relevant, then one should expect behavior more in line with the prediction of the refinement for individuals of higher intelligence. This prediction finds some support when games are strictly competitive (such as the Hit 15 game in Burks et al. [2009]). Palacios-Huerta and Volij (2009) show that individuals who are better trained (or better able) to solve complex problems by backward induction make choices that are closer to game theoretic predictions in the centipede game. In a repeated beauty contest experiment, Gill and Prowse (2016) show that more intelligent individuals demonstrate better analytic reasoning and thus converge faster to the unique Nash equilibrium.

While these contributions provide important insights into the way cognition affects reasoning on strategic interactions, fundamental questions remain. First, in games that are not strictly competitive, which are per-

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haps more relevant for social behavior, the prediction fails. This occurs already in the case of one-shot games. In Burks et al. (2009), the authors study the behavior of subjects in a sequential trust game. Using a strategy method to identify choices of subjects as first and second mover, and relating this behavior to the intelligence of the subjects, the authors find that initial transfers are increasing with the IQ score, a behavior that is further from the prediction of the subgame perfect equilibrium, and so the opposite of what we should expect according to the general hypothesis. Similarly, transfers as second movers among the more intelligent subjects are higher when the first mover transfers more and smaller in the opposite case. A second and more important consideration is that the prediction of a unique strategic behavior is rare: for example, repeated games generally present a multiplicity of equilibria. Thus, games with a unique Nash equilibrium cannot address the crucial issue for the social sciences of how individuals coordinate to reach one among many possible equilibria. Game theory and the initial intuition of modeling strategic behavior as a cognitive task leave us with few useful predictions.

A. *Strategies and Rules*

To progress, we think of strategies as composed of rules. A rule is a conditional statement prescribing an action given a relevant condition. In our experimental setup, relevant conditions are the histories available to players. These histories include the partial histories of play in all the matchings that have occurred until the current round. An example of a rule is "If the other player defects, defect for one period." A strategy is a complete set of rules—complete because an action is prescribed by the set of all rules in all possible contingencies.

When we consider performance of players in isolation, evidence suggests that intelligence may affect implementation of rules even in simple tasks. For example, Duncan et al. (2008) study a specific form of failure called *goal neglect*; this occurs when an individual knows he should apply a rule and, if asked, is even able to state it but nevertheless fails to apply it. Such failures occur more frequently in individuals with lower intelligence. Goal neglect is identified in a task in which subjects have to consider pairs of numbers and letters presented sequentially (e.g., $(A, 7)$, (S, M), $(2, 6)$). They initially have to follow this rule: "Read the item on the right, if it is a letter, and ignore it, if a number." So, in our example they should read the letter M in the second pair and nothing from the other two pairs. At some random interval, a plus or a minus sign appears that may modify the rule. The plus means "Continue as before" and the minus means "Read the item on the left," again, only if it is a letter. With subjects of lower intelligence, the modifier of the rule (the plus or the minus) tends to be ignored. The result indicates a high correlation between IQ score and the ability to adjust to the switch required by the appearance of the minus sign. We model this error in decision making by relying on a new axiomatic theory of stochastic choice (Cerreia-Vioglio et al. 2017); the model allows for precise estimation of the way in which intelligence and personality traits affect the frequency of errors.

B. *Experimental Design*

The main hypothesis we test is the potential association between intelligence, personality, and strategic behavior in groups. The strategic interaction takes place between two players, but within a pool of subjects who are similar in intelligence or personality. We rely on a well-established methodology in the experimental analysis of repeated games and use the same setting as in Dal Bó and Fréchette (2011), where the authors show how, with appropriate probability of continuation and payoffs, subjects in a repeated Prisoner's Dilemma game with a random probability of termination may collectively converge to cooperation equilibria. We test whether higher intelligence in such an environment favors a more flexible and precise behavior that allows processing of richer information, that is, whether higher intelligence allows for more efficient equilibria to be reached. We use the same methodology to test whether other personality traits (Conscientiousness and Agreeableness) have similar effects.

C. *Paper Layout*

The paper is organized as follows: In Section II, we formulate our hypotheses on the role of intelligence and personality on the strategic behavior. In Section III, we present the experimental design and our model of error in decision making. The next two sections analyze the role of intelligence: in Section IV, we discuss how intelligence affects errors in implementation and thus cooperation, while in Section V, we show how differences in intelligence affect strategic reasoning. The role of Conscientiousness and Agreeableness is discussed in Section VI. The effect of intelligence on response time is discussed in Section VII. Section VIII presents our conclusions. Additional technical analysis, robustness checks, details of the experimental design, and descriptive statistics are in the online appendix.

II. Intelligence, Personality, and Strategic Behavior: Hypotheses

In a repeated game with a high discount factor the set of subgame perfect equilibrium outcomes may be large, so the analysis of the effect of personality on choice may seem hard at first sight. However, experimental evidence on subjects' behavior indicates that the set of observed outcomes is considerably smaller than the entire one predicted by subgame perfect equilibria. Typically subjects reach a tacit (the only communication occurs through history of actions) agreement on outcomes that are efficient within the equilibrium set (constrained efficient). The outcomes are also simple to implement; for example, a formulation of the strategy profile with a finite state automaton is natural, and the number of the states of the automaton is small. Finally, the agreement is usually reached on outcomes that give at least approximately equal payoffs, within the limits imposed by the payoff of the game. We summarize these criteria into an assumption to organize our analysis:

Assumption 2.1. Subjects try to achieve a constrained efficient, simple outcome with minimum difference among final payoffs of the players.

Our data in this paper offer additional support for assumption 2.1. Under this simplifying assumption, we proceed to formulate more substantial predictions.

A. *Intelligence and Strategic Behavior*

We investigate how intelligence affects strategic behavior in repeated interactions and hypothesize that intelligence may affect behavior in two different ways:

i. Intelligence may affect the choice of strategies by affecting the set of strategies that are conceived by the individual. For example, a strategy like Always Defect (AD) in a repeated Prisoner's Dilemma (PD) is very simple to conceive. By contrast, a strategy prescribing cooperating in the first round, defecting against a defection of the partner for three periods, and then returning to cooperation only after the partner has cooperated for the past three periods is more complex to ideate. Thus, more intelligent individuals may choose more profitable strategies in a larger set.
ii. Intelligence may affect the implementation of the strategies. More complex strategies are more difficult to implement; for example, the AD strategy does not require a record of actions of the two players and does not require a check of a sequence of conditional statements, whereas Tit-for-Tat (TfT) does. We hypothesize that the performance failure of lower-Intelligence players is related to that observed in goal neglect.

We formulate the general hypothesis:

Hypothesis 2.1. Higher-Intelligence subjects (i) find a better strategy—that is, with higher payoff—and conceive a larger set of strategies in a given environment and (ii) are more consistent in their implementation. Given the aim stated in assumption 2.1 (which holds independently of the intelligence level), higher-Intelligence subjects will achieve, in general, higher rates of cooperation.

We will test part ii of the hypothesis in Section IV and part i in Section V; in the rest of this section we will derive more specific predictions from these hypotheses.

B. *Intelligence and Rule Implementation*

The next hypotheses are easier to present if we describe the games we use in our experiments. We consider repeated games with a symmetric two-player, two-action stage game. These are now well understood experimentally. After relabeling of the action choices of one or both players, this game can be written in the standard form:

$$\begin{array}{ccc} & L & R \\ T & a, a & c, b, \\ B & b, c & d, d \end{array} \tag{1}$$

where a, b, c, and d are four possibly different numbers. Again relabeling, if necessary, we can assume $a \geq d$ and $b \geq c$. In appendix A we present a detailed and simple analysis of the equilibria of repeated games with discount $\delta \in (0, 1)$ with such stage games. We will formulate our specific hypotheses on the basis of this analysis. Here are our main conclusions.

The four different repeated games we use in the paper are representative of different and very specific strategic situations. They are Prisoner's Dilemma, PD (where $(a, b, c, d) = (48, 50, 12, 25)$), Battle of Sexes, BoS ($(0, 48, 25, 0)$), Stag Hunt, SH ($(48, 25, 0, 25)$), and a new game that we call the Battle of the Sexes with Compromise, BoSC ($(48, 52, 12, 10)$) (see app. tables A.1–A.4). The BoSC game may be considered as a modification of the Hawk-Dove game, requiring the payoff from (Dove, Dove) to be strictly larger than the mean of (Hawk, Dove) and (Dove, Hawk). Actions are labeled in the paper with mnemonic letters: C and D for the PD, B (allowing the players' best payoff) and W (worst nonzero payoff) for BoS and BoSC, and finally S (stag) and H (hare) for SH.

In the analysis (app. A) we show that the stage games we consider in this paper cover the interesting cases of repeated games with stage games of the form (1) above. The few (two) cases we do not address have no substantial independent interest. The first is a stage game with a single equal outcome Nash equilibrium that is efficient (this is case 3 in app. A); we consider this game too trivial to be worth analyzing experimentally, since the efficient equilibrium is obvious. The other is mentioned in case 4b, namely, the PD with an efficient alternating equilibrium: but the essential point of this game is covered by the BoSC.

The games we consider have natural and simple equilibria: the corresponding action profile outcomes are (S, S) in every round giving the SH efficient outcome and an alternation between the action profiles giving the best outcome for one player and the worst (among the positive ones) outcome for the second, that is, (B, W) and (W, B) for BoS and joint cooperation (C, C) in every round for PD, when the parameters make cooperation sustainable. In these equilibria the outcome in every round is either a repetition of the same action profile or an alternation between two action profiles (in BoS). The new game, the BoSC, has a simple outcome mirroring that of the BoS of alternating between (B, W) and (W, B); but the *compromise* action profile (W, W) in every round gives a payoff (48, 48) that is higher than the average of the two outcomes (52, 12) and (12, 52) given by alternating. The positive and symmetric payoff outcome (10, 10) for the (B, B) profile (rather than (0, 0), as in BoS) was chosen to make the coordination on the constant outcome (W, W) more difficult. In all cases, an equilibrium that satisfies assumption 2.1 is easy to discover after simple inspection of the stage game; that is, within the class of symmetric two-player, two-action stage games, a typical college student can easily identify the equilibrium and safely assume that the partner does too. The existing literature on experimental repeated games confirms for PD, BoS, and SH that the equilibria we describe as natural are indeed typically the outcome. In light of these considerations, it is possible that, when subjects are college students, there is no substantial difference in the ideation of the possible strategies in the class of repeated games with a symmetric two-player, two-action stage game. To see these differences, research will have to adopt different groups of subjects or a different class of games.

There is a specific difficulty in the case of the BoS that is clearer when we compare the game with the SH, a game in which (as we see later) there should be no difference in implementation. The efficient equilibrium outcome in SH is particularly simple to see, and achieving coordination on it is easy: the only tempting feature of the choice of action H is the lack of risk associated with it. By comparison, the alternating equilibrium in BoS is more complex. First, subjects have to understand that alternation is a way to avoid the zero payoff outcomes, and they have to communicate this idea to their partner. Second, they have to agree on the order of the alternation, and the only symmetric way to do this is to play randomly either action in the early rounds, starting the alternation at the first instance of coordination on a positive payoff outcome. Although these considerations are within the intellectual reach of a college student, the details of the coordination process are more complex in the BoS; hence there might be a difference in the speed at which subjects of different intelligence reach coordination, and there is the possibility that players of lower intelligence never reach that point. Thus, we formulate the following hypothesis:

Hypothesis 2.2. Subjects of higher intelligence are faster in achieving coordination in the efficient alternating equilibrium in BoS, whereas there is no substantial difference in SH.

From the point of view of strategy implementation, instead, there are two classes of games with a substantial difference concerning the trade-off between gain from deviation in the current round and loss from deviation in the continuation game. In the first group (which includes BoS, SH, and in general the classes 1, 2*a*, and 3 in app. A) there is no trade-off between gain from deviation in the current round and change in the continuation value: a deviation induces a loss in both. In the other group (which includes PD and BoSC and in general classes 2*b* and 4 in app. A) there is a trade-off: deviating from the equilibrium action profile induces a gain in the current payoff and a loss in the continuation value.

This opens the possibility of errors depending on the intelligence level of the subjects, similar to the "goal neglect" concept described in Section I. When there is a trade-off between short-term gain and long-term loss, subjects of lower intelligence may neglect to follow the rule dictated by the chosen strategy and may play to maximize their earnings in the short term. Accordingly, a fundamental difference between SH and BoS on one hand and PD and BoSC on the other is that at the equilibrium action profile there is a trade-off present in every round between short-run gain from deviation and long-run loss. Instead, there is no such trade-off in SH and BoS. This justifies a specific hypothesis in our environment:[1]

Hypothesis 2.3. The trade-off between current gain and continuation value loss from deviation in PD and BoSC produces a difference in cooperation rates across IQ groups in these games. In SH and BoS, there is no trade-off, and, thus, no difference in the implementation between the IQ groups, once coordination is reached.

C. *Strategic Behavior and Personality*

Two of the Big Five factors are more likely to be relevant for strategic behavior: Agreeableness and Conscientiousness. Agreeableness directly affects the social behavior of individuals; Conscientiousness influences the effectiveness and orderliness of execution of tasks, in particular of cognitive tasks like strategy implementation.

In the IPIP-NEO-120 inventory (Johnson 2014) that we use for conceptualization and measurement of personality, Conscientiousness has six facets. Four are potentially relevant in fostering equilibrium cooperation in our context, because they ensure an effective and mindful implementation of the strategy, considered here as a rule of individual behavior; they are *self-efficacy*, *orderliness*, *achievement-striving*, and *self-discipline*. Two other facets are more specific to the strategic side of our experiment: a higher score

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[1] In app. C, we offer the historical evolution of hypothesis formulation and design.

in *dutifulness* might prevent a subject from defecting, whereas a higher score in *cautiousness* might induce the individual to refrain from cooperation in PD, because it exposes her to a risk of defection of the other. Part of this effect may be captured by risk aversion, but cautiousness might have a distinct effect and be particularly relevant when the individual has experienced past defection. In summary, the first five facets might induce a more cooperative behavior, while cautiousness might have an opposite effect on the willingness of the individual to cooperate.[2]

Hypothesis 2.4. The facet cautiousness of Conscientiousness may decrease unconditional cooperative behavior in repeated PD; the other facets may increase it. Thus the overall effect of Conscientiousness is ambiguous and may require analysis of the facets.

Agreeableness has six facets; three of them are particularly relevant for behavior in repeated games. One, *altruism,* may indicate how much the payoff to the other player matters to the subject. The other two, *trust* and *cooperation,* should affect how likely they expect cooperative behavior from others (e.g., when choosing C in PD) and how inclined they are to cooperate with others. All these facets should clearly provide a motivation to cooperate. Our natural hypothesis is then as follows:

Hypothesis 2.5. Agreeableness increases unconditional cooperative behavior in repeated PD through the facets of altruism, trust, and cooperation.

III. Experimental Design and Estimation

Our design involves a two-part experiment administered over two different days separated by 1 day in between. Participants are allocated into two groups according to some individual characteristic that is measured during the first part, and they are asked to return to a specific session to play several repetitions of a repeated game. Each repeated game is played with a new partner. The individual characteristics that we consider are Intelligence, Agreeableness, and Conscientiousness, across different treatments that we will define as IQ-split, A-split, and C-split, respectively. In one treatment, participants are not separated according to any characteristic, but rather allocated to ensure similar groups across characteristics; we define this as the combined treatment.

The matching of partners is done within each session under an anonymous and random rematching protocol. The group size of different sessions varies depending on the numbers recruited in each week.[3] Unless

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[2] All the questions we used to assess the personality traits and their facets can be found in the Experimental Documents available online.

[3] The bottom panels of tables A.5–A.11 list the sample size of each session across all treatments. Participants were not directly informed of the number of subjects in their session, but they could see how many people would take part prior to their entry to the lab.

specified otherwise, the length of play of the repeated game during the second day was 45 minutes. As usual, we define as a supergame each repeated game played; period refers to the round within a specific supergame; and, finally, round refers to an overall count of the number of times the stage game has been played across supergames during the session.

Subjects in the two different groups based on the specific characteristic of the different treatments are otherwise reasonably similar (see tables A.61–A.67). We observe systematic differences only in one treatment, the C-split; this is unlikely to generate confounding as will be clear from the econometric analysis below.

Across all treatments, the subjects are not informed about the basis on which the split was made.[4] In a subset of our sessions (IQ-split sessions only) we ask the participants during the debriefing stage (i.e., after all the tasks were completed during the second day) whether they understood the basis on which the allocation to sessions was made. Only one or two participants out of the approximately 100 asked mentioned Intelligence as the possible determining characteristic; the rest appeared to be unaware of the allocation procedure. (Many participants believed that the allocations were done randomly.)[5] A complete list of the treatments is reported in appendix D.2.

Unless stated otherwise, all participants were noneconomists who had not taken any game theory modules or classes.[6] A total of 792 subjects participated in the final experimental sessions. They earned on average around £20 each; the participation payment was £4. The ethical approval for the design was granted by the Humanities and Social Sciences Research Ethics Committee at the University of Warwick under the Decision Research at Warwick Umbrella Approval (Ref: 81/12–13). All details about the design are in appendix D, and descriptive statistics of the different sessions and treatments are in appendix H.

Strategy of analysis.—In the experiment we generally collect multiple data for each subject $i \in \{1, \dots, N\}$ making choices or achieving a payoff in different periods $t \in \{1, \dots, T_i\}$ that we aim to explain. Hence our raw data have a panel structure. In appendix E.1.1 we present three types of

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[4] We initially ran two sessions in which we informed participants about their Raven scores as well as the average in the session. The cooperation rates of these sessions are presented in app. K and do not seem to be different from the other sessions in which participants did not have this information.

[5] How intelligent players adjust their strategy if they know that they interact only with high-IQ types or with heterogeneous types in our experimental setting would be an interesting subject for further research. Palacios-Huerta and Volij (2009), analyzing this issue in an experimental analysis based on the centipede game, show that there is an effect.

[6] The recruitment was conducted with the Decision Research at Warwick system, based on the SONA recruitment software. The recruitment ensured that the participants were selected from across the university student population and represented a wide variety of degree courses, which were evenly divided across sessions. Some examples of the participants' degree courses are accounting and finance, business, film studies, physics, and psychology (see tables A.12–A.18 in app. D for the full list of degree courses across the different treatments).

models we estimate in the analysis of the effect of intelligence and personality traits on the cooperative choices.

In what follows, we give a precise and testable formulation of the second part of hypothesis 2.1 relying on the axiomatic characterization (Cerreia-Vioglio et al. 2017) of choice probabilities of the *softmax* form, which depend on a parameter t describing a characteristic or type of the subject:

$$p_t(x, X) = \frac{e^{\lambda(t)u(x)}}{\sum_{z \in X} e^{\lambda(t)u(z)}}, \tag{2}$$

where $p_t(x, X)$ is the probability that alternative x is selected from the set X of feasible alternatives. The function λ takes nonnegative values; the utility function u in equation (2) is cardinally unique, and if u is nonconstant, the function λ is unique given u. In the original interpretation (Cerreia-Vioglio et al. 2017) the parameter t is time, which can be interpreted as experience or reflection time. In the interpretation proposed here, t is the type of the decision maker. At the lowest value of $\lambda(t)$ all alternatives have the same chance of being selected. At its highest value, $+\infty$, u is maximized over A. At intermediate values, u is soft-maximized with intermediate accuracy. As $\lambda(t)$ increases (e.g., if $t =$ IQ score increases), the probability that the true optimal alternative according to the utility u is chosen increases monotonically. We adapt the formulation to our current environment of choice in repeated games, restricting the attention to the two-actions case, labeled x and y. The value of each action in a round is defined given (i) a history preceding the trial and (ii) the strategy of the players. So $u_G(x)$ is the value for a player of choosing the action x in the game G in the set {PD, BoS, SH, BoSC} (representing Prisoner's Dilemma, Battle of Sexes, Stag-Hunt, and Battle of Sexes with Compromise, respectively). It includes the expected current payoff, given the belief on the action of the other, and the continuation value after that action given history and strategy. We assume $u_G(x) < u_G(y)$ (so x is the error); the probability of error is defined as the probability of choosing x given the characteristics t and the values of each action and given by

$$\Pr(Ch = x | G, t) = \frac{1}{1 + e^{-\lambda(t)[u_G(x) - u_G(y)]}} \tag{3}$$

so that the probability of error is higher with lower values of $\lambda(t)$ and with lower difference $u_G(x) - u_G(y)$.

IV. Path of Cooperation and Errors in Implementation

In our general hypothesis 2.1 we identified two possible main directions of the effect of intelligence. As we are going to see, consistency in strategy implementation (point ii) has the strongest effect, and we begin from that point. We provide two main tests of this hypothesis.

The first test we present in the section below relies on an experimental manipulation: our main substantive hypothesis 2.3 predicts a difference in behavior between the two groups of subjects with different intelligence in games (such as, in our design, PD and BoSC), where the natural equilibria (those satisfying assumption 2.1 and described in Sec. II.B and app. A) exhibit a trade-off between short-term gain from deviation and long-term loss. We then compare these results with games in which this trade-off does not exist (such as, in our design, SH and BoS), which we analyze in Section IV.B.

The second test is an analysis of the probability of error in choice (in the precise sense of eq. [3]), testing the prediction that error is more likely in subjects with a lower IQ score; this test is provided in the descriptive analysis of Section IV.C and in the model-based analysis of Section IV.D.

A. Games with Trade-offs

We present here the evidence supporting hypothesis 2.3, focusing first on the repeated PD, where cooperation is likely in general groups of subjects (as shown in Dal Bó and Fréchette [2011]), and on the BoSC, both with high continuation probability, $\delta = .75$. The natural equilibria we consider are those giving (C, C) outcome in all periods in PD (e.g., a pair of Grim Trigger strategies for each player; the analysis of the empirical frequency of the strategies is developed later) and those giving (W, W) outcome for the BoSC (e.g., a pair of strategies in which both players play W until either defects and then play the mixed-strategy equilibrium). The feature common to the two games is the short-run gain (of 2 points in PD and 4 points in BoSC) at the equilibrium choice and the continuation value loss from deviating. The difference between the two games is that for PD a continuation strategy is easy to identify (e.g., play (D, D) in all periods), whereas what to do after the agreement to play (W, W) fails is harder to identify. Some natural possibilities are switching to the mixed strategy or alternating between (B, W) and (W, B), but coordinating on one of these is harder.

1. Differences in Cooperation and Compromise

In the top-left panel of figure 1, we present the evolution of cooperation in the low- and high-IQ sessions of the PD.[7] The initial cooperation rates (first five supergames) are similar in the two groups, but they progressively diverge until the rate reaches between 80 and 90 percent for the high-IQ group while remaining at about 40 percent for the low-IQ group. The average individual payoff per round follows that of the cooperation

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[7] Similar patterns replicate when we consider each individual IQ session; see fig. A.7 in app. K.

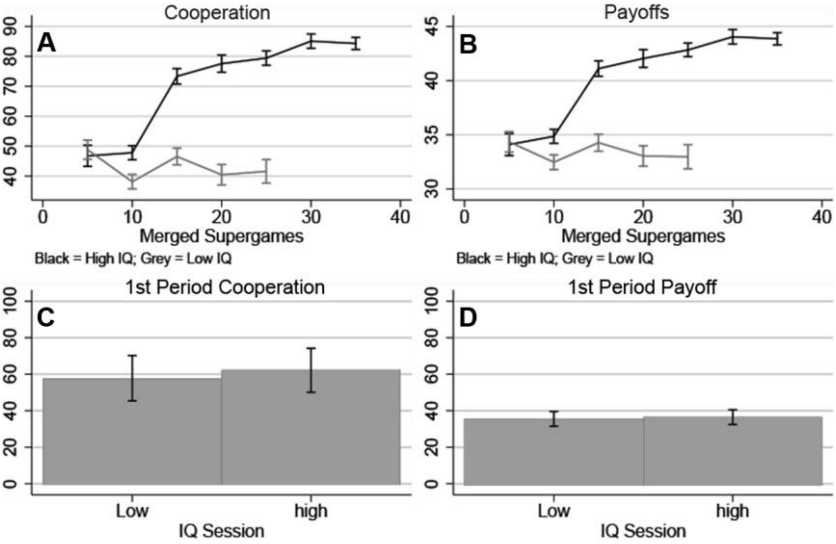

Fig. 1.—PD with high continuation probability: cooperation and payoffs per period in the low- and high-IQ sessions. Panels A and B report the averages computed over observations in successive blocks of five supergames of all high- and all low-IQ sessions, aggregated separately. The black and gray lines report the average cooperation for high- and low-IQ subjects in each block. Panels C and D report the average of cooperation and payoffs in the first round (of a repeated game) that occurs in the two IQ sessions separately. Bands represent 95 percent confidence intervals.

rates (right panel of fig. 1). In figure 2 we report the cooperation rates for PD sessions in which individuals are not separated according to IQ (i.e., the combined treatment); in the analysis of these sessions, we group players into statistical partitions of high (Raven score larger than the specific session median) and low IQ. Here the cooperation rate increases over time in both partitions, but it is consistently higher among the high-IQ partition's subjects, who also earn higher payoffs per supergame.[8] This pattern lends support to the hypothesis that individuals with higher intelligence may try to teach individuals with lower intelligence, as in Hyndman et al. (2012). We will see below more evidence consistent with this hypothesis. The payoffs of both partitions tend to grow and converge in the end, which seems to rule out the possibility that more intelligent individuals might extract surplus from those less intelligent.

The top-left panel of figure 3 reports the percentage of subjects reaching the compromise outcome in the BoSC;[9] the data are aggregated as in

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[8] Similar patterns replicate when we consider each individual session; see fig. A.9 app. K.

[9] In the BoSC and later in the BoS we consider outcome rather than choice as the dependent variable. In both games there are different natural equilibria, e.g., in BoSC alternating between (W, B) and (B, W) or compromising on (W, W). So it is easier to identify whether they have coordinated on the first or on the second by considering outcomes.

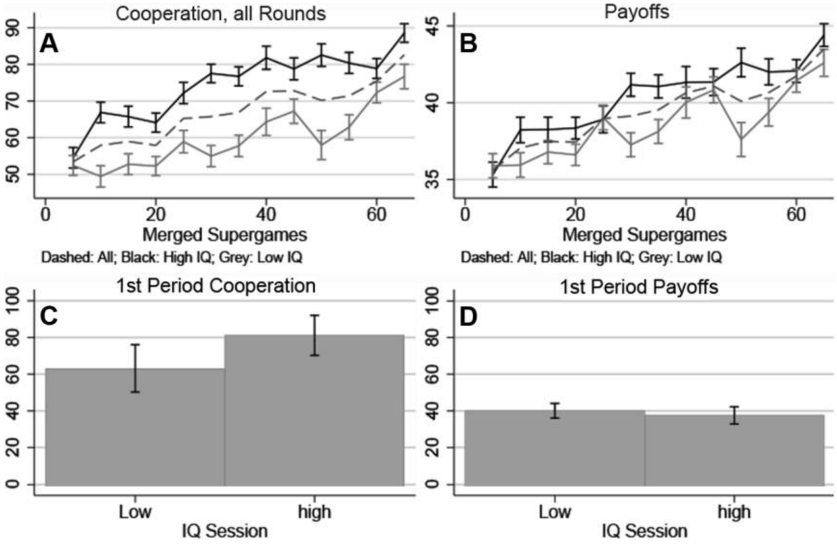

FIG. 2.—PD with high continuation probability and combined sessions: cooperation and payoffs per period in the low- and high-IQ partitions. Panels A and B report the averages computed over observations in successive blocks of five supergames of all high- and all low-IQ partitions, aggregated separately. The dashed lines represent the average cooperation in each block; the black and gray lines report the average cooperation for high- and low-IQ partitions in each block. Panels C and D report the average of cooperation and payoffs in the first round (of a repeated game) among the two partitions. Bands represent 95 percent confidence intervals.

figure 1.[10] The figure clearly illustrates a difference in long-run behavior in compromise rates of the two IQ groups. In the high-IQ group the fraction of subjects playing the compromise outcome (*W*, *W*) is higher than in the low-IQ group, with an overall positive trend in the high-IQ group and a negative trend for those in the low-IQ group. The bottom panels of figure 3 show that the behavior in the first period is similar in the two groups. The top-middle panel of figure 3 shows that the low-IQ group more frequently plays the coordination outcomes (*W*, *B*) or (*B*, *W*), which constitute a lower average payoff. The difference in this frequency is approximately of the same size as the difference in the two groups' compromise rates.

Therefore, in summary, we have the following result:

RESULT 4.1. In PD and in BoSC the high-IQ group has larger rates of cooperation and (respectively) compromise than the low-IQ group, as hypothesis 2.3 predicts.

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[10] Similar patterns replicate when we consider each individual session; see app. L.

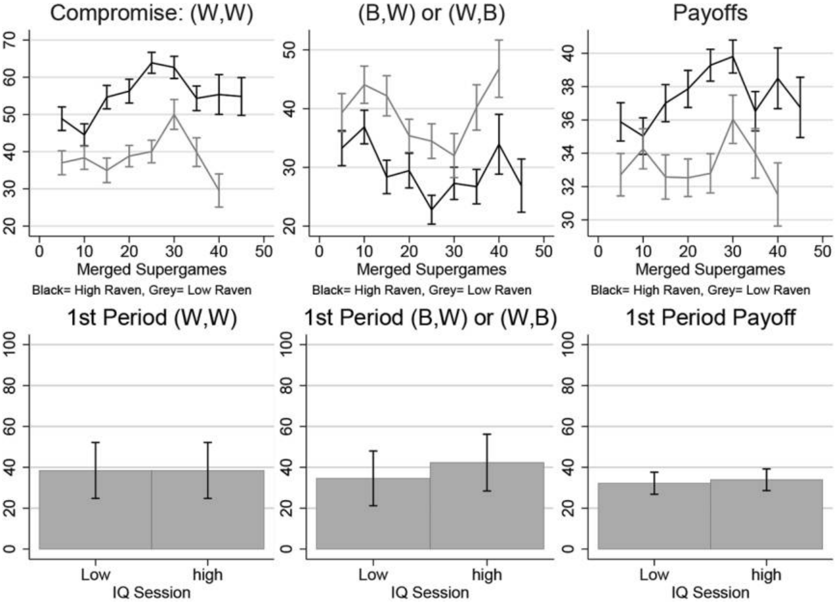

Fig. 3.—BoSC: compromise, coordination, and payoffs per period in the low- and high-IQ sessions. The top panels report averages computed over observations in blocks of five supergames of all high- and all low-IQ sessions, aggregated separately; the black and gray lines report the percentage of subjects achieving a compromise output, coordination output, and average payoffs for high- and low-IQ sessions. The bottom panels report the averages in the first period among the two groups of sessions. Bands represent 95 percent confidence intervals.

2. Effect of Individual Intelligence on Cooperation and Compromise

In appendix E.2.1, we estimate the effect of individual IQ and show that the effect of intelligence is not due to observable confounding factors at the individual levels and/or environmental factors at the session levels (observable or not).

To disentangle the effect of individual intelligence from that of group intelligence, we compare in table 1 the effect of the treatment of separating individuals according to their IQ group with the combined sessions. The cooperation rate in the low-IQ sessions is about 14 percent lower than in the combined sessions, costing about 3.5 units per round. There is no significant difference between high-IQ sessions and combined sessions. From column 3 we derive an estimate of the loss, in terms of payoffs, for any individual with a given level of IQ, in participating in a low-IQ session. This is about three experimental units per round, not considering the experience effect of being able to play more rounds (col. 3). This

TABLE 1

Effect of IQ-Split Treatment in PD with High Continuation Probability

	Supergame ≤ 12			All		
	Cooperate (1)	Payoff (2)	Payoff (3)	Cooperate (4)	Payoff (5)	Payoff (6)
IQ			7.3393***			9.9126***
			(2.3336)			(2.1377)
High-IQ session	−.0242	−.3979	−1.5384	.0395	1.0376	−.5039
	(.0511)	(.8920)	(.9477)	(.0522)	(.8939)	(.9195)
Low-IQ session	−.1430***	−3.5286***	−2.9563***	−.1831***	−4.6319***	−3.8919***
	(.0504)	(.8807)	(.8834)	(.0481)	(.8239)	(.8061)
Number of subjects	−.0101	−.2275	−.2448	−.0139*	−.3234**	−.3502**
	(.0087)	(.1527)	(.1500)	(.0084)	(.1441)	(.1383)
Average rounds supergames	.0605**	1.5867***	1.5302***	.0351	.8658	.8088
	(.0279)	(.4872)	(.4786)	(.0390)	(.6677)	(.6405)
R^2	.055	.104	.140	.115	.217	.283
Observations	240	240	240	240	240	240

Note.—The regressions include the data from PD (high δ), IQ-split, and combined treatments. The dependent variables are average cooperation and average payoff across all interactions. In cols. 1–3, the averages are calculated over the same number of supergames played by every individual, so that the longer sessions are truncated. Cols. 4–6 use all supergames. Ordinary least squares estimator. Standard errors are in parentheses.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

becomes about 3.9 units if we consider also the effect of the experience (col. 6).

3. Evolution of Behavior over the Session

We cannot make specific predictions for initial rates of cooperation in the two groups: subjects in the early stages of the session know only that they are facing repeated interactions within a match, and with repeated partners within the session, so it is difficult to predict what they are thinking about the behavior of others before they see how the others are playing. For example, if the natural strategies in a game were complex, some initial difference in behavior according to intelligence might be possible. It is a fact, however, that in our sessions we consistently observed a very similar behavior in the initial periods in the two groups. In our sample, the difference in behavior follows almost entirely from the experience acquired during the session.[11]

The bottom panels of figure 1 show that there is no significant difference in the first period.[12] Similarly in the BoSC, figure 3 shows no difference in the rate of compromise outcomes in the initial period. Recall, however, that in the BoSC we are considering the outcome rather than the choice; thus the interpretation is less straightforward because of the difficulty of achieving coordination in period 1 between pairs.

In appendix E.2.2 we examine how the difference in cooperation and compromise rates between the two groups develops taking as benchmark the first-round choice of a player who is facing a new partner and, hence, cannot rely on a history of play. Players in high-IQ groups are increasingly more likely to open with a cooperative choice if compared with the benchmark represented by the combined sessions; this trend in the low-IQ session is smaller. In the BoSC we cannot detect any significant difference in the trends of the first-round outcomes between the high- and low-IQ

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[11] The behavioral attitude to cooperate also is similar in the two groups: in the debriefing questionnaire we asked subjects about their intrinsic motivation to cooperate and found no significant difference between the two IQ groups. Participants were asked whether they agreed that they cooperate because "I feel that is the right thing to do" and "It makes me feel nice"; there are no significant differences in the responses between the two IQ groups (p-value = .7402 and p-value = .2443, respectively).

[12] The first-period cooperation choice for the PD is examined in detail in table A.20, where we consider all PD data together to increase the power of our estimation. In these regressions we include all data concerning the PD. Hence, we also use the low continuation probability treatment data and the personality split treatments that will be illustrated below. From col. 1, there is no significant effect due to the IQ level; considering the other individual characteristics, only Agreeableness has a significant positive effect in the expected direction of increasing the initial cooperation rate. This effect, as we will argue later, is transitory.

groups. The reason could be that in the BoSC the difference between high- and low-IQ groups appears faster than in the PD because coordination is probably more difficult in the BoSC than in the PD; we discuss the difficulty of achieving coordination more extensively in Section V.B.

4. Cooperation with Low Continuation Probability

We have seen substantial differences in the long-run rate of cooperation of the two groups of players, with more intelligent groups achieving higher rates of cooperation. This could be explained by an unconditional attitude: more intelligent players could have a generalized inclination to cooperate in strategic environments. We reject this hypothesis by considering repeated games with the same PD stage game (payoffs again as in table A.1) but lower continuation probability, $\delta = .5$. Figure 4 aggregates the different sessions; the dotted line represents an anomalous behavior we observed only in one session (session 7). If we exclude that exception, cooperation rates in the two groups are similar, and low, as in Dal Bó and Fréchette (2011) when they use the same parameters we use in this treat-

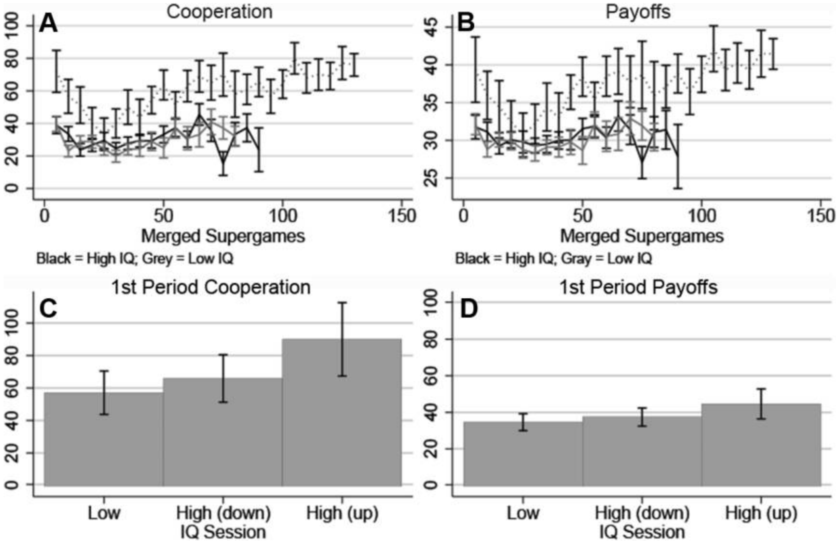

FIG. 4.—PD with low continuation probability: cooperation and payoffs per period in the low- and high-IQ sessions. Panels A and B report averages computed over observations in blocks of five supergames. The gray lines represent all low-IQ sessions, the black lines represent the high-IQ sessions featuring a downward or stable trend of cooperation, and the dotted line represents the high-IQ session with an upward trend of cooperation (session 7). Panels C and D report the average of cooperation and payoffs in the first round (of a repeated game) that occurs in the three different groups of sessions separately. Bands represent 95 percent confidence intervals.

ment (p. 419, fig. 1, third panel in top row).[13] We make the following conclusion:

RESULT 4.2. Subjects of higher intelligence are not unconditional cooperators. In some cases they fail to establish high rates of cooperation or even an upward trend.

B. *Games without Trade-offs*

The second prediction of our substantive hypothesis 2.3 is the similarity in behavior of the two groups of subjects with different intelligence in games in which the natural equilibria do not have the trade-off between short-term gain and long-term loss (BoS and SH).

Our data provide strong support for the hypothesis that intelligence has a very different effect in games with trade-off if compared with games without trade-off. In the treatment in which subjects—separated according to their IQ—play a repeated Stag Hunt (SH) game (payoffs in table A.3) and continuation probability $\delta = .75$, cooperation is reached soon and maintained throughout the session; this is true independently of the intelligence group as we illustrate in figure 5.[14] The stability of the agreement hinges on the small deviations from past successes in implementing cooperation on (S, S) (see panel A of fig. 6; this holds for both groups).[15]

In the BoS (payoffs in table A.2) and $\delta = .75$, coordination is more complex because players have to find an agreement on how to implement the alternation; lacking communication, and in the absence of a natural symmetric way to reach an agreement, players have to rely on chance, for example, waiting until the first time coordination on a positive outcome occurs and then alternating. In the top panel of figure 7, where we aggregated the level of coordination and payoffs of all sessions by IQ group, we see that a very similar pattern between the two groups is realized, with the high-IQ group achieving coordination slightly faster.[16] However, panel B of figure 6 suggests that once coordination on alternating across nonzero outcomes is achieved, both groups of subjects deviate

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[13] From panel B of fig. A.7 in app. K, we note that cooperation rates in all low-IQ sessions decline from an initial 50 percent to very low values. In the high-IQ sessions high rates of cooperation occur but are infrequent. In only one session (session 7) cooperation rates increase. In the other high-IQ sessions (sessions 1, 3, and 5), cooperation declines or is roughly stable as in the low-IQ sessions.

[14] In fig. A.16 of app. L, we see similar patterns replicated in each pair of contiguous sessions. Tables A.26 and A.27 in app. M confirm what fig. 5 suggests: IQ is a nonsignificant predictor of the rate of S choice, payoffs, and the S choice in period 1.

[15] In table A.73, we present the estimation of the individuals' strategies in the two groups.

[16] See fig. A.15 in app. L for the plots of coordination per single session, where similar patterns per each group are displayed. Table A.28 in app. M shows that IQ has no effect on the coordination rate (cols. 1 and 2).

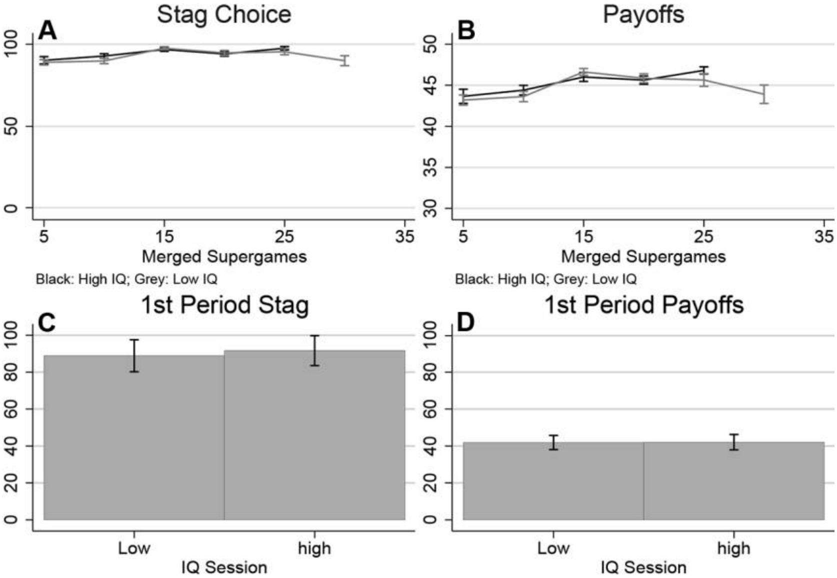

Fig. 5.—SH: stag choice and payoffs per period in the low- and high-IQ sessions. Panels A and B report the averages computed over observations in successive blocks of five supergames of all high- and all low-IQ sessions, aggregated separately; the black and gray lines report the average stag choices for high- and low-IQ subjects in each block, respectively. Panels C and D report the stag choices and payoffs in the first period in the two IQ sessions separately. Bands represent 95 percent confidence intervals.

very little from the alternating strategy and in a way that is not statistically different. Hence we get the following result:

Result 4.3. As hypothesis 2.3 predicts, in games with no trade-off between short-run gain and continuation loss—in SH and BoS—no significant coordination differences occur between the two intelligence groups.

Instead, we find that the high- and low-IQ groups undergo a different process (in BoS and SH) to reach agreement. We discuss this below in Section V.B.

C. *Errors in the Strategy Implementation*

We have seen that, in games with the trade-off, cooperation and compromise rates in the low- and high-IQ groups are initially similar and diverge later. Our hypothesis 2.3 predicts that the two groups differ in consistency of strategy implementation. Here we test the prediction and the hypothesis that such inconsistency explains the divergence in behavior. The hypothesis is supported: we see a cumulative effect of a small but significant difference in cooperation and compromise induced by the choices of the partner in the past; these small differences cumulate to produce large

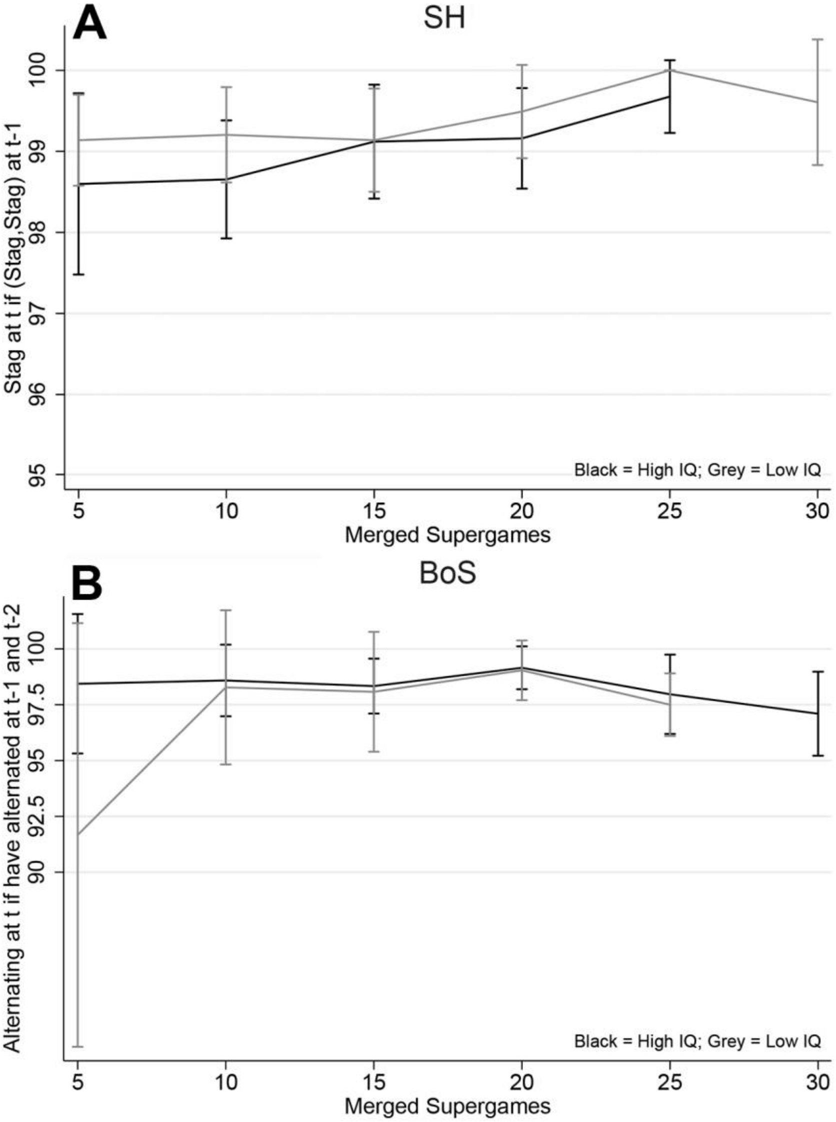

FIG. 6.—Consistency in SH and BoS. Stag Hunt: Panel A reports the percentage of the Stag choices if the same pair coordinated on (Stag, Stag) in period $t-1$, computed over observations in successive blocks of five supergames, of all high- and all low-IQ sessions aggregated separately. Battle of Sexes: Panel B reports the percentage of the alternating choices if the same pair coordinated on an alternated outcome in periods $t-1$ and $t-2$ computed over observations in successive blocks of five supergames, of all high- and all low-IQ sessions aggregated separately. The black and gray lines refer to the high- and low-IQ subjects in each block, respectively. Bands represent 95 percent confidence intervals.

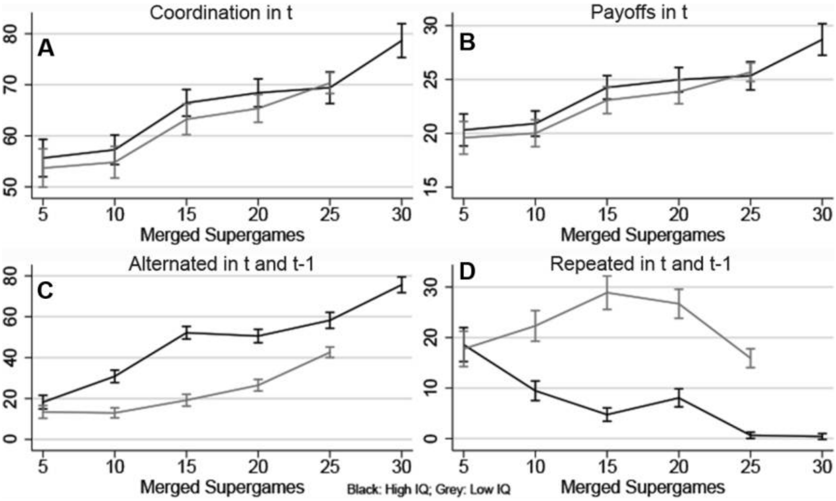

FIG. 7.—BoS: outcomes and payoffs in the low- and high-IQ sessions. The four panels report the averages computed over observations in successive blocks of five supergames of all high- and all low-IQ sessions, aggregated separately. The black and gray lines report the average choices for high- and low-IQ subjects in each block, respectively. Alternating occurs when subjects in the same match choose (*B*, *W*) and (*W*, *B*) in two consecutive periods; repeating occurs when (*B*, *W*) or (*W*, *B*) happens consecutively for two periods in the same match. Bands represent 95 percent confidence intervals.

differences between the two groups. Panels A and D of figure 8 illustrate how low-IQ groups choose cooperation less frequently following cooperation of the partner in the previous period.

This lower *C* response to *C* of the partner in the previous period might be due either to a higher general inclination to choose *D* or, more specifically, to a switch to *D* after a joint (*C*, *C*) choice. Panels C and F of figure 8 show that a significant part of the decline in cooperation is explained by a defection after a joint cooperation in the low-IQ group, as goal neglect theory would suggest (the number of observations of joint cooperation in this group is small; hence the higher standard errors). Following defection, we see a very high rate of *D* choice in both groups; if anything, the rate is higher in the high-IQ group (see panels B and E of fig. 8): more intelligent players are better at disciplining behavior of defectors, and, thus, they are better teachers.

The bottom panels of figure 8 show the corresponding results for compromise rates in BoSC. The pattern matches what we have seen in the PD, as hypothesis 2.3 predicts. In this case the low-IQ group subjects are less likely to respond to a *W* choice of the partner in the previous period by making the same *W* choice in turn (panel G of fig. 8). After a choice of the best-outcome action *B* by the partner, the response is, in both groups, a choice of *B*. The deviation to a *B* choice after a joint com-

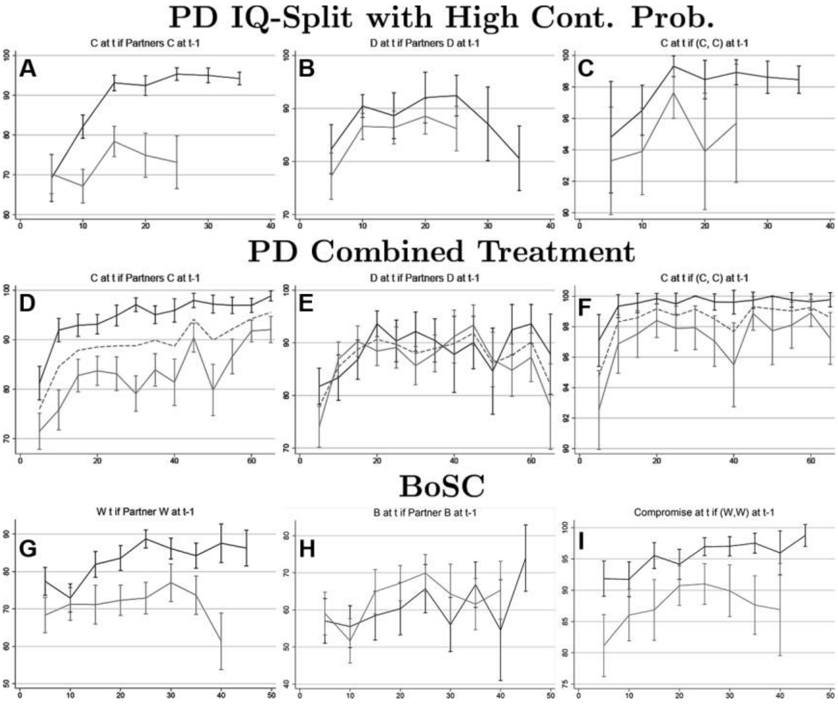

FIG. 8.—Conditional cooperation and coordination per period. We report the averages computed over observations in successive blocks of five supergames. For PD IQ-split, the black and gray lines report the average cooperation for high- and low-IQ subjects in each block. For PD combined treatment, the dashed lines represent the average cooperation in each block; the black and gray lines report the average cooperation for high- and low-IQ partitions in each block. For BoSC, the gray line represents all low-IQ sessions and the black line represents the high-IQ sessions.

promise choice (*W*, *W*) is significantly and clearly higher for the low-IQ group (panel I of fig. 8), as the goal neglect hypothesis 2.3 proposes.[17]

Figure 9 shows the effect of individual intelligence on the probability of defection in PD and failure to compromise in BoSC. We graph the fraction of deviating choices following successful cooperation or compromise in the previous round, hence, representing the propensity to exhibit goal neglect. The probability of goal neglect declines with intelligence. Comparing the histograms in figure 9 between the IQ-split and the combined treatments, we can argue that in the combined treatment, the choices that individuals make in the second-lowest IQ quantile are less inconsistent than those in the IQ-split treatment, suggesting that they benefit from being combined with subjects of higher intelligence. It is also interesting to

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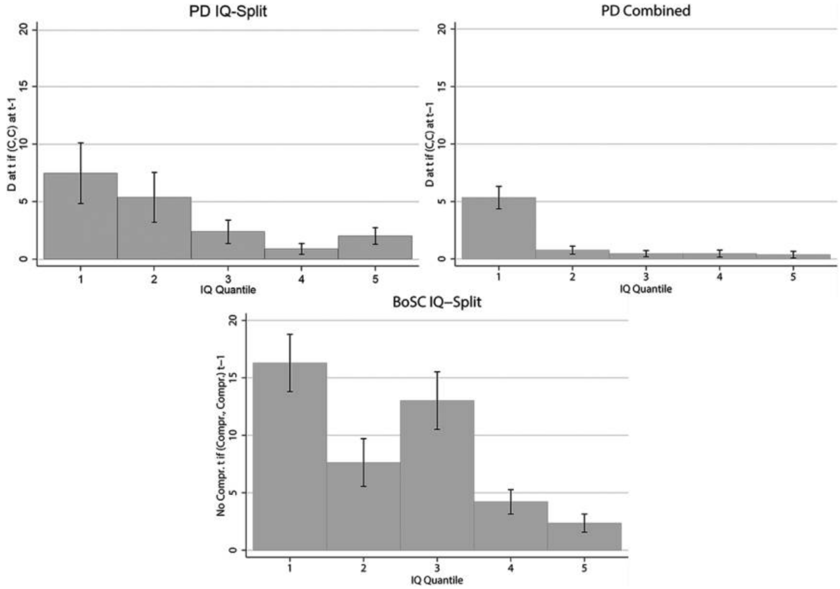
[17] In app. E.2.3 we analyze how subjects react to partners' choices using a variation of the econometric model A-2 presented in Sec. E.



PD IQ-Split

PD Combined

BoSC IQ–Split

FIG. 9.—PD and BoSC: deviation from natural equilibrium if natural equilibrium is the outcome at time $t - 1$ by subjects sorted in IQ quantiles. Vertical axis: fraction of D choice when the action profile in the previous period was (C, C) for PD and fraction of B choice when the action profile in the previous period was (W, W). Bands represent 95 percent confidence intervals.

note that in the BoSC, subjects seem to be more inconsistent than in the PD, which is reasonable given that the BoSC is a more complex game, as we have argued above.

We conclude this section by stating that in the BoSC and in the PD, subjects of higher intelligence are more consistent in strategy implementation. In the next section we provide a formal presentation of these results by estimating the model of errors presented in Section III.

D. *Errors: Test and Estimates*

In table 2 we estimate equation (3) by postulating a linear functional form for the function λ, with coefficients λ^0 and $\lambda^{IQ} > 0$ (λ increasing). In the table we report coefficients rather than odds ratios (as we do elsewhere in the paper) because we focus here on the structural estimation of equation (3).

The dependent variable is the error choice; for the PD it is set equal to one if the subject chooses defect (D) after a round of mutual cooperation (C, C) and equal to zero if the subject chooses cooperate (C) after a round of mutual cooperation (C, C). We classify a choice of D after a last-period action profile (C, C) as an error, that is, as providing a total

TABLE 2

Errors of Strategy Implementation for PD, SH, BoS, and BoSC: Effects of IQ, Personality, Other Characteristics, and Groups

	PD	BoSC	SH	BoS
Errors	.0248	.0738	.0081	.0192
Δu_G	−16.75	−13.14	−23	−16.107
Constant	−4.39020**	.31035	4.33101	−3.78149*
	(1.8656)	(3.3263)	(3.5788)	(2.2222)
IQ	−5.28479***	−6.12849***	−1.73294	−3.26260*
	(1.0094)	(1.7425)	(3.2501)	(1.8357)
Openness	1.09335	1.60513	−1.30327	.99838
	(.8488)	(1.6059)	(3.2827)	(2.1065)
Conscientiousness	1.11803	−.25533	−9.58399***	−.17029
	(.9245)	(1.2196)	(2.9917)	(1.6033)
Extraversion	1.35014	.17331	3.01258	−.19362
	(.9491)	(1.3762)	(2.0499)	(1.2930)
Agreeableness	−.16864	1.04193	−7.03396**	.55189
	(.8353)	(1.2148)	(3.1563)	(1.4925)
Neuroticism	.86062	−.56918	−4.34203	.44175
	(.9595)	(1.3762)	(2.9467)	(1.4534)
Risk aversion	−1.89355**	−1.32862	3.93315	−.25920
	(.8900)	(1.5058)	(2.8547)	(1.4665)
Female	.22983	.56763	.18144	.69519
	(.3423)	(.5559)	(.9453)	(.5163)
Age	.00177	.01746	−.04414	.02335
	(.0554)	(.0948)	(.0972)	(.0429)
$\ln \sigma_u^2$				
Constant	2.18462***	1.55227***	2.05973***	.66884
	(.1509)	(.1890)	(.2959)	(.6140)
Culture fixed effects	Yes	Yes	Yes	Yes
Type	No	Yes	No	Yes
Observations	29,982	4,998	7,252	2,411

Note.—The regressions include the data in the high-δ treatments. For the PD, the dependent variable (error) is set equal to one if the subject chooses defect (D) after a round of mutual cooperation (C, C) and equal to zero if the subject chooses cooperate (C) after a round of mutual cooperation (C, C). For the SH, the dependent variable (error) is set equal to one if the subject chooses hare after a round of stag outcome; it is set equal to zero if the subject chooses stag after a round of stag outcome. For the BoS, the dependent variable (error) is set equal to one if the subject makes the same choice in t and $t-1$ after two rounds of alternation at $t-1$ and $t-2$; it is set equal to zero if the subject makes a different choice in t and $t-1$ after two rounds of alternation at $t-1$ and $t-2$. For the BoSC, the dependent variable (error) is set equal to one if the subject chooses the best option (B) after a round of mutual compromise; it is set equal to zero if the subject chooses compromise after a round of mutual compromise. Data with different histories are ignored. The terms Δu_G are estimates of costs in terms of the utilities of making a mistake. Logit with individual random-effect estimator. Coefficients are displayed. IQ, personality traits, and risk aversion are normalized between zero and one; standard errors in parentheses are clustered at the individual level.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

payoff smaller than the alternative, since for none of the strategies that we have identified is choosing D optimal. Using a similar reasoning for the SH, the dependent variable (error) is set equal to one if the subject chooses H after a round of (S, S) and set equal to zero if the subject chooses S after a round of (S, S). For the BoSC, the dependent variable (error) is set equal to one if the subject chooses the best option, B, after a round of mutual compromise (W, W), and it is set equal to zero if the subject chooses compromise after a round of mutual compromise. For the BoS, the dependent variable (error) is set equal to one if the subject makes the same choice in $t - 1$ and t after two rounds of alternation at $t - 1$ and $t - 2$; it is set equal to zero if the subject makes a different choice in t and $t - 1$ after two rounds of alternation at $t - 1$ and $t - 2$.

In table 2 we see that in all four games the coefficient of IQ is negative, but of much greater magnitude in the PD and the BoSC, while it is not significant in the SH and BoS. Therefore, we have the following result:

Result 4.4. In BoSC and in PD subjects of lower intelligence make a larger number of errors in strategy implementation, while there is no significant difference in the SH and in the BoS, as hypothesis 2.3 predicts.

From the estimates of costs in terms of utility of making a mistake (the values of Δu_G on the top of the table) we observe that there is no increasing relationship between Δu_G and the coefficient of IQ as the more restrictive model 3 (or A-10 in app. E.3) would suggest. Results in table 2 clearly suggest a difference in the effect of the intelligence between games with a trade-off and games without a trade-off as in the general form A-9 presented in appendix E.3, where we also provide a further test of this difference. Overall, we summarize as follows:

Result 4.5. Subjects of higher intelligence are more consistent in strategy implementation, as point ii of the general hypothesis 2.1 predicts.

V. Strategic Reasoning

The second general way in which intelligence may affect strategic behavior is in the ability to identify the most profitable strategies in an environment, as we state in our general hypothesis 2.1.

A. *Best Response and Intelligence*

A direct test of the hypothesis that intelligence affects the ability to identify the most profitable strategies is the test of whether subjects' choices are the best responses to the empirical frequency of the strategy of the other participants in the session. We consider, consistently with Dal Bó and Fréchette (2011), the set (Always Defect, Always Cooperate, Grim Trigger, Tit for Tat, Win Stay Lose Shift, Tit for 2 Tats) of strategies in the repeated game, respectively denoted as {AD, AC, GT, TfT, WSLS, TfT2}. For each pair of such strategies we can compute the payoff in a repeated game if the two players adopt that pair. We call Sophisticated Cooperation, SC, any strategy in the set different from AD and AC. A very useful simplification of the analysis is possible because the payoff to each player is the same for any representative strategy we choose in this set. For instance, the profile (AD, GT) gives a profile of payoffs $((1-\delta)50+\delta 25, (1-\delta)12+\delta 25)$, which is the same as the payoff induced by (AD, TfT). We have thus defined a new normal form game, which we call the *strategy choice* game. The payoff matrix for the row player is

$$\begin{array}{cccc} & \text{AD} & \text{AC} & \text{SC} \\ \text{AD} & 25 & 50 & (1-\delta)50+\delta 25 \\ \text{AC} & 12 & 48 & 48 \\ \text{SC} & (1-\delta)12+\delta 25 & 48 & 48 \end{array}.$$

An entry in the row labeled SC means that any strategy in the SC set gives to the row player the payoff in the corresponding entry against the respective strategy in the column, including the case in which in the column we have SC, again to be interpreted “for any strategy in the set SC.” The strategy AC is weakly dominated by SC if $\delta > 0$. Note that the strategy choice game restricted to actions AD and SC is a symmetric 2×2 coordination game with two pure Nash equilibria (AD, AD) and (SC, SC).

To assess the optimality of the strategy chosen by our subjects in both the low-IQ and high-IQ groups, we need to estimate the empirical frequency with which they played the different strategies. This will allow us to compute the expected returns from playing each strategy. We use the same method used in Dal Bó and Fréchette (2011). The likelihood of each strategy is estimated by maximum likelihood, assuming that the subjects have a fixed probability of choosing one of the six strategies in the time horizon under consideration. We focus on the last five and first five interactions. The likelihood that the data correspond to a given strategy was obtained by allowing the subjects some error in their choices in any round, where error is defined as a deviation from the prescribed action according to their strategy. A detailed description of the estimation procedure is in Dal Bó and Fréchette’s online appendix.[18] In appendix M (tables A.68–A.70) we report the results of the estimation for the high continuation probability, low continuation probability, and combined treatments.

Table 3 reports the expected payoffs and empirical frequencies in the two groups (high- and low-IQ) across the two continuation probabilities

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[18] See pp. 6–11, available online at https://www.aeaweb.org/articles?id=10.1257/aer.101.1.411.

TABLE 3
Payoff at Empirical Frequency and Frequency

	High IQ		Low IQ	
	Payoff	Frequency	Payoff	Frequency
$\delta = .75$:				
AC	46.49	.089	32.03	.027
AD	32.65	.042	28.97	.443
SC	46.90	.869	36.36	.530
Expected payoff	46.27		32.97	
$\delta = .5$:				
AC	26.33	0	20.21	0
AD	29.97	.602	27.85	.772
SC	30.24	.398	25.22	.228
Expected payoff	30.08		27.25	

Note.—The frequency column reports the empirical frequency of each strategy in the set {AC, AD, SC} in the last five supergames, as reported in table A.68 for the high δ and table A.69 for the low δ. The payoff column reports the expected payoff using the strategy against the empirical frequency. The expected payoff is computed using the empirical frequency against the empirical frequency.

we used for the PD, for the last five supergames played, respectively. Consider first the case $\delta = .75$. For the high-IQ group, AC and SC give the same payoff, 43 percent larger than AD; the frequency is concentrated on SC (87 percent). For the low-IQ group, SC is the best response (28 percent higher than AD and 13 percent higher than AD), but the best response is played 53 percent of the time and the worst 44 percent of the time. In the case $\delta = .5$, for the high-IQ group, SC and AD give approximately the same payoff, 15 percent higher than the AC; and the best responses are the only strategies played. The low-IQ group plays the best response AD (giving a payoff 8 percent higher than the second-best response, SC) 77 percent of the time.

The above comparison does not adequately take into account the fact that players with higher intelligence play a larger number of games; so if experience comes from the number of rounds played, rather than clock time elapsed, the players are more experienced in the last games. A way to compensate for this is to consider the frequency at rounds in which players of the two groups have equivalent experience measured by number of rounds. Table 4 reports the same analysis for the last five supergames with equivalent experience. It shows that the difference in ability to best respond is already in place. For example, in the case $\delta = .75$, SC gives the highest payoff, 5 percent larger than AC and 38 percent larger than AD; the frequency is already concentrated in the responses (74 percent), with the inferior strategy AD chosen 21 percent of the time. For the low-IQ group the highest payoff strategy (SC) is played 50 percent of the time and the worst strategy (AD) 43 percent of the time. If we consider the low-δ case, in the high-IQ group, the best response is AD or SC

TABLE 4
PAYOFF AT EMPIRICAL FREQUENCY AND FREQUENCY

	HIGH IQ		LOW IQ	
	Payoff	Frequency	Payoff	Frequency
$\delta = .75$:				
AC	40.36	.044	32.62	.075
AD	30.75	.212	29.99	.427
SC	42.43	.743	36.79	.498
Expected payoff	39.86		33.57	
$\delta = .5$:				
AC	25.79	.081	21.45	.037
AD	30.81	.616	28.74	.737
SC	29.80	.301	26.24	.226
Expected payoff	30.09		27.91	

NOTE.—The frequency column reports the empirical frequency of each strategy in the set {AC, AD, SC} in the last five equivalent experience supergames, as reported in table A.68 for the high δ and table A.69 for the low δ. The payoff column reports the expected payoff using the strategy against the empirical frequency. The expected payoff is computed using the empirical frequency against the empirical frequency.

(the payoffs from these two strategies are approximately equal, and 20 percent higher than AC, and it is played 91 percent of the time). In the low-IQ group, the best response is AD (9 percent higher than SC, and it is played 73 percent of the time).

The average payoff per round in the high IQ-group is higher than in the low-IQ group. For example, in table 4 the expected payoff (from empirical frequency against empirical frequency) for the high-IQ group is 39.86, while for the low-IQ group it is 33.57. We can think of this difference as the outcome of two separate effects. The first effect is on individual choice: a subject in a group can increase his payoff by choosing the best response to the frequency of the group. In the high-IQ group, shifting from AD to SC gives a large gain (a gain of 11.68 over the 30.75 from using AD), while in the low-IQ group the shift gives a smaller gain (a gain of 6.8 over the 29.99 from using AD). The reason for the smaller gain is, of course, that a large fraction of subjects in the latter group are playing AD. The second effect is on group choice. We measure this effect with the difference between the maximum payoffs that a subject can achieve in the two groups at the best response within his group. This difference is due only to the group behavior. In the high-IQ group the difference is 42.43, and in the low-IQ group it is 36.79.

In conclusion, independently of the fact that higher total payoffs will accrue to highly intelligent players simply because they play a larger number of rounds, we can state the following result:

RESULT 5.1. Subjects in the high-IQ sessions have a higher payoff per round, in part because they are closer to the best response and in substantial part because they are coordinating closer to the (SC, SC) equilibrium of the strategy choice game. This is as point i of the general hypothesis 2.1 predicts.

This is particularly noticeable in the last five supergames, where the fraction of AD in the high-IQ group has fallen below 5 percent. An additional benefit of higher intelligence in our experiment, and likely in real life, is the ability to process information faster, and hence to accumulate more extensive experience, and to learn from it.[19]

B. *Achieving Coordination*

As we argued in Section II.B, achieving coordination on the natural alternating equilibrium in BoS is harder than coordinating on (S, S) in SH. Achieving coordination at the alternating equilibrium is not easy without communication. This provides a test of the hypothesis that more intelligent players identify efficient equilibria more rapidly. Figure 7 shows that although the two groups are virtually identical in the frequency of achieving coordination on a positive payoff outcome (and thus on payoffs), they differ in the frequency of alternating coordination, even in the long run, with a difference of more than 10 percent (panel C). Panel D indicates that subjects in low-IQ sessions are more likely to replicate the same outcome between two consecutive periods.[20]

Clearly, in the first round of a repeated game with a new partner, subjects have no way to coordinate, even if they have a history of successful coordination with previous partners and are very intelligent or inclined to cooperation. But in the second round of a repeated game, the successful start of an alternating equilibrium may take place, and this depends crucially on the correct choice of the move: the player who played B should now play W and vice versa.[21] We summarize this observation as follows:

Result 5.2. Subjects of higher intelligence are faster in achieving coordination in the efficient alternating equilibrium in BoS, whereas there is no substantial difference in SH, as predicted by hypothesis 2.2.

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[19] One has to consider these results with some care, considering the difference between the analyst's situation and that of the subjects. In estimating the best response we are using information on frequency of strategies that subjects do not have; they do not observe the entire sequence of plays. Instead, they observe the sequence of plays only for the games in which they are participants. Limiting the identification of the strategies to the sample observed by each subject is impossible because the sample is too small.

[20] Similar reasoning applies for the BoSC: from fig. 3 we note that in the high-IQ groups more participants reach the most efficient outcome (i.e., compromise) almost from the beginning.

[21] This is confirmed by table A.28, which shows that IQ has a very strong and significant effect on alternating (see col. 3) and no effect on coordination (col. 2).

VI. Personality and Strategic Behavior

A. *Conscientiousness*

In Section II.C, we hypothesized that, in general, the effect of Conscientiousness may be different for different facets, making the net effect that can be predicted on theoretical grounds ambiguous. In our data, the net effect in the C-split treatment is clear in figure 10: Conscientiousness reduces cooperation rates, and it does so from the first period, even before interaction takes place and learning modifies behavior. The reduction is particularly strong in one of the sessions of high-Conscientiousness (high-C); the trend relative to this session is singled out in figure 10.[22] The histogram at the bottom of figure 10 shows that the difference is substantial and significant in the first period. The effect is in the same direction for payoffs. The econometric analysis in the appendix shows that the pooled data of subjects in the low-Conscientiousness (low-C) sessions show an increase of more than 15 percent in the cooperation rate and an increase of four experimental units in payoff (see the last three columns of table A.31).[23]

The effect of Conscientiousness on cooperative choices appears smaller (and nonsignificant) if we consider the data in the combined treatment (see fig. A.12 in the appendix). Clearly, as was the case for the role of Intelligence, the effect of Conscientiousness on behavior is stronger when individuals with a similar score interact. However, Conscientiousness appears to be distinct from Intelligence in that the presence of two highly conscientious players—rather than one individual—seems a necessary condition for the trait to have a measurable impact on outcomes.[24] Why this negative net effect of Conscientiousness?

Our hypothesis 2.4 identifies the cautiousness facet as possibly producing a reduction of cooperation rates in our environment, with all the other facets having the opposite effect. We test this explanation by considering the specific effect of each facet. We first perform factor analysis on the answers provided to the questionnaire and identify four main factors (those with eigenvalues larger than one). Analyzing the coefficients of each ques-

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[22] In app. K we present a more detailed analysis of all sessions of the C-split treatments in fig. A.10.

[23] The effect is also evident from table A.21, where we note that in the low-C sessions the odds ratio for the trend is bigger than in the combined sessions.

[24] This could explain why we do not observe any significant effect of individual Conscientiousness when we include session fixed effects, as table A.19 shows. The negative effect of Conscientiousness in the C-split treatment is clear from the strategy table A.72 that we include in the appendix; the table shows the frequency of strategies used by different groups in early and late supergames. Subjects in the high-C group start with a larger fraction of the AD strategy, 31 percent compared to 12 percent of the low-C group; this is consistent with the first-period behavior shown in fig. 10.

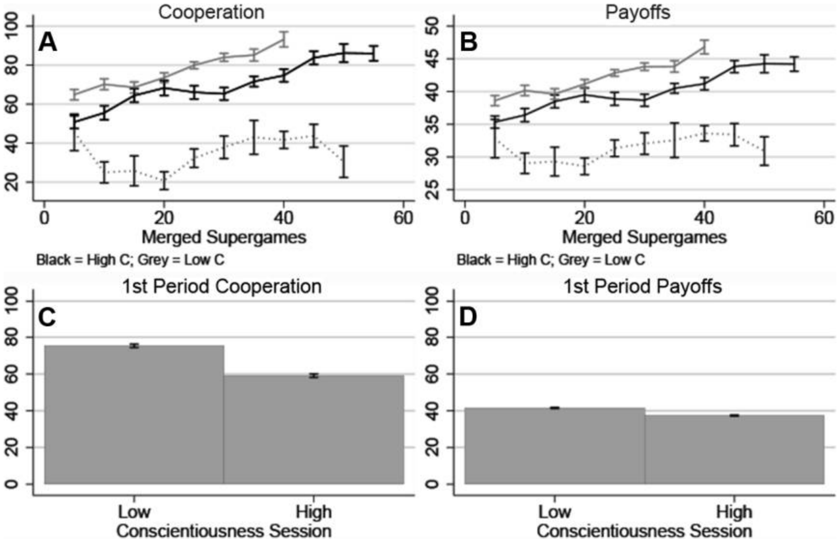

Fig. 10.—PD with high continuation probability: cooperation and payoffs per period in the low- and high-Conscientiousness sessions. Panels A and B report the averages computed over observations in successive blocks of five supergames of all high- and all low-Conscientiousness sessions, aggregated separately; the black and gray lines report the average cooperation and average payoffs for high- and low-Conscientiousness sessions, respectively. The dotted line represents session 5, which has not been aggregated with the other high-C sessions. Panels C and D report the average of cooperation and payoffs in the first period among the two groups of sessions. Bands represent 95 percent confidence intervals.

tion, we identify the first factor as the cautiousness facet.[25] We then regress cooperation rate and payoff on the four factors we have identified and the Conscientiousness score. The analysis reported in table 5 confirms the role of cautiousness: the corresponding factor 1 is the only significant factor, and its effect is a reduction of the cooperation rate by between 33 and 40 percent. We make the following conclusion:

Result 6.1. Conscientiousness has a negative impact on cooperation due to the cautiousness facet, as predicted by hypothesis 2.4.

B. *Agreeableness*

Agreeableness as a factor is naturally associated with cooperative behavior, and so are all its facets (see hypothesis 2.5); this should translate to higher cooperation rates, independent of experience, and should be re-

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[25] For example, the two items with the highest coefficient for the first factor are "Jump into things without thinking" and "Make rush decisions" (both reverse coded). Table A.30 reports the items, facets, and the coefficients for each item.

TABLE 5
ANALYSIS OF FACETS IN THE CONSCIENTIOUSNESS-SPLIT TREATMENTS PD WITH HIGH CONTINUATION PROBABILITY

	C-Split Cooperation	C-Split Cooperation	C-Split Cooperation	C-Split Payoff
Factor 1 (cautiousness)	−.3358***		−.4011***	−8.4645***
	(.1109)		(.1281)	(2.1373)
Factor 2	.0654		.0421	−.8574
	(.1529)		(.1693)	(2.8243)
Factor 3	−.1223		−.1053	−1.7562
	(.1572)		(.1671)	(2.7881)
Factor 4	.0096		−.0338	−.3650
	(.1311)		(.1390)	(2.3189)
Conscientiousness		−.5652***		
		(.1837)		
IQ	.2357	.1542	.1576	4.0172
	(.1831)	(.1909)	(.1934)	(3.2255)
Openness		−.0574	−.0070	−.1371
		(.1564)	(.1660)	(2.7697)
Extraversion		−.0689	−.0896	−.0110
		(.1604)	(.1726)	(2.8790)
Agreeableness		.2614	.2901	.5439
		(.1750)	(.1846)	(3.0787)
Neuroticism		.0853	.0664	3.0796
		(.1600)	(.1797)	(2.9977)
Risk aversion	.0512	.0262	.0426	3.2139
	(.1324)	(.1326)	(.1341)	(2.2374)
Female	−.0209	−.0304	−.0326	−.3221
	(.0549)	(.0613)	(.0640)	(1.0674)
Age	.0075	.0061	.0054	.1590
	(.0075)	(.0077)	(.0078)	(.1300)
Number of subjects	−.0229	−.0212	−.0215	−.4517*
	(.0139)	(.0138)	(.0141)	(.2347)
Culture fixed effects	Yes	Yes	Yes	Yes
R^2	.169	.182	.190	.318
Observations	122	122	122	122

NOTE.—The regressions include the data from the PD C-split treatment. The dependent variables are average cooperation and average payoff per interaction. The factors represent the principal factor deriving from the Conscientiousness questions in the 120-item Big Five questionnaire. We identify factor 1 with the cautiousness facet on the basis of the survey items with the largest (in absolute value) scoring coefficient. Averages are calculated over the same number of supergames played by every individual; thus, the longer sessions are truncated. IQ, personality traits, factors, and risk aversion are normalized between zero and one. Ordinary least squares estimator. Standard errors clustered at the individual level are in parentheses.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

alized from first periods. Our data, as seen in figure 11, confirm this. The bottom histograms show a large and significant positive difference in the first-period cooperation rates of high-Agreeableness (high-A) groups compared to low-Agreeableness (low-A) groups, with a difference of ap-

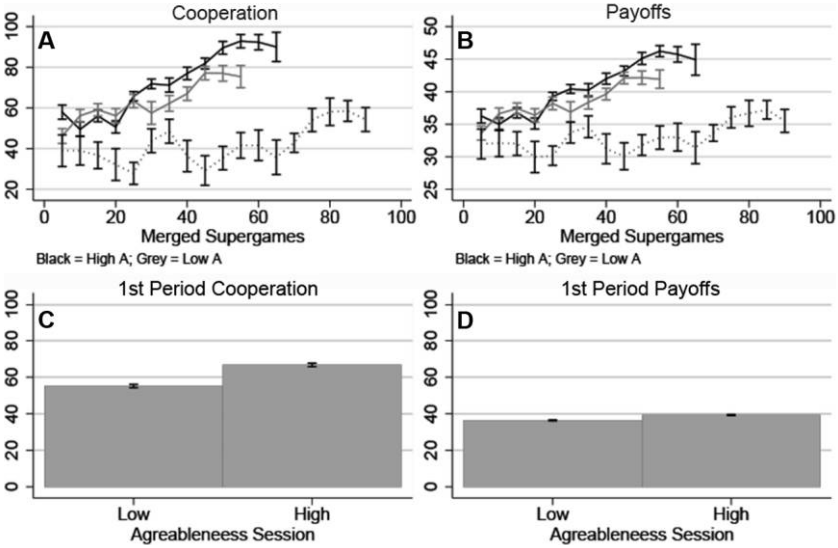

FIG. 11.—PD with high continuation probability: cooperation and payoffs per period in the low- and high-Agreeableness sessions. Panels A and B report the averages computed over observations in successive blocks of five supergames of all high- and all low-Agreeableness sessions, aggregated separately; the black and gray lines report the average cooperation and average payoffs for high- and low-Agreeableness sessions. The dotted line represents session 7, which not been aggregated with the other high-A sessions. Panels C and D report the average of cooperation and payoffs in the first period among the two groups of sessions. Bands represent 95 percent confidence intervals.

proximately 10 percent, giving support to hypothesis 2.5 that Agreeableness increases unconditional cooperation.[26]

From panel A of figure 11 (where we exclude an anomalous session represented by the broken line; see app. K for details), we note that both groups have a positive trend of cooperation. In the long run, however, the difference is small, in both cooperation rates and payoffs; this can be observed as well in the econometric analysis we report in the appendix.[27] The effect of Agreeableness on cooperative choices is similar if we consider the two partitions in the combined treatment; from figure A.13 in

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[26] This strong initial effect is confirmed in table A.20. There we find a significant effect for Agreeableness even after including session fixed effects (i.e., controlling for "environmental" effects and, more specifically, for the effect of being in a high-A group as well). The odds that a more agreeable person cooperates are 4.5 times greater than those for a less agreeable person. This is the only significant predictor in the regression.

[27] As shown in table A.31 (first three columns), the effect of being in a low- or high-A group in all periods is small on payoffs and insignificant on cooperation rates. Consistently, table A.19 (in which we consider all the sessions) reports similar effects of Agreeableness in cols. 1 and 3. Furthermore, from col. 2 of table A.21, we note that there is no difference in the trend of cooperation between low- and high-A groups and the combined groups. From col. 2 of table A.22, we note that subjects scoring higher on Agreeableness are less likely to reciprocate more as they acquire more experience, again suggesting that Agreeableness mostly has an effect on unconditional cooperation.

the appendix, we can clearly observe a difference between the high- and low-A partitions in the beginning and their convergence toward the final rounds. In conclusion:

Result 6.2. Agreeableness has a positive impact on cooperation, but the effect is strong in magnitude only in the early stages, as hypothesis 2.5 predicts.

VII. Response Time

The time to decide has minor direct interest for economic analysis but provides very useful information on the decision process and thus on how the observed differences in cooperation rates and payoffs originate.

Our first hypothesis concerns equilibrium choices and deviations, or response to deviations. After convergence to a natural equilibrium has occurred, the implicitly agreed behavior becomes the natural choice and, thus, the output of a decision that should not require specific attention. On the contrary, a choice of deviation or the response to a deviation of others is slower:

Hypothesis 7.1. For all types of subjects, the equilibrium choice takes less time than a deviation or a response to a deviation.

The relationship between cognitive and noncognitive skills and time to decide is provided by the conceptual structure that we have developed, differentiating games with respect to the existence of a trade-off between short-run gains and long-run losses. We hypothesize that less intelligent players who have to avoid the goal neglect error will need more time when they have to evaluate this trade-off:

Hypothesis 7.2. In PD and BoSC, namely, games with a trade-off between short-run gains and long-run losses from deviation at the natural equilibrium, response time is shorter for players of higher intelligence when they choose cooperation for PD and compromise for BoSC than when they choose otherwise. There is little difference in response time in the two choices in BoS and SH.

We now turn to the test of the hypotheses. In PD and in the BoSC, high-IQ groups have a shorter response time, as we see from figure 12.

Result 7.1. In line with hypothesis 7.1, subjects think longer when they decide to deviate from cooperation to defection in the PD.

In figure 12 we observe that this difference is large and significant for the high-IQ group and small and not statistically significant in the low-IQ group, which has lower cooperation rates, as predicted in hypothesis 7.1.[28]

In BoSC, the analysis is complicated by the fact that we have more than one natural equilibrium. Subjects can coordinate on compromise (i.e., out-

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[28] Furthermore, table A.32 confirms this: individuals choosing *C* take less time to make the choice (sign of cooperate in col. 1), and this effect is stronger the higher is the subjects' IQ (col. 2).

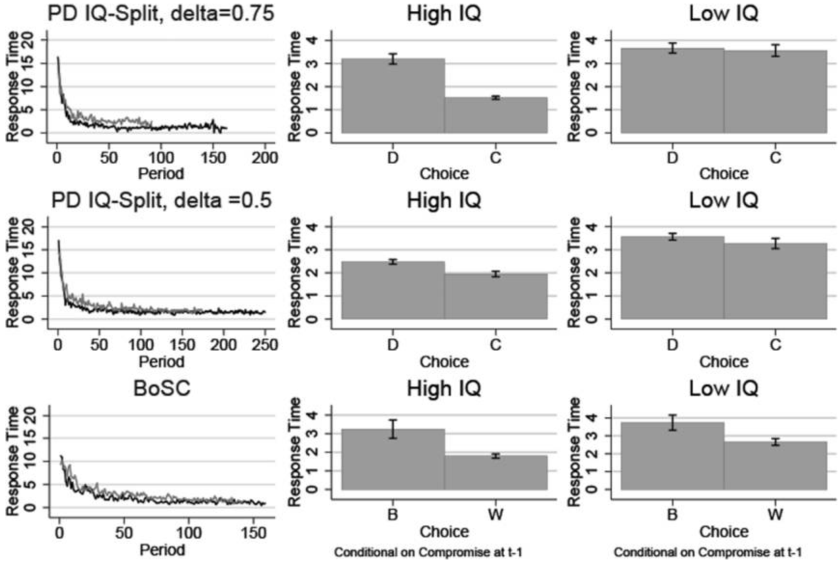

Fig. 12.—PD and BoSC: response time in the different treatments by IQ groups and choice *C*, *D*, *W*, and *B* represents the different choices in the two games. For the BoSC the choices are conditional on the fact that at $t-1$ the two players compromised (i.e., played (W, W)). The gray line represents all low-IQ sessions, and the black line represents the high-IQ sessions. Bands represent 95 percent confidence intervals.

come (W, W) in table A.4) or alternate between the two outcomes (W, B) and (B, W) or finally settle on one of the (W, B), (B, W) outcomes. The analysis is unambiguous for equilibria yielding the (W, W) outcome. From the bottom panels of figure 12, more intelligent players that saw the compromise (W, W) outcome at $t-1$ have a shorter response time for when they choose W (aiming at a compromise outcome) than when they choose B, confirming hypothesis 7.2.

Table A.33 in the appendix confirms the result illustrated in figure 12 for the BoSC: individuals in general respond faster when they are playing the compromise (W, W) outcome (col. 1), and this decision is quicker for higher-IQ individuals (col. 2). This last effect is not significant but is quite high in magnitude, possibly because of the rarity of event B at t, if (W, W) occurred at $t-1$. For games with no trade-off between short-term and long-term advantages, there is little difference in response time between the two actions in both the high-IQ and low-IQ groups for BoS (see fig. 13).[29] We summarize the above discussion as follows:

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[29] From fig. 13, note that in SH the lower payoff action H takes longer for both types, and particularly for the low-IQ group. Given that this is a complex trade-off (between riskiness and payoff), the difference is natural.

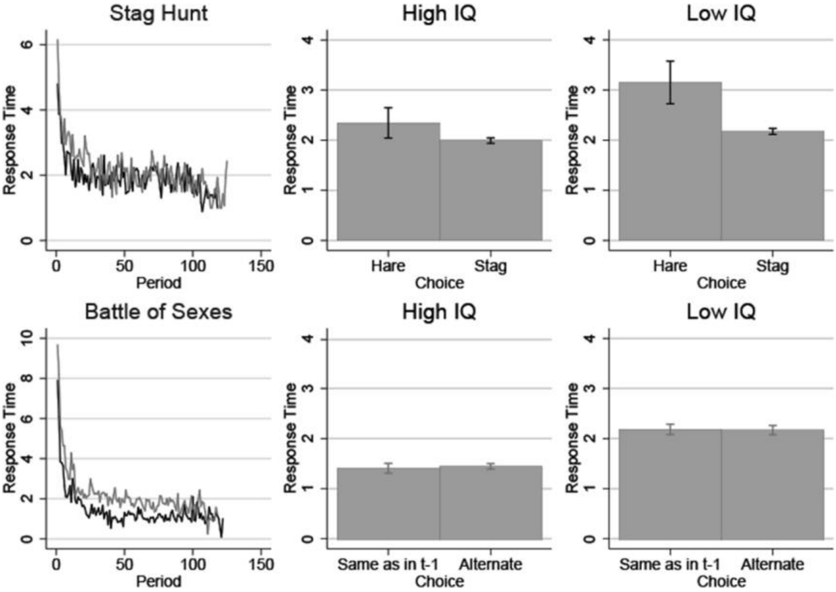

FIG. 13.—SH and BoS: response time in the different treatments by IQ groups and choice. In the Battle of Sexes, the "alternate" choice denotes a choice different from the one taken at $t - 1$. The gray line represents all low-IQ sessions, and the black line represents the high-IQ sessions. Bands represent 95 percent confidence intervals.

RESULT 7.2. In PD and BoSC, response time is shorter for players of higher intelligence when they choose cooperation for PD and compromise for BoSC than when they choose otherwise. There is little difference in response time in the two choices in BoS. This in part confirms hypothesis 7.2.

A trait that might affect the length of response time is Conscientiousness. We discuss this briefly in appendix G, where we show that response time is shorter for the subjects in high-Conscientiousness groups.

VIII. Conclusions

Our experiment tested the hypothesis that groups of individuals with different levels of intelligence or different personalities, but who are otherwise similar, will exhibit different levels of cooperation in bilateral interactions with others from their group. The interactions were repeated, giving time and opportunity for each participant to observe and to reflect on the past behavior of the other.

The outcome of games with a trade-off between short-run gain and continuation value loss was strikingly different when played by subjects with higher or lower levels of intelligence. Higher intelligence resulted in significantly higher levels of cooperation and earnings. The failure of individuals with lower intelligence to appropriately estimate the future consequences of current actions accounts for these difference in outcomes. Personality also affects behavior, but in smaller measure, and with low persistence. These results have potentially important implications for policy. For example, while the complex effects of early childhood intervention on the development of intelligence are still currently being evaluated (e.g., Heckman et al. 2006), our results suggest that any such effect would potentially enhance not only the economic success of the individual but the level of cooperation in society (at least when interactions are repeated).

More in detail, our main conclusions for the class of simple repeated games are as follows:

Everything else being equal, groups composed of individuals with higher levels of intelligence exhibit higher or equal levels of cooperation in the class of games we consider. In our data, intelligence is associated with different long-run behavior in a sequence of repeated games played within the group, and higher cooperation rates are associated with higher intelligence.

Higher cooperation rates are produced by interaction over time in groups of individuals with higher intelligence. Cooperation rates in the initial rounds (approximately 20 rounds) are statistically equal in the two groups. Thus, the experience of past interaction, not a difference in attitude in the initial stages, explains the higher cooperation rate.

Higher cooperation is sensitive to the continuation probability, so it is not the result of an unconditional inclination of higher-intelligence individuals to cooperate. Intelligence operates via strategy implementation and strategic thinking.

We have identified a crucial distinction among games in which the gain from deviation from a given strategy has to be weighed against future losses and those in which it does not. When a nontrivial trade-off has to be evaluated, individuals with higher intelligence achieve a substantially higher rate of cooperation; the difference in intelligence levels becomes irrelevant when this trade-off is absent. In the low continuation probability game, cooperation is less profitable in the long run, and subjects in the higher-intelligence groups also experience large and growing rates of defection over time. In conclusion, both environment and incentives matter: intelligence modulates the response to incentives rather than directly determining behavior.

Intelligence matters substantially more in the long run than other factors and personality traits. Our method allows for a direct and an indirect test. The direct test is based on examining the cooperative behavior of groups systematically differing in a given trait. The indirect test is based on the analysis of the statistical relationship of traits with the choice to cooperate. We find a transitory association of cooperation rates with personality traits: intelligence is the determining factor in long-run cooperative behavior.

Intelligence operates through thinking about strategic choices. Differences in behavior could arise for different reasons. For instance, intelligence might be associated with a cooperative attitude, either as a result of a behavioral inclination or as the result of utility that individuals might derive from the outcome, such as winning approval of others or avoiding conflict. Our data instead provide support for the idea that intelligence is most likely to influence the way in which subjects think about the behavior of others, how they learn from it, and how they try to modify it. Intelligence is relevant for learning and teaching. We have produced two pieces of evidence supporting this interpretation. The first is the difference in the evolution over time of the response of individuals to the choices made by their partner in the past. A small but significant difference in the choice to cooperate with the current partner in the last period builds up over the session, and this eventually produces a substantial difference in cooperation rates. The second piece of evidence comes from response times. Among subjects of higher intelligence, cooperation after the initial stages becomes the default mode; defection and response to defection instead require a specifically dedicated and careful balancing of current gains and future losses. For groups composed of lower-intelligence individuals, there is no difference.

Conscientiousness affects strategic behavior in the direction of cautiousness, thus reducing cooperation. Theoretical analysis suggests an ambiguous effect of Conscientiousness, predicting an increase of cooperation due to facets such as dutifulness and orderliness but a decrease due to cautiousness. We find that the second dominates. This effect is clear in a game such as the PD, in which the trade-off between the short-run gain and continuation loss may be perceived as risky, thus leading a cautious individual to make the safe choice of always defecting.

Agreeableness induces a transitory increase in cooperation. The effect is natural; it is, however, small and transitory compared to that induced by Intelligence.

Our results suggest important questions for the theory of learning in games, as well as on the link between intelligence and strategies' ideation and implementation. The extension to the ability of subjects to conceive different sets of strategies will require an extension of the design to a more general class of games, particularly with nonsymmetric stage games. These are the subjects of current and future research.

References

Benjamin, Daniel J., Sebastian A. Brown, and Jesse M. Shapiro. 2013. "Who Is 'Behavioral'? Cognitive Ability and Anomalous Preferences." *J. European Econ. Assoc*. 11 (6): 1231–55.

Burks, Stephen V., Jeffrey P. Carpenter, Lorenz Goette, and Aldo Rustichini. 2009. “Cognitive Skills Affect Economic Preferences, Strategic Behavior, and Job Attachment.” *Proc. Nat. Acad. Sci.* 106 (19): 7745–50.

Cerreia-Vioglio, Simone, Fabio Maccheroni, Massimo Marinacci, and Aldo Rustichini. 2017. “Multinomial Logit Processes and Preference Discovery.” Discussion paper, Innocenzo Gasparini Inst. Econ. Res.

Dal Bó, Pedro, and Guillaume R. Fréchette. 2011. “The Evolution of Cooperation in Infinitely Repeated Games: Experimental Evidence.” *A.E.R.* 101 (1): 411–29.

Dohmen, Thomas, Armin Falk, David Huffman, and Uwe Sunde. 2010. “Are Risk Aversion and Impatience Related to Cognitive Ability?” *A.E.R.* 100:1238–60.

Duncan, John, Alice Parr, Alexandra Woolgar, et al. 2008. “Goal Neglect and Spearman’s g: Competing Parts of a Complex Task.” *J. Experimental Psychology: General* 137 (1): 131–48.

Frederick, Shane. 2005. “Cognitive Reflection and Decision Making.” *J. Econ. Perspectives* 19 (4): 25–42.

Gill, David, and Victoria Prowse. 2016. “Cognitive Ability, Character Skills, and Learning to Play Equilibrium: A Level-*k* Analysis.” *J.P.E.* 124 (6): 1619–76.

Heckman, James J., Jora Stixrud, and Sergio Urzua. 2006. “The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior.” *J. Labor Econ.* 24 (3): 411–82.

Hyndman, Kyle, Erkut Y. Ozbay, Andrew Schotter, and Wolf Ze’ev Ehrblatt. 2012. “Convergence: An Experimental Study of Teaching and Learning in Repeated Games.” *J. European Econ. Assoc.* 10 (3): 573–604.

Johnson, John A. 2014. “Measuring Thirty Facets of the Five Factor Model with a 120-Item Public Domain Inventory: Development of the IPIP-NEO-120.” *J. Res. Personality* 51:78–89.

Jones, Garett, and W. Schneider. 2010. “IQ in the Production Function: Evidence from Immigrant Earnings.” *Econ. Inquiry* 48 (3): 743–55.

Palacios-Huerta, Ignacio, and Oscar Volij. 2009. “Field Centipedes.” *A.E.R.* 99 (4): 1619–35.