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Predictive Mind Reading from First and Second Impressions: Better-than-chance Prediction of Cooperative Behavior

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Abstract: People's appearance and behaviors in strategic interactions provide a variety of informative clues that can help people accurately predict beliefs, intentions, and future behaviors. Mind reading mechanisms may have been selected for that allow for better-than-chance prediction of others' strategic social propensities based on the sparse information available when forming first and second impressions. We hypothesize that first impressions are based on prior beliefs and available information gleaned from another's description and appearance. For example, where another's gender is identified, prior gender stereotypes could influence expectations and correct guesses about them. We also hypothesize that mind reading mechanisms use second impressions to predict behavior: using new knowledge of past behaviors to predict future behavior. For example, knowledge of the last round behaviors in a repeated strategic interaction should improve the accuracy of guesses about the next round behavior. We conducted a two-part study to test our predictive mind reading hypotheses and to evaluate evidence of accurate cheater and cooperator detection. First, across multiple rounds of play between matched partners, we recorded thin slice videos of university students just prior to their choices in a repeated Prisoner's Dilemma. Subsequently, a worldwide sample of raters recruited online evaluated either thin-slice videos, photo stills from the videos, no images with gender labeled, or no images with gender blinded for each target. Raters guessed players' Prisoner's Dilemma choices in the first round, and, again, in the second round after viewing first round behavior histories. Indicative of mindreading: in all treatments where targets are seen, or their gender is labeled, or their behavioral history is provided, raters guess unacquainted players' behavior with above-chance accuracy. Overall, cooperators are more accurately detected than cheaters. In both rounds, both cooperator and cheater detection are significantly more accurate when players' photo or video are seen, where their gender is revealed by image or label, and under conditions with behavioral history. These results provide supporting evidence for predictive mind reading abilities that people use to efficiently detect cooperators and cheaters with better-than-chance accuracy under sparse information conditions. This ability to apply and hone predictive mindreading may help explain why cooperation is commonly observed among strangers in everyday social dilemmas.

Keywords: Mind reading, Cheater detection, Cooperation, Prisoner's dilemma, Photographs, Thin slices

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1. Introduction

Opportunities for cooperative interaction with strangers and for repeated interaction have presented recurrent adaptive problems over the course of human evolutionary history (Fehr & Henrich, 2003). Among our ancestors, potentially valuable interactions with strangers were often fraught with danger, exploitation, and mistrust (Daly & Wilson, 1988; Martin & Frayer, 2014, Wrangham, 2019) – shaping and prioritizing our minds to detect and predict cheaters and cooperators in social contracts (Cosmides & Tooby, 1992; Green & Phillips, 2004). These adaptive problems continue to present themselves in modern society (Nowak & Sigmund, 2005; Seabright, 2010). Once reputations from interaction histories establish, partners can reap steady gains from iterated cooperation with one another (Andreoni & Miller, 1993; Kaplan et al., 2012, 2018; Kreps et al., 1982). However, established cooperators remain vulnerable to opportunistic exploitation by previously cooperative partners. Despite these challenges, humans will often cooperate with one another. In successfully navigating these mixed-motive social dilemmas, it has been proposed that people apply *mind reading* to rapidly intuit the beliefs and intentions of others and to predict their cooperation or cheating behavior under sparse information conditions (Baron-Cohen, 1997).

Far from a magical or telepathic ability, mind reading--also known as mentalizing (Frith & Frith, 2006), applying a theory of mind (Premack & Woodruff, 1978), or using folk psychology (Dennett, 1989) -- is an ability that people make regular use of (Whiten & Byrne, 1991). Mind reading is an application of cognitive abilities universal to all normally developing humans enabling intentions to be understood and behavior predicted from the perspective of other agents' minds (Baron-Cohen, 1997). To understand others' intentions and beliefs we use available clues, evidence of past behavior, and context to update our beliefs and expectations. This allows us to predict behavior in an instant. We test the general hypothesis that people use mind reading to rapidly predict behavioral propensities under sparse information conditions, such as upon first and second impressions of strangers, a fundamental social skill important for regulating cooperative and non-cooperative behaviors across novel and repeated interactions. Below we detail our predictions that mind readers inform their guesses about strangers by applying their prior beliefs and available clues revealed by the target's description, appearance, and behaviors.

To investigate predictive mind reading, we conducted a non-deceptive two-part study with financially motivated participants. In part one, across multiple rounds of play between matched partners, we recorded “thin slice” videos (Ambady & Rosenthal, 1993) showing face-and-shoulder closeups of a university sample of participants taken just before their choices in each round of a “Split or Take All” Prisoner’s Dilemma (PD) game variant with unknown end-game. In the second part of our study, we recruited online a set of raters to first make guesses about the stereotypical male and female cooperation rates they expect from the PD, then to guess the game behavior of PD game players that they were unacquainted with. For each player guessed about we provided a unique ID number and manipulated whether raters viewed either a thin-slice video showing the player’s face, a photo still from the video, the player’s self-identified gender label without photo or video, or only the ID (i.e., no gender label, no face from photo or video). Raters guessed each player’s behavior in the first round of gameplay and in the second round after viewing round one behavioral history.

In social dilemmas like the repeated PD, the intent to pursue short-term non-cooperative interests is at odds with the intent to pursue mutually beneficial interests of cooperative partnerships. Despite the higher monetary rewards from successful non-cooperation and the normative proscription from game theory: do not cooperate because your partner will not cooperate, it has been demonstrated in social dilemma experiments that cooperation can develop with unrelated strangers in one-shot environments (Balliet & Van Lange, 2013; Dawes & Thaler, 1988; Dickhaut et al., 2008; Kiyonari et al., 2000; McCabe et al., 1996, 2003; Ostrom & Walker, 2003; Schneider & Shields, 2022), in finitely repeated games (Andreoni & Miller, 1993; Dawes & Thaler, 1988; Embrey et al., 2018; Mao et al., 2017), and in infinitely repeated games with unknown endgame (Camera and Casari, 2009; Duffy and Ochs, 2009, van den Assem et al., 2012; Normann & Wallace, 2012).

In a population of PD players believed to contain a mix of cooperative and uncooperative types, mind readers might consider a simple model where those with a cooperative intention initially choose to cooperate and those with an exploitative intention initially choose to cheat. For conditional cooperators who prefer cooperating when their partner is a cooperator, beliefs about the ratio of cooperators to exploiter types in a population should be an important predictor of the strategies deployed in first-round interactions (Kiyonari et al., 2000). To predict a player’s cooperative propensity, mind readers must first infer or detect their intention. To do this upon first-impressions --with no prior reputational information to discriminate the stranger upon, mind-readers may apply their “homemade” prior beliefs about the ratio of cooperators to non-cooperators likely to be encountered (Camerer & Weigelt, 1998), or derived from stereotyped assumptions about the target (Ames et al., 2012; McCabe et al., 2000). For example, participants expect that most other people in experiments with them are cooperative (Andreoni & Miller, 1993; McCabe et al., 2000), consistent with cooperation rate evidence (Andreoni & Miller, 1993; Camerer & Weigelt, 1998; Hayashi et al., 1999; Kiyonari et al., 2000; Kurzban & Houser, 2005; McKelvey & Palfrey, 1992). From these considerations, we derive our first prediction: (**P1**) in the treatment where gender is not revealed, first impression guesses of players’ round 1 cooperativeness will be influenced by prior beliefs about generalized cooperation propensity in the player population.

People expect behavior in social dilemmas to vary by gender and, when a player’s gender is revealed, people expect gender to be predictive of strategic behavior (Fetchenhauer et al., 2010; Schniter & Shields, 2020; Sylwester et al., 2012). Across cultures, people stereotype others’ tendencies to cooperate based on gender (Eagly, 2009). Prior research shows that gender stereotypes of cooperative, communal females and uncooperative, agentic males are shared by males and females and that gender is one of the most accurate and universally agreed-upon stereotypes among commonly stereotyped social categories (e.g., age, gender, ethnicity, and social class) (Jussim et al., 2009; Löckenhoff et al., 2014). Gender is often inferred from a person’s appearance (e.g., in terms of culturally masculine and feminine dress, makeup, hairstyle), their display of sexually dimorphic body features, their behavior, and how they are described (e.g., with symbols, labels, pronouns, and proper names). Upon visual inspection, male and female gender is differentiated in less than a second (Fletcher-Watson et al., 2008), and usually achieving accuracy above 95% (Bruce et al., 1993; Bruce & Young, 2011; Hill et al., 1995; Jaeger et al., 2020). This suggests that descriptions and appearance revealing gender inform raters of gender-specific behavioral propensities that could be used for predicting PD strategies that males and females deploy in interactions with strangers. Of course, to successfully apply gender stereotypes to predictions of a stranger’s behaviors, the stranger’s gender needs to be known and stereotypes need to be accurate. We expect that (**P2**) in the gender-label treatment and face treatments where gender is revealed, first impression guesses of players’ round 1 cooperativeness will be influenced by prior gender stereotyped beliefs about male and female players, and (**P3**) more accurate gender stereotypes will drive more correct guesses for label and face treatments than for the no-face gender-blind treatment.

When another's face can be seen in photos (Fetchenhauer et al., 2010; Tognetti et al., 2013),"thin-slices" of video only a few seconds in duration (Ambady et al., 2000; Ambady & Rosenthal, 1993; Fetchenhauer et al., 2010; Vogt et al., 2013), or during brief personal interaction (Brosig, 2002; DeSteno et al., 2012; Frank et al., 1993; Reed et al., 2012a), first impressions are formed using the static or dynamic clues encountered (Snyder, 1984). Faces may communicate information about stable dispositional traits like cooperativeness (Fetchenhauer et al., 2010; Frank, 1988; Frank et al., 1993), and distinguishing characteristics like gender, formidability, health, kinship, and ethnicity (Bruce et al., 1993; Fasolt et al., 2019; Zilioli et al., 2015). Facial displays of happiness and anger could also be helpful for predictive mind reading, as they are produced and understood by everyone, quickly interpreted –in well under a second (Batty & Taylor, 2003), and may be reliably informative of behavioral propensity (Ekman et al., 1987; Hirshleifer, 1987; Reed et al., 2012a; Verplaetse et al., 2007). As these clues can be diagnostic of cooperative propensity, and first impressions from appearances may sometimes be accurate (Fetchenhauer et al., 2010; Tognetti et al., 2013; Verplaetse et al., 2007; Vogt et al., 2013), when possible, mind readers are expected to use faces to improve guess accuracy. Thus, we predict that (**P4**) first impression guesses of round 1 cooperativeness will be more accurate in treatments showing a photo or video of the player's face than in treatments not showing the face.

Brief in-person interactions and thin slice videos of only a few seconds may reveal dynamic information about players that static photographs cannot (Ambadar et al., 2005; Harwood et al., 1999; Pike et al., 1997; Sato et al., 2004). Dynamic faces may display "tells", or involuntary facial cues, eye movements, blinking, and brief micro-expressions that can be used to assess the cooperative propensity of targets (Fetchenhauer et al., 2010; Frank, 1988; Frank et al., 1993; Hirshleifer, 1987; Reed et al., 2012). Dynamic faces may also reveal emotional expressivity, measured by the frequency and intensity of emotional expressions. Emotional expressivity can be used to index players according to the likelihood of cooperation with more emotionally expressive faces tending to be more cooperative (Schug et al., 2010). Expressive behavior sampled in first impressions can improve judgmental accuracy (Ambady et al., 2000; Ambady & Rosenthal, 1993). On the other hand, dynamic faces may be a distraction: faces are highly arousing and provocative stimuli that cannot be easily ignored (Palermo & Rhodes, 2007) and attention to faces may conflict with the ability to make accurate behavior predictions upon first-impressions – consistent with distraction-conflict models of attention allocation (Baron, 1986; Durkin et al., 2020). Videos and in-person interactions that provide longer exposure to dynamic face stimulus may exacerbate this distraction problem. For example, Sylwester et al. (2012) asked raters to assess either short or long video clips of people playing a variation of the Prisoner's Dilemma (PD) game, and to predict whether each player would choose "Split" or "Take All". They did not find that raters had above chance accuracy for long videos but did find that accuracy was higher than expected by chance for short videos. With these possibilities in mind, we generate the following alternative predictions concerning the effects of our Video treatment. The richer dynamic information from videos may be helpful for forming first and second impressions suggesting that (**P5**) guesses will be more accurate in the Video treatment than in the Photo treatment. Alternatively, the richer dynamic information may cause distraction and conflict suggesting that (**P6**) guesses of behavior will be more accurate in the Photo treatment than in the Video treatment.

In repeated interactions among partners, prior demonstrations of goodwill such as costly helping behavior or cooperative behavior can help inform beliefs about a partner's intentions to cooperate (Coricelli et al., 2000; McCabe & Smith, 2001). Even if first impressions are inaccurate, when new evidence of goodwill from cooperative behavior is revealed (e.g. after a round of game interaction), behavior predictions based on informed second impressions may become more accurate (Andreoni & Petrie, 2008; Schniter & Shields, 2014, 2020). Predictions of a player's behavior may be made based on limited evidence of the goodwill shown by that player in the previous round of interaction. A player's willingness to pursue cooperation conditionally results from their preference for mutual cooperation or exploitation and consideration of whether their partner previously demonstrated goodwill (Kiyonari et al., 2000). Conditional cooperators choose not to cooperate if their partners did not previously show goodwill while non-cooperators are always expected not to cooperate. Predictions of a player's behavior after round one should consider both the player's and their partner's previous show of goodwill. **Figure 1** outlines a goodwill accounting heuristic we hypothesize mind readers apply when predicting cooperative behavior. Mind readers should be able to evaluate the history of goodwill and then apply this simple heuristic quickly, with little cognitive effort or demand for additional information. Selection is expected to have strongly favored "fast and frugal" heuristics such as these because of their efficiency, inferential speed, and accuracy in decision-making situations constrained by limited information and available time (Gigerenzer & Goldstein, 1996; Todd, 2001). This leads us to predict that (**P7**) knowledge of past round behaviors in a repeated strategic interaction will improve the accuracy of guesses about a player's future behavior.

Our paper proceeds as follows: in section 2 we review background literature and compare our predictive mind reading study design to others. In section 3 we provide methodological details, in section 4 we present results, and in section 5 we discuss the results, study limitations, and extensions. Finally, in section 6 we conclude.

2. Background

A cheater detection adaptation appears to have evolved for solving problems associated with social exchange and cooperation (Cosmides, 1989a; Cosmides & Tooby, 1989, 1992, 2005). Accurate detection and prediction of cooperators and defectors is crucial for avoiding the pitfalls of interacting with non-cooperators or missing opportunities with cooperators (Cosmides & Tooby, 2005; Frank, 1988). If different kinds of detection or prediction errors impacted fitness differentially, for example failing to identify a real threat vs. identifying a non-existent threat, then according to the "smoke detector principle" (Nesse, 2005) selection would have tolerated detection and prediction abilities with errors at different frequencies, favoring a bias towards more of the least costly type of error (Haselton et al., 2015; Haselton & Nettle, 2006). The design of our cheater and cooperator detection systems may reflect an error management bias toward overpredicting cheaters or, alternatively, towards overpredicting cooperators in ancestral populations (Barclay, 2008; Schaller, 2008; Sparks et al., 2016). However, it cannot be known whether selection favored one error bias over another without knowing more about ancestral base rates of cooperator and cheater encounters and the relative costs of detection errors for each type. Similarly, any contemporary evidence of detection bias and accuracy can only be evaluated in terms of modern rates of cooperation. Few studies offering support for accurate game behavior prediction from first impressions provide sufficient detail to compare cheater and cooperator detection abilities. Frank et al. (1993) found that after a conversation with a partner but before playing the PD, participants were able to accurately predict their partner's behavior 69% of the time, with a greater improvement over chance seen for cheater detection than for cooperator detection. Brosig (2002) found that after a conversation with a partner but before playing the PD, participants were able to accurately predict their partner's behavior 67% of the time, with a greater improvement over chance seen for cooperator detection than for cheater detection. Based on these results, there is no clear evidence for an error-prone bias or an enhanced ability to predict cheating relative to cooperation. In general, there is a mix of evidence both for and against abilities to predict cheating and cooperation; we review this below.

A fair amount of attention has been given to the evaluation of predictive mind reading abilities using the so-called “gold standard” (Funder, 2012) of better-than-chance accuracy, though it has been limited to predictions of targets with no reputational history of prior game behavior. Our study is unique in that we study not only round 1 guesses from first impressions, but also round 2 guesses of those same players, but from informed second impressions where raters know players’ behavioral history.

A few studies find support for accurate game behavior prediction (Brosig, 2002; Frank et al., 1993; Reed et al., 2012), however, others report mixed results with only partial support, or no support (Bonnefon et al., 2013, 2017; Efferson & Vogt, 2013; Fetchenhauer & Dunning, 2010; Jaeger et al., 2022; Kiyonari, 2010; Manson et al., 2013; Sparks et al., 2016; Sylwester et al., 2012; Tognetti et al., 2013; Verplaetse et al., 2007; Vogt et al., 2013). Some of these studies do not reward raters’ correct guesses (Sylwester et al., 2012; Tognetti et al., 2013; Verplaetse et al., 2007; Vogt et al., 2013), which may negatively affect the accuracy of raters’ guesses. In our study, correct stereotypes and guesses about individual players are incentivized with monetary rewards, which should motivate raters to reveal correct stereotypes and make their best guesses (Smith, 1976).

Many behavior prediction studies draw raters and targets from the same subject pool. In some cases raters were shown targets that they had prior interactions with or went on to play subsequent games with (Brosig, 2002; DeSteno et al., 2012; Frank et al., 1993; Manson et al., 2013; Reed et al., 2012a; Sparks et al., 2016). Our worldwide online sample of raters is not drawn from the same local communities as the players they guess about, neither from the same convenience samples as the players, nor from among the set of players themselves. While convenient, more insular designs invite the possibility that prediction results are confounded by raters’ prior familiarity with targets, their involvement in the subject pool or experiment session, or behavior norms specific to their local community.

Some have given attention to uncovering what aspects of targets’ appearance might be helping people make behavior predictions (DeSteno et al., 2012; Jaeger et al., 2022; Manson et al., 2013; Reed et al., 2012a; Tognetti et al., 2013), though none of these have examined how well people can otherwise predict gameplay in the absence of personal cues from photos, videos, and face-to-face interactions, for example, by asking the question, “in the absence of visual stimulus, could strangers’ gameplay be predicted with above-chance accuracy?”. Our study design allows us to answer this question. Of the game behavior prediction studies that feature visual stimulus of players, many show images of the players under highly specific and unnatural conditions, such as where hair, clothes, and color are removed from faces or where faces are required to display emotionally neutral poses (Bonnefon et al., 2013; Jaeger et al., 2022). Other studies censor and manipulate the distributions of target characteristics to be equiprobable rather than varying naturally or representative of society's base rates (Oda et al., 2009; Olivola & Todorov, 2010). Yet other studies show videotapes of players, but drawn specifically from a setting unrelated to the game decision predicted (Brown et al., 2003; Fetchenhauer et al., 2010). Our study does not feature photos and videos from highly specific or unnatural conditions, nor does it censor or manipulate distributions of target characteristics. While our design controls the experimental settings and methods of stimulus capture, we allow PD participants to exhibit natural and ad libitum behavior in the contextually relevant moments before the PD game decision, when we capture their image.

3. Methods

3.1. Overview of experiments. Our study consists of two experimental procedures. In the first part, we use an experimental economic game and self-reported demographics to generate target stimuli consisting of thin slice videos, facial photographs, identification numbers, gender labels, and behavioral strategies from a participant sample of game players. In the second part of our study, we use an economic experiment to ask whether raters can predict targets' game behaviors based on generalized cooperation beliefs, gender-specific cooperation stereotypes, static and dynamic appearance, and behavioral history.

3.2. Stimuli (Prisoner Dilemmas). First, we conduct a computerized laboratory procedure in an experimental economics laboratory using a "Split or Take All" Prisoner's Dilemma (PD) game variant with an unknown end-game and anonymous unacquainted matched pairs. We impose a random-stopping rule to terminate the game. We explained in the instructions that a computer algorithm determines the chance of players continuing to another round, and that players would interact a minimum of two rounds of game interactions with the possibility of more rounds.

Participants recruited to be 'players' in the PD were randomly drawn from a subject pool of graduates and undergraduates at Chapman University. We used no deception and paid these players for the outcomes of their behavior in the study. As such, all game decisions were incentivized by the economic consequences of the game. We ran 13 sessions, each taking approximately 60 minutes.

In this PD each player chooses between “Split” or “Take All” strategies. Players were provided payoff matrixes explaining the consequences of both players’ choices (**Table 1**). Payoffs in the game are set up such that the reward from choosing “Take All” while one’s partner chooses “Split” is the largest payoff possible, greater than the payoff for a mutual “Split”. The mutual “Split” payoff is greater than the mutual “Take All” payoff of zero, which is equal to the payoff of zero from choosing “Split” while one’s partner chooses “Take All”. The strategy labels used are intuitive because they directly describe the payoff goals.

96 players aged 18 to 25 years old (51 men, 45 women) gave permission to be video recorded at intervals throughout the experimental procedure under standardized videographic conditions and for their recordings and experiment data to be made available for later research. Players were told that at no time would their or other players’ identities or video recordings be revealed to participants in their experiment session.

Videos of players were taken using computer display mounted digital cameras in individual computer terminal cubicles, set at the same distance from uniform backgrounds. From the original video recordings capturing head-and-shoulder closeups with ad libitum behaviors and expressions in the moments directly preceding a game decision being made, we trimmed thin slice videos two to three seconds in length without audio. Photographs showing each player’s face were captured from the thin slice video. Additional details of our PD game, procedure, and stimulus development are available online (https://doi.org/10.5281/zenodo.4321821).

3.3.1. Prisoner Dilemma Prediction Experiment. Between April 2021 and August 2022, we recruited 445 participants (M_{age}=33.6, SD_{age}=12.0; 48.53% male, 48.98% female) using www.prolific.co. Participants were allowed up to 87 minutes to complete the experiment. We restricted recruitment to volunteers residing in the US, and only allowed volunteers to participate in the study once. 422 participants remained after excluding participants for violating requirements; specifically, we excluded (i) 11 for taking the survey on a smart phone despite prohibition against using small screen devices, and (ii) 12 for completing the task in less than 480 seconds, a speed we considered to be humanly improbable. **Table 2** reports the characteristics of these participants that we refer to as raters.

All raters received instructions. To advance to the prediction study, raters had to complete, without error, a series of control questions verifying that a human responder is attentive to our questions. Instructions and survey questions are available in the online Appendix B.

Raters received the same instructions for the Prisoner's Dilemma game that were provided to players in the first experimental procedure. Raters were informed that they would first make guesses about the round 1 behaviors of the set of female players and the set of male players in the original study. For example, "On a scale ranging from 0% to 100% of the time, how often do you guess that females chose to "Split" and "Take All" in the first round of the original experiment", with the requirement that these percentages must equal 100%. Raters answered identical questions about males. These guesses inform us of raters' female stereotype beliefs and male stereotype beliefs. Next, raters made a series of guesses about the game behaviors of each player from the original study by selecting either the cooperative strategy ("Split") or the uncooperative strategy ("Take All") that they expect the player had chosen. Each rater made these guesses about each of the 94 players. First, all guesses about round 1 game behavior were made. Next, with the history of each player and partner's round 1 behavior provided, raters made all guesses about round 2 game behavior. We used no deception and paid raters for the accuracy of their guesses in the study. As such, all guesses made were incentivized by the economic consequences of their accuracy.

3.3.2. Treatment groups. We conducted a 4 x 1 between-subjects design with raters. Raters were randomly assigned to one of the treatment cells. There are four treatments manipulating information for the players being guessed about that we call "None" (n=108), "Label" (n=101), "Photo" (n=108), and "Video" (n=105). The Photo and Video treatments provide static and dynamic facial and appearance information, respectively, while the other two treatments show no facial or appearance information. Of those treatments without facial or appearance information, the Label treatment details each player's self-identified gender, and the None treatment does not. All treatments manipulate behavioral history. This design allows us the ability to test predictions about the role of prior beliefs (**P1**) the role of player gender (**P2**, **P3**), face/appearance (**P4**) static vs. dynamic face/appearance (**P5**, **P6**) and behavioral history (**P7**). We preregistered our treatments at aspredicted.org (#61202, #103594) before collecting their data.

3.4. Consent and data availability. Internal review board approval was granted by Chapman University (#1718H016, #1314H065). The data for statistical analyses are available at https://doi.org/10.5281/zenodo.7465288.

3.5. Measurements and analyses. To evaluate raters' abilities to predict player behaviors, we measure the correctness, cooperator and cheater detection rates, accuracy, bias, and odds-ratios of raters' guesses. We define 'correctness' as the proportion of observations for a rater where cooperators (those choosing "Split") and cheaters (those choosing "Take All") are correctly guessed. Likewise, 'cooperator detection' measures the proportion of observations for a rater where "Split" was guessed given the player chooses "Split", and 'cheater detection' measures the proportion of observations for a rater where "Take All" was guessed given the player chooses Take All. We define 'accuracy' as the function of a rater's cooperator detection rate (*H*) and cheater detection rate (*R*). Formally, this is defined as $[Z(H) - Z(1-R)]$.[1] Bias is a measure of the rater's tendency to over- or under-predict actual cooperator or cheater rates. Formally, this is defined as $-0.5\,[Z(H) + Z(1-R)]$. Negative values represent a bias towards predicting cooperation and positive values represent a bias towards predicting cheaters. The 'odds-ratio' of guesses is the number of correct guesses in a round divided by the expected number of correct guesses due to chance alone, where α is the proportion of time that the rater guesses "Split", β is the proportion of the time that players choose "Split", and the expected number of correct guesses due to chance is $\alpha\beta + (1-\alpha)(1-\beta)$. Better-than-chance accuracy is defined by odds-ratio values greater than one.

We use logit analysis to evaluate effects of stereotypes, labels, static appearance, and dynamic appearance on raters' first and second impression predictions, correctness, cooperator and cheater detection rates, accuracy, and bias after first and second impressions. For round 1 guesses about unknown gender players in the mixed gender population, we calculate raters' 'generalized cooperation beliefs' from an average of their male and female stereotyped beliefs. To assess whether raters with more accurate gender stereotypes make more pre-impression correct choices, we create dummy variables for gender stereotype accuracy that we call the 'sufficiently correct median'. The dummy is one if the rater's gender stereotype is greater than or

[1] The Z(.) is the inverse of the standard normal cumulative distribution, where rates are greater than zero but less than one (Macmillan & Creelman, 2004). The function converts probabilities into z scores. For example, Z(.05) = -1.64, which means that a one-tailed probability of .05 requires a z score of -1.64. Rates of zero (one) are transformed to 1/100 (99/100) so that the z scores are more (less) than negative (positive) infinity.

equal to 50% and players of that gender are cooperative, or if the rater's gender stereotype is less than 50% and players of that gender are non-cooperative. Otherwise, the dummy is zero. If raters base guesses only on correct stereotypes, then there should be an increase in correctness but not accuracy.

All models presented in this study can be replicated using the statistical and data files presented as electronic supplementary materials. Statistical analysis was performed using Stata/SE 17.0.

4. Results

Among PD players we can observe the endogenous emergence and natural distribution of cooperative behaviors among matched pairs and the effects of game interaction outcomes on subsequent game behavior.[2] Below we describe the results of our PD prediction study which elicited raters' gender stereotyped beliefs about male and female cooperativeness followed by a series of predictions about individual PD players' game behavior based on first and second impressions. On average, raters completed the study procedure in 24.4 minutes and earned \$4.56. Prediction response times per target by treatment are reported with rater demographics in **Table 1.** Payoffs in the "Split or Take All" prisoner's dilemma game.

		Column player	
		Split	Take All
Row player	Split	5, 5	0, 10
	Take All	10, 0	0, 0

Note: Row, column player payoffs in US dollars.

Table .

4.1. Stereotyped beliefs about PD players' cooperation rates

Raters' generalized cooperation beliefs indicate that they expect players will cooperate 54 percent of the time in the first round (**Table 3**).[3] Males were stereotyped as less cooperative (44.2%) than females (63.9%). Gender-specific stereotypes about male and female players were heterogeneous (**Figure 2**), significantly correlated (Pearson 0.503, $p < .001$), and significantly

[2] Game data is available at https://doi.org/10.5281/zenodo.4321821.
[3] There were no significant differences in the generalized cooperation belief between treatments (Kruskal-Wallis, $p = .114$). Male and female generalized cooperation beliefs did not differ significantly (Kruskal–Wallis, $p = .300$)

different (Wilcoxon matched-pairs signed-rank test, Z = 16.1, p < .001). These stereotype beliefs significantly underestimated actual male player cooperation (61.4%) and female player cooperation (86.0%) in the first round (Wilcoxon, males: Z = -14.3, p < .001; females: Z = -17.5, p < .001). Male raters stereotyped males to be slightly more cooperative (46.3%) than female raters did (42.2%), a significant difference (Wilcoxon, Z = 2.29, p = .022). Similarly, female raters stereotyped females to be more cooperative (66.5%) than male raters did (61.8%), a significant difference (Wilcoxon, z = 2.00, p = .045).

4.2. First impression guesses about PD players' round 1 game behavior

Upon exposure to stimulus describing and sometimes showing PD players deciding how to play in round 1 of a repeated PD, raters made rapid first impressions and predictions of each of 94 players, averaging across conditions 1.2 (None), 1.4 (Label), 3.1 (Photo), and 8.3 (Video) seconds per player. Consistent with their stereotypes, raters underestimated round 1 cooperation in all treatments, predicting 58.7 percent cooperation, when it was actually 74.5 percent (**Table 4**).[4] Despite underestimated cooperation, raters show significantly better

[4] Guesses of cooperation are reported in the first column of

Table 3. Raters' stereotyped and generalized beliefs about PD players' cooperativeness.

	Stereotype about male players	Stereotype about female players	Generalized beliefs about all players
Belief revealed by:			
Male Rater	46.3	61.8	54.1
N = 206	(18.6)	(18.4)	(16.6)
Female Rater	42.2	66.5	54.4
N = 206	(17.7)	(15.2)	(13.8)
All Other Raters	40.3	50.4	45.4
N = 10	(13.6)	(18.7)	(15.3)
Combined	44.2	63.9	54.0
N = 422	(18.1)	(17.2)	(15.3)
Players' actual cooperativeness:	Males	Females	All players
Round 1	61.4	86.0	74.5
	(49.2)	(35.1)	(43.8)
Round 2	43.2	62.0	53.2
	(50.1)	(49.0)	(50.2)
Both Rounds	52.3	74.0	63.8
	(50.2)	(44.1)	(48.2)

Note. Where beliefs are reported, values are percent of time (SD in parenthesis) raters guess that each gender chooses 'Split' in round 1 of the repeated PD. Where players actual cooperativeness is reported, values are percent of time (SD in parenthesis) players choose 'Split'.

cooperation detection than cheater detection (Wilcoxon matched-pairs signed-rank test, all $p < .041$).[5] Round 1 correctness, cheater detection, and cooperator detection rates are shown in **Figure 3**. Correctness differs significantly between treatments (Kruskal-Wallis, $p < .001$), as does accuracy (Kruskal-Wallis, $p < .001$), and bias (Kruskal-Wallis, $p < .001$). Round 1 guess correctness shows no difference between conditions that do or do not reveal gender (Wilcoxon, $p = .259$). In gender conditions, cheater detection rates are significantly higher ($p < .001$) while cooperator detection rates are significantly lower ($p = .005$). In conditions revealing players' faces, round 1 cheater detection rates are significantly higher (Wilcoxon, $p < .001$), while guess correctness and cooperator detection rates are significantly lower (Wilcoxon, both $p < .001$). The odds-ratios in the Label, Photo, and Video treatments indicate better-than-chance accuracy (**Figure 4**) and are significantly higher than in the None treatment (Wilcoxon signed-rank test, all $p < .003$). In all treatments, the average bias is towards overpredicting cheaters (Wilcoxon, all $p < .043$).

Below, we evaluate our research questions concerning the predicted effect of stereotypes, labels, photos, and videos on guesses of round 1 game behavior.

Where gender cannot be detected, are round 1 guesses influenced by prior beliefs about generalized cooperation propensity in the player population (P1)? Yes.

In the None treatment, where the rater could not determine a player's gender, raters generally *believed* that players would cooperate 54.0% of the time and *guessed* that 58.7% of players would cooperate in round 1. The effect of generalized beliefs on guesses is significant in the None treatment ($p < .001$) (**Table 5**, regression 1).

Are round 1 guesses influenced by gender stereotypes in treatments where player gender is labeled or seen (P2)? Yes.

Table , where there were significant differences in guesses between treatments (Kruskal-Wallis, $p < .001$).

[5] This difference in detection rates is significant between treatments (Kruskal-Wallis, $p < .001$).

The effect of gender-specific stereotypes on guesses is positively significant in Label, Photo, and Video treatments where gender can be visually detected (all $p < .001$). (**Table 5**, regression 2). The effect of gender-specific stereotypes is significantly stronger for the Label treatment than the Photo treatment ($p < .001$), and the effect is significantly stronger for the Photo treatment than for the Video treatment ($\chi^2(1) = 258.98$, $p < .001$).

Is correctness of round 1 guesses influenced by the accuracy of male and female stereotype beliefs in treatments where gender is labeled or seen (P3)? Yes.

Using a logit analysis, we find that more accurate stereotypes are correlated with more correct guesses (**Table 6**). For all treatments—including the None treatment, sufficiently correct stereotypes are positively significantly correlated with correct guesses (all $p < .001$). The effect of sufficiently correct stereotypes on correct guesses is significantly stronger for Label treatment than for the Photo treatment ($\chi^2(1) = 14.78$, $p < .001$) or the Video treatment ($\chi^2(1) = 29.83$, $p < .001$). The effect of sufficiently correct stereotypes on correct guesses is marginally stronger for the Photo treatment than for the Video treatment ($\chi^2(1) = 3.04$, $p < .081$). The effect of sufficiently correct stereotypes on correct guesses is not statistically different in the Video treatment than the None treatment.

Are round 1 guesses more accurate in the treatments showing the player's face (P4)? Yes.

Guesses in the Photo and Video treatments showing the player's face are significantly more accurate than in treatments not showing the face (Wilcoxon, $p = .013$). Bias was significantly closer to neutral (zero) in treatments showing the player's face (Wilcoxon, $p < .001$).

Are round 1 guesses more accurate in the Video treatment (P5) or in the Photo treatment (P6)? Guesses are more accurate in the Photo treatment.

Accuracy in the Video treatment is significantly lower than in the Photo treatment (Wilcoxon, $p < .045$) and the Label treatment (Wilcoxon, $p = .019$). Bias was not significantly different between treatments showing the player's face.

4.3.1. Second impression guesses of PD players' round 2 game behavior

Raters guessed 58.8% of players would cooperate in round 2, quite close to their guess of 58.7% cooperation in round 1 (**Table 4**). Players' cooperative behavior decreased from 74.5% in round 1 to 53.2% in round 2. Compared to round 1 guesses, correctness improved 5.3%, cheater detection improved 7.8%, and cooperator detection improved 9.1% for round 2 guesses (**Table 4**, **Figure 3)**. Below we report results that help explain these performance improvements.

Does knowledge of past round behavioral history improve the accuracy of guesses (P7)? Yes.

Across treatments, round 2 guesses were more accurate than chance (**Figure 2**), with accuracy differing between some treatments (Wilcoxon, all $p < .001$).[6] The accuracy of the round 2 guesses (0.595) increased above the accuracy of round 1 guesses (0.124) (**Table 4**). In every treatment, the increase in accuracy was significant (Wilcoxon signed-rank test, all $p < .001$). Next, we conduct post-hoc analysis to determine whether the artifactual conditions endogenously created by players' round 1 behavioral history affected raters' round 2 guess performance, and how gender stereotypes or players' facial appearance may have played a role.

4.3.2. Post-hoc analyses of round 2 guesses given stereotypes, conditions with gender or faces revealed, and behavioral history.

Though stereotypes are closer to round 2 than to round 1 player behavior, across behavioral histories, stereotypes and knowing the player's gender affect round 2 guesses significantly less than round 1 guesses (**Table A1**). Round 2 guess correctness, cheater detection, and cooperator detection show no relative improvement in gender conditions (Wilcoxon, $p = .140$, $p = .091$ and p =. 079, respectively). However, in conditions revealing players' faces, round 2 guess cheater detection rates are significantly higher (Wilcoxon, $p = .010$), while cooperator detection rates are significantly lower (Wilcoxon, $p = .014$) and there is no significant difference in correctness (Wilcoxon, $p = .080$).

Raters' round 2 guesses and correctness vary across the players' four possible behavioral histories: 'Both Take All', 'Take All/Partner Split', 'Split/Partner Take All', and 'Both Split' (**Table**

[6] While we find that the guesses were more marginally more accurate than chance when raters had access to player's faces (Wilcoxon, $p = .072$), there were no significant differences between the None and Label treatments ($p = .522$), nor between the Photo and Video treatments ($p = .479$).

7). Compared to the round 1 guesses, raters significantly increased their round 2 guesses of cooperation for the 'Both Split' behavioral history condition, and significantly decreased their guesses of cooperation for behavioral history conditions where at least one partnered player chose "Take All".

Round 2 guesses are affected by seeing gender labels or faces in the context of round 1 behavioral history, as these cues help improve guess correctness about male players generally (**Table A1**), and guess correctness for all players in the behavioral conditions where one or both partners chose "Take All" (**Table A2**).[7] When raters see a player's face in a 'Take All/Partner Split' interaction, they more aptly detect whether the player will be a round 2 cheater. Likewise, when raters see the player's face in a 'Split/Partner Take All' interaction, they more aptly predict that the player will choose 'Split'—resulting in more correctness than in conditions without the player's face visible (Table A2).

5. Discussion

These results provide supporting evidence for mind reading mechanisms designed to rapidly predict others' cooperativeness when forming first and second impressions. Below we discuss the importance of beliefs, personal and contextual clues, and methodological approaches for revealing predictive mind reading abilities.

Our results suggest that mind-reading does not wait for strategic interaction to begin. When the incentive structure of a game is easily understood and in the absence of direct behavioral evidence, raters can make these predictions easily and in rapid succession, taking about 3 to 4 seconds to evaluate and guess about each player. The incentive structure we chose for our "Split or Take All" PD game is one that we expect can be widely understood – leading to common perspectives and expectations among players and raters; it is identical to that of games featured on television shows such as *Friend or Foe*, *Golden Balls*, or *Take It All* which have since been analyzed as a natural experiment of cooperation (Burton-Chellew & West, 2012; van den Assem et al., 2012). In *Friend or Foe*, *Golden Balls*, or *Take It All* games, players choose "Split" 53 percent of the time, and young adult males are less cooperative than young adult females, though the gender effect reverses for older players (Burton-Chellew & West, 2012; van den Assem et al.,

[7] We find significant differences in correctness when raters had access to player's faces, but no significant differences between the Photo and Video treatments.

2012). Our raters expected males to be less cooperative, and for players to cooperate 54 percent of the time, almost identical to the game show average.

Raters in our study appear to rely on gender stereotyping to predict strangers' future behavior. With sufficiently correct gender stereotype beliefs and knowledge of the players' gender or appearance, raters make better-than-chance guesses of unacquainted players' round 1 cooperation behaviors in a repeated PD. Interestingly, the effect of correct gender stereotypes on correct guesses of a player's round 1 behavior is strongest in the gender label treatment.

Most studies evaluating the role of gender in raters' evaluations of target's cooperativeness rely on raters inferring gender from visual inspection and provide no control for whether something about appearance other than gender might be confounding the effect attributed to target gender (Fetchenhauer et al., 2010; Sylwester et al., 2012; Tognetti et al., 2013; Vogt et al., 2013). We created a gender-label treatment to carefully isolate the effect of male or female gender from other effects of visual appearance.[8] The informational differences afforded by our treatments suggest that raters may not have equal reason to rely on gender stereotypes across treatments. Across conditions where gender can be visually detected, the Label treatment provides raters less player information than the Photo treatment, which provides less player information than the Video treatment. As a result of these differences in available information, raters may trade off the value of gender clues for additional visual clues. An additional concern about differences across these treatments is that the appearance of static or dynamic faces may present an unhelpful distraction for raters who might be better off relying on accurate prior beliefs. The formation of first impressions from faces may be so automatic and non-conscious that they are relied upon even when objectively better information is available (Olivola & Todorov, 2010; Rezlescu et al., 2012) or when it is known that one should avoid being influenced by faces (Blair et al., 2004; Hassin & Trope, 2000; Palermo & Rhodes, 2007). While raters in our study appear to be trading off the influence of correct gender stereotypes for additional appearance information, the effect of more appearance information on guess correctness and accuracy is negative: the Photo treatment is less correct and accurate than the Label treatment, and the Video treatment is even worse off, consistent with the conflict-distraction model.

[8] While all our PD players self-identified as either male or female, a small portion of our raters chose to not identify as male or female. Future studies will benefit from inquiry into the alternative gender identities and concepts that are becoming increasingly preferred by survey respondents and might better reveal gender influences if carefully measured (Snyder et al., 2022).

Attention to faces in the Video treatment is especially costly: visual and auditory attention to dynamic faces (e.g., changing eye gaze, expressions, utterances) requires more time and attentional resources–potentially causing distractions or interference with processing capacity for tasks separate from visual and aural inspection (Lavie, 1995; Pessoa et al., 2002). The attentional costs and longer response time in our Video treatment may have contributed to a greater conflict-distraction effect, producing less guess correctness and accuracy than in the Photo treatment. Though our research design did not compel standard response times across treatments to control for these costs, future research may benefit from designs with response time controls or from the investigation of potential response time effects. As gender identity and photo or video appearance are influential parameters in self-presentation across a variety of human interaction mediums affecting investment, voting, legal decisions, hiring, mate selection, and cooperative interaction (Snyder et al., 2022; Todorov, 2017), our results provide important insight into key hazards and tradeoffs involved with revealing or not revealing gender identity and static or dynamic appearance when first or second impressions form and new relationships develop.

Upon learning the details of players' round 1 PD interactions, raters can form updated second-impressions with the new information gleaned. From these second impressions, raters make better-than-chance predictions of players' round 2 PD game behaviors across all treatments – improving their guess performance from round 1 guesses. Additionally, the treatments showing players' faces improve cheater detection but hurt cooperator detection. Correct and accurate round 2 guesses are also affected by behavioral history conditions where one or both partners chose "Take All". Prior research suggests that more masculine male faces are associated with perceptions of aggressiveness and dominance (Geniole et al., 2015; Sell et al., 2009; Zilioli et al., 2015), consistent with the idea that males who appear stronger and more masculine have greater potential bargaining power via coercive formidability and therefore can be expected to act more aggressively, reactively, and less cooperatively in social dilemma interactions (Daly & Wilson, 1988; Sell et al., 2012). Given our effects of male faces on round 2 guesses, it may be productive for future research to investigate further how variation in male cues, such as facial masculinity and formidability, may be predictive of cooperativeness in repeated games, especially in the context of previously non-cooperative interactions where entitlement and reactive anger may be at play.

Combined, cheater and cooperator detection abilities provide raters better-than-chance behavior prediction abilities in most of the treatments for round 1 guesses, and in all the treatments for round 2 guesses. When cooperator and cheater detection are compared, we see that cooperators were more accurately detected than cheaters. Across round 1 and round 2 guesses, cooperator detection is higher in the gender label condition than in the conditions showing players' faces, and cheater detection improves in conditions showing players' faces. The bias to over-predict cooperation in our study might reflect the error management associated with social dilemma problems in hyper-cooperative modern society: where the costs of not detecting cheaters and exposing oneself to interactions with them are small relative to the gains of mutual cooperation with cooperative partners (Delton et al., 2011; Sparks et al., 2016). If our adaptations for social exchange have been sensitive to changing costs of being cheated versus missing cooperation opportunities, the calibration of our error management for cheater versus cooperation detection might be facultative rather than fixed – responding to serve the more costly challenges in the local social exchange environment (Barclay, 2008). Our results also suggest that cheater versus cooperator detection abilities may facultatively respond to sparse cues, like gender and appearance, available in first and second impressions.

6. Conclusion

Our study provides an explanation for why cooperation is so commonly observed among strangers in social dilemmas like the PD despite the game-theoretic prediction not to cooperate: people are able to mind-read, effectively intuiting the cooperation propensities of the majority of other people in a way that should allow them to seek out and maintain mutually beneficial cooperative relationships. The cheater and cooperator detection from sparse person and context information demonstrated in our study complements the evidence of cheater detection abilities particularly sensitive to rule violation information (Brown & Moore, 2000; Cosmides, 1989b; Cosmides & Tooby, 1992; Fiddick & Erlich, 2010; Oda et al., 2006). Our study also provides insight into accurate predictions of trust re-extension, an important but precarious and all-too-common problem in personal and business relationships (Robinson & Rousseau, 1994; Schniter & Sheremeta, 2014).

The behavioral sciences have closely studied the design of people’s chosen behaviors in potentially cooperative strategic interactions. However, a clean experimental test and clear understanding of people’s expectations of others’ behaviors in unacquainted and repeated interactions have been largely missing. The evidence presented here suggest people can accurately predict the cooperativeness of strangers, helping explain the broad extent of human cooperativeness revealed by experimental and ethnographic studies. In conclusion, our study provides further support for the claim that an evolutionary–functional framework is a productive and promising approach to uncovering the nature of human mind reading.

Table 1. Payoffs in the “Split or Take All” prisoner's dilemma game.

		Column player	
		Split	Take All
Row player	Split	5, 5	0, 10
	Take All	10, 0	0, 0

Note: Row, column player payoffs in US dollars.

Table 2. Rater demographics.

	Guess response time (seconds per target)			Self-identify with			Prior familiarity with		
Treatment (N)	First Impression – Round 1	Second impression – Round 2	Age in years	Male	Female	Other or prefer no answer	Player(s) in image	University students	University
None	1.16	2.21	36.3	47.2	50.0	2.8	N/A	0.9	2.8
(108)	(1.05)	(1.49)	(12.7)					(9.6)	(16.5)
Label	1.40	2.40	32.8	50.5	45.5	4.0	N/A	1.0	3.0
(101)	(0.64)	(1.44)	(11.3)					(9.9)	(17.1)
Photo	3.13	3.70	33.6	49.1	50.0	0.9	0.9	0.9	0.9
(108)	(2.56)	(2.39)	(11.8)				(9.6)	(9.6)	(9.6)
Video	8.32	8.82	32.6	48.6	49.5	1.9	0.0	0.0	1.9
(105)	(2.39)	(3.21)	(12.3)				(0.0)	(0.0)	(13.7)
Total	3.50	4.28	33.9	48.8	48.8	3.6		0.7	2.1
(442)	(3.43)	(3.49)	(12.1)					(8.4)	(14.4)

Note: ‘Self-identify with’ values indicate percentages of raters’ responses. ‘Prior familiarity with’ values are percentages of raters with responses that indicate some familiarity (see online Appendix B for survey question details).

Table 3. Raters’ stereotyped and generalized beliefs about PD players’ cooperativeness.

	Stereotype about male players	Stereotype about female players	Generalized beliefs about all players
Belief revealed by:			
Male Rater	46.3	61.8	54.1
N = 206	(18.6)	(18.4)	(16.6)
Female Rater	42.2	66.5	54.4
N = 206	(17.7)	(15.2)	(13.8)
All Other Raters	40.3	50.4	45.4
N = 10	(13.6)	(18.7)	(15.3)
Combined	44.2	63.9	54.0
N = 422	(18.1)	(17.2)	(15.3)
Players’ actual cooperativeness:	Males	Females	All players
Round 1	61.4	86.0	74.5
	(49.2)	(35.1)	(43.8)
Round 2	43.2	62.0	53.2
	(50.1)	(49.0)	(50.2)
Both Rounds	52.3	74.0	63.8
	(50.2)	(44.1)	(48.2)

Note. Where beliefs are reported, values are percent of time (SD in parenthesis) raters guess that each gender chooses ‘Split’ in round 1 of the repeated PD. Where players actual cooperativeness is reported, values are percent of time (SD in parenthesis) players choose ‘Split’.

Table 4. Summary statistics for raters' guesses about PD players.

Treatment (N)	Guessed Split	Correctness	Cooperator Detection	Cheater Detection	Accuracy	Bias	Odds-ratio
First Impression: Round 1 guesses [actual Split = 74.5%]							
None	63.6	56.1	63.2	35.4	-0.061	-0.480	0.990
(108)	(27.2)	(14.0)	(27.4)	(28.0)	(0.324)	(1.131)	(0.074)
Label	61.0	58.7	63.2	45.5	0.238	-0.277	1.062
(101)	(15.9)	(8.6)	(15.8)	(19.7)	(0.363)	(0.548)	(0.092)
Photo	56.1	55.9	58.1	49.6	0.214	-0.149	1.059
(108)	(16.8)	(8.7)	(16.5)	(20.6)	(0.348)	(0.619)	(0.095)
Video	54.0	53.4	55.0	48.9	0.113	-0.087	1.028
(105)	(13.2)	(8.5)	(13.9)	(15.9)	(0.362)	(0.381)	(0.101)
All	58.7	56.0	59.8	44.8	0.124	-0.249	1.034
(422)	(19.4)	(10.4)	(19.5)	(22.2)	(0.368)	(0.743)	(0.095)
Second Impression: Round 2 guesses [actual Split = 53.2%]							
None	60.0	60.2	68.9	50.2	0.536	-0.268	1.188
(108)	(18.4)	(8.2)	(20.4)	(19.7)	(0.451)	(0.685)	(0.160)
Label	60.8	60.7	70.3	49.9	0.561	-0.317	1.199
(101)	(14.6)	(7.9)	(15.5)	(17.9)	(0.438)	(0.511)	(0.159)
Photo	59.0	62.5	70.2	53.8	0.674	-0.227	1.237
(108)	(12.1)	(6.3)	(12.9)	(14.5)	(0.351)	(0.361)	(0.126)
Video	55.4	61.6	66.0	56.6	0.606	-0.131	1.223
(105)	(11.1)	(6.5)	(12.9)	(12.9)	(0.352)	(0.312)	(0.128)
All	58.8	61.3	68.9	52.6	0.595	-0.235	1.212
(422)	(14.5)	(7.3)	(15.8)	(16.6)	(0.402)	(0.493)	(0.145)

Note: Values for guessed split, correctness, cooperator detection, and cheater detection are percentages. Standard deviations are in parentheses.

Table 5. Logit regression predicting Round 1 guesses controlling for the gender of PD players and raters' beliefs.

	(1)		(2)	
Detected Gender	2.13	***		
	(5.59)			
Photo			0.52	***
			(3.46)	
Video			1.30	***
			(8.78)	
Stereotype	0.08	***	0.05	***
	(13.66)		(30.47)	
Detected Gender X Stereotype	-0.04	***		
	(-6.60)			
Photo X Stereotype			-0.01	***
			(-5.04)	
Video X Stereotype			-0.03	***
			(-12.89)	
Constant	-3.7	***	-2.37	***
	(-11.00)		(-21.24)	
Raters	422		314	
Log-Likelihood	-24,031		-18,057	
AIC	48,071		36,128	
BIC	48,114		36,186	
Chi-Squared (3 df) / (5 df)	323	***	1,861	***

T-statistic in parenthesis. ***: p < .001. Regression (1) includes round 1 data from all treatments. Detected gender is equal to one if the treatment is Label, Photo or Video. Regression (2) includes round 1 data only from treatments where player gender can be visually detected: Label, Photo, and Video. The variable *Stereotype* in regression (1) refers to raters' generalized beliefs (i.e., the average of their male and female stereotypes), whereas *Stereotype* in regression (2) refers to the applicable male or female stereotype given the player's self-description. As we control for Photo and Video in regression (2), *Stereotype*'s effect is from the label treatment only.

Table 6. Logit regression predicting correct round 1 guesses controlling for sufficiently correct gender stereotypes.

Label	-0.23	**
	(-2.98)	
Photo	-0.12	
	(-1.63)	
Video	-0.13	
	(-1.86)	
Sufficiently correct median	0.37	***
	(7.01)	
Label X sufficiently correct median	0.51	***
	(6.42)	
Photo X sufficiently correct median	0.20	**
	(2.70)	
Video X sufficiently correct median	0.06	
	(0.81)	
Constant	0.01	
	(0.21)	
Guesses	39,668	
Raters	422	
Log-Likelihood	-26,603	
AIC	53,225	
BIC	53,302	
Chi-Squared (7 df)	483.18	***

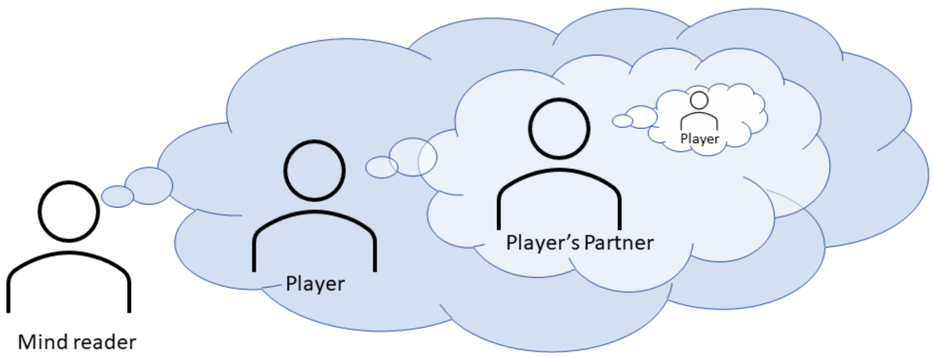
T-statistic in parenthesis. **: p < .01, ***: p < .001.

Table 7. Second impression round 2 guess and correctness by players' behavioral history.

		Raters' round 2 guess				
Behavioral History	Actual Split (Round 2)	None	Label	Photo	Video	Combined
Both Take All	83.3	40.0	38.3	31.9	33.8	36.0
Take All/Partner Split	22.2	38.6	34.7	24.0	22.2	29.8
Split/Partner Take All	26.3	25.9	32.2	31.4	27.9	29.3
Both Split	70.6	82.6	83.4	84.8	79.9	82.7
Total	53.2	60.0	60.8	59.0	55.4	58.8
		Raters' round 2 guess correctness				
Behavioral History	Percentage of Players	None	Label	Photo	Video	Combined
Both Take All	6.4	43.4	41.1	39.4	41.0	41.2
Take All/Partner Split	19.1	55.7	59.8	66.0	65.6	61.8
Split/Partner Take All	20.2	61.0	58.8	60.2	61.2	60.3
Both Split	54.3	63.4	64.1	64.9	62.8	63.8
Total	100	60.2	60.7	62.5	61.6	61.3

Note: All values reported for raters' round 2 guess are percent of time raters guess players would choose Split. All values reported for raters' round 2 guess correctness are the percent of raters' round 2 guesses that are correct.

To predict cooperation in any round of repeated Prisoner's Dilemma after round one, the mind reader accounts for goodwill that the player and their partner each demonstrated in the previous round and will next respond to.



Simple heuristic predicting cooperation: The player will cooperate in the next round only if mutual cooperation occurred in the previous round. If either the player or their partner did not cooperate, the player will not cooperate in the next round.

Figure 1. Mind readers' goodwill accounting heuristic for predicting players' cooperative propensity in a repeated prisoner's dilemma game with unknown endgame.

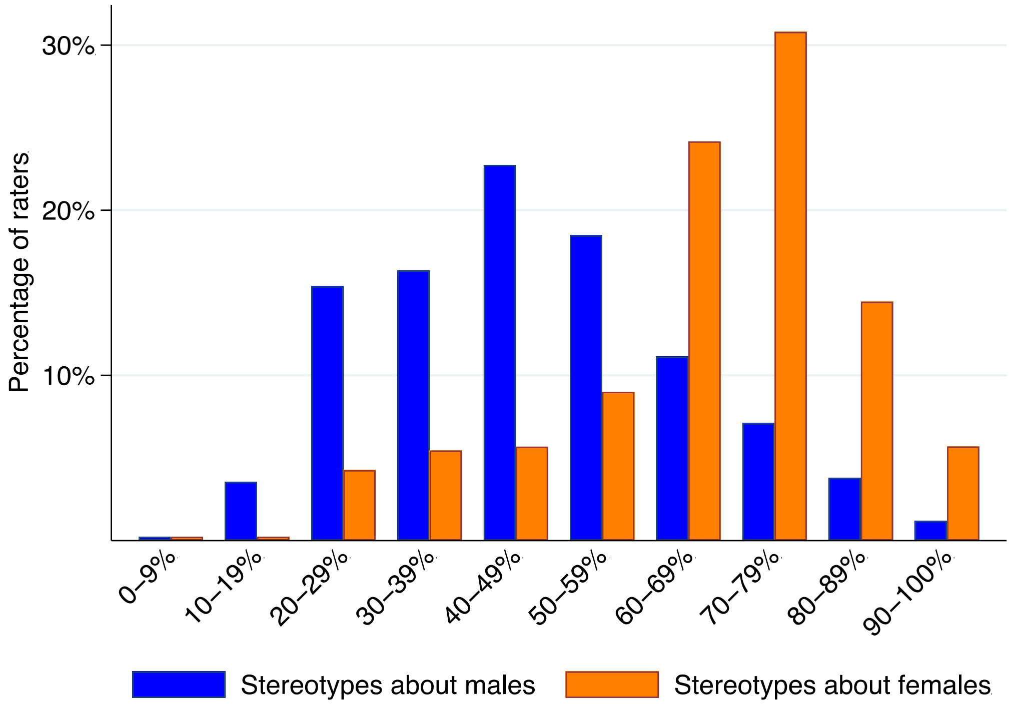


Figure 2. Raters' gender-specific stereotype beliefs about male and female players of a repeated prisoner's dilemma game with unknown endgame.

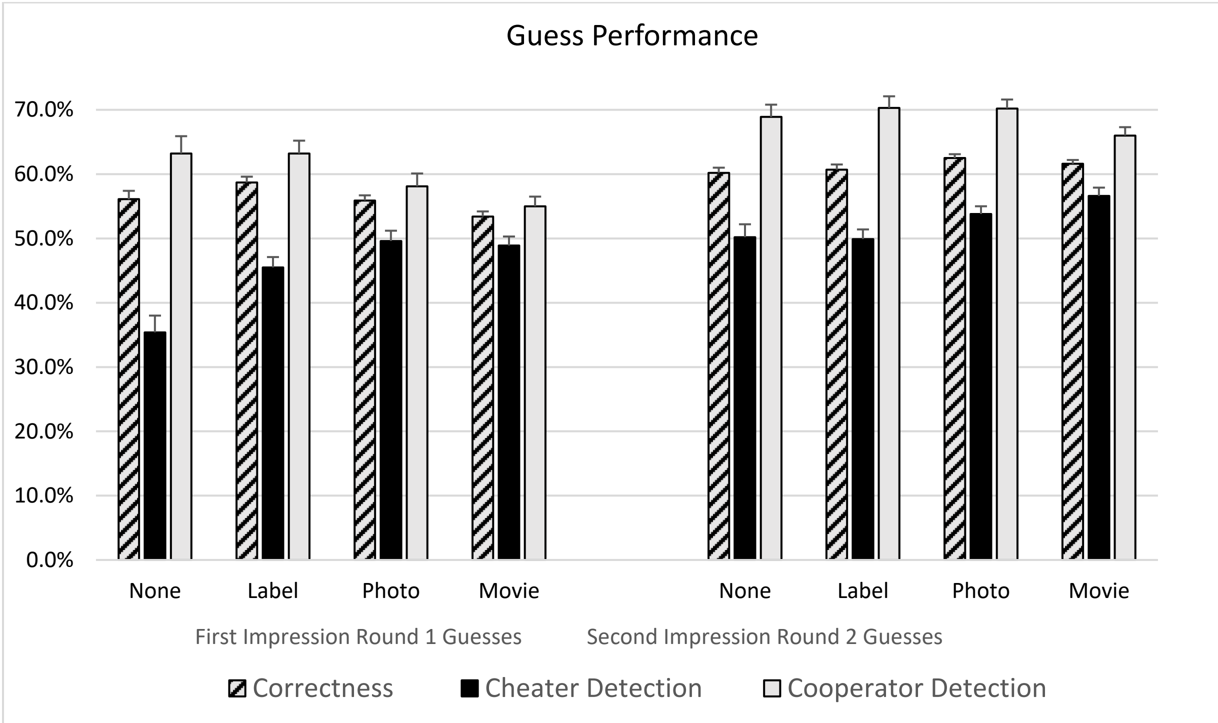


Figure 3. Bars show guess performance percentages for correctness, cheater detection, and cooperator detection by first and second impressions. Error bars show the standard error of the mean.

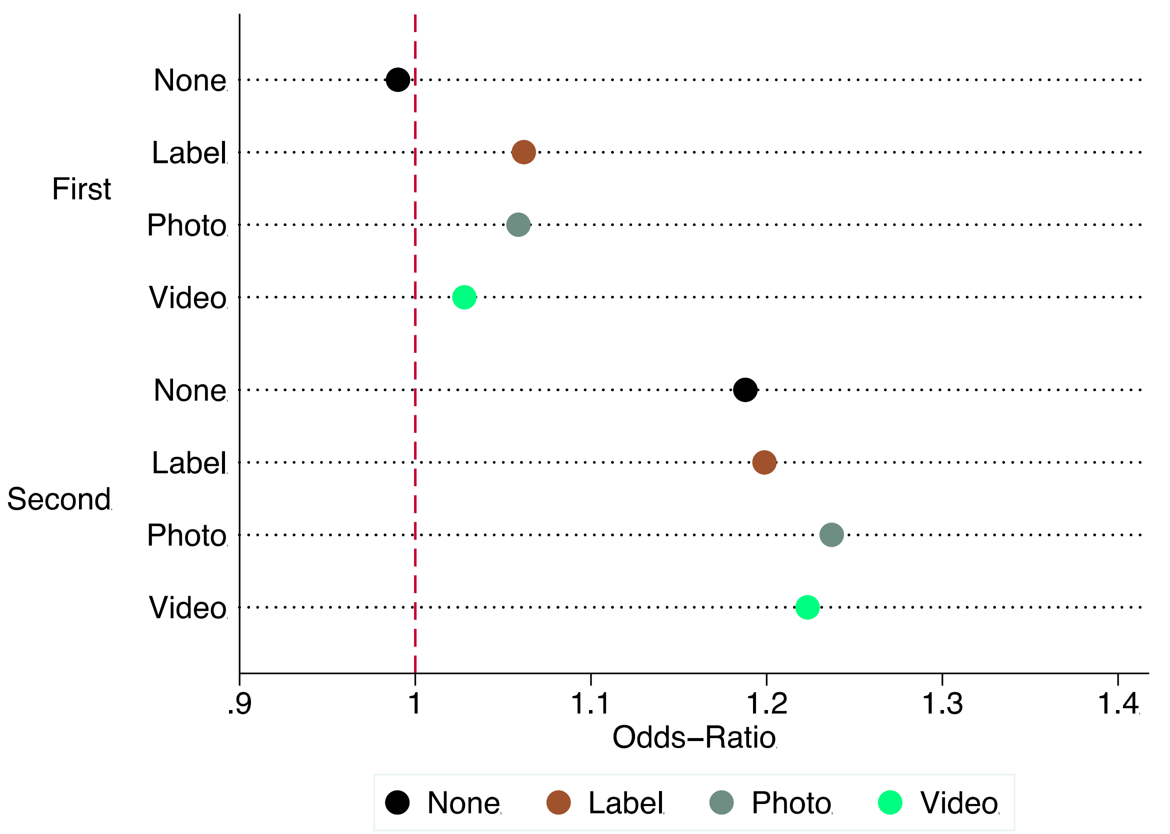


Figure 4. Odds-ratio of guesses by first and second impression. The odds ratio is the number of correct guesses in a round divided by the expected number of correct guesses due to chance alone. Better-than-chance guesses are defined by values greater than one. The maximum odds-ratio value, for a rater that guesses correctly 100% of the time, is 1.61 and 1.99 for first and second round guesses, respectively.

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Appendix A

Table A1: Correct guess of player behavior conditioned on behavioral history, sufficiently correct median, and PD player gender

Both Take All	-0.69	***
	(-5.38)	
Take All/Partner Split	0.16	
	(1.91)	
Split/Partner Take All	0.02	
	(0.29)	
Both Split	0.56	***
	(10.94)	
Sufficiently correct median	0.31	***
	(10.19)	
Sufficiently correct median X Both Take All	-0.31	**
	(-2.61)	
Sufficiently correct median X Take All/Partner Split	-0.26	***
	(-3.44)	
Sufficiently correct median X Split/Partner Take All	-0.27	***
	(-3.66)	
Sufficiently correct median X Both Split	-0.19	***
	(-3.61)	
Male player	-0.43	***
	(-15.77)	
Male player X Both Take All	0.50	***
	(4.78)	
Male player X Take All/Partner Split	0.60	***
	(8.91)	
Male player X Split/Partner Take All	0.78	***
	(12.11)	
Male player X Both Split	-0.33	***
	(-7.65)	
Constant	0.25	***
	(7.69)	
N	59,032	
Groups	314	
Log-Likelihood	-38,938.03	
AIC	77,908.05	
BIC	78,051.83	
Chi-Sq (14 df)	1,800.65	***

T-statistic in parenthesis. **: $p < .01$, ***: $p < .001$. The baseline history is the no history condition (first impression). Regression is on those treatments where the player gender could be visually detected.

Table A2: Round 2 guesses and correctness conditioned on behavioral history and treatments with photos and videos

	Guess		Correct	
Both Take All	-2.45	***	-0.83	***
	(-24.55)		(-9.79)	
Take All/Partner Split	-2.52	***	-0.33	***
	(-36.66)		(-6.07)	
Split/Partner Take All	-3.23	***	-0.10	
	(-44.02)		(-1.93)	
Faces	-0.15		0.02	
	(-1.23)		(0.52)	
Both Take All X Faces	-0.03		-0.14	
	(-0.26)		(-1.44)	
Take All/Partner Split X Faces	-0.38	***	0.33	***
	(-4.73)		(5.17)	
Split/Partner Take All X Faces	0.54	***	-0.06	
	(6.58)		(-0.99)	
Constant	1.91	***	0.56	***
	(18.37)		(15.63)	
N	39,668		39,668	
Groups	422		422	
Log-Likelihood	-19,176.8		-26,140.2	
AIC	38,371.6		52,298.3	
BIC	38,448.8		52,375.6	
Chi-Sq (7 df)	9,817.0	***	514.3	***

T-statistic in parenthesis. ***: p < .001. the condition ‘Both Split” is the baseline. Faces is equal to one if the treatment is photo or video.

Appendix B

Instructions and Survey Questions

Experimental Task

A unique set of questions is being generated that will test your eligibility to complete this study. Participants who answer these questions incorrectly are NOT eligible, will be screened out immediately, and will NOT receive any payment.

What did you see?
[One of the images below was randomly selected and displayed]

- A blue rectangle and black oval
- A green cross and orange triangle
- A red circle and green star
- A yellow triangle and red circle
- A black oval and blue cross
- A pink square and purple star

What is the answer to this question?
[One of four randomly selected word problems, with unique answer below, would appear here]

- Six
- Five
- Twelve
- Ten

Consent

We invite you to participate in a research study being conducted by XXXXX and XXXXX, both professors from XXXXX. The purpose of the study is to understand individuals' ability to predict. If you agree to participate, we would like you to complete tasks that involve making guesses and answering survey questions. The study will take on average 30 minutes to complete. Your payment will be your wage and a bonus. The bonus will be as high as $3 depending on the accuracy of your predictions. At the end of the study, you will learn your task performance and the associated payment amount. You will receive payment for completing the study in its entirety. There is minimal foreseeable risk associated with this study. All responses are anonymous. Taking part in this research study is completely voluntary. If you do NOT wish to participate in this study, you can exit the study anytime. However, incomplete responses cannot be used for research and therefore you will NOT receive payment. If you have any questions about the study, please contact XXXXX. If you have any questions about your rights as a research participant, please contact the Human Subjects Office at XXXXX. Thank you very much for your consideration of this research study. Select the appropriate option below to indicate whether you agree to participate.

- Yes, I agree to participate in this study
- No, I do NOT agree to participate in this study

Introduction

This survey is part of an experiment in the economics of decision-making. Various research agencies have provided funds for this research. By following the instructions carefully and making good decisions, you may earn an additional amount of money besides the payment for completing the survey. The actual amount of additional money that you may earn will depend on your decisions. Your earnings will be reported to you after you have completed the survey. There are a couple basic rules you must follow:

1) Do not communicate with others or allow others to assist you while completing the survey.
2) Do not discuss this survey with others after completing the survey.
3) If you have any questions, comments, or concerns please communicate them to the researchers running this study by xxxx.

General Description of the Survey

The survey is broken into four separate parts. All four parts must be completed to earn payment. After you finish you will be provided with a Completion ID. In the first, second, and third parts of the survey, one randomly chosen guess determines your additional earnings from that part. Your overall income from the survey will be based on the sum of earnings from the first three parts of the survey and from your wage for completing all sections of the survey. It is in your best interest to make a careful decision in all possible situations. Researchers at XXX have previously conducted an experiment using an anonymous economic interaction (between a randomly paired Person 1 and Person 2) over a computer network. Participants in the original experiment earned money based on the interactions of their choices. Today's survey will ask you to make guesses about what participants did in that original experiment. A description of that experiment follows.

IMPORTANT: You will NOT participate in the experiment explained below, but it is important that you understand it because you will make guesses related to people and decisions from this original experiment conducted at XXX. Below are the instructions that were provided to participants in that original experiment.

The First-Round Decision *[hover over text]*

In this experiment you will be randomly paired with one other person. The other person, like yourself, was recruited from the XXX. During this experiment you will be paired with this person through a computer network. At no time will your true identity be revealed to the other participants here today. Even though we are video recording for research purposes, during this experiment your video recorded image will never be transmitted or shown to other participants in today's experiment.

The choices made by both you and the other person will affect how a $10 dollar jackpot will be allocated. Because these choices affect your earnings, you should make a deliberate and conscious choice. You can either choose *Split* or you can choose to *Take All*. The other person you are paired with makes the same choice. If BOTH you and the person you are paired with choose *Split* you will both get a payoff of $5. If you BOTH choose to *Take All* you will both get a payoff of $0. If you choose to *Take All* but the other person chooses *Split* you will get a payoff of $10 and the other person will receive $0. Likewise, if you choose *Split* but the other person chooses to *Take All,* then you receive $0 and the other person receives $10. These payoffs are summarized in the table below. The bold number in each quadrant of the box below is the payment received by you, the other non-bold number is the payment received by the other person:

		The Other Person Chooses	
		Split	*Take All*
You Choose	*Split*	**Your payoff 5** Other's payoff 5	**Your payoff 0** Other's payoff 10
	Take All	**Your payoff 10** Other's payoff 0	**Your payoff 0** Other's payoff 0

When making your choice, you will not know the choice made by the other person. We first will ask you to state your intention while being recorded. That is, we want you to make a non-binding statement about what you intend to do, *Split* or *Take All*. Next, we ask you to make your choice: *Split* or *Take All*. After everyone in the experiment has made their choice, the computer will report the results: your choice, the choice made by the other person, and your payoffs. After reviewing the results, you will be asked to complete a short survey before moving on.

Set of Multiple Rounds

You will participate in a set composed of more than a single round. Each round is the same. The number of rounds that you will participate in is determined probabilistically by the computer. After each round has been finished, the probability of participating in another round is (1/4)^(n-1) where n is the number of rounds so far. Since (1/4)^0 = 1 there will be at least 2 rounds and some probability of future rounds. However, it is uncertain how many more rounds there will be beyond these first 2 rounds. In all rounds you will interact with the same person that you were paired with in the first round.
Reminder

You will be participating in a set of two or more rounds and interacting with the same other person for all rounds. Even though we are video recording for research purposes, you are guaranteed that during this experiment your video recorded image will never be transmitted or shown to other participants in today's experiment.

SITUATION UNDERLYING TODAY'S SURVEY

Display This Question:
If Treatment = None or Label

Researchers have collected extensive data from the original experiment that was just described and are now interested to learn more about what you think participants did in the experiment. After being presented with a participant identification number and any relevant information about previous round choices and outcomes, you will have the opportunity to guess whether the participant went on to choose "*Split*" or "*Take All*" during that round. A correct guess can earn you $1.00 and an incorrect guess can earn you $0.00. You will have the opportunity to make 188 guesses across 3 parts of the survey. With a guess randomly chosen for payment from each part, you can earn a maximum of $3.00 in addition to the wage you are guaranteed to earn by completing this survey.

Display This Question:
If Treatment = Photo

Researchers have collected extensive data from the original experiment that was just described and are now interested to learn more about what you think participants did in the experiment. We have prepared images (photos from videos) of the participants during each of their multiple rounds of interaction, taken moments after they stated their intentions, but before making their choice to "*Split*" or "*Take All*". We will present each of these photos to you (one at a time). Reminder: participants never saw any images or videos of each other. After being presented with a participant identification number, a photo of a participant from the original experiment, and any relevant information about previous round choices and outcomes, you will have the opportunity to guess whether the participant went on to choose "*Split*" or *Take All*" during that round. A correct guess can earn you $1.00 and an incorrect guess can earn you $0.00. You will have the opportunity to make 188 guesses across 3 parts of the survey. With a guess randomly chosen for payment from each part, you can earn a maximum of $3.00 in addition to the wage that you are guaranteed to earn by completing this survey.

Display This Question:
If Treatment = Video

Researchers have collected extensive data from the original experiment that was just described and are now interested to learn more about what you think participants did in the experiment. We have prepared short videos of the participants during each of their multiple rounds of interaction, taken moments after they stated their intentions, but before making their choice to "*Split*" or "*Take All*". We will present each of these videos to you (one at a time). Reminder: participants never saw any images or videos of each other. After being presented with a participant identification number, a video of a participant from the original experiment, and any relevant information about previous round choices and outcomes, you will have the opportunity to guess whether the participant went on to choose "*Split*" or "*Take All*" during that round. A correct guess can earn you $1.00 and an incorrect guess can earn you $0.00. You will have the opportunity to make 188 guesses across 3 parts of the survey. With a guess randomly chosen for payment from each part, you can earn a maximum of $3.00 in addition to the wage that you are guaranteed to earn by completing this survey.

You will learn the total reward from correct guesses after completing all guesses and responding to a final set of questions. Starting on the next page, you will always have the option to review the description of the original experiment by hovering your mouse over the phrase below

Original Experiment Description

[When the mouse hovered over the bold text above, the text from The First-Round Decision block would appear as an overlay]

Survey Part 1: gender guesses

Original Experiment Description

[When the mouse hovered over the bold text above, the text from The First-Round Decision block would appear as an overlay]

Males and females (self-identified) participated anonymously in the original experiment. In the first rounds of interaction in the original experiment, before they discovered what their partners did, how often did females choose “split” or “take all” and how often did males choose “split’ or “take all”? Your guesses will be compared to the observations from the original experiment.

Your guess can earn you as much as $1.00 so long as it is within 16.7%, above or below, the observed frequency of the target(s)’ behavior.

On a scale ranging from 0% to 100% of the time, how often do you guess that **females** chose to “split” or to “take all" in the first round of the original experiment? Complete the following statements according to your expectations by choosing values that total 100%.

_______ % of the time females chose “take all”.
_______ % of the time females chose “split”.

On a scale ranging from 0% to 100% of the time, how often do you guess that **males** chose to “split” or to “take all" in the first round of the original experiment? Complete the following statements according to your expectations by choosing values that total 100%.

_______ % of the time males chose “take all”.
_______ % of the time males chose “split”.

Congratulations, you have finished Part 1. Next, you will make guesses about what participants did in their *first-round* interactions with matched partners. A correct guess can earn you $1.00. Ready to go to Part 2?

Survey Part 2: *first round* guesses
[This choice was looped over the 94 target players randomly]
# of 94

Original Experiment Description

[When the mouse hovered over the bold text above, the text from The First-Round Decision block would appear as an overlay]

Display This Question:
If Treatment != Label
ID# is deciding what to do. What do you guess they will do in the first round?
Display This Question:
If Treatment = Label
ID# a **<gender>** is deciding what to do. What do you guess they will do in the first round?
Display This Question:
If Treatment = Photo
<insert photo>
Display This Question:
If Treatment = Video
<insert video – options below would not appear until the video ended>

○ Take All ○ Split

Congratulations, you have finished Part 2.

Next, you will be able to see what participants did in the *first-round* interactions and make guesses about what they do in their *second-round* interactions. A correct guess can earn you $1.00. Ready to go to Part 3?

Survey Part 3: *second round* guesses
[This choice was looped over the 94 target players randomly]
# of 94

Original Experiment Description

[When the mouse hovered over the bold text above, the text from The First-Round Decision block would appear as an overlay]

Display This Question:
If Treatment != Label

ID# is deciding what to do is deciding what to do.
They found out that in the *first* round their partner chose to **<split/take all>.**
In the first round Participant **ID#** chose to **<split/take all>.**
What do you guess they will do in the second round?

Display This Question:
If Treatment = Gender

ID #X, a **<gender>** is deciding what to do is deciding what to do.
They found out that in the *first* round their partner chose to **<split/take all>.**
In the first round Participant **ID#** chose to **<split/take all>.**
What do you guess they will do in the second round?

Display This Question:
If Treatment = Photo

<insert photo>

Display This Question:
If Treatment = Video

<insert video – options below would not appear until the video ended>

○ Take All ○ Split

Congratulations, you have finished Part 3.

In the next part of the survey, we ask you to answer a final set of questions, required for your completion of the survey. Ready to go to Part 4?

Survey Part 4

What is your age? [input number]
Which gender do you identify with? [male, female, other, don't want to answer]

Before providing you feedback on your guess, we present to you a final set of statements concerning men and women and their relationships in contemporary society. Please indicate the degree to which you agree or disagree with each statement. Your answers will not affect your rating or payment.

- No matter how accomplished he is, a man is not truly complete as a person unless he has the love of a woman.
- Many women are actually seeking special favors, such as hiring policies that favor them over men, under the guise of asking for "equality."
- In a disaster, women ought not necessarily to be rescued before men.
- Most women interpret innocent remarks or acts as being sexist.
- Women are too easily offended.
- People are often truly happy in life without being romantically involved with a member of the other sex.
- Feminists are not seeking for women to have more power than men.
- Many women have a quality of purity that few men possess.
- Women should be cherished and protected by men.
- Most women fail to appreciate fully all that men do for them.
- Women seek to gain power by getting control over men.
- Every man ought to have a woman whom he adores.
- Men are complete without women.
- Women exaggerate problems they have at work.
- Once a woman gets a man to commit to her, she usually tries to put him on a tight leash.
- When women lose to men in a fair competition, they typically complain about being discriminated against.
- A good woman should be set on a pedestal by her man.
- There are actually very few women who get a kick out of teasing men by seeming sexually available and then refusing male advances.
- Women, compared to men, tend to have a superior moral sensibility.
- Men should be willing to sacrifice their own well-being in order to provide financially for the women in their lives.
- Women, as compared to men, tend to have a more refined sense of culture and good taste.

[All questions answered with 6-point Likert: disagree strongly, disagree somewhat, disagree slightly, agree slightly, agree somewhat, agree strongly]

Before participating in today's study, were you familiar with XXX University?

- No. I had no familiarity with XXX University.
- Yes, I was familiar with XXX University before, but don't have personal connections to it.
- Yes, I was familiar with XXX University and have personal connections to it.

Before participating in today's study, were you familiar with XXX University's students?

- No. I had no familiarity with XXX University's students.
- Yes, I was familiar with XXX University's students before, but don't have personal connections to them.
- Yes, I was familiar with XXX University's and have personal connections to them.

Display This Question:
If Treatment = Photo
Or Treatment = Video

Have you ever seen any of the people shown in today's study before today?

- No. I did not recognize any of the people shown in the survey as people I have seen before today.
- Yes, I recognized a person or people shown in the survey as someone I have seen before today.

Payment Feedback

Based on the sum of your earnings from a randomly chosen guess in Part 1, a randomly chosen guess in Part 2, and a randomly chosen guess in Part 3 of the survey, you earned $X in addition to your fixed payment for survey completion.