The Potential of Social Identity for Equilibrium Selection

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Appendix

Appendix A. Theory

Proof of Proposition 1: Maximizing Equation (7) gives us a new threshold marginal cost value, which is a function of the group-contingent other-regarding parameter α_i^g,

$$c^*(n, \{\alpha_i^g\}_{i=1}^n) = \frac{1}{n - \sum_{i=1}^n \alpha_i^g}. \tag{A1}$$

When $\alpha_i^I > \alpha_i^N > \alpha_i^O$, $\forall i$, the corresponding threshold marginal cost is as follows:

$$c^*(n, \{\alpha_i^I\}_{i=1}^n) > c^*(n, \{\alpha_i^N\}_{i=1}^n) > c^*(n, \{\alpha_i^O\}_{i=1}^n).$$

Furthermore, a more salient group identity increases α_i^I, which leads to an increase in the threshold marginal cost, $c^*(n, \{\alpha_i^I\}_{i=1}^n)$.

Proof of Proposition 3: Based on the standard assumption of the logit model that payoffs are subject to unobserved shocks from a double-exponential distribution, player i's probability density is an exponential function of the expected utility, $u_i^e(x)$,

$$f_i(x) = \frac{\exp(\lambda u_i^e(x))}{\int_{\underline{x}}^{\bar{x}} \exp(\lambda u_i^e(s))ds}, \qquad i = 1, \cdots, n, \tag{A2}$$

where $\lambda > 0$ is the inverse noise parameter and higher values correspond to less noise.

Let $F_i(x)$ be player i's corresponding effort distribution. For player i, let $G_i(x) \equiv 1 - \prod_{k \neq i}(1 - F_k(x))$ be the distribution of the minimum of the $n-1$ other effort levels. Thus, player i's expected utility from choosing effort level x is:

$$u_i^e(x) = \int_{\underline{x}}^{x} y g_i(y) dy + x(1 - G_i(x)) - c[(1-\alpha_i)x + \alpha_i \int_{\underline{x}}^{\bar{x}} y dF_i(y)], \tag{A3}$$

where the first term on the right side is the benefit when another player's effort is below player i's own effort, the second term is the benefit when player i determines the minimum effort, and the last term is the cost of effort weighted by player i's own effort and the average effort of others. The first and very last term of the right side of (A3) can be integrated by parts to obtain:

$$u_i^e(x) = \int_{\underline{x}}^{x} \prod_{k \neq i}(1 - F_k(y))dy - c(1-\alpha_i)x + c\alpha_i \int_{\underline{x}}^{\bar{x}} F(y)dy + \underline{x} - c\alpha_i \bar{x}. \tag{A4}$$

Differentiating both sides of (A2) with respect to x and using the derivative of the expected utility in (A4), we obtain:

$$
\begin{aligned}
f_i'(x) &= \lambda f_i(x) \frac{du_i^e(x)}{dx} \\
\text{(A5)} \qquad &= \lambda f_i(x)[\prod_{k \neq i}(1 - F_k(x)) - c(1 - \alpha_i)], \qquad i = 1, \cdots n.
\end{aligned}
$$

Using symmetry (i.e., dropping subscripts), further assuming $\alpha_i = \alpha$ for all i, and integrating both sides of (A5), we obtain:

$$\int_{\underline{x}}^{x} f'(s)ds = \lambda \int_{\underline{x}}^{x} f'(s)[1 - F(s)]^{n-1} ds - c(1 - \alpha)\lambda \int_{\underline{x}}^{x} f(s)ds.$$

Simplifying both sides, we obtain the first-order differential equation for the equilibrium effort distribution:

$$f(x) = f(\underline{x}) + \frac{\lambda}{n}[1 - (1 - F(x))^n] - c(1 - \alpha)\lambda F(x).$$

The proofs of Propositions 4 and 5 use similar structure and techniques as those of the corresponding Propositions 4 and 5 in Simon P. Anderson, Goeree and Holt (2001), with the marginal cost of effort, c, replaced by $c(1-\alpha)$. We present them here for completeness.

Proof of Proposition 4: Let the other regarding parameters be $\alpha_1 < \alpha_2$, and let $F_1(x)$ and $F_2(x)$ denote the corresponding equilibrium effort distributions. We want to show that $F_1(x) > F_2(x)$ for all interior x.

Suppose $F_1(x) = F_2(x)$ on some interval of x values. Then the first two derivatives of these functions must equal on the interval, which violates (A5). Therefore, the distribution functions can only be equal, or cross, at isolated points. At any crossing, $F_1(x) = F_2(x) \equiv F$. From (A2), the difference in slopes at the crossing is:

$$\text{(A6)} \qquad f_1(x) - f_2(x) = f_1(\underline{x}) - f_2(\underline{x}) - \lambda c(\alpha_2 - \alpha_1)F,$$

which is decreasing in F, and hence is also decreasing in x. It follows that there can be at most two crossings, with the sign of the right-hand side nonnegative at the first crossing and nonpositive at the second. Since the distribution functions cross at $\underline{x}$ and $\bar{x}$, these are the only crossings. The right-hand side of (A6) is positive at $x = \underline{x}$ or negative at $x = \bar{x}$, so $F_1(x) > F_2(x)$ for all interior x. This implies that an increase in α results in a distribution of effort that first-degree stochastically dominates that associated with a smaller α.

Proof of Proposition 5: First, consider the case $c < c^*$, or $cn(1 - \alpha) < 1$. We have to show that $F(x) = 0$ for all $x < \bar{x}$. Suppose not, and $F(x) > 0$ for $x \in (x_a, x_b)$. From (9), we have:

$$\begin{aligned} f(x) &= f(\underline{x}) + \frac{\lambda}{n}[1-(1-F)^n] - c(1-\alpha)\lambda F \\ &= f(\underline{x}) + \frac{\lambda}{n}[1-(1-F)^n - cn(1-\alpha)F] \\ &> \frac{\lambda}{n}[1-(1-F)^n - F] \\ &= \frac{\lambda}{n}(1-F)[1-(1-F)^{n-1}]. \end{aligned}$$

Since density cannot diverge on an interval, $F(\cdot)$ must be zero on any open interval. Therefore, $F(x) = 0$ for $x < \bar{x}$.

Next, consider the case $c < c^*$, or $cn(1-\alpha) > 1$. In this case, we have to prove that $F(x) = 1$ for all $x > 0$. Suppose not, and $F(x) < 1$ for $x \in (x_a, x_b)$. From (9), we have:

$$\begin{aligned} f(\bar{x}) &= f(\underline{x}) + \frac{\lambda}{n}[1-(1-F(\bar{x}))^n] - c(1-\alpha)\lambda F(\bar{x}) \\ &= f(\underline{x}) + \frac{\lambda}{n} - c(1-\alpha)\lambda \\ &= f(\underline{x}) + \frac{\lambda}{n}[1-cn(1-\alpha)], \end{aligned}$$

which enables us to rewrite (9) as:

$$\begin{aligned} f(x) &= f(\bar{x}) - \frac{\lambda}{n}[1-cn(1-\alpha)] + \frac{\lambda}{n}[1-(1-F)^n] - c(1-\alpha)\lambda F \\ &= f(\bar{x}) + \frac{\lambda}{n}[cn(1-\alpha)(1-F) - (1-F)^n] \\ &> \frac{\lambda}{n}(1-F)[1-(1-F)^{n-1}]. \end{aligned}$$

Again, since density cannot diverge on an interval, $F(\cdot)$ must be one on any open interval. Therefore, $F(x) = 1$ for $x > 0$.

Finally, consider the case $c = c^*$, or $cn(1-\alpha) = 1$. In this case, (9) becomes:

$$\begin{aligned} f(x) &= f(\underline{x}) + \frac{\lambda}{n}[1-(1-F)^n] - c(1-\alpha)\lambda F \\ &= f(\underline{x}) + \frac{\lambda}{n}[1-(1-F)^n - F] \\ &= f(\underline{x}) + \frac{\lambda}{n}(1-F)[1-(1-F)^{n-1}]. \end{aligned}$$

This equation implies that the density diverges to infinity as $\lambda \to +\infty$, when $F(x) \neq 0$ or 1. Hence, $F(\cdot)$ jumps from 0 to 1 at the mode M. The above equation implies that $f(\underline{x}) = f(\bar{x})$, so the density is finite at the boundaries and the mode is an interior point.

Using symmetry, we can rewrite (A5) as $f'(x) = \lambda f(x)[(1-F(x))^{n-1} - c(1-\alpha)] = \lambda f(x)[(1-F(x))^{n-1} - 1/n]$, or $\frac{f'(x)}{\lambda f(x)} = (1-F(x))^{n-1} - 1/n$. Integrating both sides from $\underline{x}$ to $\bar{x}$ yields $\frac{1}{\lambda}\ln(f(\bar{x})/f(\underline{x})) = M - (\bar{x} - \underline{x})/n$, since $1-F$ equals one to the left of M and zero to the right of M. The left side is zero since $f(\bar{x}) = f(\underline{x})$, so $M = (\bar{x} - \underline{x})/n$.

Effort and Efficiency Benchmarks:

We use the equilibrium distribution described in Equation (9) to compute the expected effort and efficiency for different values of α. For each distribution, we assume that $\lambda = 0.125$, the value estimated by Jacob K. Goeree and Charles A. Holt (2005). Summary statistics of this distribution for various values of α are included in Table 5.

Table 5—Theoretical Distributions

	Effort		
α	μ	σ	Efficiency
-1.0	116.49	5.86	0.563
-0.8	117.40	6.59	0.558
-0.6	118.61	7.50	0.553
-0.4	120.30	8.69	0.546
-0.2	122.79	10.23	0.539
0.0	126.77	12.18	0.533
0.2	133.54	14.21	0.541
0.4	143.37	14.66	0.598
0.6	151.37	12.89	0.684
0.8	156.10	10.83	0.751
1.0	158.99	9.16	0.797

This table shows that the expected efficiency depends nonmonotonically on the exact level of α. As α increases from -1, the expected efficiency decreases until α reaches 0, then increases until α reaches 1. Given the above definition of efficiency, this behavior is expected. That is, at low values of α, subjects mostly give low effort. This results in a medium level of efficiency. At high values of α, subjects give high effort, resulting in a high level of efficiency. The lowest level of efficiency should be achieved when subjects giving low effort are paired with subjects giving high effort. This occurs more frequently when α is not extreme.

Appendix B. Experimental Instructions

We present the experimental instructions for the Enhanced Ingroup treatment. Instructions for other treatments are similar and can be found on the second author's website.

Economic Decision Making Experiment: Part 1 Instructions

This is an experiment in decision-making. The amount of money you earn will depend upon the decisions you make and on the decisions other people make. Your earnings are given in tokens. This experiment has 2 parts and 12 participants. Your total earnings will be the sum of your payoffs in each part. At the end of the experiment you will be paid IN CASH based on the exchange rate

$1 = 350 tokens.

In addition, you will be paid $5 for participation. Everyone will be paid in private and you are under no obligation to tell others how much you earn.

Please do not communicate with each other during the experiment unless asked to do so. If you have a question, feel free to raise your hand, and an experimenter will come to help you.

Before the experiment started everyone drew an envelope which contained either a Green or a Red slip. You have been assigned to the Green group if you received a Green slip, and the Red group if you received a Red slip. There are 6 people in each group. Your group assignment will remain the same throughout the experiment. That is, if you drew a Green slip, you will be in the Green group for the rest of the experiment, and if you drew a Red slip, you will be in the Red group for the rest of the experiment.

In Part 1 everyone will be shown 5 pairs of paintings by two artists. You will have 5 minutes to study these paintings. Then you will be asked to answer questions about two other paintings. Each correct answer will bring you 350 additional tokens. You may get help from or help other members in your own group while answering the questions.

After Part 1 has finished, we will give you instructions for the next part of the experiment.

Economic Decision Making Experiment: Part 2 Instructions

The next part of the experiment consists of 50 periods. In each period, you will be randomly matched with 1 other person in the room. If you are a member of the Green group, your match will always be a member of the Green group, and if you are a member of the Red group, your match will always be a member of the Red group. You will be reminded every period of your own group and of your match's group. Your earnings for this part of the experiment depend on your choices as well as the choices of the people you are matched with.

Every period, each person will choose an effort level between 110.00 and 170.00. You will earn a number of tokens equal to the minimum effort level chosen by you and the person you are matched with, minus the cost of your own effort, which is 0.75 times your own effort choice. This is captured by the equation:

Payoff (Tokens) = Minimum Effort - 0.75*Your Effort

Note that the minimum effort here refers to the minimum of the effort levels chosen by you and your match. Refer to the handout for some examples. Note that there may be some case in which you earn a negative payoff. If your final payoff is negative, we will deduct that amount from your participation fee.

We will show you a running tally of the number of tokens you have earned from this part of the experiment, and after 50 rounds, we will add your earnings from Part 1 to this total and convert your total earnings into a dollar amount based on the exchange rate. We will also show you a list of your past effort choices and payoffs, as well as your matches' past effort choices and payoffs.

When you are ready to begin Part 2 of the experiment, please click OK.

Appendix C. Postexperimental Survey

(*summary statistics in italics*)

Please answer the following survey questions. Your answers will be used for this study only. Individual data will not be exposed.

1) What is your age? (*Mean 21.37, Std Dev 3.27, Median 21, Min 18, Max 40*)

2) What is your gender? (*Male 48.53%, Female 51.47%*)

3) Which of the following best describes your racial or ethnic background? (*Asian 38.73%, Black 6.37%, Caucasian 42.16%, Hispanic 3.43%, Native American 0.49%, Multiracial 4.41%, Other 4.41%*)

4) In what country or region were you primarily raised as a child? (*US/Canada 74.51%, Africa 0.00%, Asia 23.53%, Australia 0.49%, Europe 0.98%, Latin America 0.00%, Middle East 0.49%*)

5) What is your marital status? (*Never Married 96.08%, Currently Married 3.43%, Previously Married 0.49%*)

6) How would you best describe your employment status? (*Employed Full Time 5.88%, Employed Part Time 38.24%, Not Employed 55.88%*)

7) How many siblings do you have? (*Mean 1.55, Std Dev 1.13, Median 1, Min 0, Max 6*)

8) Who in your household is primarily responsible for expenses and budget decisions? Please select all that apply (*Self 38.24%, Spouse 0.49%, Shared Responsibility with Spouse 3.43%, Parent(s) 64.22%, Other 1.47%*)

9) Have you ever voted in a state or federal government election (in any country)? (*Yes 53.92%, No 46.08%*)

10) Before today, how many times have you participated in any economics or psychology experimental studies? (*Mean 3.46, Std Dev 3.47, Median 2, Min 0, Max 20*)

11) In the past twelve months, have you donated money to or done volunteer work for charities or other nonprofit organizations? (*Yes 77.94%, No 22.06 %*)

12) On a scale from 1 to 10, please rate how much you think communicating with your group members helped solve the two extra painting questions, with 1 meaning “not much at all”. (*Mean 6.04, Std Dev 2.90, Median 7, Min 1, Max 10*)

13) On a scale from 1 to 10, please rate how closely attached you felt to your own group throughout the experiment, with 1 meaning “not closely at all”. (*Mean 3.97, Std Dev 2.67, Median 3, Min 1, Max 10*)

14) In Part 2 when you were asked to decide on an effort level, how would you describe the strategies you used? Please select all that apply (*I tried to earn as much money as possible for myself 46.08%, I tried to earn as much money as possible for me and my match 50.00%, I tried to earn more money than my match 17.65%, I gave high effort if my previous matches gave high efforts and low effort if my previous matches gave low efforts 27.45%, Other 14.22%*)

15) Please tell us how your match's group membership affected your decision. If I had been matched with someone from the other group [my own group], (*I would have picked higher effort levels 16.67% [23.61%], I would have picked lower effort levels 8.33% [1.39%], I would not have changed my effort levels 69.44% [72.22%], Other 5.56% [2.78%]*)

16) On a scale from 1 to 10, please rate how familiar you were with the paintings made by Klee and Kandinsky before this experiment, with 1 meaning "not familiar at all". (*Mean 1.31, Std Dev 1.00, Median 1, Min 1, Max 6*)

Appendix D. Chat Coding Training Session Summary and Instructions

D1. Summary of Coding Procedures:

For the line level, the coders are told to take each line of each communication log and sort it into one or more categories. These categories denote whether the line is (a) about the paintings, (b) about the experiment or experimenter, (c) about the subject's group, (d) an expression of excitement, or (e) irrelevant information or none of the other categories. The "paintings" category is further subdivided by whether the line shows (i) painting analysis, (ii) a question about the paintings, (iii) agreement with another participant regarding the paintings, or (iv) disagreement with another participant regarding the paintings. The coders are told that any line can be part of multiple categories.

Next, the coders examine the communication from the subject level. First, for each subject, the coders tell us (a) whether or not the subjects made initial guesses regarding the paintings' artists. In particular, the coders examine whether the subjects (i) made a guess about painting 6, (ii) guessed painting 6 correctly ("Klee"), (iii) made a guess about painting 7, or (iv) guessed painting 7 correctly ("Kandinsky"). We also ask the coders to rate, on a 1 to 5 scale, each subject's level of (b) engagement in the conversation, (c) assertiveness, (d) confidence, and (e) politeness. Finally, the coders examine each communication on a group level (i.e. each communication log as a whole). Again, the coders are asked to rate, on a 1 to 5 scale, each group's level of (a) agreement, (b) confidence, (c) excitement, and (d) politeness.

To ensure that the coders understood their task and the system they would use to complete the coding, we held a training session for the coders. This training session was held on March 1, 2010, and lasted 2 hours. During this session, we first read the instructions out loud, answering any clarifying questions along the way. A copy of these instructions is included in Appendix D. Next, we had the coders examine 2 example communication logs. For this purpose, we obtain communication logs from an experiment conducted by Yan Chen and Sherry Xin Li (2009) that used the same paintings and communication procedure as this experiment. After this was completed, the coders were given a week to code the rest of the communication logs. All coding, including the practice coding, was performed on Google Docs. The coders were paid $15 an hour, with a total average payment of $78.

D2. Coding Training Instructions:

You are now taking part in a study that seeks to characterize the communication patterns in chat logs. Your participation will take the form of coding conversations on several factors.

After taking part in this training session, you will code other conversations at home using a web-based system (Google Docs) over the next week. We ask you to not communicate with others about the coding during the course of this week. Should you have any questions while coding on your own, please email me at [email redacted].

The purpose of this training session is to familiarize you with the coding methodology to be employed, and to ensure a common understanding of the factors used. However, this does not mean that you should all give identical codings. We are interested in eliciting objective codings from impartial coders. We ask you to rely on your own judgment when coding.

In the chat logs that you will be coding, the participants were asked to complete a task. First, the participants were divided into 2 groups, named "Red" and "Green" (For the chat logs we will be examining for this training session, the participants were instead in a group called "Maize"). They were shown 5 paintings by Paul Klee and 5 paintings by Wassily Kandinsky (which were labeled 1a, 1b, 2a, 2b, etc.). Then, the participants were given paintings labeled 6 and 7, and were asked to identify which artist painted each painting. These chat logs are the discussions that the participants had with members of their group in order to try to solve this problem.

In this training session you will be asked to code two chat logs. For each chat log, you will be asked to code the conversation at three levels, as shown below:

1) For each line of conversation, code whether it is
   a) about the paintings. For this category, code whether the line shows
      i) analysis (1 = yes, 0 = no)
      ii) a question (1 = yes, 0 = no)
      iii) agreement with another participant (1 = yes, 0 = no)
      iv) disagreement with another partcipant (1 = yes, 0 = no)
   b) about the experiment or experimenter (1 = yes, 0 = no)
   c) about the participant's group (1 = yes, 0 = no)
   d) an expresssion of excitement (1 = yes, 0 = no)
   e) irrelevant information or none of the above categories (1 = yes, 0 = no)
2) For each chat participant, code whether that participant
   a) made initial guesses about the paintings. For this category, code whether or not the participant
      i) made a guess about painting 6 (1 = yes, 0 = no)
      ii) guessed "Klee" for painting 6 (1 = yes, 0 = no)
      iii) made a guess about painting 7 (1 = yes, 0 = no)
      iv) guessed "Kandinsky" for painting 7 (1 = yes, 0 = no)
   b) was engaged in the conversation (1 = not engaged at all 5 = very engaged)
   c) was assertive (1 = not assertive at all 5 = very assertive)
   d) was confident (1 = not confident at all 5 = very confident)
   e) had a nice tone towards the other participants (1 = very cold 5 = very warm and friendly)
3) For each chat log, code whether the participants, as a group,
   a) agreed with each other (1 = no agreement at all 5 = full agreement)
   b) were confident (1 = not confident at all 5 = very confident)
   c) were excited (1 = not excited at all 5 = very excited)
   d) had a nice tone towards each other (1 = very cold 5 = very warm and friendly)

Note that each line of the chat log can be coded into multiple categories. For example, if someone says, "I think that 6 is Kandinsky. What do you think?", this would be coded as painting analysis (1.a.i.) and as painting question (1.a.ii.).

The procedure we will follow in the training session is as follows:

1) First, we ask that you fill out a background questionnaire, included with the papers handed to you in your training packet. Please hand those to [the experimenter] once you have completed them.

2) Next, click on the link to Training Chat 1.

3) You will code Training Chat 1, working individually. Please let us know when you have finished coding the chat log (don't forget the participant-level and group-level categories, located on different sheets of the spreadsheet). If you do not remember the definitions of any of the variables, you can refer to this instruction sheet or the "Coding Category Legend" file. You may ask us questions at any time.

4) When coding variables that are either 0 or 1, we have set the default value to 0. To code any of these variables to be 1, simply change the 0 to a 1.

5) When coding the participant-level variables, you will want to sort the chat lines by the participants so that you can easily see what each participant said during the chat. To do this, click on the cell that says "Participant". Then, click on "Tools", and then click on "Sort sheet by column B, A→Z". To revert to the default line order, click on the cell that says "Line Number", click on "Tools", and then click on "Sort sheet by column A, A→Z".

6) When everyone has completed coding the chat log, there will be a brief discussion, no longer than 30 minutes, regarding the coding activity. We will go over each line, asking each of you for your codings. We will also present our codings and why we coded them the way we did.

7) When all questions have been addressed, you will click on the link to Training Chat 2 and code that chat log.

Are there any questions? Before we start, we would like to ask you to please take the time to read each chat log carefully when coding. We have found that it takes between 15 and 30 minutes to code each chat log when evaluating them carefully. If there are no further questions, let's begin.

Appendix E. Additional Tables

Table 6—Interclass Correlation Coefficients (ICC)

Category	ICC	St. Error
Line Level Coding		
Painting analysis	0.808	0.010
Question about paintings	0.706	0.013
Agreement regarding paintings	0.746	0.012
Disagreement regarding paintings	0.453	0.019
Experiment or experimenter	0.551	0.018
Group	0.550	0.018
Level of excitement	0.553	0.017
Irrelevant (none of the above)	0.622	0.016
Subject Level Coding		
Made a guess about painting 6	0.537	0.058
Guessed Klee for painting 6	0.522	0.059
Made a guess about painting 7	0.585	0.055
Guessed Kandinsky for painting 7	0.609	0.053
Level of engagement	0.744	0.040
Level of assertiveness	0.508	0.060
Level of confidence	0.346	0.064
Level of politeness	0.254	0.064
Group Level Coding		
Level of agreement	0.434	0.159
Level of confidence	0.449	0.157
Level of excitement	0.259	0.160
Level of politeness	0.018	0.126

Table 7—Group Identity and Equilibrium: Probit Regression

$(\Phi^{-1}(\text{equilibrium}) = \beta_0 + \beta_1{*}\text{Ingrp}+\beta_2{*}\text{Outgrp}+\beta_3{*}\text{Ingrp*Enh}+\beta_4{*}\text{Outgrp*Enh}+u_{it})$

	Dependent Variable: Equilibrium
Ingroup	0.14
	(0.11)
Outgroup	0.02
	(0.11)
Ingroup*Enhanced	0.21**
	(0.10)
Outgroup*Enhanced	0.01
	(0.13)
Observations	5400
Pseudo-R^2	0.0584

Notes: Standard errors are adjusted for clustering at the session level. Significant at the: ** 5 percent level.

Table 8—Average Efficiency by Session and Treatment

	Ingroup	Outgroup	Control
	0.65	0.49	0.56
Near-minimal	0.63	0.67	0.70
	0.70	0.68	0.63
Average	0.66	0.62	0.63
	0.85	0.80	0.58
Enhanced	0.90	0.50	0.80
	0.86	0.55	0.57
Average	0.87	0.62	0.65

Table 9—Group Identity and Efficiency: Random-Effects

(Efficiency $= \beta_0 + \beta_1$*Ingrp+β_2*Outgrp+β_3*Ingrp*Enh+β_4*Outgrp*Enh+u_{it})

	Dependent Variable: Efficiency
Ingroup	0.02
	(0.04)
Outgroup	-0.03
	(0.06)
Ingroup*Enhanced	0.21***
	(0.03)
Outgroup*Enhanced	0.00
	(0.09)
Constant	0.64***
	(0.04)
Observations	5400
R^2	0.1251

Notes: Standard errors are adjusted for clustering at the session level. Significant at the: *** 1 percent level.

Table 10—Effort Distributions

Treatment		Calibrated α^g	Predicted Mean	Predicted SD	Actual Mean	Actual SD
Near-Minimal	Control	0.41	145.65	14.90	133.28	13.07
	Ingroup	0.51	128.91	23.67	148.29	19.18
	Outgroup	0.65	164.37	18.61	157.46	20.96
Enhanced	Control	0.31	137.33	14.89	132.83	27.13
	Ingroup	0.83	139.94	19.09	166.15	6.78
	Outgroup	0.42	157.33	23.61	133.65	25.97

Appendix F. Reconciling Theory and Experiments

In this appendix, we apply our theoretical framework to previous experimental studies on coordination games, including the minimum-effort games, Battle of the Sexes, and the provision point mechanism. By incorporating group identity into the potential games framework, we can reconcile findings from previous studies and thus showcase the applications of our theory.

We first examine studies of the minimum-effort games that are successful in achieving higher effort levels contrary to the predictions of the theory of potential games. A summary of these studies and the other studies of the minimum-effort game mentioned in Section I is shown in Table 11.[17] In addition to the parameter configurations of each experiment (strategy space, T, n, a, b and c), the last three columns present the cut-off marginal cost c^*, the theoretical predictions from standard potential maximization, and the empirical trend observed in the experiment, respectively. Recall that standard potential maximization theory predicts that choices converge to the low (high) effort equilibrium if $c > c^*$ ($c < c^*$). This prediction is consistent with the results from the three baseline studies by John B. Van Huyck, Raymond C. Battalio and Richard O. Beil (1990), Goeree and Holt (2005), and Marc Knez and Camerer (1994), as well as many treatments in subsequent categories. Whenever the theoretical prediction is inconsistent with the observed trend, we put the treatment in bold face. In what follows, we discuss the three approaches used in the literature to achieve higher effort levels contrary to the theoretical predictions and how incorporating group identity into the potential function could reconcile theory and the empirical findings (Propositions 1 and 4).

Over two papers, Camerer and Knez (1994 and 2000) show that, if they use the same parameters as VHBB ($a = 0.2, b = 0.6, c = 0.1$) in the minimum-effort game, subjects will converge to the efficient equilibrium after 5 periods if $n = 2$, but not if $n = 3$. Using the phenomenon of "transfer of precedent," Camerer and Knez show that it is possible to make 3-player matches converge to the efficient equilibrium if the game is first played for 5 periods by two-player matches with the third player observing, and then for 5 more periods with all 3 players. The two-player matches establish a group norm of high effort that is consistent with potential theory, which is then transferred to the three-player matches. Allowing the third player to watch the other 2 players for 5 periods implicitly creates a group, establishes a group norm, and increases subjects' other-regarding preferences.

Roberto A. Weber (2006) shows that it is possible to apply Camerer and Knez's result successively to achieve higher effort levels in larger groups. Using parameters similar to VHBB ($a = 0.2, b = 0.2, c = 0.1$), Weber slowly grows the number of players in the minimum-effort game over 22 periods from $n = 2$ to $n = 12$. He shows that, if growth is too fast, or if no history is shown to the new players, then subjects converge to the least efficient equilibrium. If, on the other hand, the groups are grown slowly enough, and it is common knowledge that the new players observe the entire history of efforts provided, the entire 12-person group is able to achieve a minimum effort of 5 by the final period. Again, the observation of smaller groups facilitates the establishment of group norms.

Gary Bornstein, Uri Gneezy and Rosemarie Nagel (2002) use a different method, intergroup competition, to promote higher effort levels. Taking essentially the same game as VHBB ($a = 20, b = 60, c = 10$), Bornstein et al. divide subjects into two competing groups of size $n = 7$. The group with the higher chosen minimum effort level is paid according to the normal payoff function, while the group with the lower chosen minimum effort level is paid nothing (in the case of a tie, everyone is paid according to half the

[17] Rather than exhaustively listing all experiments of the minimum-effort games, we instead present representative studies in each category.

normal payoff function). This revised payment method changes the game. In particular, the set of Nash equilibria is expanded. It is still a Nash equilibrium for every member of both groups to give the same level of effort, but it is also a Nash equilibrium for the members of one group to all give the same effort, and two members of the other group to give a lower effort (the rest of the members of this other group can give any level of effort and still preserve the Nash equilibrium). While the potential function is also changed in this scenario, the potential maximizing Nash equilibrium remains the equilibrium in which every member of both groups gives the minimum possible effort of 1. So, if social preferences are ignored, then the prediction of potential theory is that players will converge to the least efficient equilibrium. In another treatment, the subjects are all paid according to the normal payoff function, but are also given the extra information of what the minimum effort level is in the other group (this information is withheld in the control). This separates the effect of receiving this information from the actual competition. While Bornstein et al. find that the extra information has no effect (the control yields an average effort of 3.6 while the information treatment yields an average effort of 3.5), there is a significant increase in chosen effort with intergroup competition (average effort 5.3). In another session, instead of punishing the losing group, the winning group receives a bonus. This yields an average effort of 4.5, also significantly higher than in the control or information sessions. By explicitly tying the subjects' payoffs to the choices of the group, and by making the 2 groups compete with each other, Bornstein et al. create a very strong ingroup and outgroup effect that is able to raise the threshold c^* above the marginal cost of 10 used in the experiment.

Another approach to increase effort is to facilitate communication across group members. Specifically, Ananish Chaudhuri, Andrew Schotter and Barry Sopher (2009) suggest that giving subjects advice from previous subjects of the experiment can increase effort in large groups. Using the same parameters as VHBB and $n = 8$, the authors attempt to induce higher effort by providing subjects with full histories of previous sessions of the experiment, and by providing advice about the game given by previous subjects. Most of this advice suggests that players always give the highest effort. While this is not successful in most treatments, all of which have "private advice"(all subjects receive the advice but this is not common knowledge), the subjects do converge to the highest effort level when the advice is "public"(common knowledge). One plausible interpretation is that, communication between subjects creates an ingroup effect strong enough to induce high efforts, even if subjects in a session simply receive communication from a third party, as long as it is common knowledge that this communication is taking place.

Jordi Brandts and Cooper (2007) also examine the effect of communication in the minimum-effort game. Communication in this study is achieved through a manager, who is the only subject allowed to talk to the other 4 subjects in a "firm." These 4 other subjects are workers of the firm who play a minimum-effort game ($a = 6$ or $14, b = 200, c = 5$) with efforts restricted to 0, 10, 20, 30 or 40. The manager's payoff is also positively related to the minimum effort given by the 4 workers. Brandts and Cooper run three different treatments. In the first, the manager cannot communicate with the other subjects, but can control their financial incentives. In the second, managers can send messages to the other subjects (after the 10th period). This treatment is the most similar to the study run by Chaudhuri et al. The only difference here is that the third-party communicator has a stake in the game being played between the other players. In the third treatment, managers can send messages to other subjects and the subjects can send messages to the manager (also after the 10th period). The main result of this paper is that more avenues of communication lead to higher minimum effort levels. The two-way communication treatment yields higher minimum effort levels than the one-way communication treatment, and the same is true for the one-way communication treatment compared to the no-communication treatment. This result holds even when they consider only the sessions with minimum effort levels of 0 after the 10th period. The effect of communication in a coordination game may work through a different channel than other-regarding preferences, such as trust or learning (see Brandts and Cooper (2007) for a list, based on the content of the messages sent by the managers). However, discussions with the authors reveal that the most successful messages appeal to a group identity.

In addition to the minimum-effort game, experimental studies of the provision point mechanism (PPM) indicate that competition between groups increases the likelihood of successful coordination to an efficient equilibrium. The PPM is proposed by Mark E. Bagnoli and Bart L. Lipman (1989), with the property that it fully implements the core in undominated perfect equilibria in an environment with one private good and a single unit of public good.[18] In a complete information economy, agents voluntarily contribute any nonnegative amount of the private good they choose and the social decision is to provide the public good if and only if contributions are sufficient to pay for it. The contributions are refunded otherwise. This mechanism has a large class of Nash equilibria, some of which are efficient while others not. Among a large number of experimental studies of this mechanism, two studies highlight the effects of group competition in equilibrium selection, even though neither was explicitly designed to test group effects. First, Bagnoli and Michael McKee (1991) study the mechanism with several independent groups simultaneously in the same room and publicly posted contributions for all groups. They find public good is provided in 86.7 percent of the rounds. Second, Michael B. Mysker, Peter K. Olson and Arlington Williams (1996) use the same parameters but with single, isolated groups. The latter is not nearly as successful as the former in coordinating to the efficient outcome. In the Bagnoli and McKee study, the efficient equilibrium contribution is a modal distribution, while in the Mysker, Olson and Williams study, contributions are evenly distributed along the strategy space. From the perspective of potential games, we can show that, in general, PPM is not a potential game.[19] However, with group competition, it can be transformed into a potential game where the potential maximizing equilibrium is the set of efficient equilibria.

Another well-studied coordination game is the Battle of the Sexes game (BoS hereafter). Charness, Luca Rigotti and Aldo Rustichini (2007) report a series of experiments on the effects of group membership on equilibrium selection in BoS games (as well as the prisoner's dilemma games). In treatments where groups are salient, the authors find that group membership significantly affects the rate of successful coordination. Taking a version of BoS such as the one on the left in the table below (Charness, Rigotti and Rustichini 2007), it is straightforward to show that it is a potential game with the potential function given by $P = 4p_1p_2 - p_1 - 3p_2$, where p_i denotes the probability with which player i chooses A. Hence the potential is maximized by the mixed strategy equilibrium $(p_1 = 0.25, p_2 = 0.75)$. This prediction is consistent with the findings of Russell W. Cooper et al. (1989), who show that subjects converge to a frequency of choices that is close to the mixed strategy equilibrium in BoS. If we transform the game to incorporate the effects of group identity, we obtain the game on the right, with the new potential function $P = 4(1+\alpha)p_1p_2 - (1+3\alpha)p_1 - (3+\alpha)p_2$, which is again maximized at its mixed strategy equilibrium. It is straightforward to show that the probability of coordination, $p_1p_2 + (1-p_1)(1-p_2)$, is increasing in α. This leads to a directional prediction that the probability of coordination is higher for ingroup matching compared to the control and

[18]With multiple discrete units, the theoretical results also hold, but there have been very few experimental studies of the multiple-unit case.

[19]A counter example can be constructed from an example used in Flavio M. Menezes, Paulo K. Monteiro and Akram Temimi (2001). Let $x_i = \{0, c\}$. In the two-player case, $\pi_i(c,c) - \pi_i(c,0) - [\pi_i(0,c) - \pi_i(0,0)] = -v_i$, which violates the definition of potential games when $v_1 \neq v_2$.

outgroup matching, and increases with the salience of group identity.

Original BoS

	A	B
A	3, 1	0, 0
B	0, 0	1, 3

Transformed BoS

	A	B
A	$3+\alpha$, $1+3\alpha$	0, 0
B	0, 0	$1+3\alpha$, $3+\alpha$

In sum, we find that social identity, group competition, and group norms improve coordination in games with multiple Nash equilibria. Incorporating group identity into potential games provides a unifying framework which reconciles findings from a number of coordination game experiments.

TABLE 11—SUMMARY OF STUDIES REGARDING THE MINIMUM-EFFORT GAME

	Study	Treatment	Efforts	T (# of rounds)	n (# per match)	$\pi_i = a\min(x) - cx_i + b$ / $P = a\min(x) - c\sum_i x_i$: a	b	c	Threshold $c^* = \frac{a}{n}$	Theoretical Prediction	Observed Trend
Baseline	Van Huyck, Battalio, Beil (1990)	Large Groups	{1,...,7}	10	14-16	0.20	0.60	0.10	0.01	Low	Low
		No Cost	{1,...,7}	5	14-16	0.20	0.60	0.00	0.01	High	High
		2-person	{1,...,7}	7	2	0.20	0.60	0.10	0.10	High	High
	Goeree, Holt (2005)	2-person, c=1/4	[110,170]	10	2	1.00	0.00	0.25	0.50	High	High
		2-person, c=3/4	[110,170]	10	2	1.00	0.00	0.75	0.50	Low	Low
		3-person, c=1/10	[110,170]	10	3	1.00	0.00	0.10	0.33	High	High
	Knez, Camerer (1994)	3-person	{1,...,7}	5	3	0.20	0.60	0.10	0.07	Low	Low
		6-person	{1,...,7}	5	6	0.20	0.60	0.10	0.03	Low	Low
Transfer of Precedent	Camerer, Knez (2000)	2-person	{1,...,7}	5	2	0.20	0.60	0.10	0.10	High	High
		2-person	{1,...,7}	5	2	0.20	0.60	0.10	0.10	High	High
		3-person	{1,...,7}	5	3	0.20	0.60	0.10	0.07	Low	Low
		2-, 3-person	{1,...,7}	5	2→3	0.20	0.60	0.10	0.07	**Low**	**High**
	Weber (2006)	No Growth	{1,...,7}	12	12	0.20	0.20	0.10	0.02	Low	Low
		No History	{1,...,7}	22	2→12	0.20	0.20	0.10	0.02	Low	Low
		Fast Growth	{1,...,7}	22	2→12	0.20	0.20	0.10	0.02	Low	Low
		Slow Growth	{1,...,7}	22	2→12	0.20	0.20	0.10	0.02	**Low**	**High**
Inter-Group Competition	Bornstein, Gneezy Nagel (2002)	No Comp.	{1,...,7}	10	7	20	60	10	2.86	Low	Low
		Info	{1,...,7}	10	7	20	60	10	2.86	Low	Low
		Group Comp.	{1,...,7}	10	7	20	60	10	2.86	**Low**	**High**
Communication	Chaudhuri, Schotter, Soper (2001)	Low Cost	{1,...,7}	10	8	0.20	0.60	0.10	0.03	Low	Low
		Progenitor	{1,...,7}	10	8	0.20	0.60	0.10	0.03	Low	Low
		History, Advice	{1,...,7}	10	8	0.20	0.60	0.10	0.03	Low	Low
		Advice	{1,...,7}	10	8	0.20	0.60	0.10	0.03	Low	Low
		Public Advice	{1,...,7}	10	8	0.20	0.60	0.10	0.03	**Low**	**High**
	Brandt, Cooper (2007)	Computer	{0,...,40}	20	4	10	200	5	2.50	**Low**	**High**
		No Comm.	{0,...,40}	20	4	9.3*	200	5	2.33	Low	Low
		One-way Comm.	{0,...,40}	20	4	9.3*	200	5	2.33	**Low**	**High**
		Two-way Comm.	{0,...,40}	20	4	9.9*	200	5	2.48	**Low**	**High**

*Chosen by subjects; average reported

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