Theory of Mind and Strategic Decision Making

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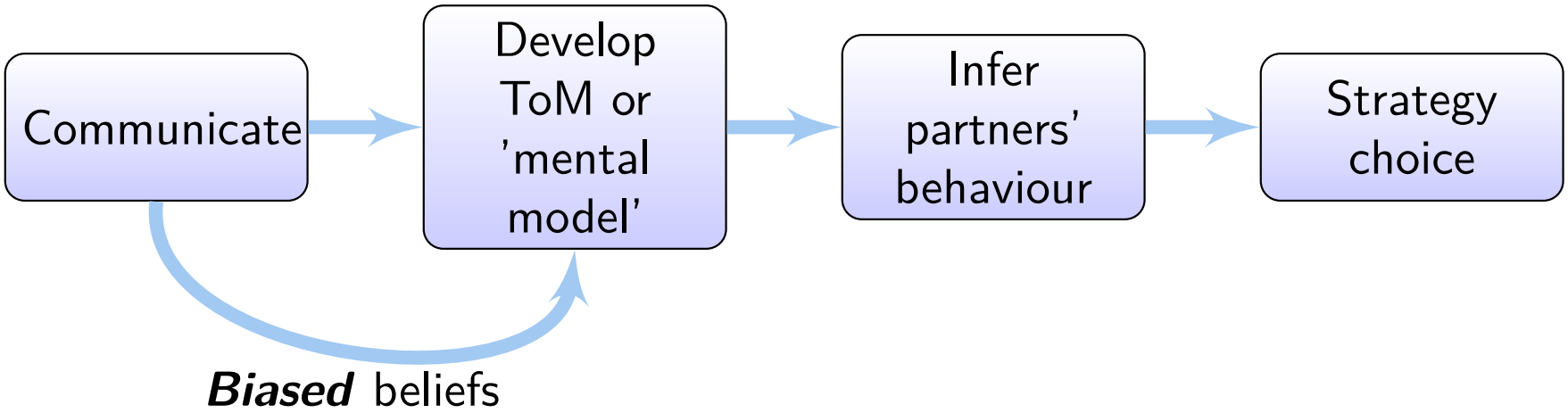
Outline

Theory of Mind

* Theory of mind (ToM) is the ability to think about others' thoughts and mental states to predict their intentions and actions.
* ToM is ubiquitous but varies by individual's 'type'. It's important for economic behaviour, game theory and decision making.
* Decision making:



* ToM is generally measured using psychometric tests.
* This paper proposes an alternative way of measuring ToM - through *belief elicitation*.

Personality Theory

* One way to differentiate between types is through personalities.
* Psychologists have argued that an individual's personality can be explained with regards to 5 traits - the so-called "Big Five" - Extraversion, Agreeableness, Conscientiousness, Neuroticism and Openness.
* Measured by the BFI.
* It has become increasingly important in Economics and the real world (in the labour market).

BFI

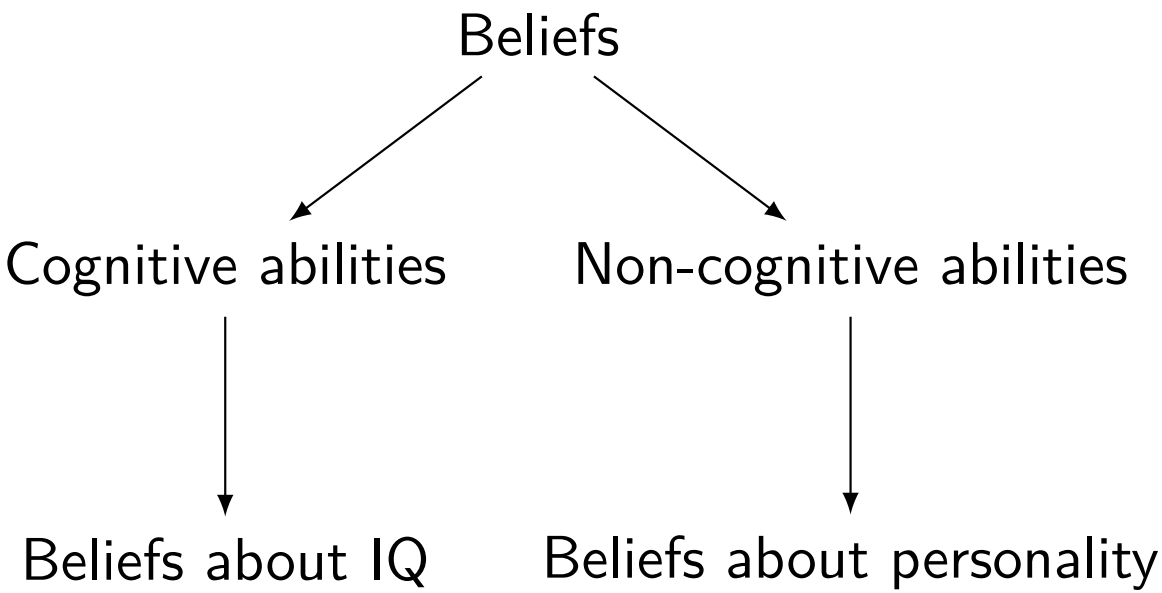
Communication

- Communication before interactive games affects behaviour.
- Reasons for this could be social norms, guilt aversion, lying aversion.
- Rules of the game are known during communication leading to the formation of *informal agreements*.

Communication

- Communication before interactive games affects behaviour.
- Reasons for this could be social norms, guilt aversion, lying aversion.
- Rules of the game are known during communication leading to the formation of *informal agreements*.
- *What would be the effect of communication if rules of the game were unknown?*

Belief Formation



- Extraversion and Neurotcisim are the two fundamental personality traits (Guilford et al., 1976, Cattell, 1973).
- Extraversion is linked with positive emotions where as neurotcisim is linked with negative emotions.

Research Questions

* Do beliefs about the partner's personality and intelligence impact beliefs about partner's actions and in turn own decisions?
* Which impacts decision making more - own personality or beliefs about partner's personality?
* Does own personality or intelligence play a role in beliefs formed about the partner?

Preview of Findings

- Extraverted people overstate the positive emotions or extraversion and understate the negative emotions or neuroticism in others.
- Paper uses two tasks - a commonly used level-k reasoning task and a public goods game.
  - For social preferences, decisions are affected by own personality as well as beliefs about partner's personality. Players believed to be extraverted are expected to cooperate more.
  - For level-k reasoning, it is the perceived similarity between the player's and beliefs about the partner's personality which impacts decision-making.

Outline

Literature

* Prior literature: Theory of mind impacts decision making (Bruguier et al. (2010) and De Martino et al. (2013)).

  Novelty: New approach to measuring ToM.

* Prior literature: Individuals develop strategic sophistication and adjust strategies against others (Georganas et al. (2015) and Fe and Gill (2018)).

  Novelty: Players adjust strategies based on own beliefs.

* Communication before strategic decision making affects behaviour (Krupka et al. (2017), Bochet et al. (2006), and Dawes et al. (1977)).

  Novelty: Communication without knowing the rules of the game.

Framework

* **Convention:** Decision making is associated with individual characteristics.

$$Choice_i = z_i + \mu_i \tag{1}$$

* **Prior Literature:** Decision making is associated with own personality (Rustichini et al. (2016), Proto and Rustichini (2014), Johnson et al. (2009)).

$$Choice_i = \lambda(personality_i) + z_i + \mu_i \tag{2}$$

* **Hypothesis:** Decision making *also* associated with beliefs about partner's personality.

$$Choice_i = \lambda(personality_i, E_i(personality_j)) + z_i + \varepsilon_i \tag{3}$$

Framework

* **Prior Literature:** People have *lay theories* about how personality relates to behaviour (Cooper et al. (2015), Kugler et al. (2014)). An *unbiased* personality prediction would be:

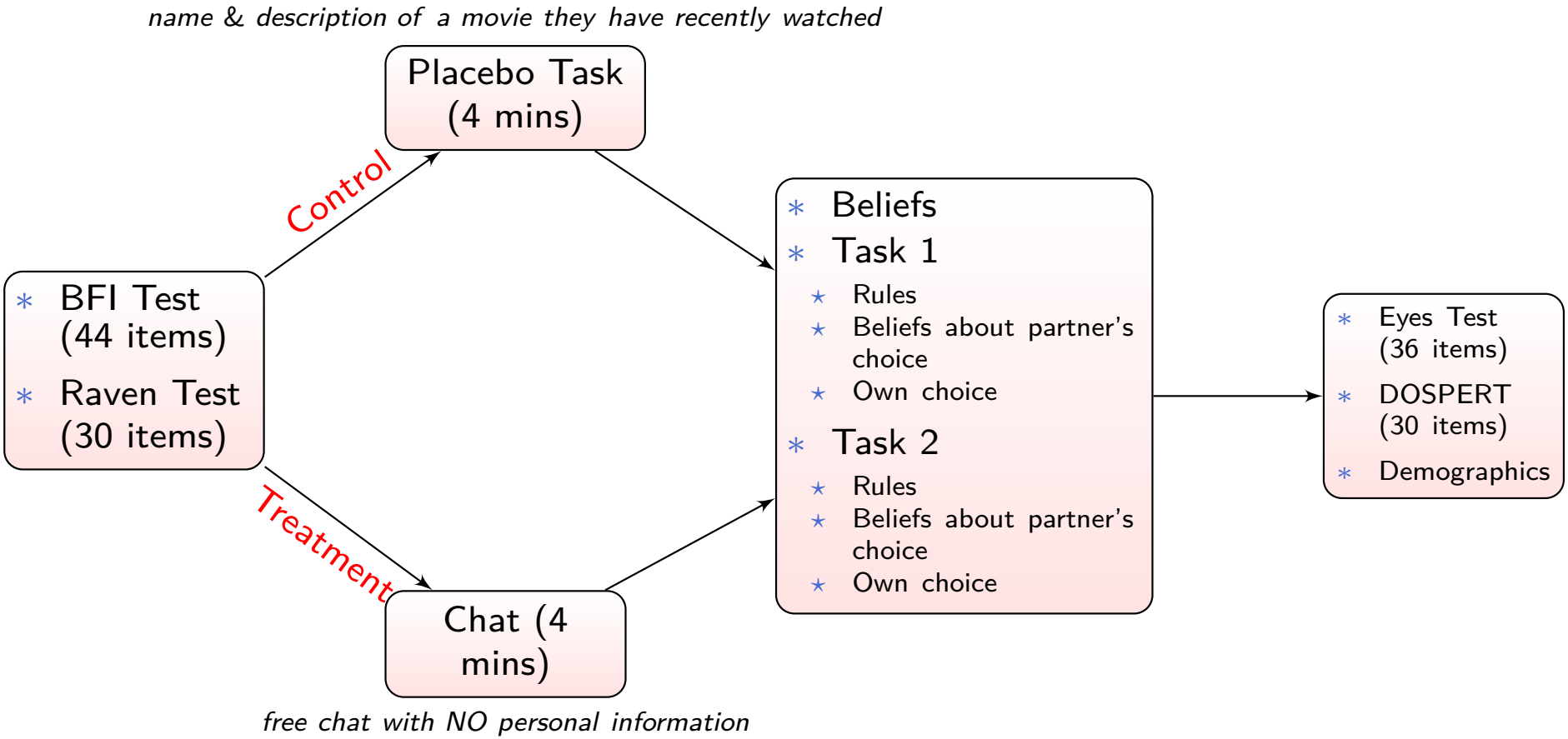
$$E_i(personality_j) = f(personality_j) + e_i \tag{4}$$

* **Hypothesis:** Beliefs about the partner's personality can be *biased* by one's own personality.

$$E_i(personality_j) = f(personality_j) + g_i(personality_i) + \epsilon_i \tag{5}$$

Outline

Experiment Design



Appendix

Task Descriptions

* Public goods game:

  Each subject was allocated 20 Experimental Pounds (EP) and were simultaneously asked to choose how much to contribute (c_i) to a joint project. c_i can be any integer between 0 and 20. Payoffs were determined as follows: $\pi_i = (20 - c_i) + 3/4(c_i + c_j)$

* 11-20 money request game:

  Both players will be asked to request an amount of money between 11 and 20 EP. Each player will receive the amount she requests and an additional amount of 20 EP if she asks for exactly one less than the other player.

Outline

Results - Belief Formation

Table 1: Impact of own personality on beliefs about partner's personality

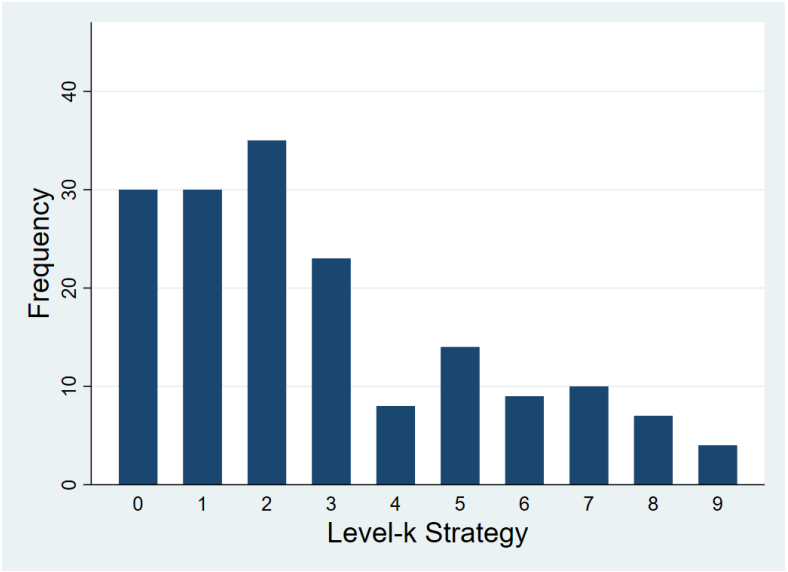
	Extraversion Belief				Neuroticism Belief			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OwnExtraversion × Treatment	0.2342**	0.2134*	0.2151*	0.2955**	-0.1949**	-0.1117	-0.1255	-0.0581
	(0.091)	(0.117)	(0.119)	(0.125)	(0.092)	(0.118)	(0.131)	(0.123)
OwnNeuroticism × Treatment	0.1406	0.1481	0.1512	0.1527	-0.0008	-0.0475	-0.0423	-0.0450
	(0.091)	(0.124)	(0.124)	(0.131)	(0.074)	(0.111)	(0.110)	(0.111)
PartnerExtraversion × Treatment	0.2820***	0.4097***	0.4010***	0.4188***				
	(0.081)	(0.108)	(0.110)	(0.110)				
PartnerNeuroticism × Treatment					0.1148	0.0272	-0.0005	0.0195
					(0.075)	(0.104)	(0.103)	(0.101)
Own Extraversion		0.0208	0.0606	0.0247		-0.0832	-0.0726	-0.0890
		(0.073)	(0.079)	(0.080)		(0.074)	(0.076)	(0.074)
Own Neuroticism		-0.0075	0.0078	0.0008		0.0468	0.0607	0.0705
		(0.085)	(0.086)	(0.087)		(0.084)	(0.081)	(0.082)
Partner's Extraversion		-0.1277*	-0.1242*	-0.1336*				
		(0.070)	(0.074)	(0.075)				
Partner's Neuroticism						0.0876	0.1081	0.0960
						(0.072)	(0.071)	(0.070)
Treatment	0.3768***	0.3768***	0.3490***	-0.2838	-0.5214***	-0.5214***	-0.1973	-0.5138***
	(0.098)	(0.098)	(0.100)	(0.631)	(0.104)	(0.104)	(0.558)	(0.103)
Controls	No	No	Yes	Yes	No	No	Yes	Yes
Controls × Treatment	No	No	No	Yes	No	No	Yes	No
N	338	338	338	338	338	338	338	338

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

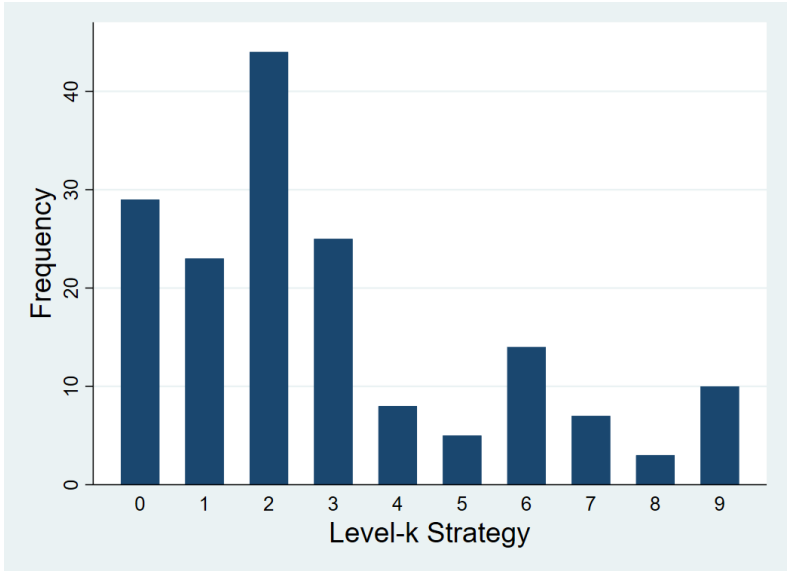
IQbelief

* Extraverted individuals suffer from self projection bias i.e. they project their positive emotions onto their partners. Also, partner's true extraversion significantly enhances extraversion beliefs.

Results - 11-20 money request game



(a) Control



(b) Treatment

Figure 1: The distribution of level-k strategies

* Level-2 is played most often among both treatment and control group players.
* There is no statistical difference between the distribution of level-k strategies played by both conditions.

Results - 11-20 money request game

Table 2: Impact of (absolute) difference between own personality and predicted on level-k strategy chosen

	Level Belief			Level Chosen		
	(1)	(2)	(3)	(4)	(5)	(6)
DiffExtraversion × Treatment	-0.5241*	-0.5035*	-0.3996	-0.6521***	-0.6092**	-0.5069*
	(0.266)	(0.289)	(0.316)	(0.234)	(0.248)	(0.279)
DiffNeuroticism × Treatment	0.1920	0.2769	0.2975	-0.0424	0.0923	0.0864
	(0.254)	(0.280)	(0.289)	(0.254)	(0.273)	(0.275)
Treatment	0.1704	-2.9506	-2.3402	0.0705	-2.2353	-1.5632
	(0.267)	(2.083)	(2.174)	(0.278)	(1.855)	(1.919)
DiffExtraversion	0.1453	0.1135	0.1357	0.2022	0.1477	0.0547
	(0.196)	(0.199)	(0.214)	(0.175)	(0.174)	(0.191)
DiffNeuroticism	-0.1614	-0.2475	-0.2667	-0.1640	-0.3064	-0.2918
	(0.187)	(0.206)	(0.213)	(0.178)	(0.187)	(0.191)
Eyes Test Score × Treatment		0.5400*	0.5460*		0.5763*	0.5804*
		(0.298)	(0.305)		(0.307)	(0.311)
Female × Treatment		-0.7668	-0.7330		-0.9598*	-0.9454*
		(0.591)	(0.605)		(0.547)	(0.563)
Order × Treatment		1.0661*	1.1001*		1.0414*	1.0714*
		(0.575)	(0.583)		(0.589)	(0.593)
Eyes Test Score		-0.4614*	-0.4458*		-0.4835*	-0.4781*
		(0.246)	(0.250)		(0.249)	(0.250)
Female		1.0774***	1.0846**		1.4572***	1.4690***
		(0.411)	(0.417)		(0.369)	(0.379)
Order		-0.7183*	-0.7544*		-0.9382**	-0.9501**
		(0.396)	(0.404)		(0.414)	(0.418)
Extraversion × Extraversion quartile	No	No	Yes	No	No	Yes
Controls	No	Yes	Yes	No	Yes	Yes
N	338	338	338	338	338	338

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results - 11-20 money request game

Findings:

- In the treatment condition, smaller the perceived difference between own extraversion and partner's extraversion, higher the beliefs about the level chosen by the partner. Also, higher the level chosen by the player herself.
- This is consistent with the *perceived similarity hypothesis*.

Results - 11-20 money request game

Table 3: Distribution of Level-k beliefs

Level	0	1	2	3	4	5	6	7	8	9
Equilibrium (%)	5	10	15	20	25	25				
Treatment (%)	12.50	32.14	17.26	5.95	4.17	11.31	4.17	2.38	3.57	6.55
Control (%)	17.06	25.88	18.82	5.29	7.06	10.00	7.06	3.53	1.76	3.53

Table 4: Expected Payoffs

Level	0	1	2	3	4	5	6	7	8	9
Treatment (EP)	20.00	21.50	24.43	20.45	17.19	15.83	16.26	13.83	12.48	11.71
Control (EP)	20.00	22.41	23.18	20.76	17.06	16.41	16.00	14.41	12.71	11.35

- Majority of players (32% in Treatment and 26% in Control) believe their partners will choose level-1 (i.e. 19).
- Given this distribution of beliefs, level-2 (i.e. 18) has the maximum expected payoffs in both conditions.

Results - 11-20 money request game

Table 5: Impact of perceived difference between own personality and predicted on the probability of choosing the best response

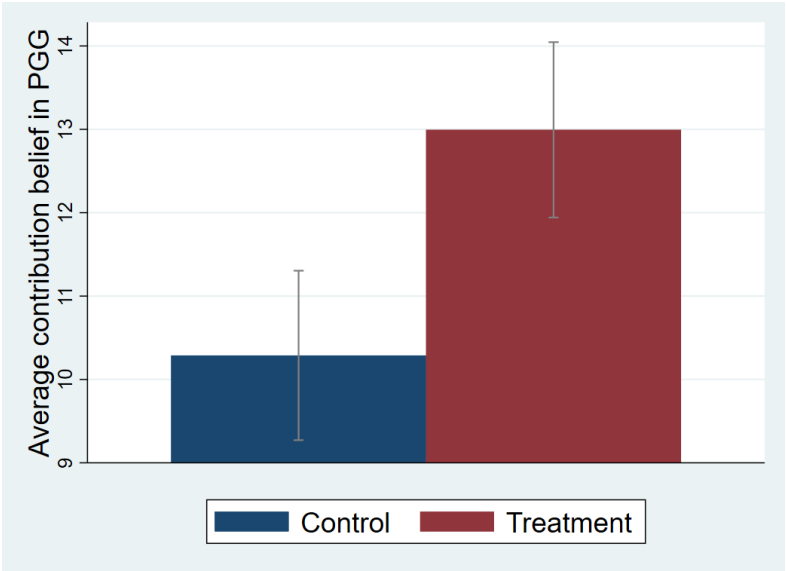
	Control		Treatment	
	(1) Pr(Level=2)	(2) Pr(Level=2)	(3) Pr(Level=2)	(4) Pr(Level=2)
DiffExtraversion	-0.0448	-0.0458	0.0837***	0.0911***
	(0.037)	(0.036)	(0.029)	(0.029)
DiffNeuroticism	-0.0008	-0.0124	-0.0469	-0.0452
	(0.031)	(0.032)	(0.033)	(0.034)
Own IQ		0.0458		0.0532
		(0.033)		(0.034)
Eyes Test Score		0.0408		0.0415
		(0.038)		(0.032)
Control	No	Yes	No	Yes
N	170	170	168	168

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

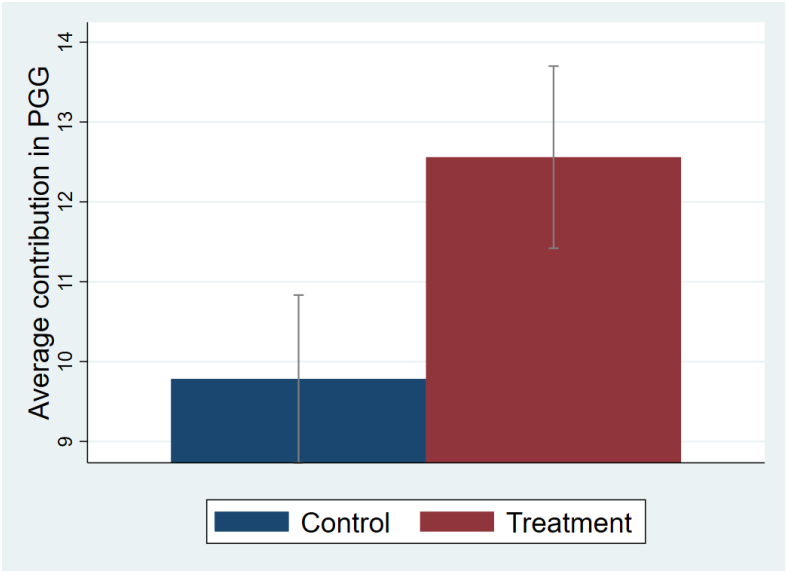
LPM

* The greater the perceived difference between own and partner's extraversion, the greater the probability of best responding to the distribution of beliefs in the treatment condition.

Results - Public Goods Game



(a) Contribution belief



(b) Own Contribution

Figure 2: Average contribution and beliefs about partner's contribution in PGG

Order Effect

Results - Public Goods Game

* Impact of extraversion beliefs *and* own extraversion on cooperation:

$$Choice_i = \beta_1 personality_i + \beta_2 E_i(personality_j) + \gamma z_i + \varepsilon_i \quad (6)$$

$$E_i(personality_j) = \lambda_1 personality_j + \lambda_2 personality_i + \epsilon_i \quad (7)$$

* Endogeneity issue.
  - Estimation requires valid instruments to correct bias.
  - Use partner's true personality to instrument beliefs about her personality.
  - First stage shows that partner's true extraversion is a valid instrument for extraversion beliefs *only* in the Treatment group.

First Stage

Results - Public Goods Game

Table 6: Impact of beliefs about partner's personality on beliefs about partner's contribution and own contribution in Public Goods Game (IV approach)

	Control Order 1		Treatment Order 1	
	(1) Contribution Belief	(2) Own Contribution	(3) Contribution Belief	(4) Own Contribution
ExtraversionBelief	-0.4512	-0.9892	0.6273**	0.5385*
	(0.658)	(0.462)	(0.022)	(0.060)
OwnExtraversion	-0.0570	-0.1741	-0.3120**	-0.1994
	(0.647)	(0.327)	(0.020)	(0.187)
Controls	Yes	Yes	Yes	Yes
N	110	110	106	106

p-values in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- The direct effect of player's own extraversion is negative in the Treatment group, contrary to literature.
- However, Extraversion belief has a direct positive impact on contribution beliefs and own contribution.
- Therefore, overall effect is positive. This highlights the importance for disentangling the two effects.

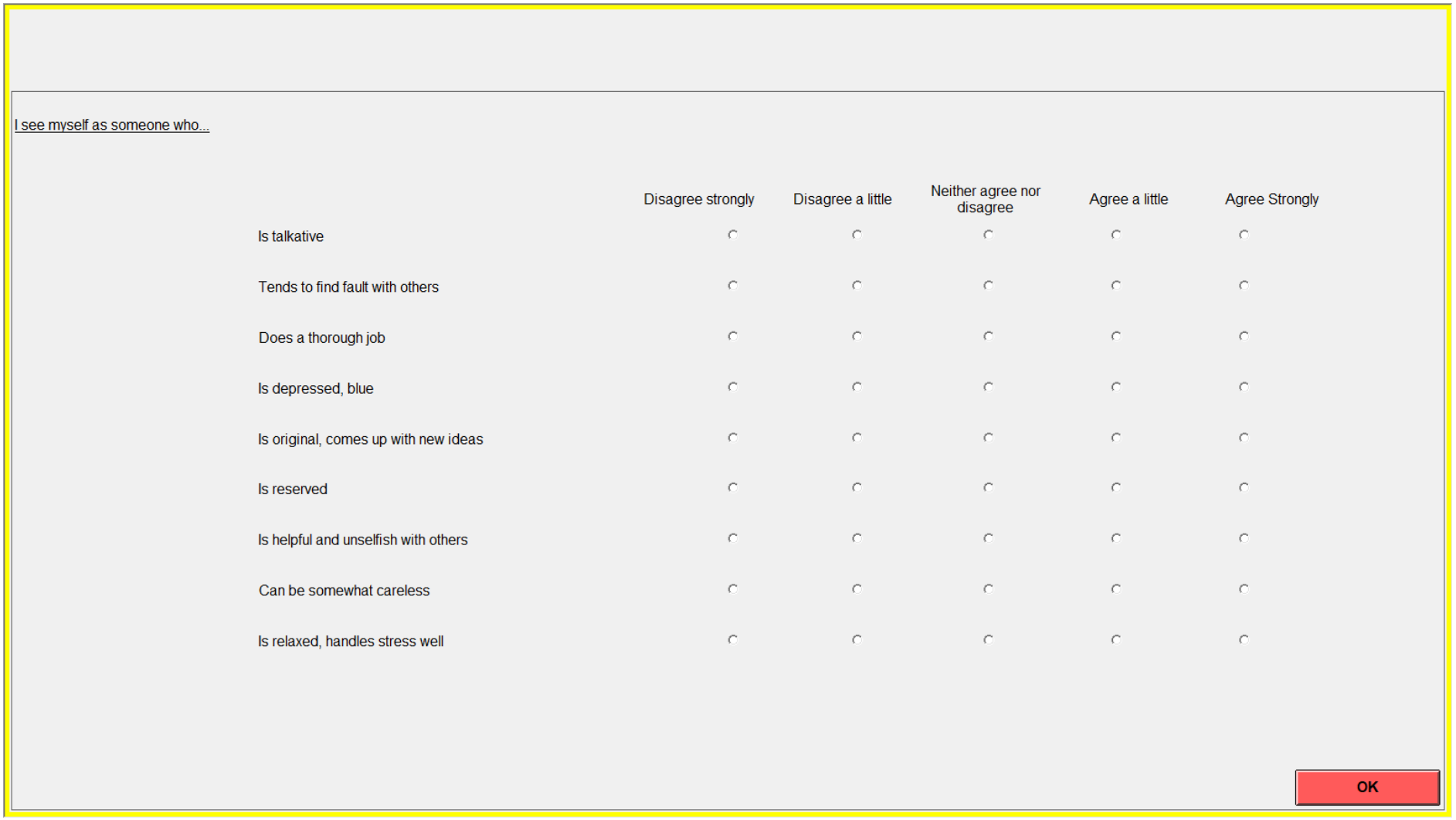
Combined

Outline

Conclusion and Future Work

- Extraverts suffer from *self projection bias*. They project their extraversion or positive emotions onto their partners and overlook the partners' negativity or neuroticism.
- Contribution levels in PGG increase when partners are believed to be extraverted. However, once extraversion belief is accounted for, own extraversion has a negative direct effect on cooperation.
- Level chosen in the 11-20 game is impacted by perceived similarity between player and their partner's extraversion. The smaller the perceived difference, the higher the level-k strategy chosen.
- Future work:
  - Language analysis (in progress). Chat
  - Alternative chat scenarios.

Appendix - Personality Test (Oliver P John and Srivastava, 1999)



I see myself as someone who...

	Disagree strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree Strongly
Is talkative	○	○	○	○	○
Tends to find fault with others	○	○	○	○	○
Does a thorough job	○	○	○	○	○
Is depressed, blue	○	○	○	○	○
Is original, comes up with new ideas	○	○	○	○	○
Is reserved	○	○	○	○	○
Is helpful and unselfish with others	○	○	○	○	○
Can be somewhat careless	○	○	○	○	○
Is relaxed, handles stress well	○	○	○	○	○

OK

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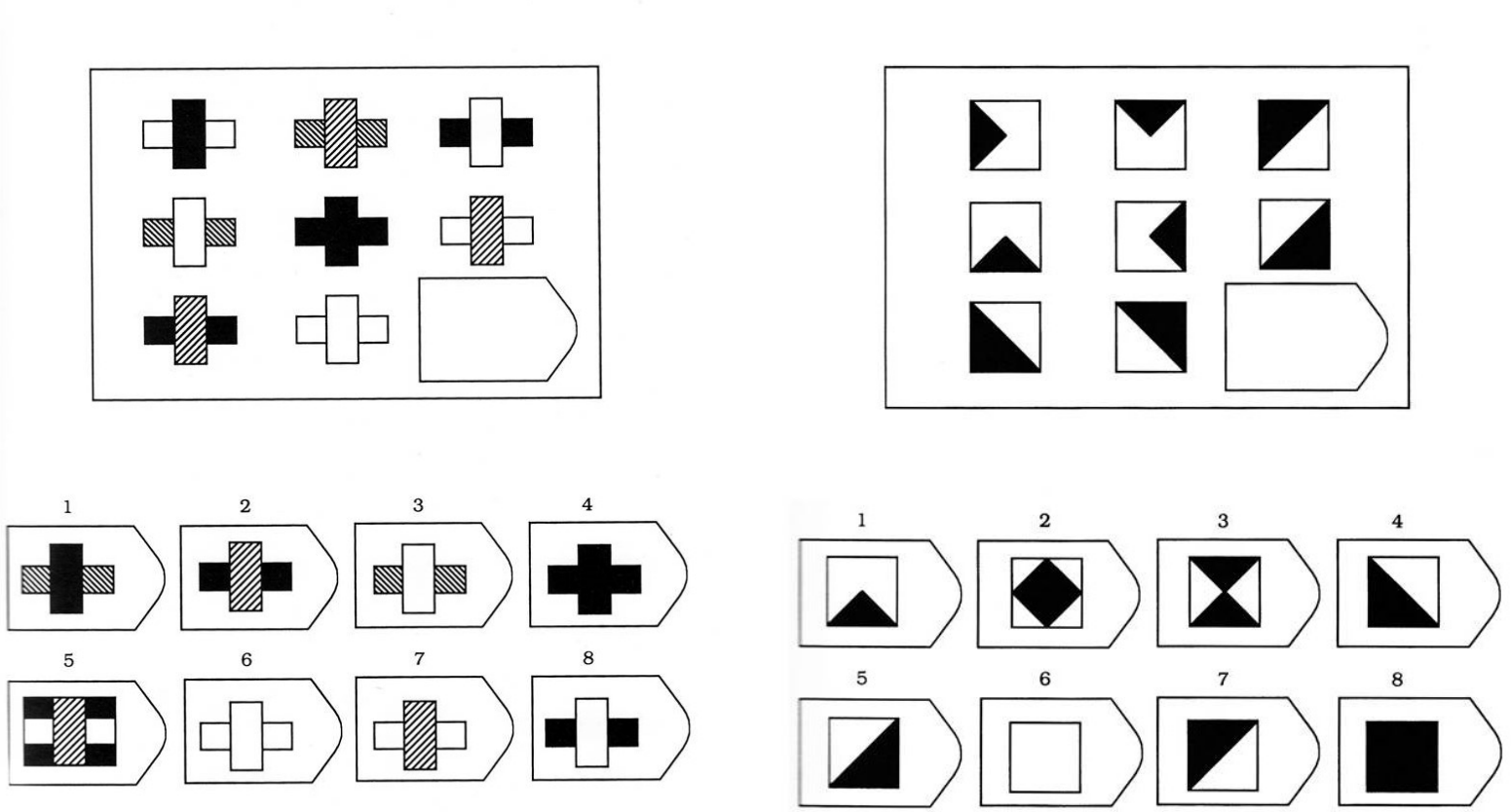
Appendix - Raven Test



(a) (b)

Figure 3: Raven Progressive Matrices

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Appendix - Placebo and Chat

Placebo Task Instructions

Can you please indicate the title and summarize the story of the last movie you have seen? Please be as specific as possible and include as many details as possible. Please use a minimum of 250 characters. You will have 4 minutes to write the summary. Please write the summary in the box provided on the next screen.

Chat Instructions

You have been randomly and anonymously matched with another person in this room who is participating in the experiment. Before you proceed with the tasks, you are allowed to chat with the other player for 4 minutes. You can type in the box provided at the bottom of the screen and press Enter on your keyboard to send your messages. Your message should not contain any personal information such as your name or your computer ID. The purpose is to preserve anonymity throughout the experiment. You are allowed to chat freely in English and in a non-abusive manner.

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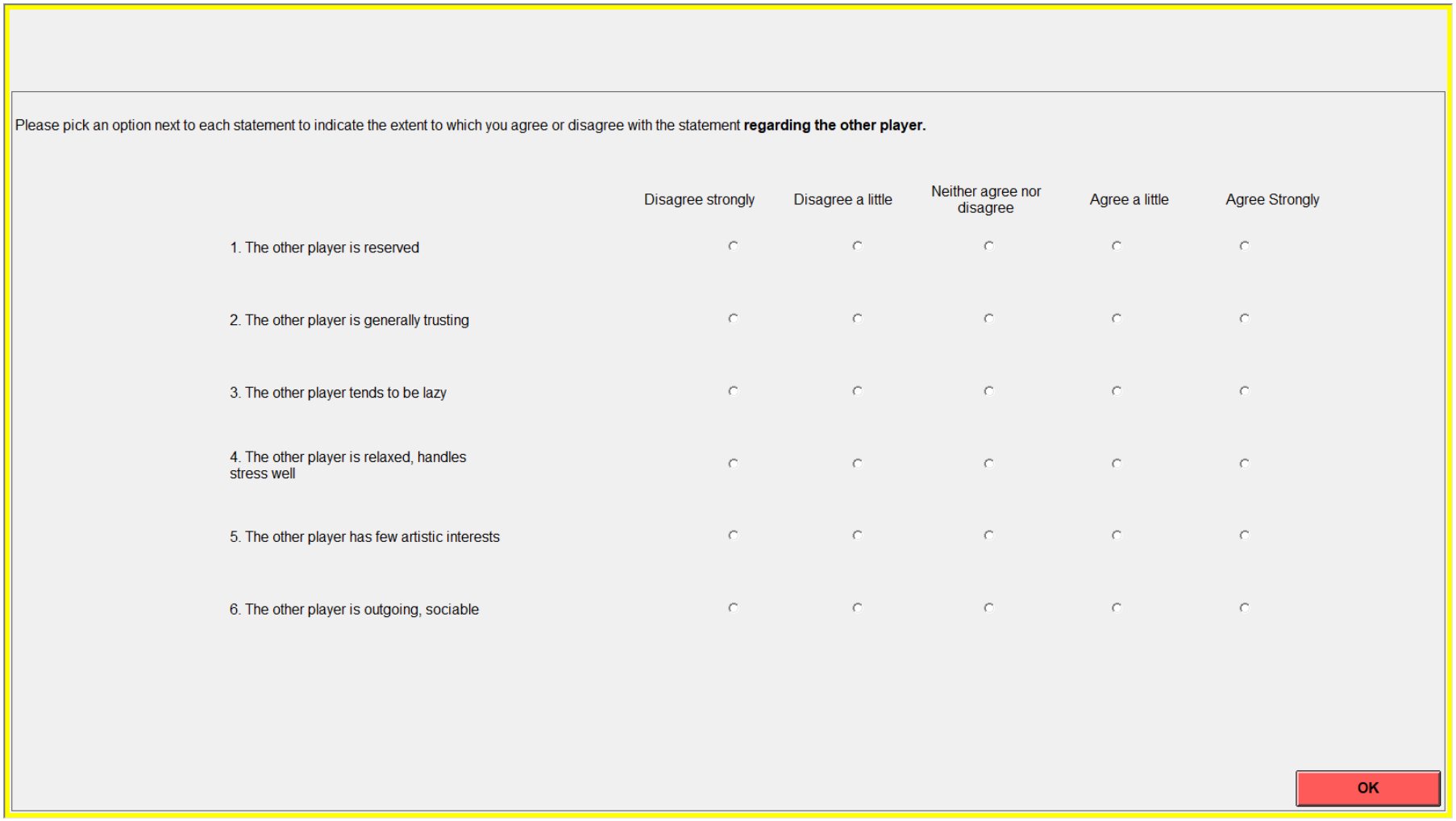
Appendix - Personality Beliefs (Rammstedt and Oliver P. John, 2007)



Please pick an option next to each statement to indicate the extent to which you agree or disagree with the statement **regarding the other player.**

	Disagree strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree Strongly
1. The other player is reserved	○	○	○	○	○
2. The other player is generally trusting	○	○	○	○	○
3. The other player tends to be lazy	○	○	○	○	○
4. The other player is relaxed, handles stress well	○	○	○	○	○
5. The other player has few artistic interests	○	○	○	○	○
6. The other player is outgoing, sociable	○	○	○	○	○

OK

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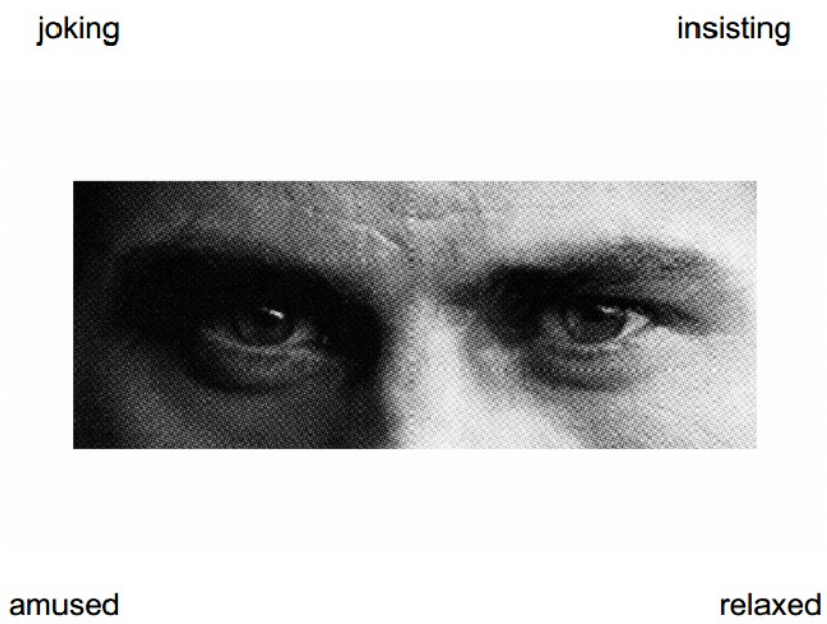
Appendix - Eyes Test (Baron-Cohen et al., 2001)

(a)



(b)

Figure 4: Adult Eyes Test

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Results - Belief Formation

Table 7: Impact of beliefs about own cognitive ability on beliefs about partner's cognitive ability

	IQ Belief		Accuracy of IQ Belief		
	(1)	(2)	(3)	(4)	(5)
Own IQ Belief × Treatment	-0.0586	-0.0624		-0.1982*	-0.3049**
	(0.086)	(0.116)		(0.109)	(0.139)
Partner's IQ × Treatment	-0.0345	-0.0186			
	(0.081)	(0.082)			
Own IQ belief	0.6686***	0.7297***		-0.0825	0.0198
	(0.060)	(0.078)		(0.075)	(0.103)
Partner's IQ	0.0937*	0.0895*			
	(0.050)	(0.050)			
Treatment	-0.0866	0.4422	0.0459	0.0638	0.3960
	(0.083)	(0.514)	(0.110)	(0.107)	(0.604)
Eyes Test Score × Treatment		0.0279	0.1834	0.1682	0.1658
		(0.100)	(0.122)	(0.120)	(0.123)
Eyes Test Score		0.0196	-0.1875**	-0.1662**	-0.1862**
		(0.078)	(0.085)	(0.084)	(0.082)
Own IQ × Treatment		-0.0172			0.1425
		(0.110)			(0.118)
Own IQ		-0.0714			-0.1190
		(0.069)			(0.084)
Controls	No	Yes	No	No	Yes
N	338	338	338	338	338

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Appendix - 11-20 money request game

Table 8: Impact of (absolute) difference between own personality and predicted on probability of best responding (Linear Probability Model)

	Prob(Level=2)		
	(1)	(2)	(3)
DiffExtraversion × Treatment	0.1333***	0.1429***	0.1046*
	(0.049)	(0.052)	(0.057)
DiffNeuroticism × Treatment	-0.0431	-0.0283	-0.0244
	(0.043)	(0.047)	(0.047)
Treatment	0.0581	0.1117	0.0423
	(0.042)	(0.283)	(0.292)
DiffExtraversion	-0.0441	-0.0420	-0.0152
	(0.036)	(0.036)	(0.040)
DiffNeuroticism	-0.0009	-0.0142	-0.0231
	(0.031)	(0.034)	(0.032)
Own Extraversion × Treatment		0.0226	-0.0871
		(0.059)	(0.113)
Own Extraversion		-0.0073	0.0232
		(0.030)	(0.081)
OwnExtraversion × Q2 × Treatment			0.2860
			(0.344)
OwnExtraversion × Q3 × Treatment			0.1610
			(0.407)
OwnExtraversion × Q4 × Treatment			0.2172
			(0.206)
OwnExtraversion × Q2			-0.3326
			(0.278)
OwnExtraversion × Q3			0.0960
			(0.331)
OwnExtraversion × Q4			-0.0563
			(0.146)
Controls	No	Yes	Yes
N	338	338	338

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Appendix - Public Goods Game

Table 9: First Stage

	Control Order 1		Treatment Order 1	
	(1) Extraversion Belief	(2) Extraversion Belief	(3) Extraversion Belief	(4) Extraversion Belief
Own Extraversion	0.0298	0.0319	0.2141**	0.2613**
	(0.086)	(0.104)	(0.106)	(0.102)
Partner's Extraversion	-0.1013	-0.0996	0.3532***	0.3640***
	(0.081)	(0.094)	(0.093)	(0.093)
Controls	No	Yes	No	Yes
N	110	110	106	106

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Appendix - Public Goods Game

Table 10: Impact of beliefs about partner's personality on beliefs about partner's contribution and own contribution in Public Goods Game (IV approach)

	Contribution Belief			Own Contribution		
	(1)	(2)	(3)	(4)	(5)	(6)
ExtraversionBelief × Treatment = 0	-0.8772	-0.4840	-0.4512	-0.8951	-0.8391	-0.9892
	(1.153)	(0.959)	(1.018)	(1.207)	(1.189)	(1.346)
ExtraversionBelief × Treatment = 1	0.5162*	0.5603**	0.6273**	0.4575	0.4822*	0.5385*
	(0.294)	(0.279)	(0.273)	(0.283)	(0.288)	(0.286)
OwnExtraversion × Treatment		-0.2481	-0.2550		-0.0096	-0.0252
		(0.153)	(0.183)		(0.189)	(0.233)
OwnExtraversion	-0.1461	-0.0574	-0.0570	-0.2001**	-0.1844	-0.1741
	(0.089)	(0.112)	(0.124)	(0.097)	(0.149)	(0.178)
Treatment	0.4467	0.3399	1.0694	0.5528*	0.5071*	1.6976
	(0.283)	(0.243)	(1.213)	(0.288)	(0.303)	(1.681)
Controls	No	Yes	Yes	No	Yes	Yes
Controls × Treatment	No	No	Yes	No	No	Yes
N	216	216	216	216	216	216

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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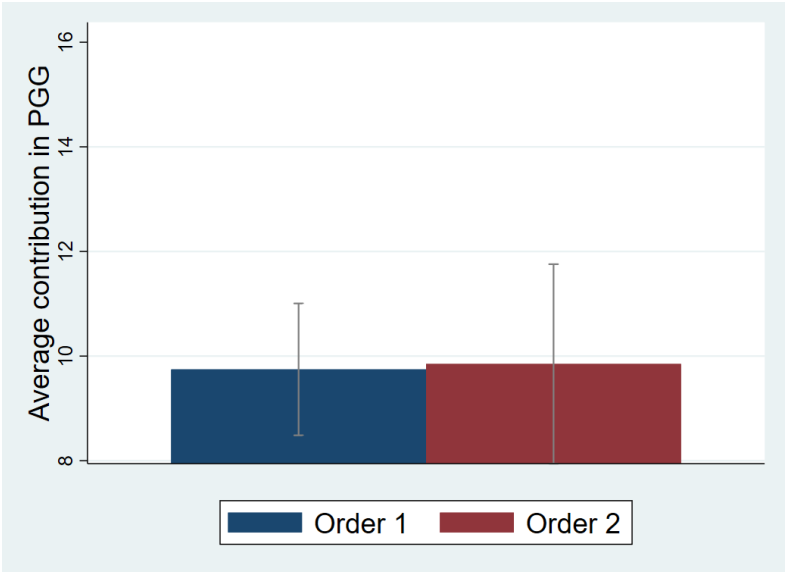
Appendix - Public Goods game (Order effect)



(a) Control

(b) Treatment

Figure 5: Average contribution in PGG

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Appendix - Public Goods game (Order effect)

Table 11: Impact of beliefs about partner's personality on beliefs about partner's contribution and own contribution in Public Goods Game(IV approach)

	Contribution Belief			Own Contribution		
	(1)	(2)	(3)	(4)	(5)	(6)
ExtraversionBelief × Treatment = 0	0.5611	0.6669	0.6036	0.7876	1.0902	1.6583
	(0.776)	(0.993)	(1.196)	(0.980)	(1.394)	(2.215)
ExtraversionBelief × Treatment = 1	0.3791	0.2311	0.0489	1.2760	0.8334	1.0936
	(0.943)	(0.819)	(0.964)	(1.763)	(1.430)	(1.714)
OwnExtraversion × Treatment		-0.0408	-0.0570		-0.0813	-0.2138
		(0.198)	(0.240)		(0.277)	(0.398)
OwnExtraversion	0.0457	0.1380	0.1862	-0.0841	0.0160	0.1058
	(0.097)	(0.164)	(0.154)	(0.150)	(0.231)	(0.271)
Treatment	0.3436	0.2814	0.9234	0.1213	0.0826	4.4746
	(0.265)	(0.285)	(3.619)	(0.332)	(0.362)	(6.016)
Controls	No	Yes	Yes	No	Yes	Yes
Controls × Treatment	No	No	Yes	No	No	Yes
N	122	122	122	122	122	122

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Appendix - Language Analysis

Table 12: Impact of language spoken by the partner on beliefs about partner's personality

	(1) Extraversion Belief	(2) Neuroticism Belief	(3) Extraversion Belief	(4) Neuroticism Belief
Number of Words	0.0088***	-0.0021		
	(0.003)	(0.002)		
First Person Plural			0.1116**	-0.0607
			(0.056)	(0.051)
Controls	Yes	Yes	Yes	Yes
N	168	168	168	168

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

* Partners are believed to be more extraverted when they speak greater number of words or use more first person plural pronouns like we, us, our, ours, ourselves.

Language Analysis

Table 13: Impact of language spoken by the partner on beliefs about partner's personality

	(1) Extraversion Belief	(2) Neuroticism Belief	(3) Extraversion Belief	(4) Neuroticism Belief
Concreteness	0.1291**	-0.1502**		
	(0.060)	(0.058)		
Valence			0.1387**	-0.1094***
			(0.061)	(0.035)
Control	Yes	Yes	Yes	Yes
N	168	168	168	168

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

* Higher concreteness (a word's ability to make specific and definite reference to particular objects) and valence (pleasantness of a stimulus) ratings enhance beliefs about partner's extraversion and diminish beliefs about partner's neuroticism.

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