Personality and social behavior

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Outline: Three main themes

- Conscientiousness and strategic behavior
- Intelligence and strategic behavior
- Neural analysis of personality ad economic behavior

Thanks to

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Main hypothesis

Cooperating and trusting behavior may be explained by personalities reflecting:

- Preferences over social outcomes (Agreeableness).
- Compliance with norms and rules (Conscientiousness).

Control treatment

- Each subject performs two series of 10 additions of 5 two-digits numbers in 4 minutes each; and a third series where she adds the two previously obtained series of numbers.
- The subject is paid proportionally to the number of correct answers to the last series, so the three series of additions are perfectly complementary to obtain the right numbers.

Co-production Treatment

- Each subject is part of a team of two randomly and anonymously matched individuals
- The tasks are identical to the control treatment, but subjects exchange the second series of addition with the partner.
- In the co-production treatment, the final outcome of each teammate is dependent on the effort of both.

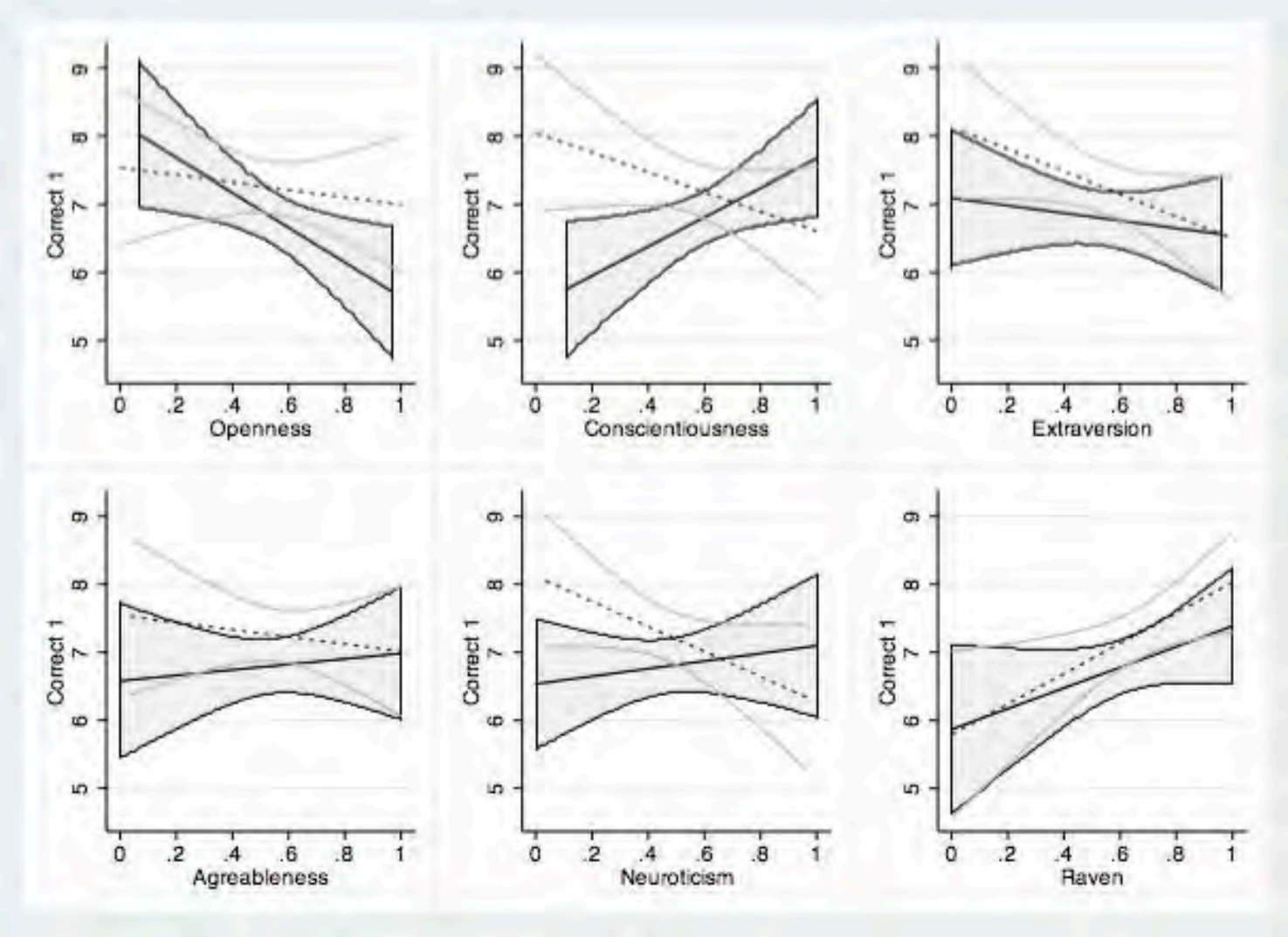
Interpretation: a symmetric, simultaneous trust game

- In the standard trust game, the first player decides whether and how much to trust the second; the second decides whether to reciprocate, conditionally on the action of the first
- In the game we use, both players in the first move of the cooperative treatment decide whether and how much to trust the other; and in the second move decide to reciprocate the hypothetical move of the other

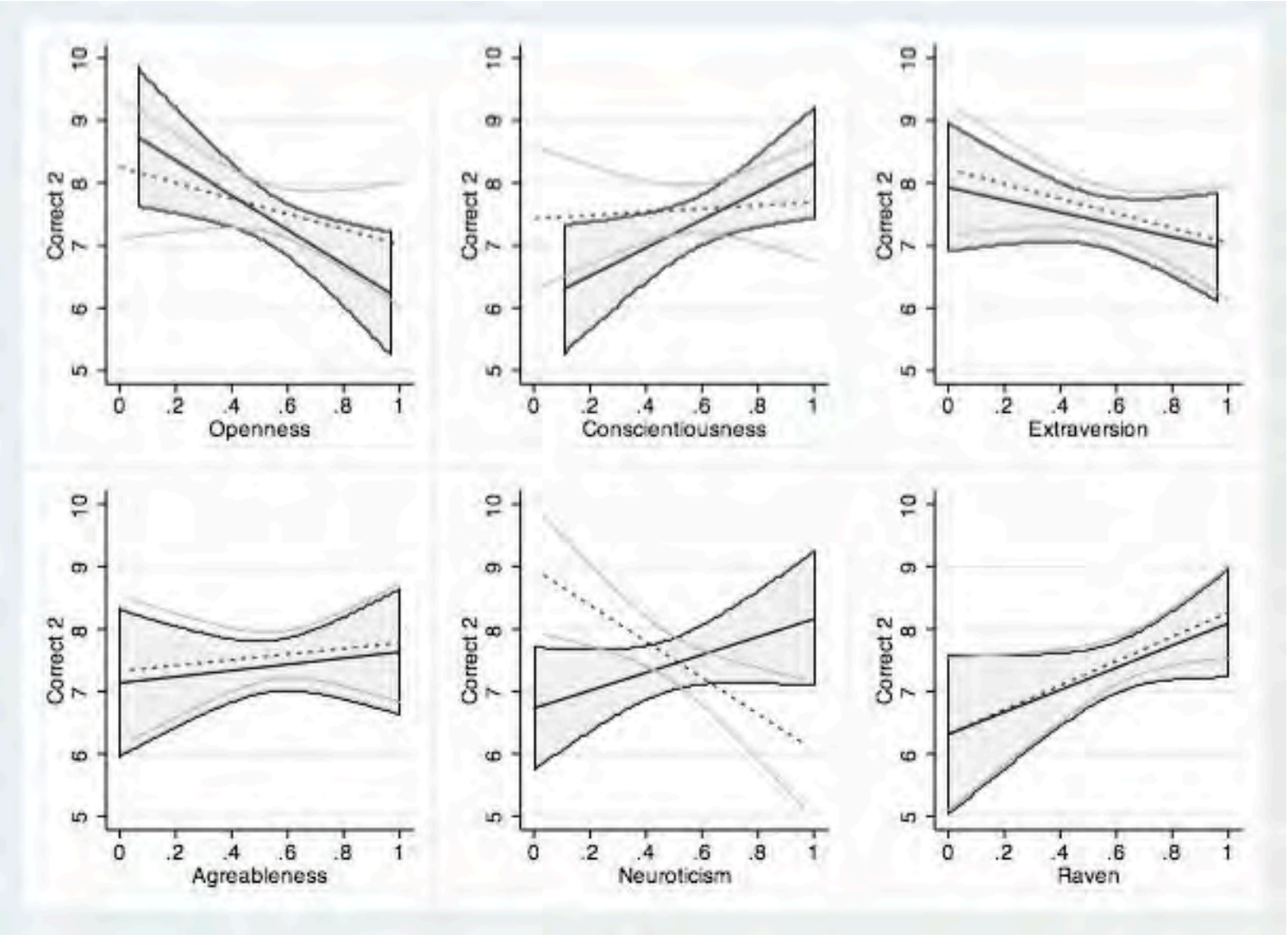
Trust and altruism in co-production

- When they do the first addition subjects have to anticipate the quality of the input that others will provide them; so their effort will be higher if they trust others.
- When they do the second addition, they might consider that their output will influence the payment to others; so their effort will be higher if they care about the outcome of others

Correct 1 (Trust)
(shaded: cooperative)



Correct 2 (Altruism)
(shaded: cooperative)



Easy task: number of correct

	Correct 1	Correct 1	Correct 2	Correct 2
Cooperative Treatment	–0.4857*	–3.1315	–0.2324	–3.3711
	(0.2699)	(1.9583)	(0.2777)	(2.0947)
Coop.*Conscientiousness		3.0395**		1.7250
		(1.3344)		(1.2870)
Coop.*Agreeableness		0.5516		0.4498
		(1.3696)		(1.3447)
Coop.*Neuroticism		2.6264*		4.6111***
		(1.5236)		(1.5056)
Coop.*Extraversion		1.9708		1.2693
		(1.2186)		(1.3221)
Coop.*Openness		–2.8547*		–1.8558
		(1.5758)		(1.7291)
Coop.*Raven		–1.1087		–0.4292
		(1.2099)		(1.2800)
Coop.*Female		1.0265*		0.5926
		(0.5448)		(0.5552)
Conscientiousness	1.0593	–0.7079	1.8109***	0.7850
	(0.6658)	(0.9456)	(0.6879)	(0.8785)
Agreeableness	0.2724	–0.3594	0.5811	0.1176
	(0.7144)	(0.9572)	(0.6776)	(1.0076)
Neuroticism	–0.1384	–1.9025*	–0.0806	–2.8677***
	(0.7745)	(1.0619)	(0.7631)	(0.9718)
Extraversion	–0.5850	–1.7780**	–0.5496	–1.3116
	(0.6302)	(0.8481)	(0.6467)	(0.8614)
Openness	–0.8371	0.8082	–1.2965	–0.0573
	(0.7857)	(1.0722)	(0.8550)	(1.0189)
Raven	1.8931***	2.3042***	1.9006***	2.0144***
	(0.6018)	(0.7513)	(0.5946)	(0.7661)
Female	–0.5440*	–1.0137***	–0.3548	–0.6169*
	(0.2763)	(0.3515)	(0.2655)	(0.3549)
Constant	5.9512***	7.7868***	5.6253***	7.4285***
	(1.0771)	(1.3824)	(1.1395)	(1.3164)
Day Dummy	Yes	Yes	Yes	Yes
R^2	0.133	0.199	0.138	0.193
N	270	270	269	269

Monetary effort experiment: design

1. Participants received an endowment of 10 units and were asked to decide how many of the 10 units they wanted to invest in an individual fund: x_1. (Trust)
2. Participants again received 10 experimental units as an endowment and were asked to decide how many of these units units they wanted to invest in an individual fund: x_2. (Altruism)
3. Participant i was anonymously and randomly matched with j in the same room
4. each individual i gets:

$$y_i = 3\, min(x_{1i}, x_{2j}) - x_{1i} - x_{2i}, j \neq i$$

Effect of Personality in the Monetary experiment

	x_1 (Trust)	x_2 (Altruism)
Conscientiousness	0.5196	0.2303
	(0.3902)	(0.4529)
Agreeableness	–0.3568	–0.1521
	(0.4209)	(0.5182)
Neuroticism	0.4361	0.2511
	(0.3627)	(0.4117)
Extraversion	0.8055*	0.6100
	(0.4723)	(0.5930)
Openness	–0.9587*	–0.3477
	(0.4917)	(0.6241)
Raven	0.2139***	0.1265*
	(0.0626)	(0.0659)
Female	–0.2248	–0.1546
	(0.4066)	(0.5288)
Risk Aversion	0.0720	–0.0874
	(0.9430)	(1.1819)
Constant	3.6020	4.1883
	(3.3508)	(3.8123)
Day Dummy	Yes	Yes
R^2	0.176	0.095
N	158	158

Monetary transfer predicts effort

	Correct 1	Correct 2
x_1 (Trust)	0.3151*	–0.2032
	(0.1626)	(0.2163)
x_2 (Altruism)	–0.0635	0.3440*
	(0.1383)	(0.2006)
Skills in additions	0.9584***	0.9795***
	(0.1473)	(0.1840)
Partners' skills in additions	0.1039	0.3069
	(0.1249)	(0.2304)
Female	–0.9027*	0.1022
	(0.5044)	(0.7864)
Risk Aversion	3.3206**	1.4874
	(1.2667)	(1.7234)
Constant	0.1727	–0.2251
	(1.6121)	(2.5917)
Day Dummy	Yes	Yes
R^2	0.545	0.298
N	84	84

Facets of Agreeableness do no predict effort

	Correct 1	Correct 2
Facet Trust	0.1615	–0.1089
	(0.2909)	(0.4001)
Facet Altruism	–0.2857	–0.0878
	(0.3365)	(0.4305)
Skills in additions	1.0249***	0.8674***
	(0.1574)	(0.2061)
Partners' skills in additions	0.1199	0.2736
	(0.1351)	(0.2409)
Female	–1.0533*	0.0614
	(0.5636)	(0.8026)
Risk Aversion	3.1492**	1.2400
	(1.3939)	(1.6902)
Constant	2.7363	2.5182
	(2.0903)	(2.5278)
Day Dummy	Yes	Yes
r2	0.510	0.252
N	84	84

Summary

1. Big 5 Agreeableness is not associated with a significant increase in effort provision in the co-production treatment in both easy and difficult tasks, nor with an higher monetary effort
2. A choice based measure of trust and altruism (based on the monetary task) seems a better predictor of behavior in the effort task
3. Cooperative and trustful behavior is more effectively predicted by Big 5 Conscientiousness and Neuroticism
4. In the monetary treatment, intelligence is significantly and positively affecting cooperative behavior

INTELLIGENCE AND STRATEGIC BEHAVIOR

Hypothesis: Higher intelligence reduces behavioral biases, and out of equilibrium behavior

True for **strictly competitive games with a single Nash**

When efficiency gains are possible, the relation is much more complex

PNAS

Cognitive skills affect economic preferences, strategic behavior, and job attachment

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Economic analysis has so far said little about how an individual's cognitive skills (CS) are related to the individual's economic pref-

results are enabled by a comprehensive data collection design, which gives us the opportunity to observe socioeconomic, demo-

HIT 15 GAME

TRUST GAME

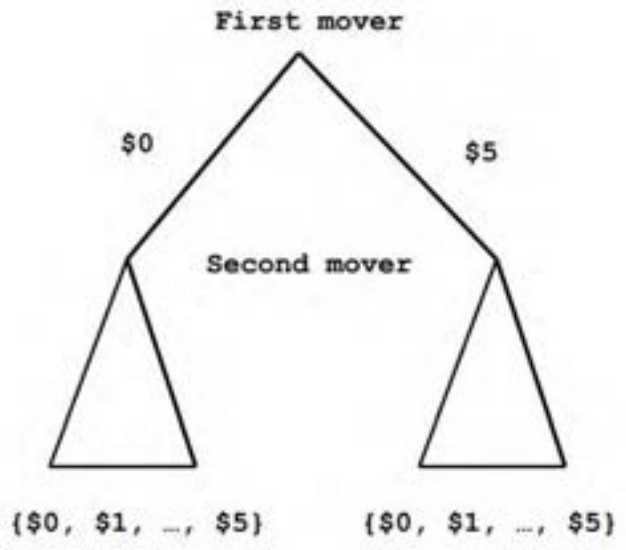
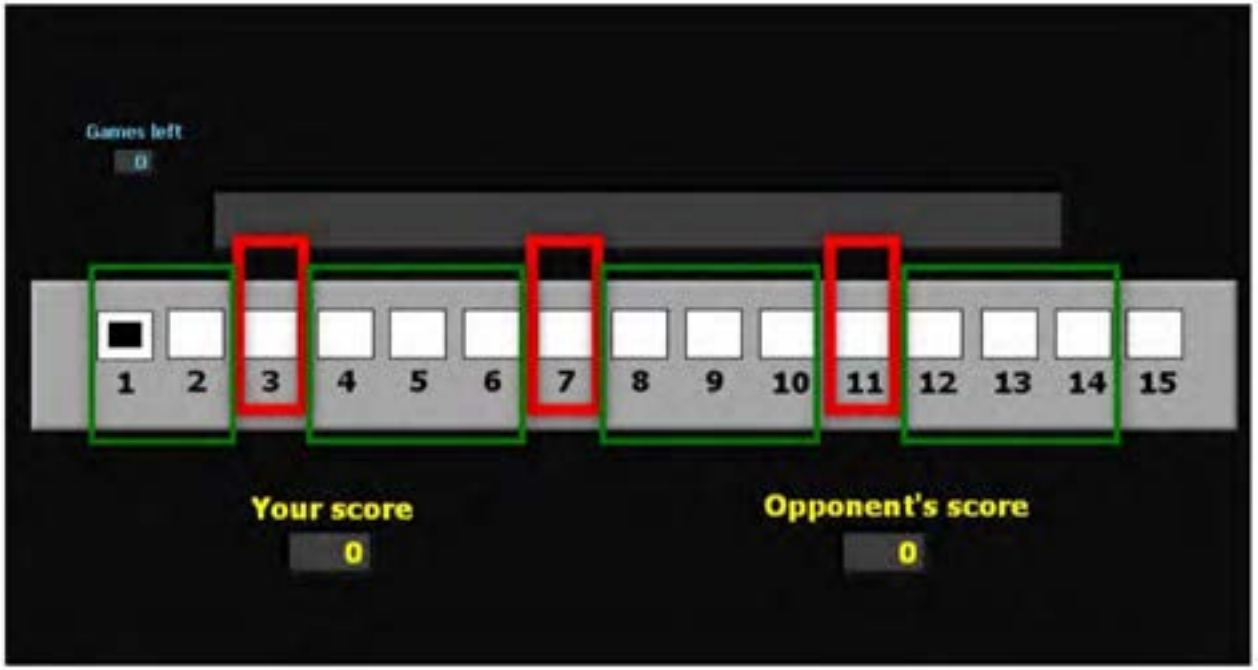
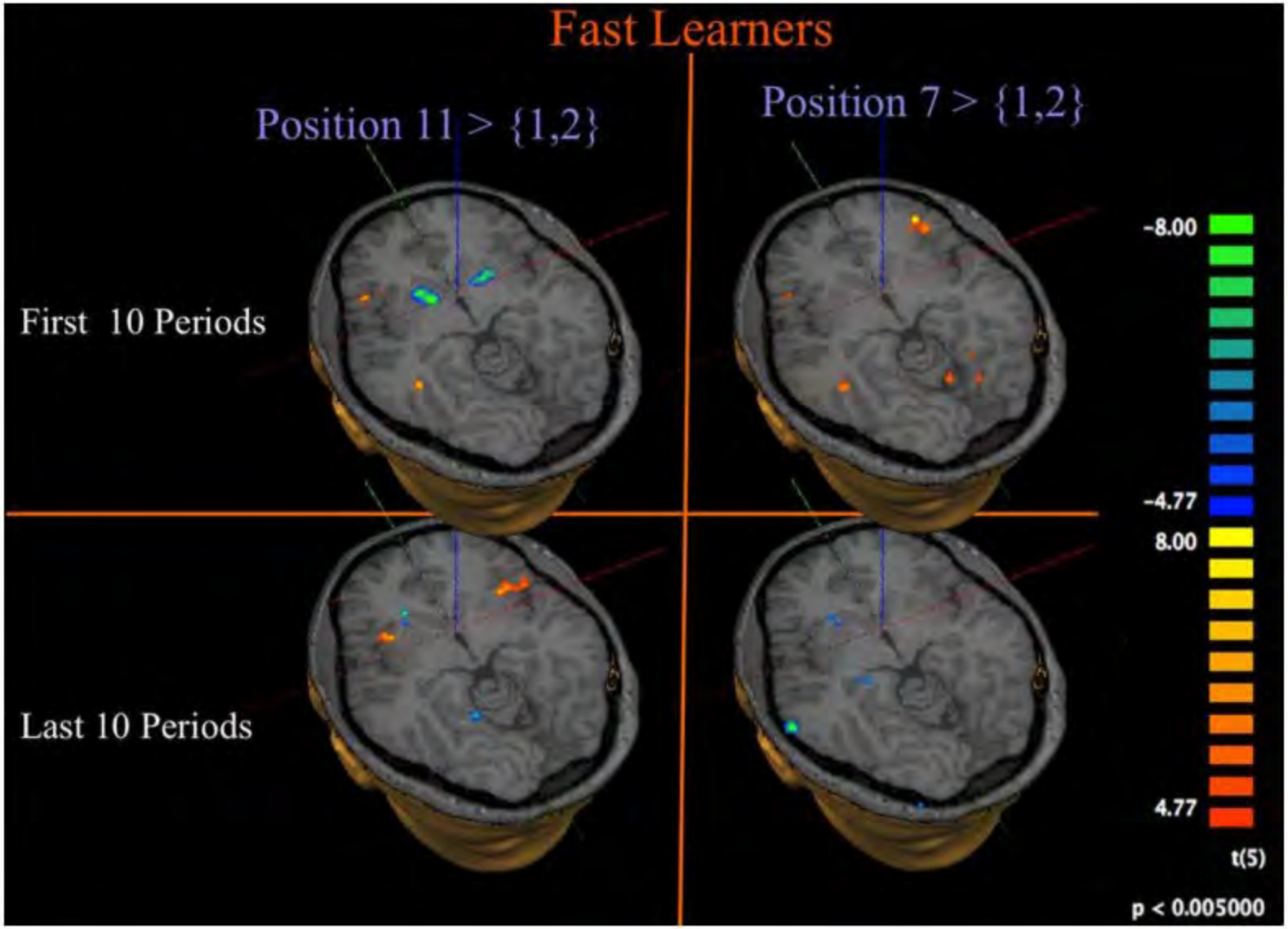


Figure 1: The Sequential Prisoners' Dilemma

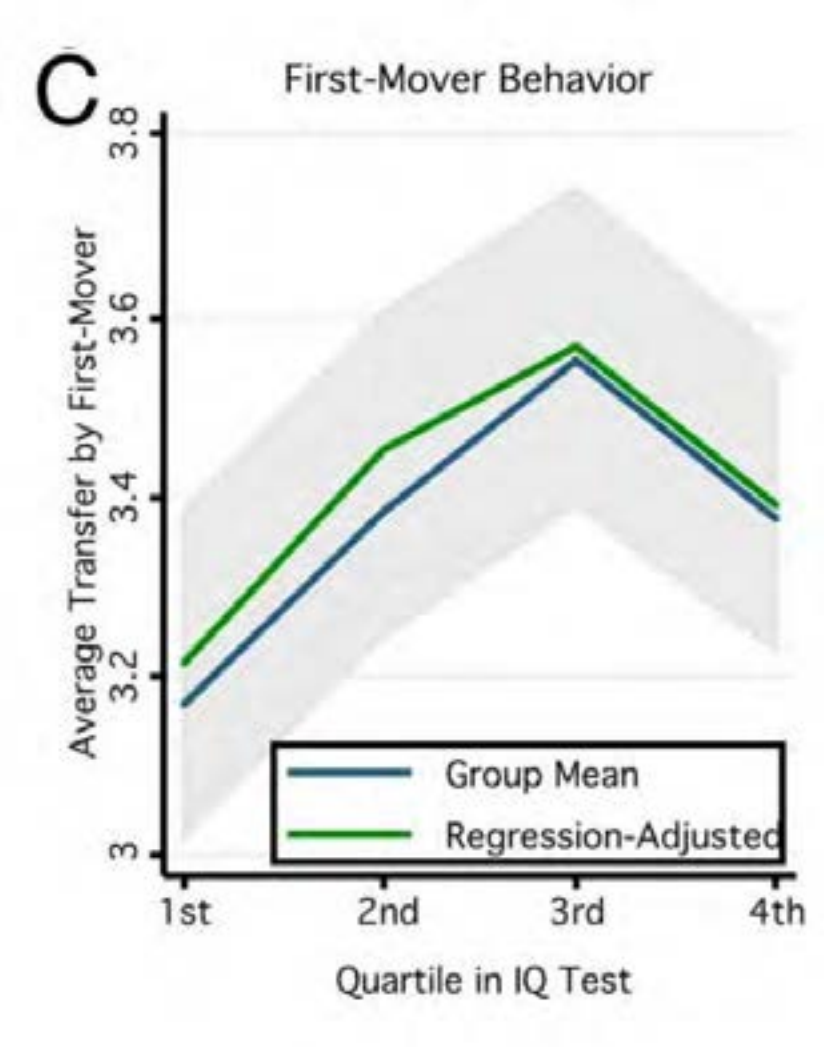
Hit 15 game



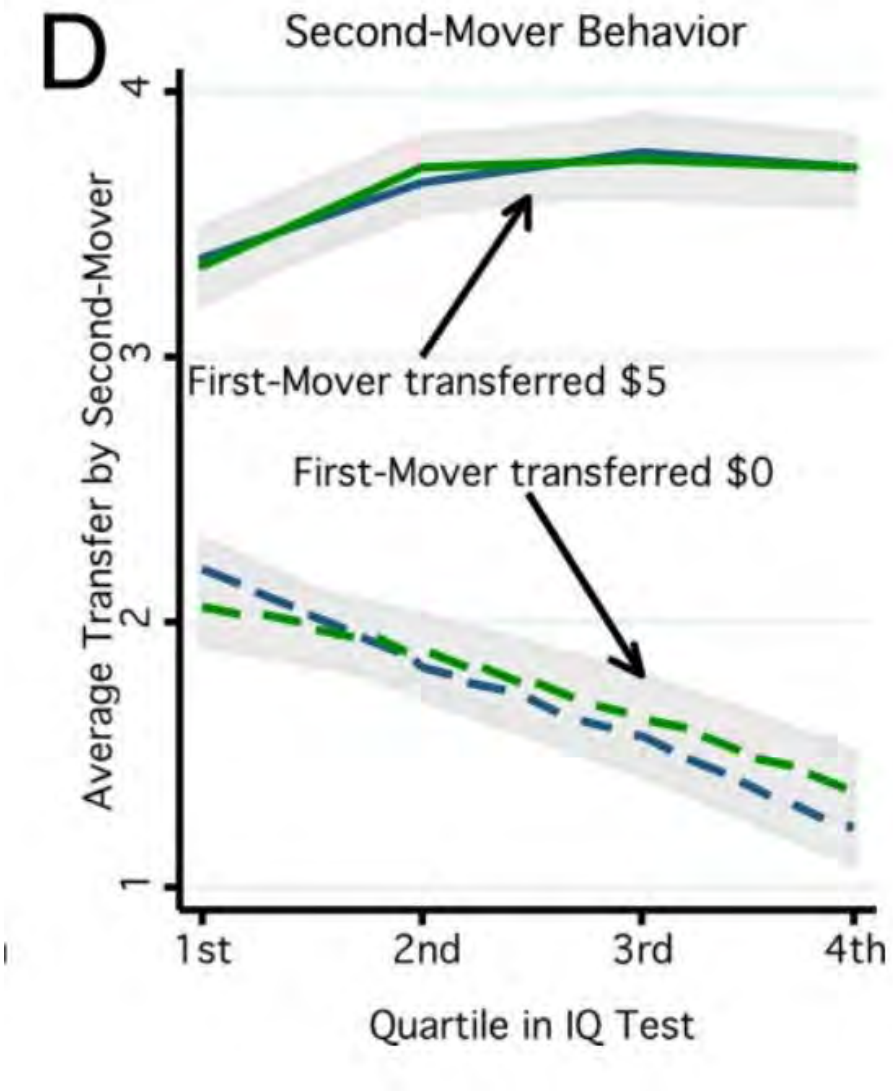
Pearson correlation with Raven score (SPM): 0.81


Fast Learners
Position 11 > {1,2}
Position 7 > {1,2}
First 10 Periods
Last 10 Periods
-8.00
-4.77
8.00
4.77
t(5)
p < 0.005000

Trust Game


C
First-Mover Behavior
Average Transfer by First-Mover
3.8
3.6
3.4
3.2
3
Group Mean
Regression-Adjusted
1st
2nd
3rd
4th
Quartile in IQ Test

Trust Game


D
Second-Mover Behavior
Average Transfer by Second-Mover
4
3
2
1
First-Mover transferred $5
First-Mover transferred $0
1st
2nd
3rd
4th
Quartile in IQ Test

Children's strategic theory of mind

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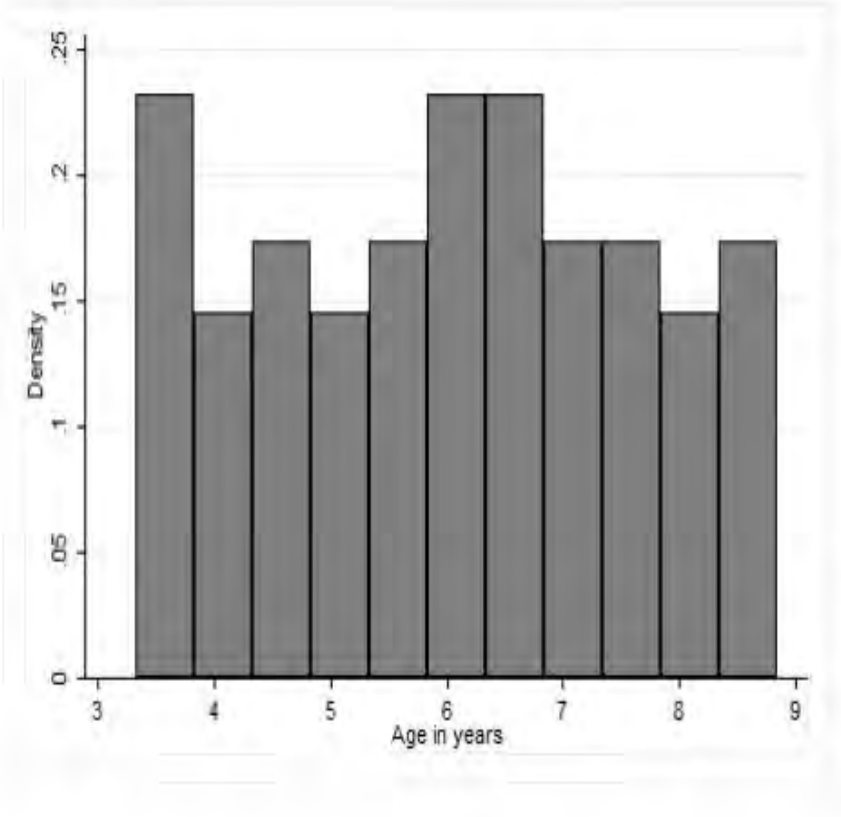
Human strategic interaction requires reasoning about other people's behavior and mental states, combined with an understanding of their incentives. However, the ontogenic development of strategic reasoning is not well understood: At what age do we show a capacity for sophisticated play in social interactions? Several

sequence. For example, in one of our ex
attributes to her adult opponent the mistr
child will lie (using the epistemic capacity),
clude that the opponent will do the oppos
suggests (using the practical capacity). STo

Sample and age distribution

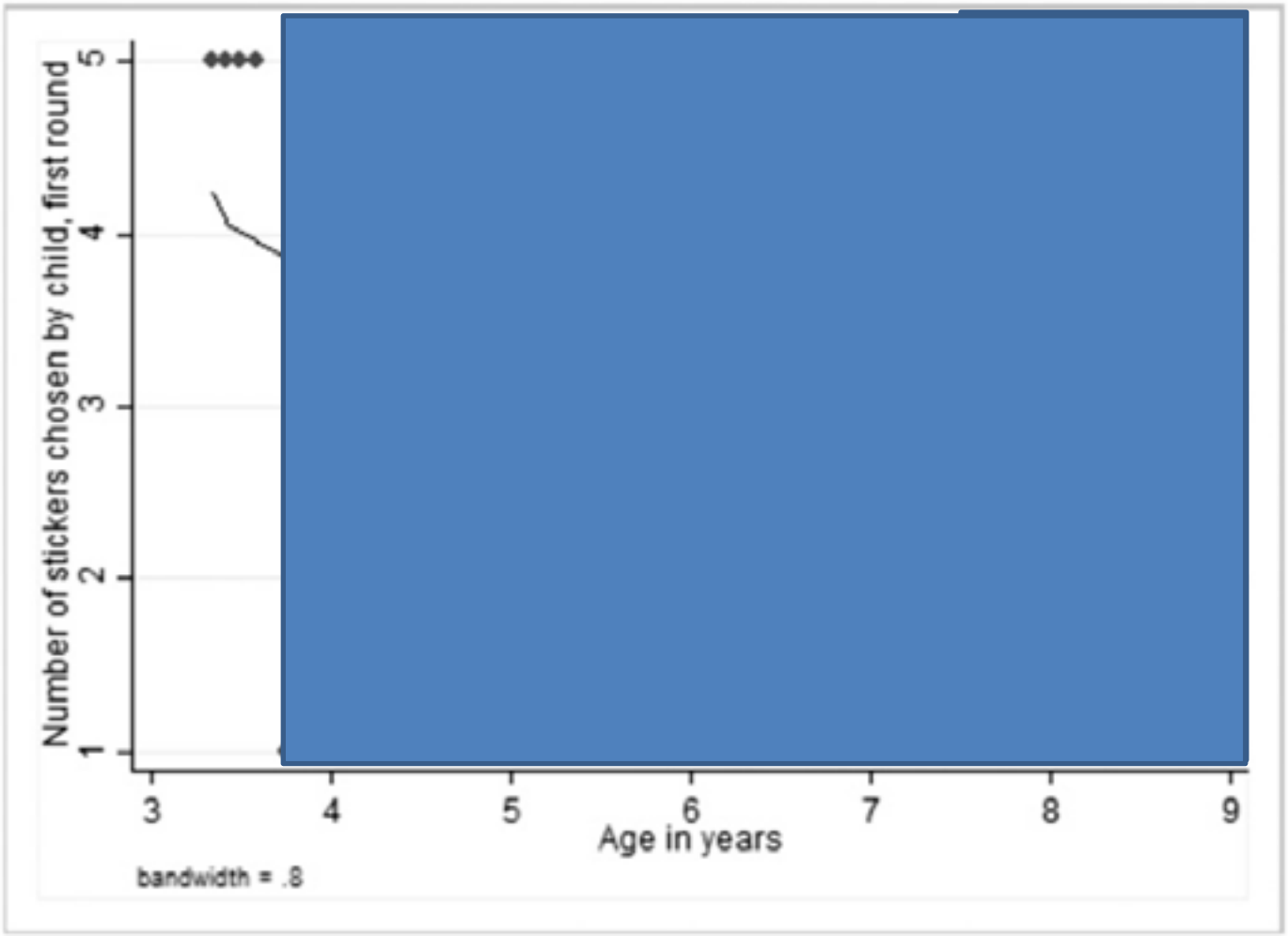
- Children predominantly Caucasian, native English speakers
- From middle to high SES
- The entire experiment lasted approximately 65 minutes.



Sticker Game (Beauty Context) Instructions

- “I’m going to give you and her (the Experimenter 1; E1) each a basket and 5 stickers. You can put however many stickers you want to into the basket: 1, 2, 3, 4, or 5! After you do that, I am going to look in your baskets and count your stickers.
- If **you put a smaller number** of stickers in your basket, then you get to keep your stickers and E1 doesn’t get any.
- But **if E1 has a smaller number** of stickers in her basket, then she gets to keep her stickers and you don’t get any.
- If you and E1 have the **same number of stickers**, then no one keeps their stickers.”
- *Sticker Game was played for 10 rounds.*

Choice of stickers by age; **first move**



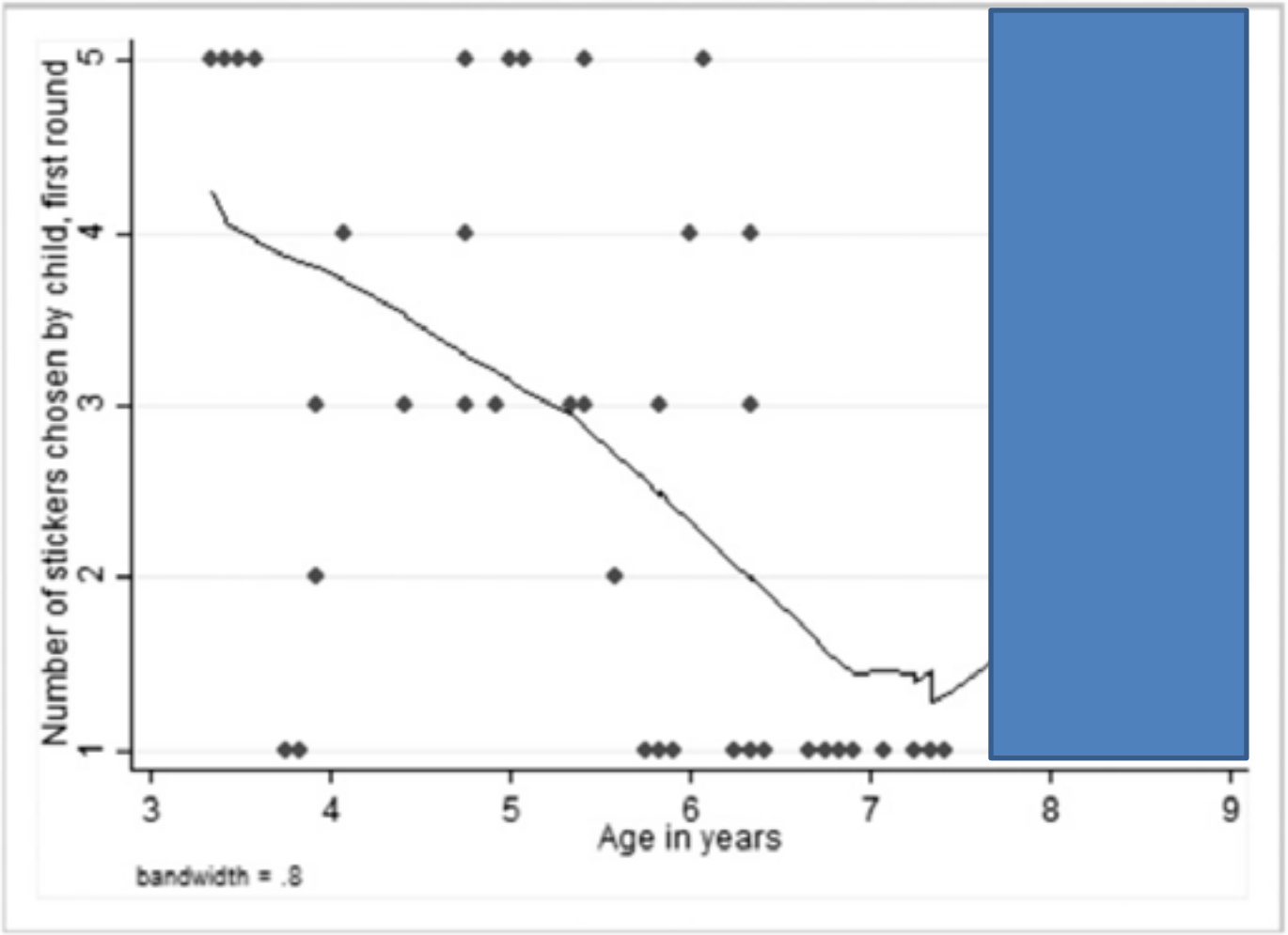
Intelligence

Table 1. Number of stickers in the first move of the stickers game: Ordinary least squares

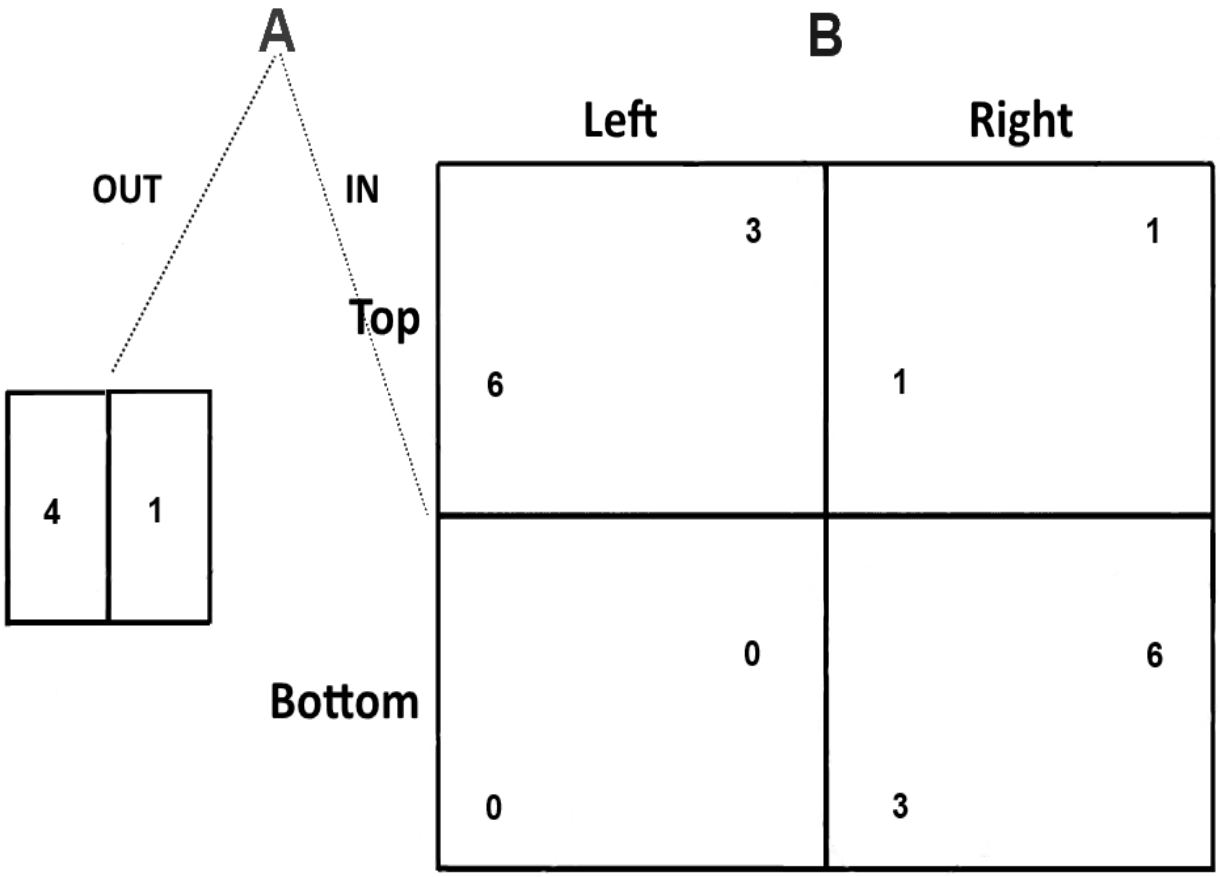
	1 B/SE	2 B/SE	3 B/SE	4 B/SE
Age	−0.510***	−0.403***	−2.465***	−1.597**
	(0.098)	(0.145)	(0.692)	(0.705)
Age squared			0.174***	0.128**
			(0.057)	(0.056)
Male		1.858	2.254*	1.807
		(1.215)	(1.150)	(1.139)
Male × age		−0.227	−0.306	−0.272
		(0.195)	(0.186)	(0.180)
n-backward score				−0.603***
				(0.171)
Constant	5.584***	4.714***	10.390***	8.942***
	(0.610)	(0.875)	(2.042)	(2.027)
N	67	7	67	65

The *n*-backward score is normalized in the unit interval. Age is in years. SEs are provided in parentheses. *$P < 0.1$; **$P < 0.05$; ***$P < 0.01$.

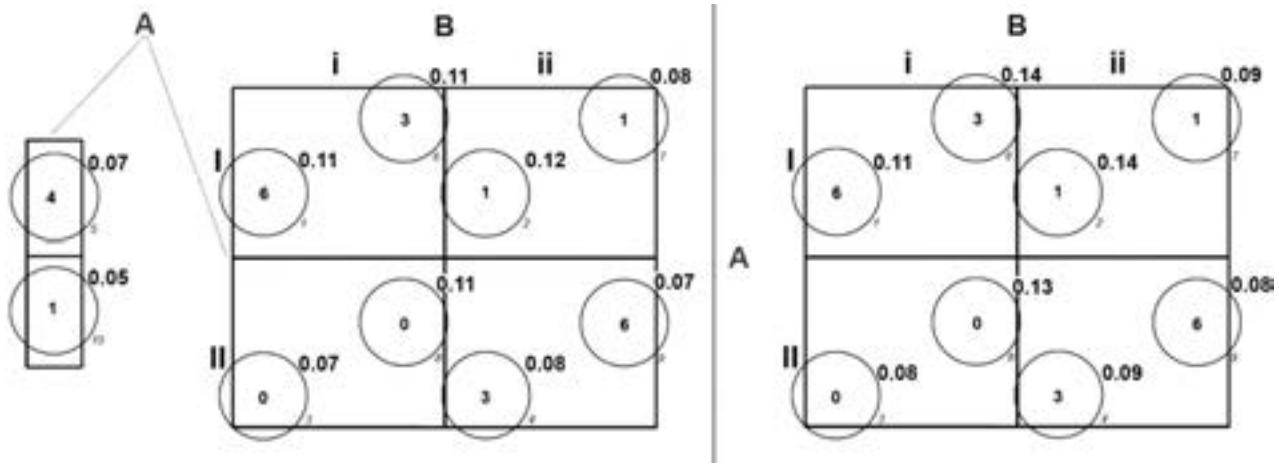
Choice of stickers by age; **first move**



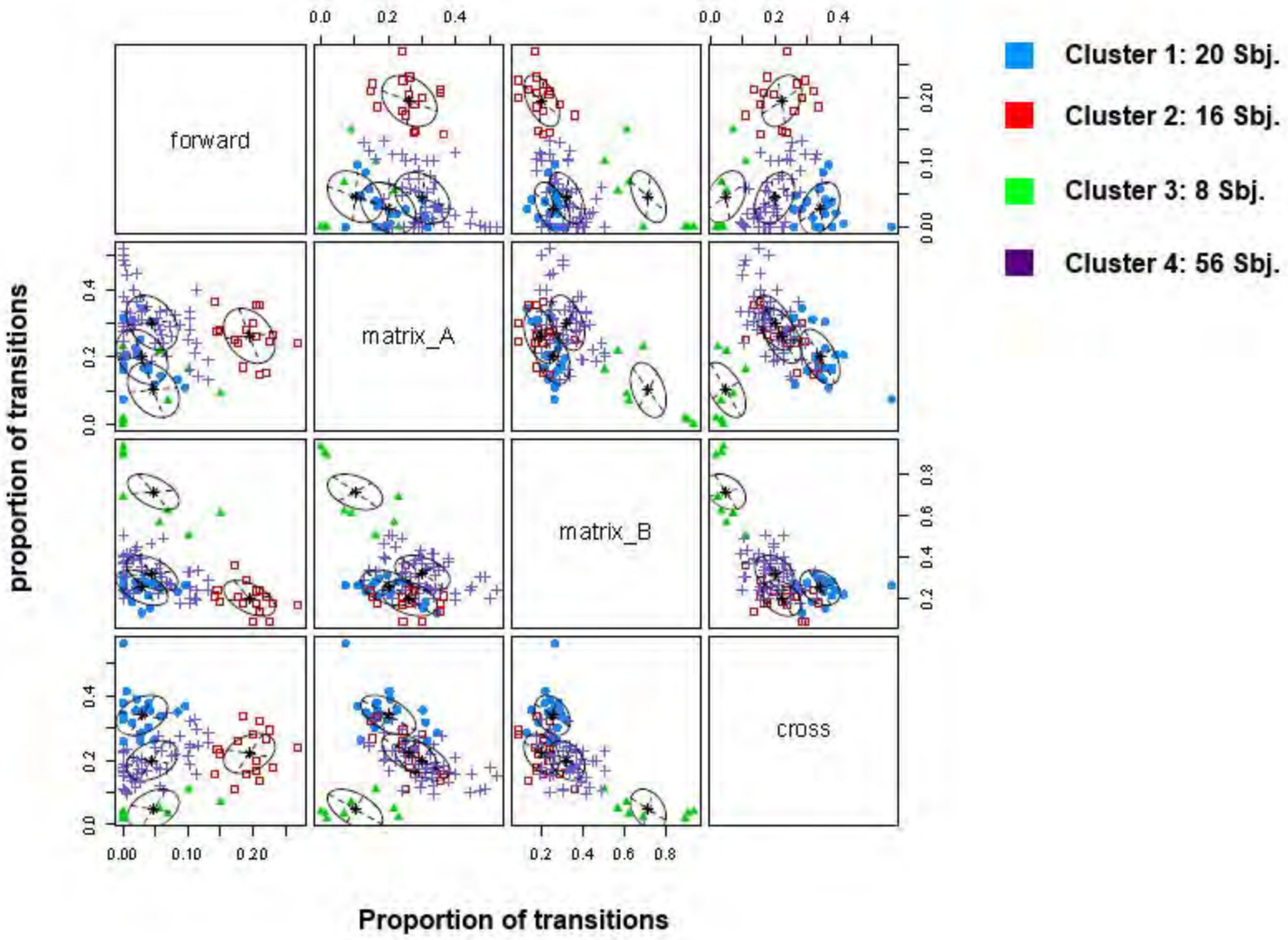
Back to grownups: Forward Induction



Eye tracking for second player



O M


forward
matrix_A
matrix_B
cross
proportion of transitions
Proportion of transitions
Cluster 1: 20 Sbj.
Cluster 2: 16 Sbj.
Cluster 3: 8 Sbj.
Cluster 4: 56 Sbj.

Correlations: intelligence scores, and choices, transitions, fixation times

		Multistage games		Matrix games	
		CRT	RAPM	CRT	Raven Ad
Choices	FI eq.	0.27***	0.14		
	eq.	-0.02	0.09		
Proportion of Transitions	$\boldsymbol{A \leftrightarrow A}$	0.15	0.27***	0.22**	0.26***
	$\boldsymbol{B \leftrightarrow B}$	-0.018	-0.15	-0.03	-0.04
	$\boldsymbol{A \leftrightarrow B}$	-0.11	-0.22**	-0.05	-0.07
	$\boldsymbol{O \leftrightarrow M, O}$	0.24**	0.20**		
Fixation Time	Out opt. A	0.32****	0.10		
	Out opt. B	0.12	0.09		

* < 0.1, ** < 0.05 , *** < 0.001, **** < 0.0001.

Repeated repeated game (Dal BO Frechette)

1. Random continuation rule: after each round, the game continues with probability δ;
2. If the game stops, a new game starts: players are randomly matched in new pairs from the same group
3. Session continues until 50 minutes have elapsed
4. $R \in \{32, 40, 48\}$, $\delta \in \{0.5, 0.75\}$

TABLE 1—STAGE GAME PAYOFFS

	C	D
C	R, R	12, 50
D	50, 12	25, 25

TABLE 2—COOPERATION AS EQUILIBRIUM (SGPE) AND RISK DOMINANT (RD) ACTION

	$R = 32$	$R = 40$	$R = 48$
$\delta = ½$	Neither SGPE nor RD	SGPE	SGPE and RD
$\delta = ¾$	SGPE	SGPE and RD	SGPE and RD

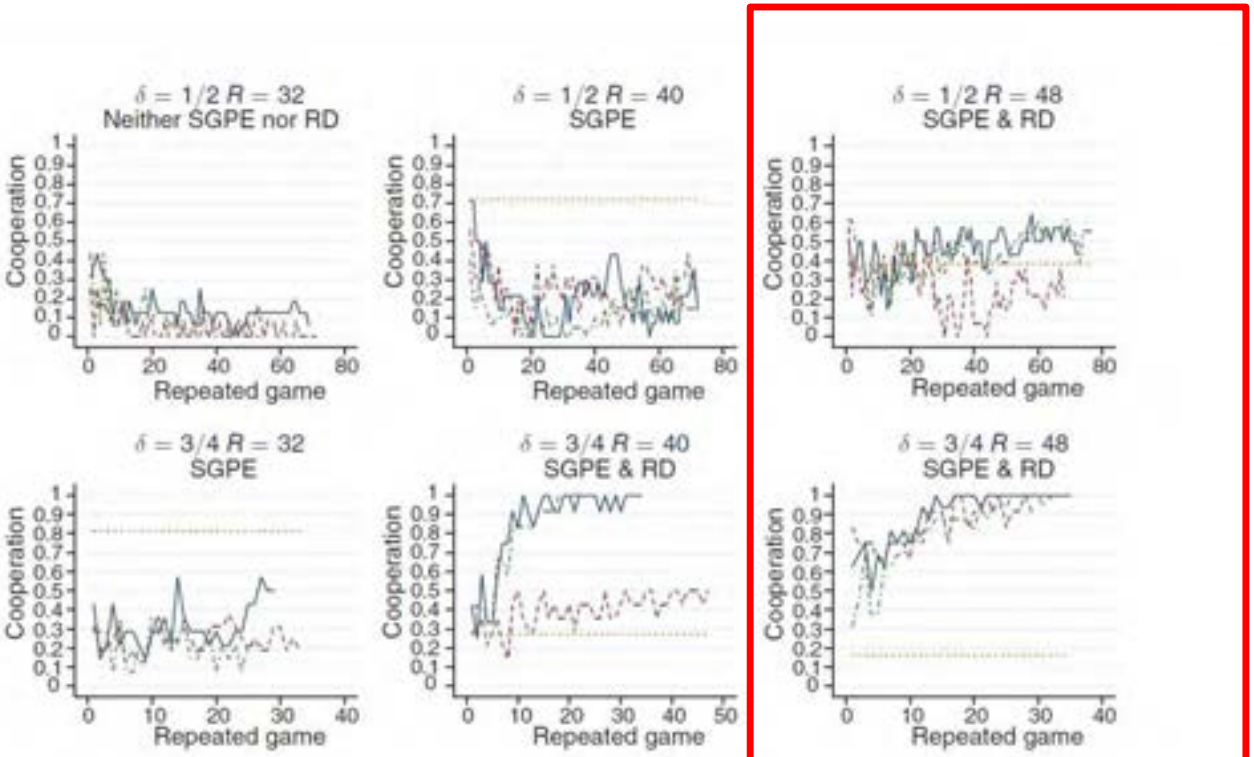


FIGURE 1. EVOLUTION OF COOPERATION BY TREATMENT AND SESSION (FIVE ROUNDS)

Notes: Solid, dashed, and dash-dotted lines denote cooperation rates in sessions 1, 2, and 3 respectively of each treatment. The horizontal dotted lines denote the limit of the basis of attraction of Always Defect versus Grim.

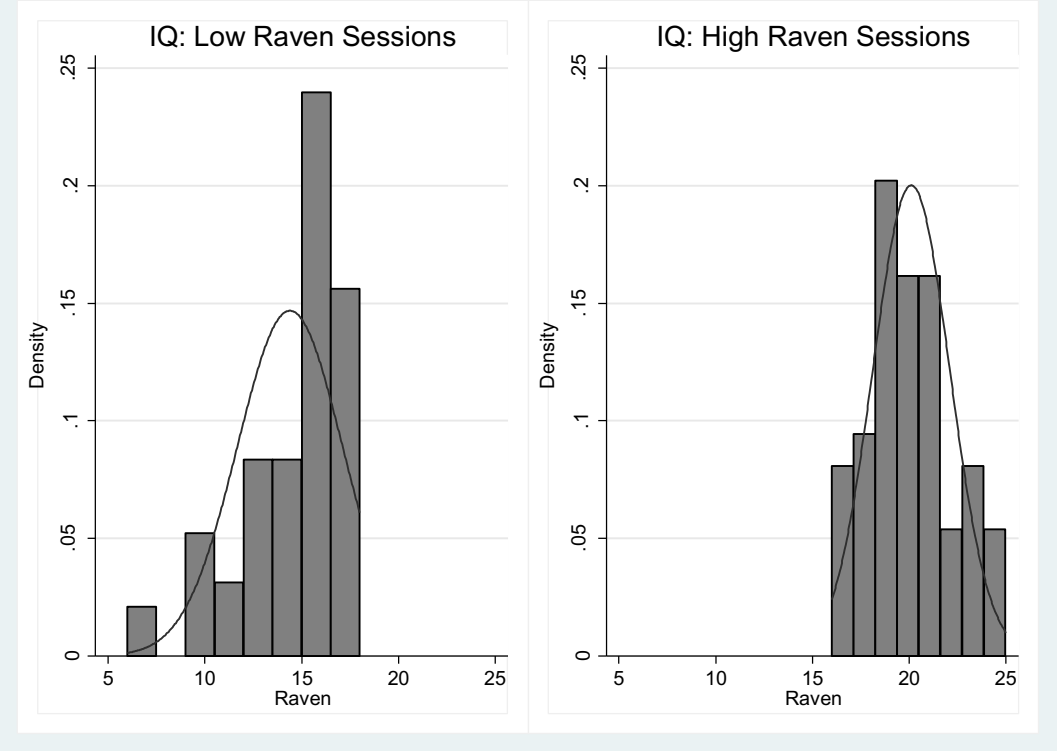
Our design

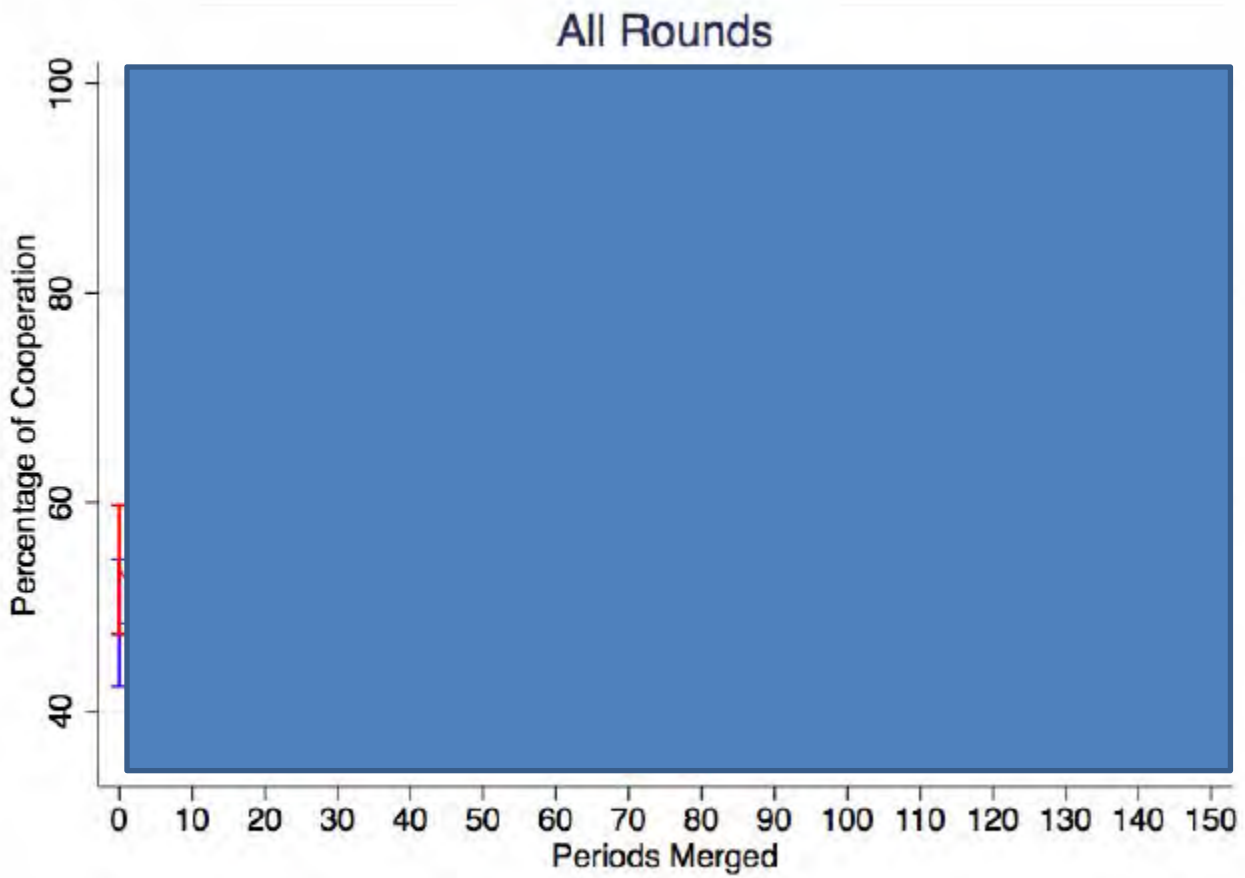
- Probability of continuation delta=.75
- Stage game:

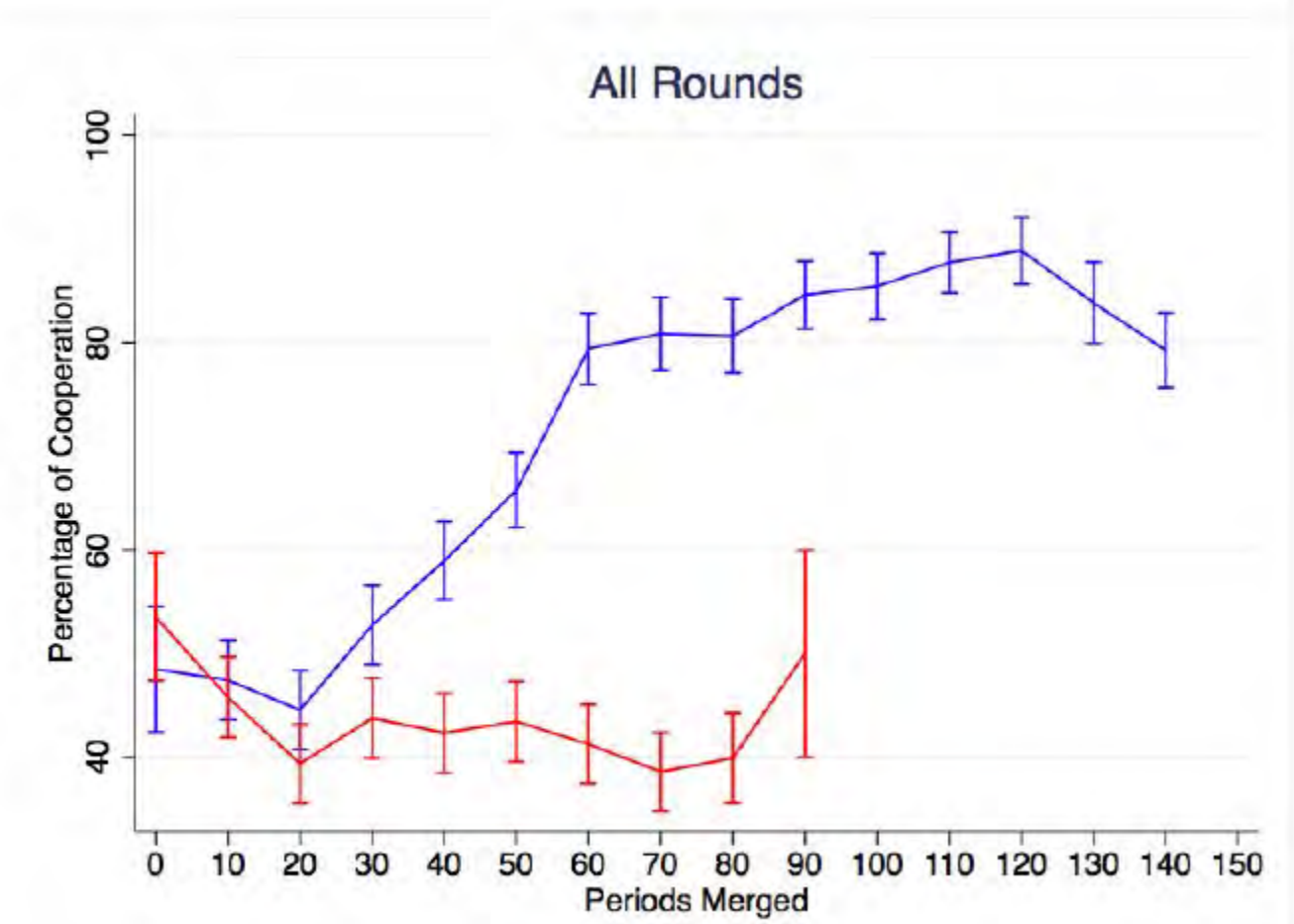
	C	D
C	48, 48	12, 50
D	50, 12	25, 25

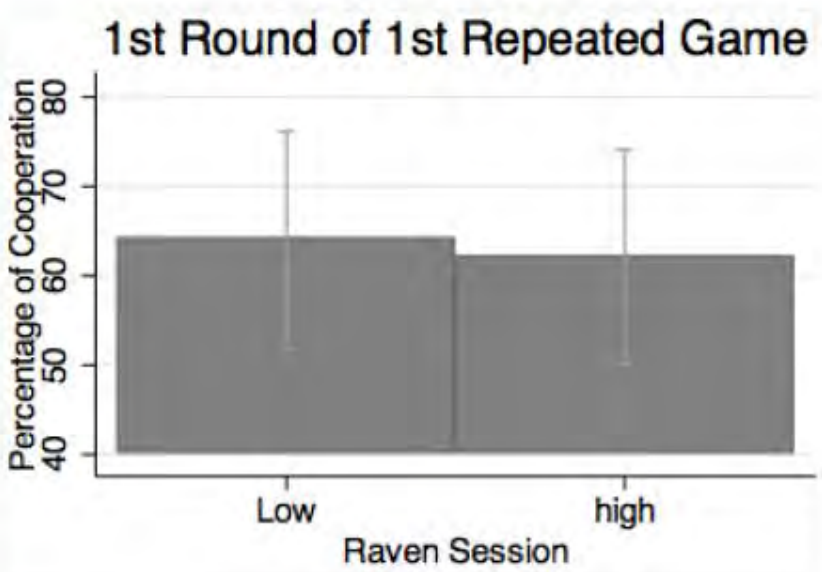
Experimental design

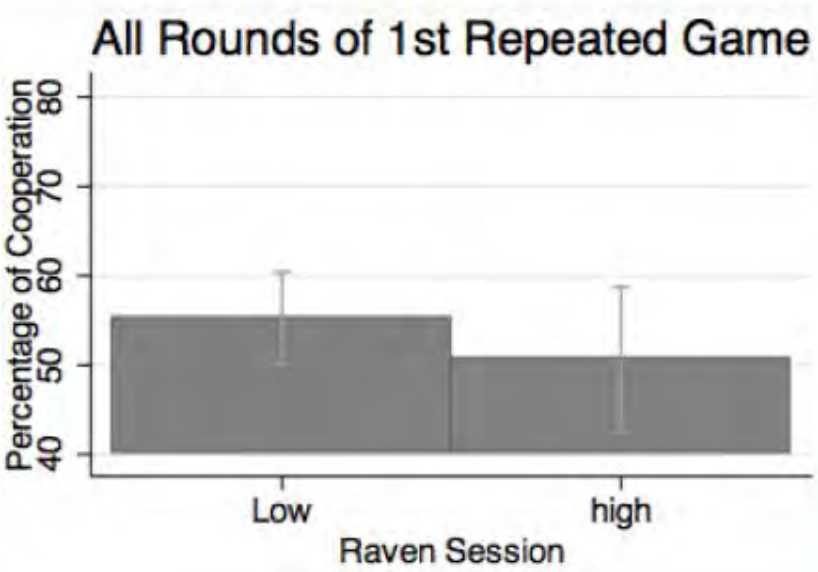
- **First day:** We tested subjects on many individual characteristics, including IQ (Raven AM);
- **Intermediate week:** We split subjects in two groups: low IQ (below sample median) and high IQ;
- **Second day:** Play the repeated game with random matching, in high and low IQ groups, separately, repeatedly;
- *We then analyze the cooperation rate in the high and low IQ groups…*

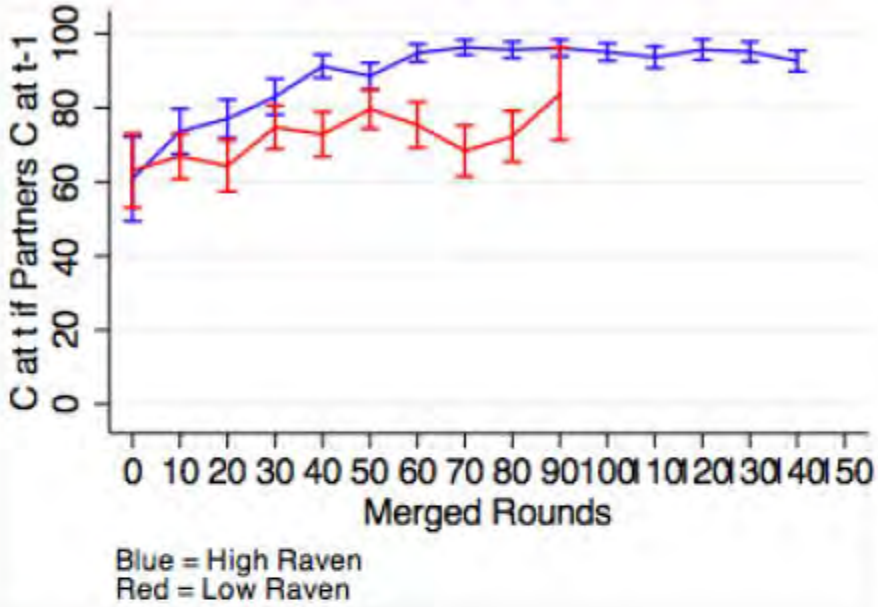

IQ: Low Raven Sessions
Density
0
.05
.1
.15
.2
.25
5
10
15
20
25
Raven
IQ: High Raven Sessions
Density
0
.05
.1
.15
.2
.25
5
10
15
20
25
Raven

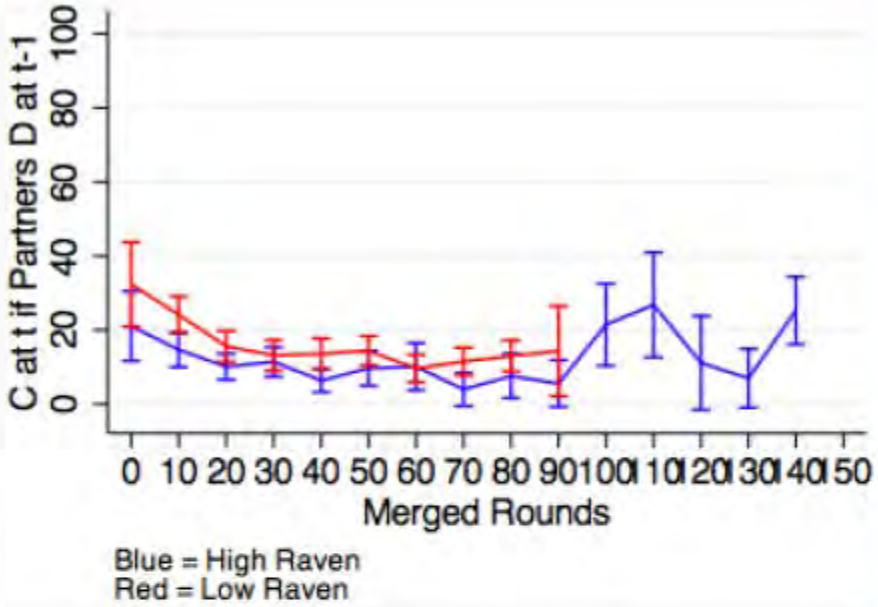

All Rounds
Percentage of Cooperation
100
80
60
40
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Periods Merged

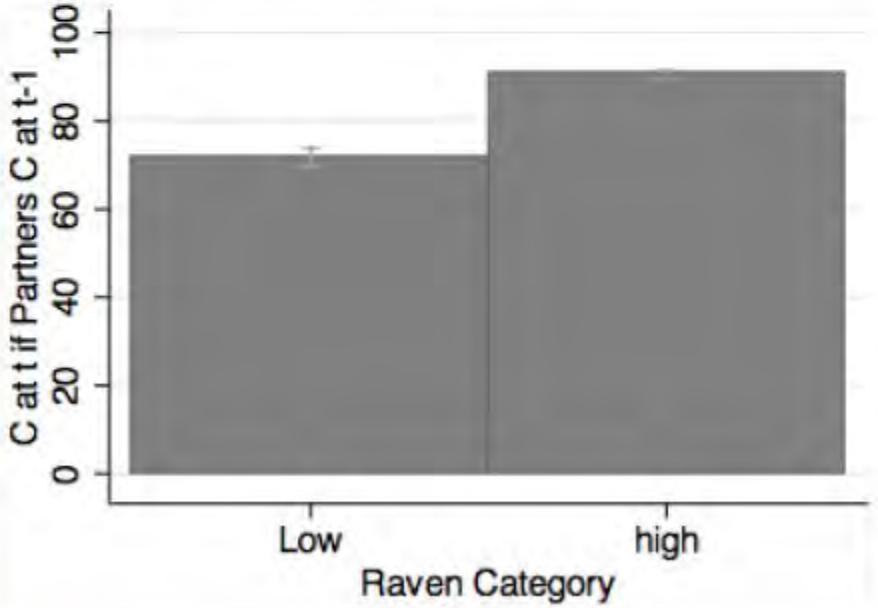

All Rounds
Percentage of Cooperation
40
60
80
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Periods Merged

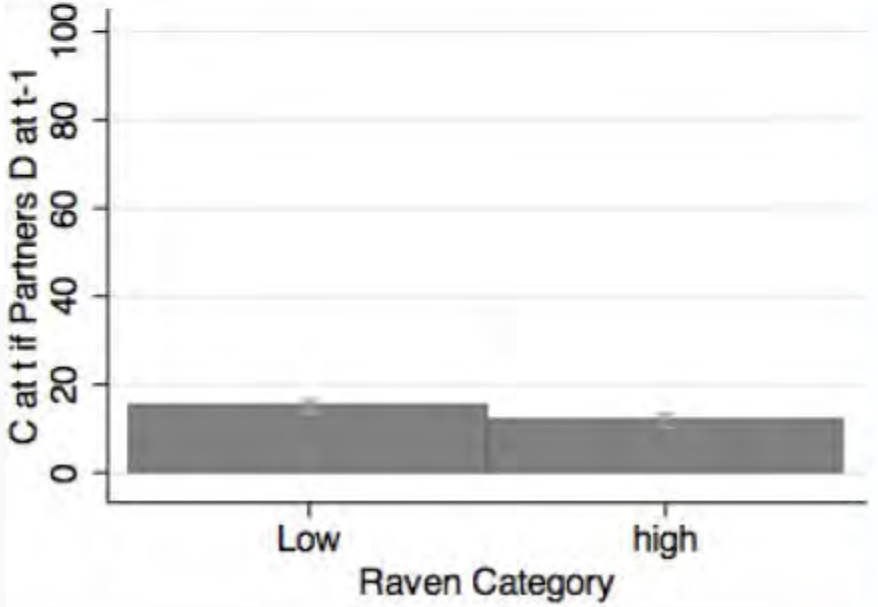

1st Round of 1st Repeated Game
Percentage of Cooperation
40
50
60
70
80
Low
high
Raven Session


All Rounds of 1st Repeated Game
Percentage of Cooperation
40
50
60
70
80
Low
high
Raven Session

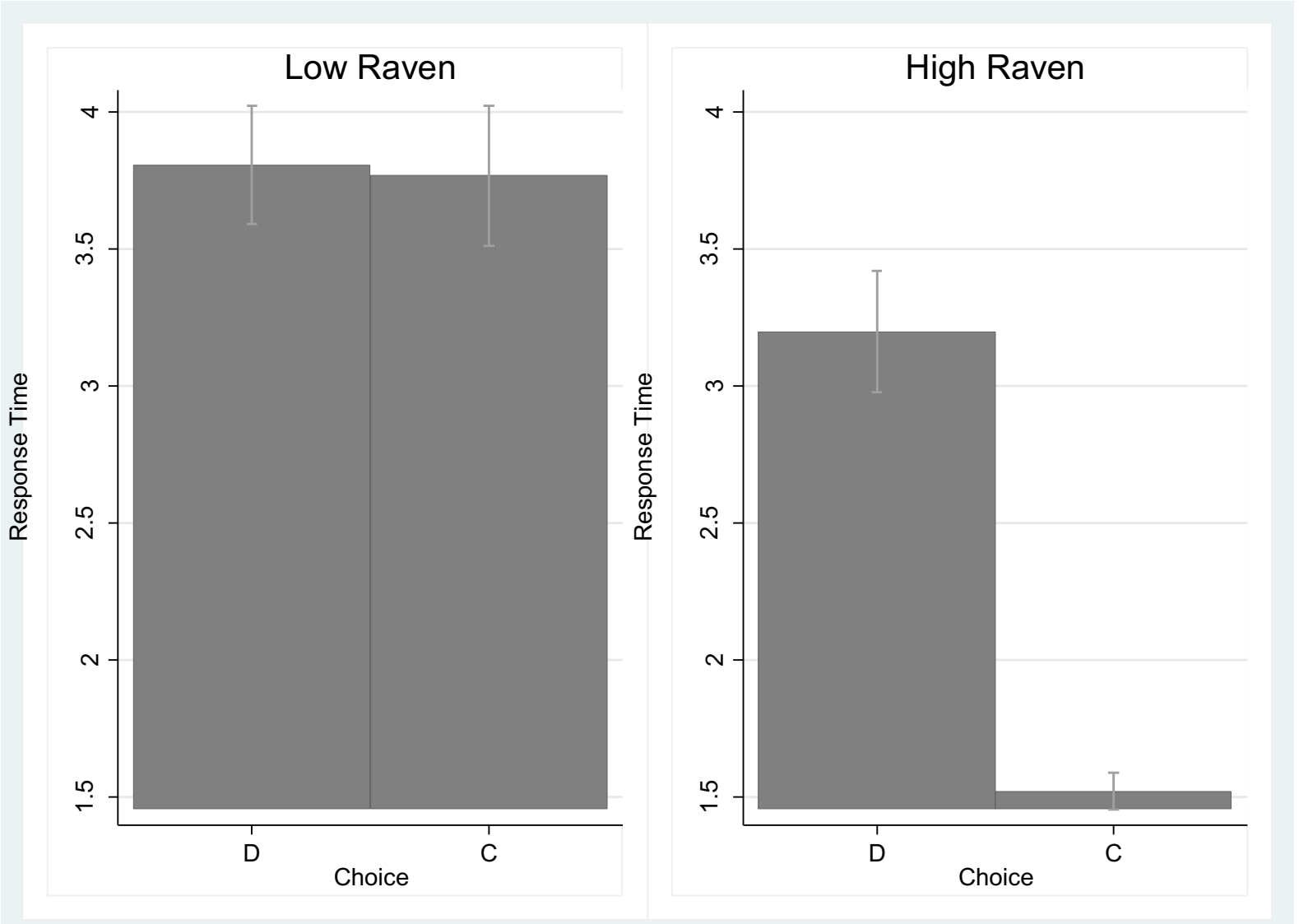

C at t if Partners C at t-1
0 20 40 60 80 100
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Merged Rounds
Blue = High Raven
Red = Low Raven


C at t if Partners D at t-1
0 20 40 60 80 100
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Merged Rounds
Blue = High Raven
Red = Low Raven


C at t if Partners C at t-1
0 20 40 60 80 100
Low
high
Raven Category


C at t if Partners D at t-1
0 20 40 60 80 100
Low
high
Raven Category

Time to decide

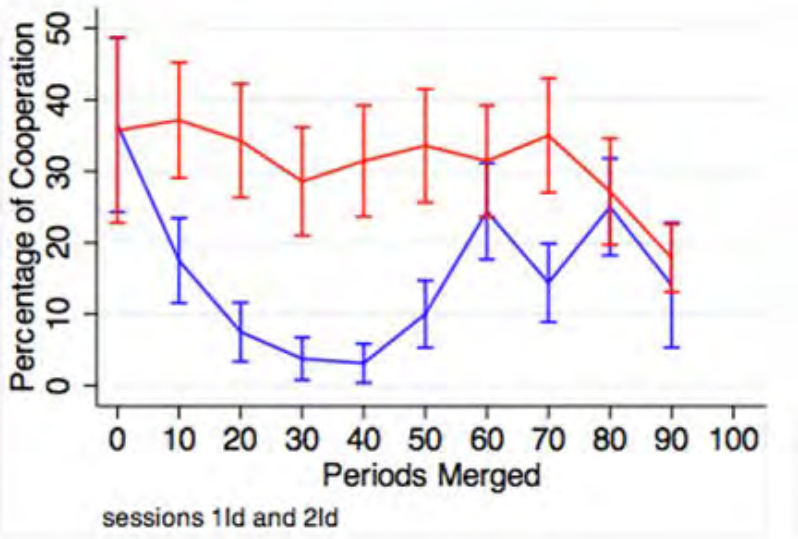


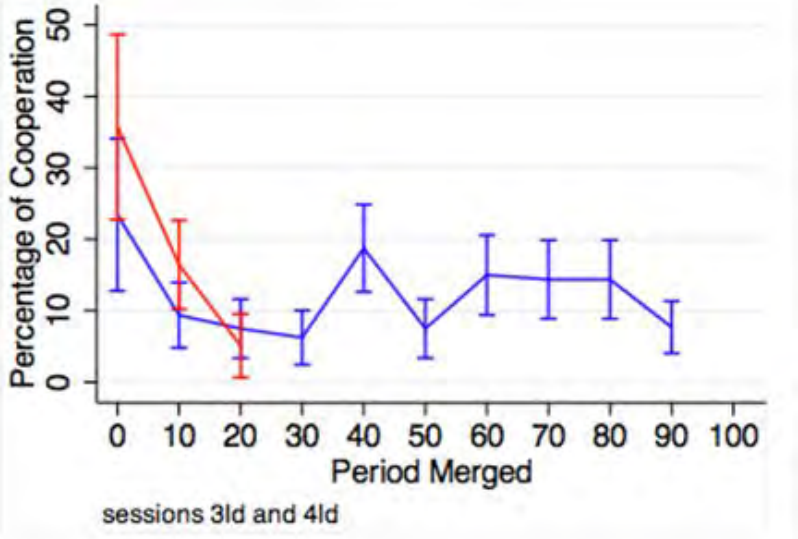
Summary statistics

Variable	Low Raven	High Raven	Differences	Std. Dev.	N
Age	22.35938	21.24242	1.116951	.7251282	130
Female	.625	.5	.125	.0870282	130
Openness	3.642188	3.595455	.0467329	.1016391	130
Conscientiousness	3.399306	3.405724	-.0064184	.1198434	130
Extraversion	3.349609	3.244318	.1052912	.1308186	130
Agreeableness	3.840278	3.765993	.0742845	.1060675	130
Neuroticism	2.910156	2.835227	.074929	.1361939	130
Raven	14.39063	20.10606	-5.715436***	.4170821	130
Risk Aversion	5.5625	5.5	.0625	.2865234	100
Final Profit	2774.297	4675.303	-1901.006***	258.9902	130
Periods	83.3125	116.4848	-33.17235***	5.039728 2	130
Profit × Period	33.26863	38.546693	-5.278058***	.8951038	130

HIGH IQ ARE NOT UNCONDITIONAL COOPERATORS

Same payoff, delta=0.5





How intelligence affects strategic choices

- In PD, at any cooperation equilibrium there is a tradeoff between current gain and continuation value loss
- This comparison is subtle: it involves the estimation of effect of the continuation probability, the forecast on the behavior after deviation, gain from current deviation and continuation value
- PD is also the only 2x2 game with this property

Prisoner's Dilemma

	C	D
C	48, 48	12, 50
D	50, 12	25, 25

Battle of Sexes

	A	B
A	0, 0	12, 50
B	50, 12	0, 0

Stag Hunt

	S	H
S	48, 48	0, 25
H	25, 0	25, 25

HOW IS INTELLIGENCE AFFECTING SOCIAL AND ECONOMIC BEHAVIOR?

INTELLIGENCE MODULATES REWARD PROCESSING

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Intelligence moderates neural responses to monetary reward and punishment

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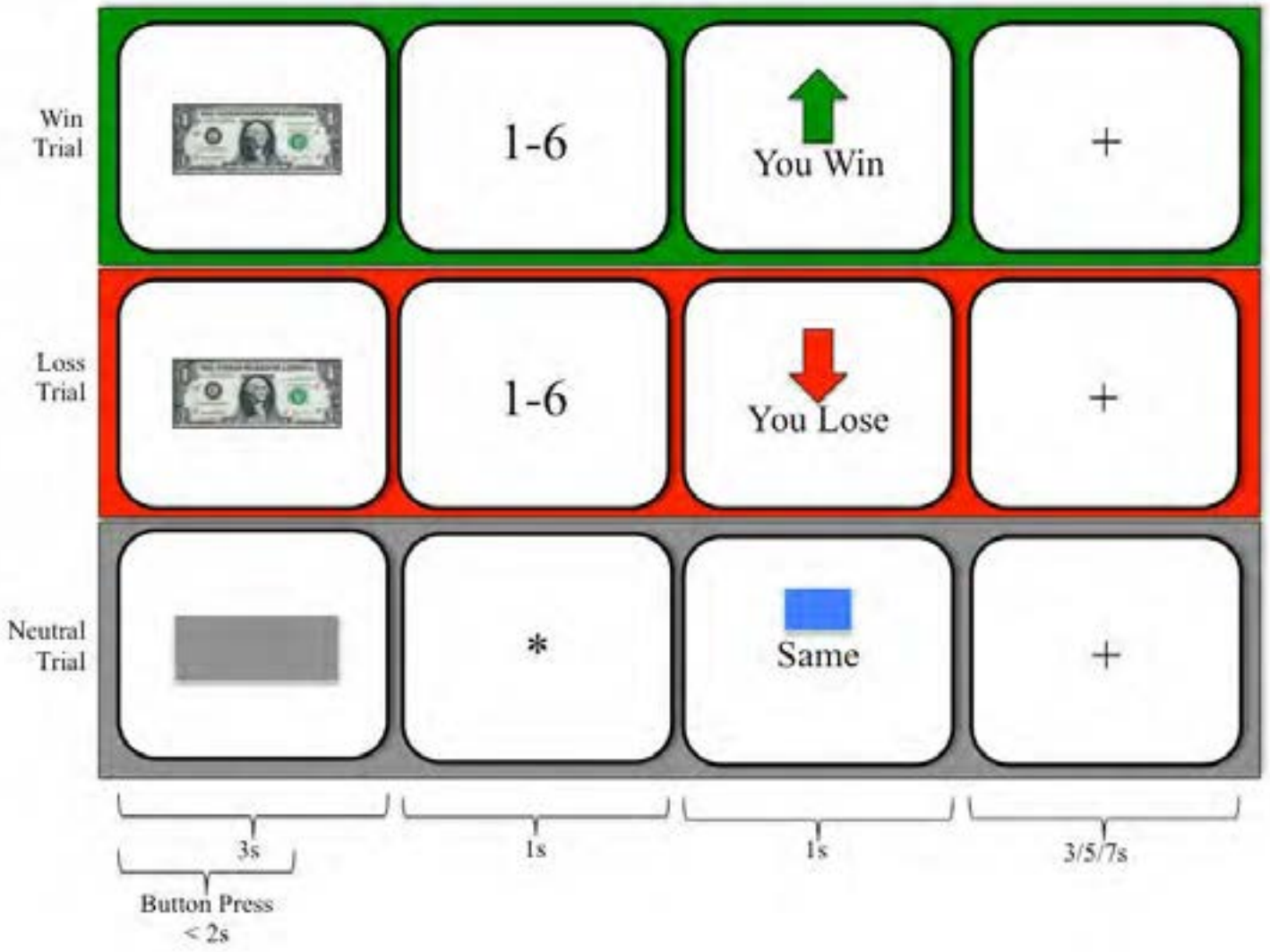
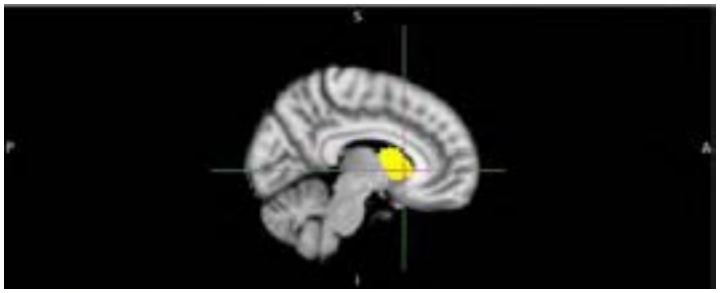
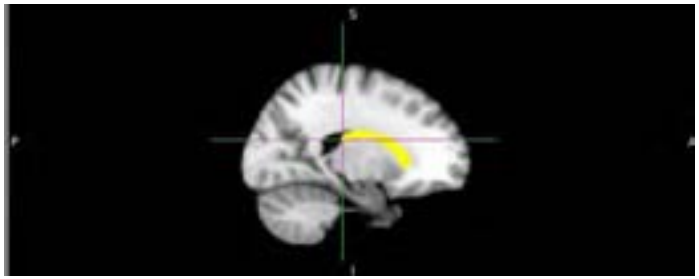
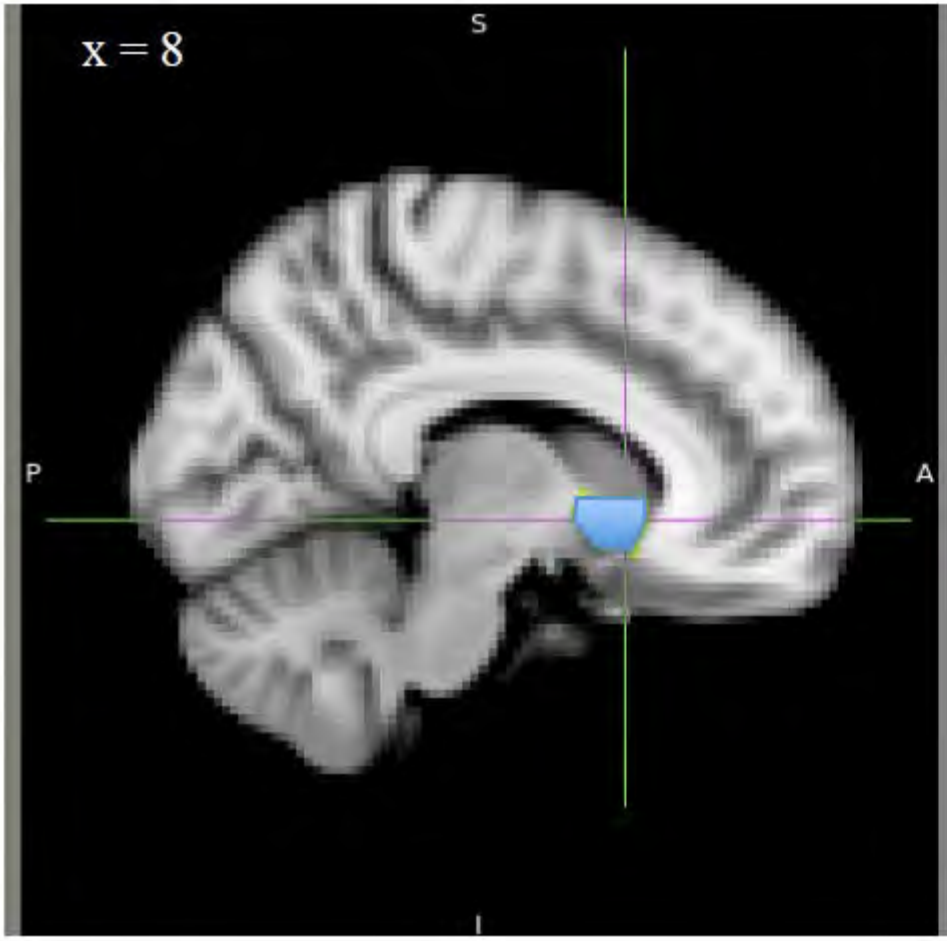
Submitted 31 May 2013; accepted in final form 6 February 2014

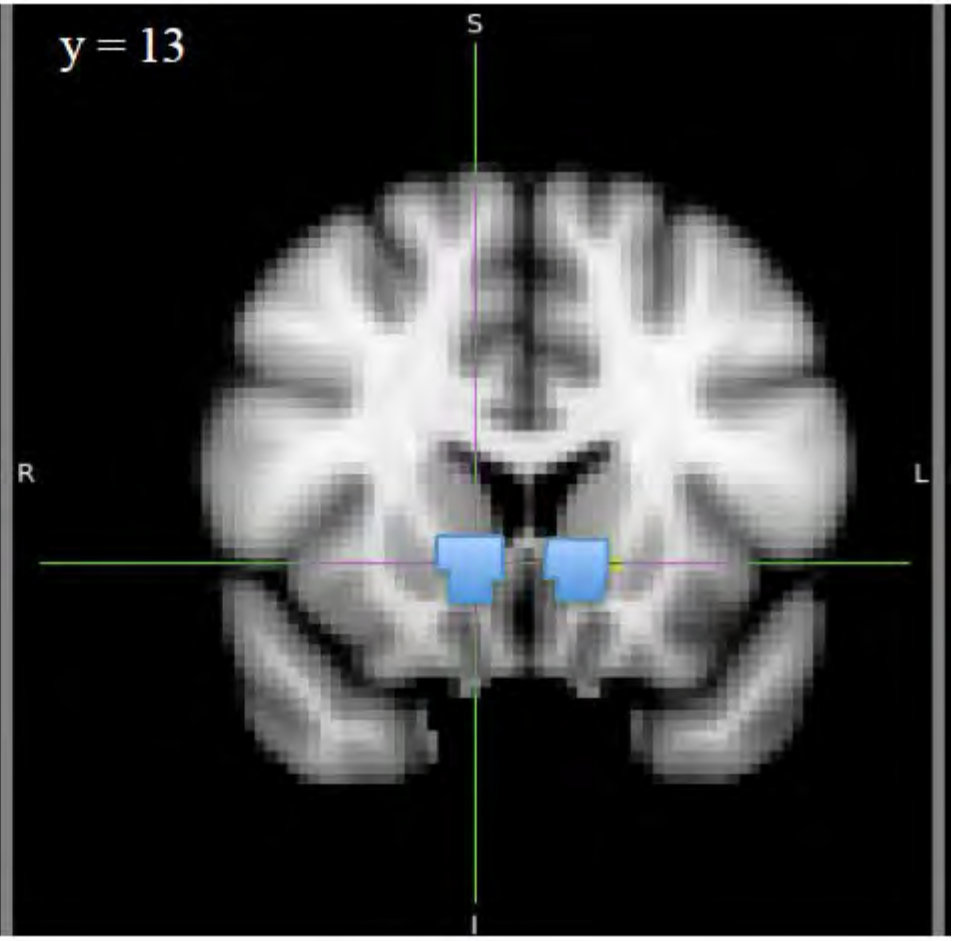
Experimental Design

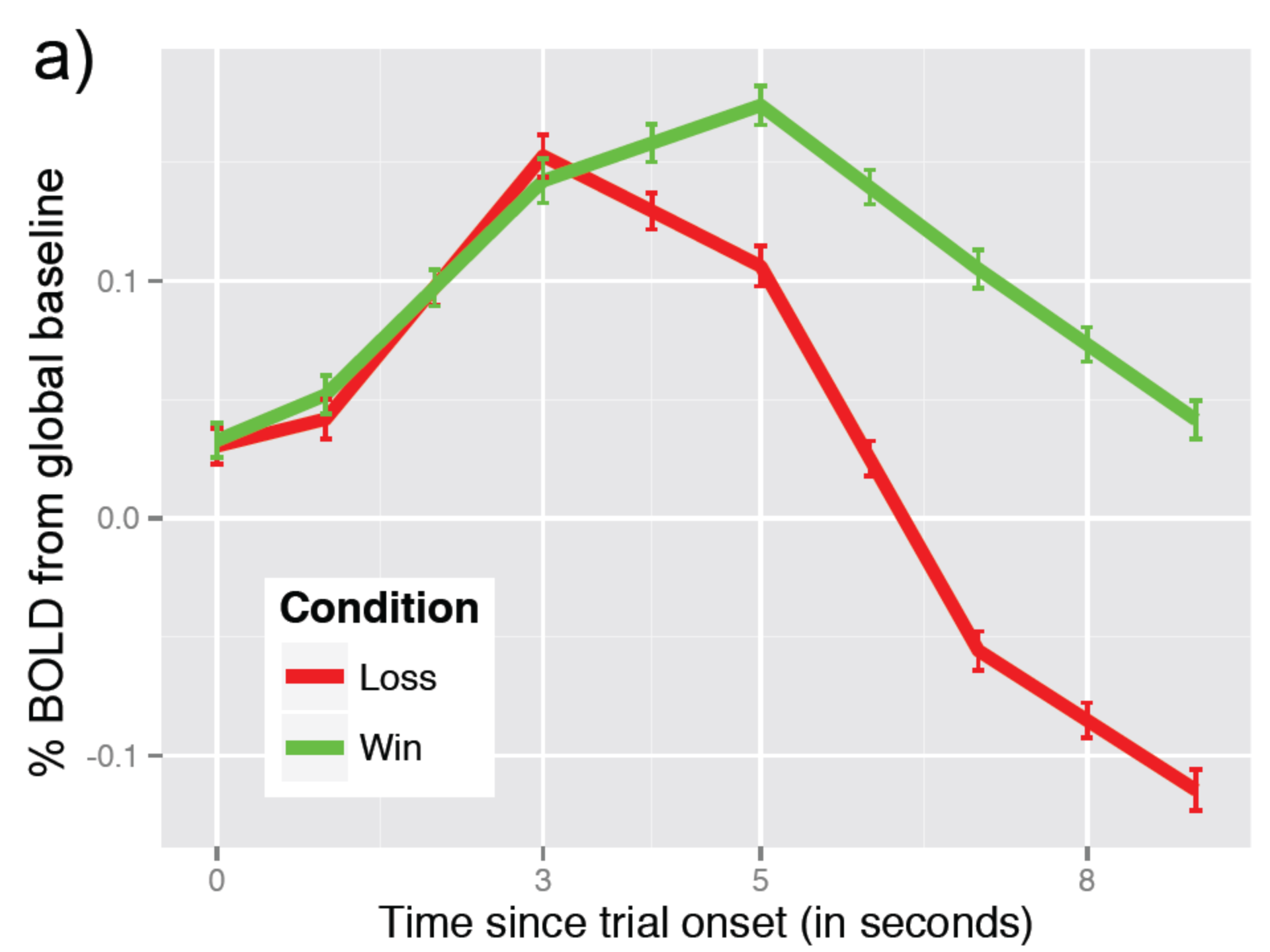


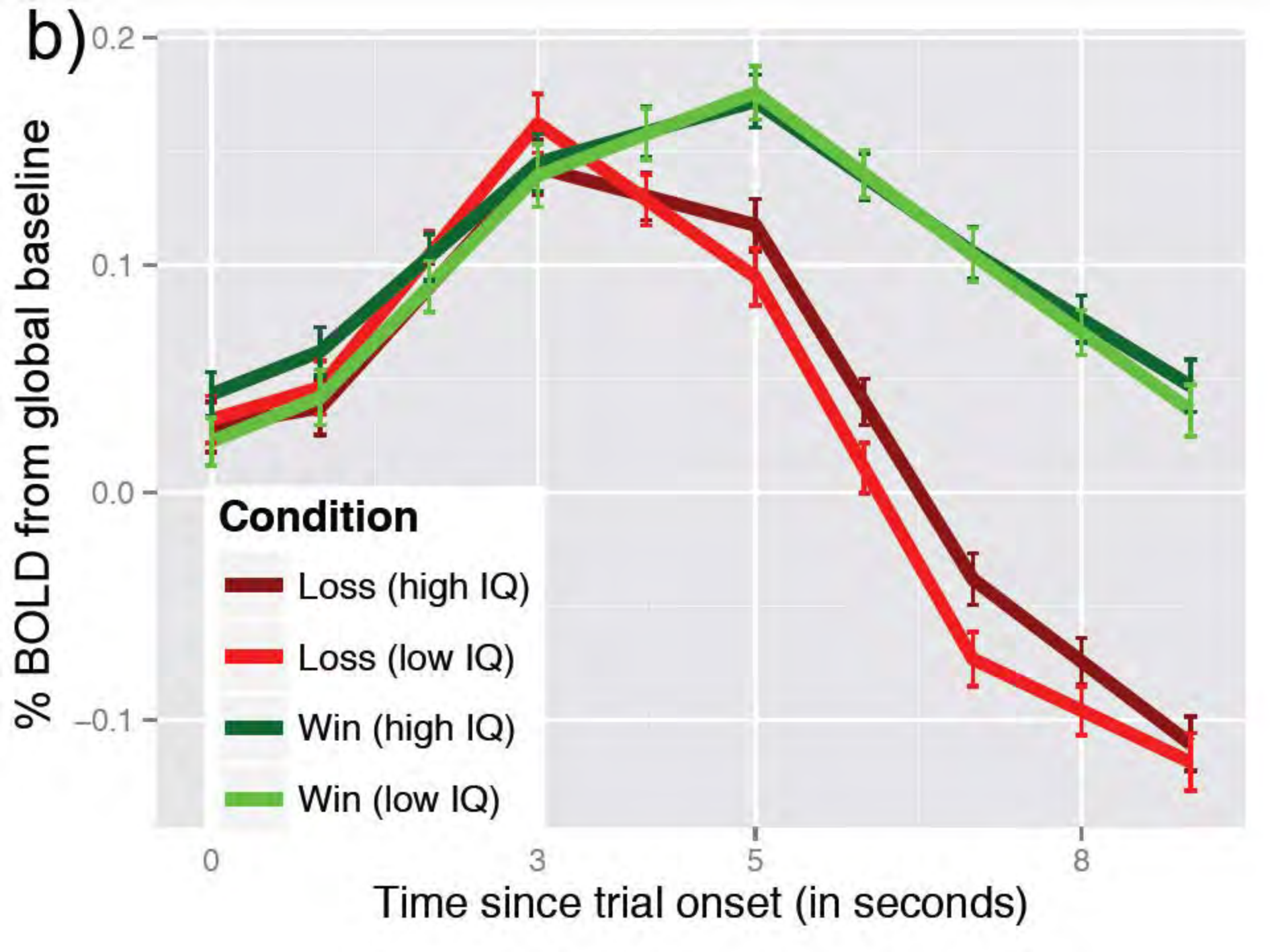




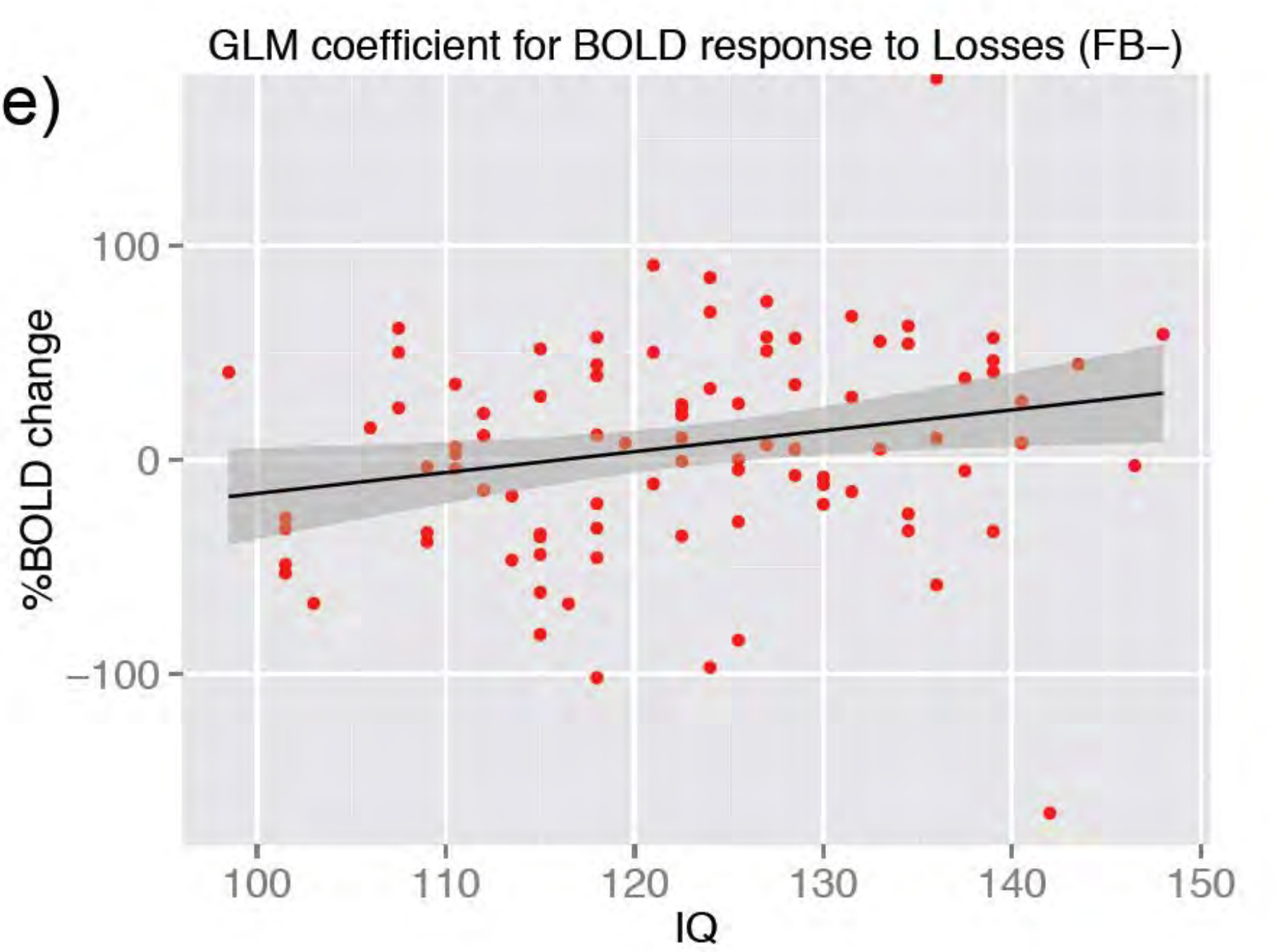

x = 8
S
P
A
I


y = 13
S
R
L
I


a)
% BOLD from global baseline
0.1
0.0
-0.1
Condition
Loss
Win
0
3
5
8
Time since trial onset (in seconds)


b)
0.2
0.1
0.0
−0.1
% BOLD from global baseline
Condition
Loss (high IQ)
Loss (low IQ)
Win (high IQ)
Win (low IQ)
0
3
5
8
Time since trial onset (in seconds)

e)


GLM coefficient for BOLD response to Losses (FB−)
%BOLD change
100
0
−100
100
110
120
130
140
150
IQ

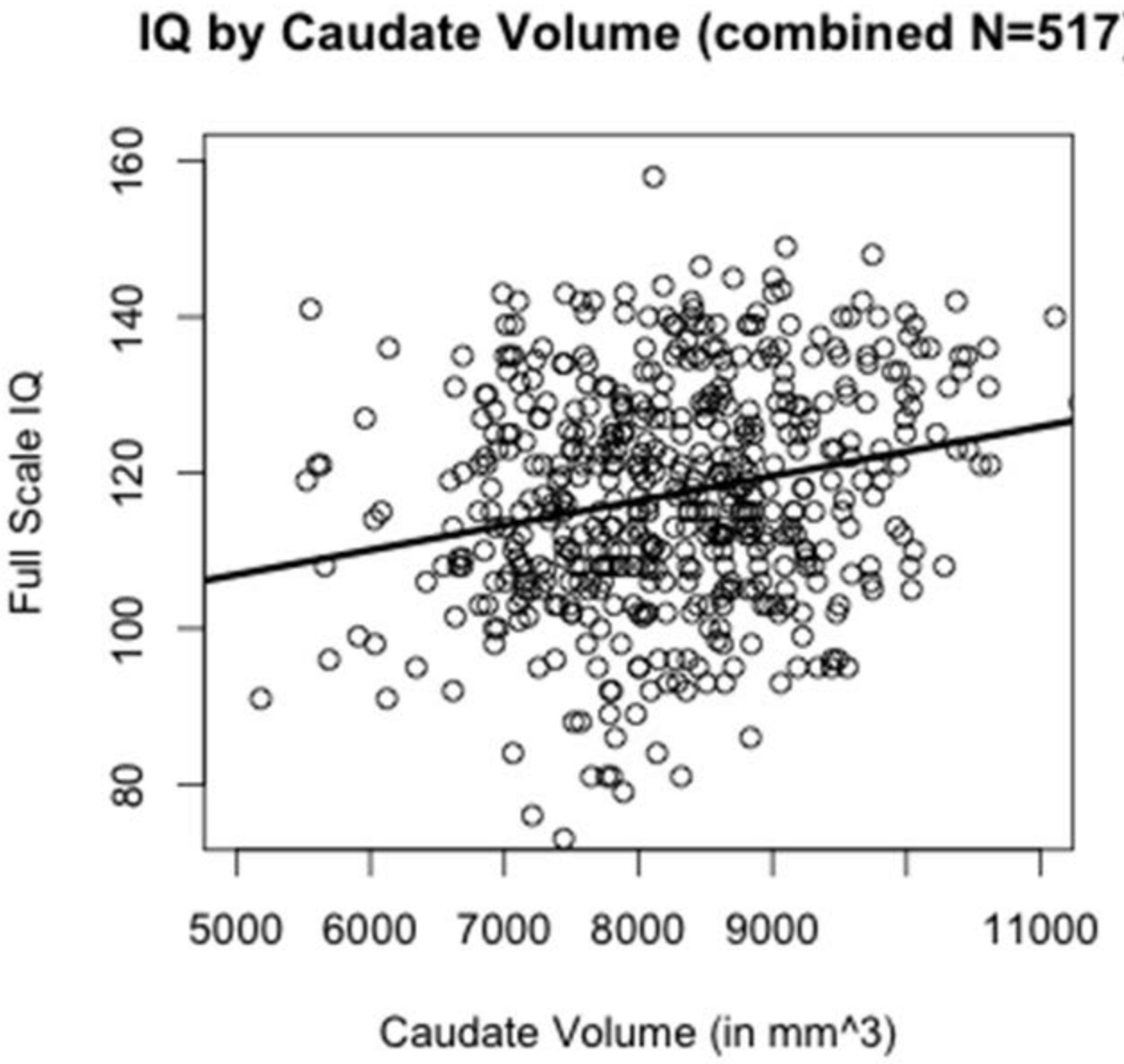
CAUDATE IS ALSO SPECIFICALLY ACTIVATED IN A SEQUENTIAL CHOICE TASK, AT THE FIRST OFFER

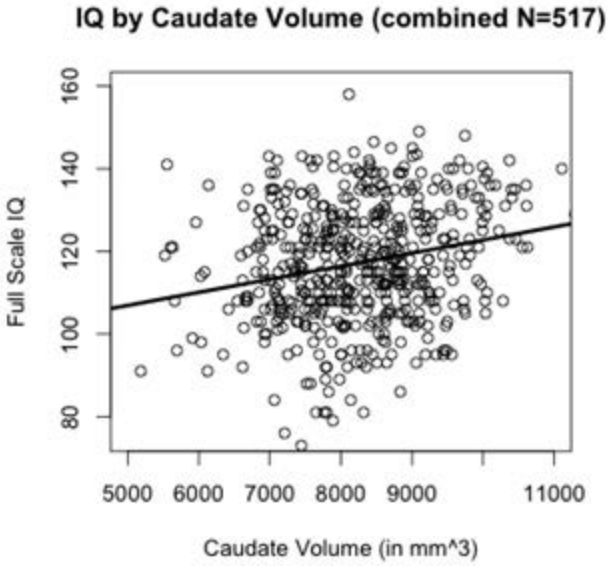
Panel of BOLD, Cluster: Anterior caudate, right

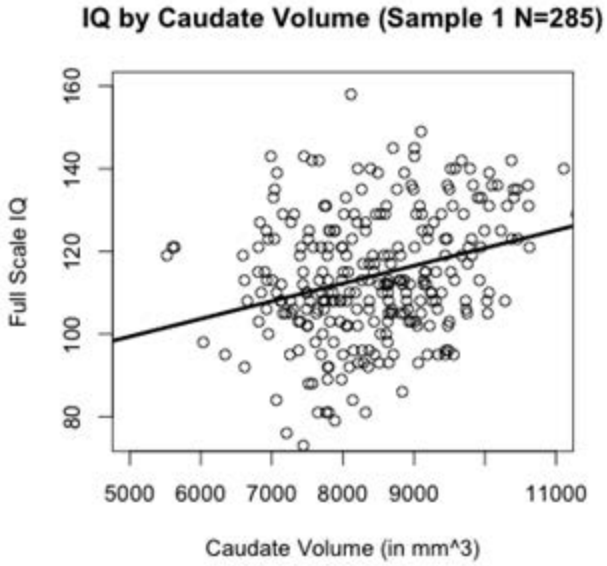
	Mean	Mean	SVO1	SVO1	SVO2	SVO2
	b/p	b/p	b/p	b/p	b/p	b/p
SV of first offer	7.680**	63.330***	75.469***	152.018***	23.899***	118.210***
	(0.028)	(0.003)	(0.000)	(0.000)	(0.000)	(0.001)
First After offer	–2.574	–2.708	–32.184***	–32.522***	–20.979***	–21.199***
	(0.195)	(0.177)	(0.000)	(0.000)	(0.000)	(0.000)
SV of second offer	–6.946*	6.729	9.576	38.566	58.408***	67.765*
	(0.058)	(0.755)	(0.121)	(0.288)	(0.000)	(0.064)
Second After offer	–9.596***	–9.743***	–12.956***	–13.011***	–39.796***	–39.796***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Choice	12.370***	12.325***	5.424	5.095	23.235***	22.947***
	(0.007)	(0.007)	(0.480)	(0.510)	(0.003)	(0.003)
SV of first offer × IQ		–0.481***		–0.661**		–0.815***
		(0.008)		(0.032)		(0.009)
SV of second offer × IQ		–0.119		–0.254		–0.084
		(0.517)		(0.413)		(0.788)
IQ		–3.816**		–16.706***		–10.993***
		(0.022)		(0.000)		(0.009)
Constant	9740.573***	10806.174***	10028.999***	12519.859***	10054.124***	12140.285***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	33585	33226	33585	33226	33585	33226

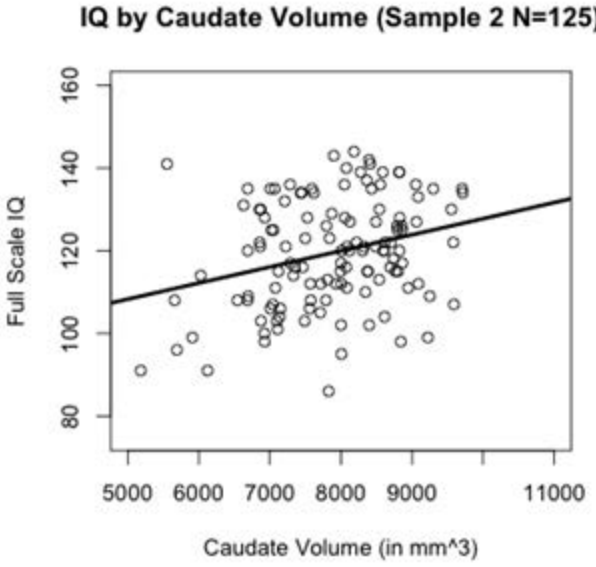
INTELLIGENCE AND CAUDATE VOLUME

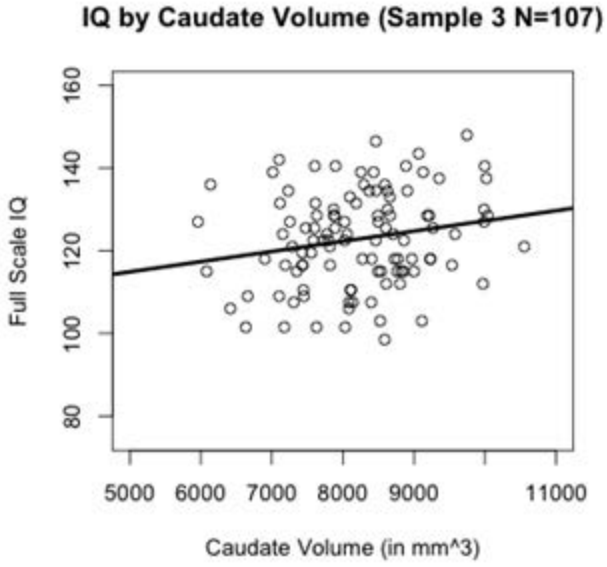
result from 3 MRI studies combined


IQ by Caudate Volume (combined N=517)
Full Scale IQ
80
100
120
140
160
5000
6000
7000
8000
9000
11000
Caudate Volume (in mm^3)


IQ by Caudate Volume (combined N=517)
Full Scale IQ
80
100
120
140
160
5000
6000
7000
8000
9000
11000
Caudate Volume (in mm^3)

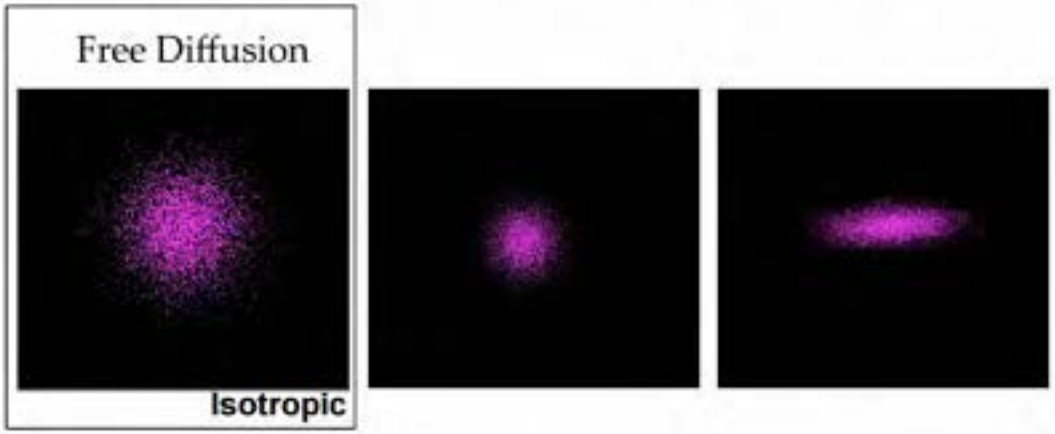

IQ by Caudate Volume (Sample 1 N=285)
Full Scale IQ
80
100
120
140
160
5000
6000
7000
8000
9000
11000
Caudate Volume (in mm^3)

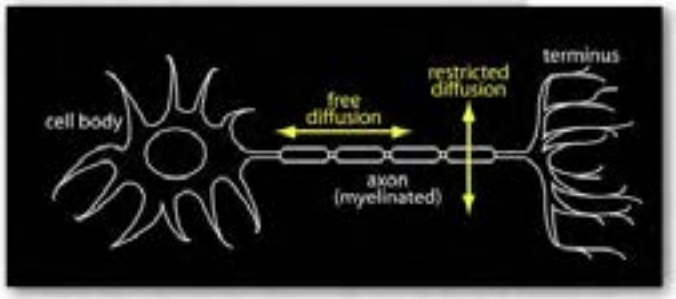

IQ by Caudate Volume (Sample 2 N=125)
Full Scale IQ
80
100
120
140
160
5000
6000
7000
8000
9000
11000
Caudate Volume (in mm^3)


IQ by Caudate Volume (Sample 3 N=107)
Full Scale IQ
80
100
120
140
160
5000
6000
7000
8000
9000
11000
Caudate Volume (in mm^3)

Diffusion Tensor Imaging (DTI)

Water Diffusion in the Brain. Why is it Interesting?

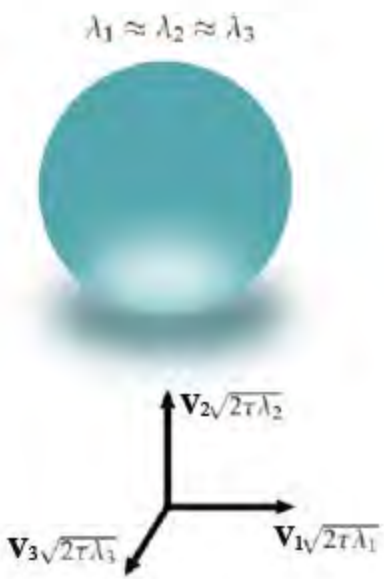




Diffusion is restricted by tissue boundaries, membranes, etc.
Marker for tissue microstructure (healthy and pathology)
Diffusion is **anisotropic** in white matter [Beaulieu, NMR Biomed, 2002]

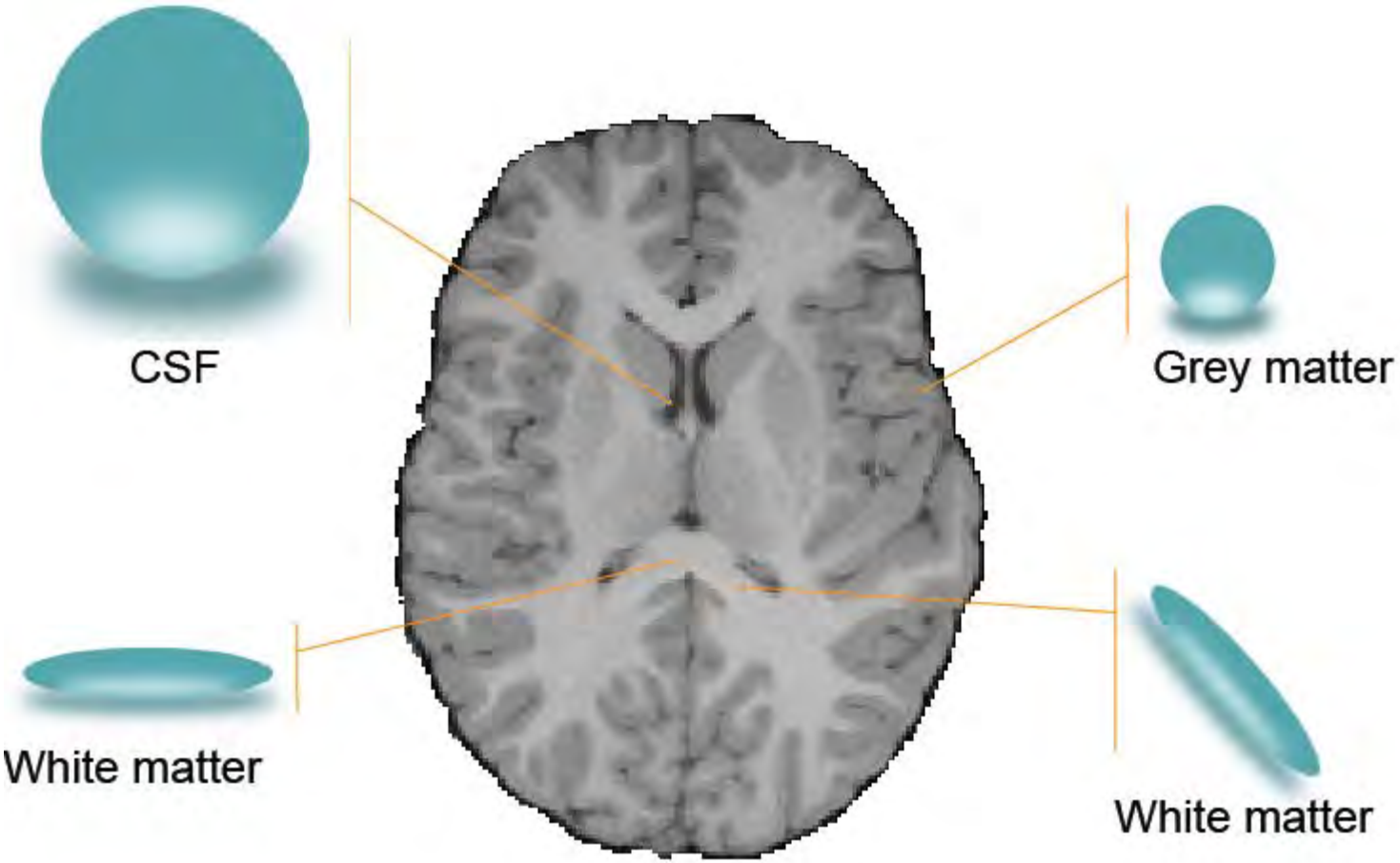
The Diffusion Tensor Ellipsoid

Isotropic voxel

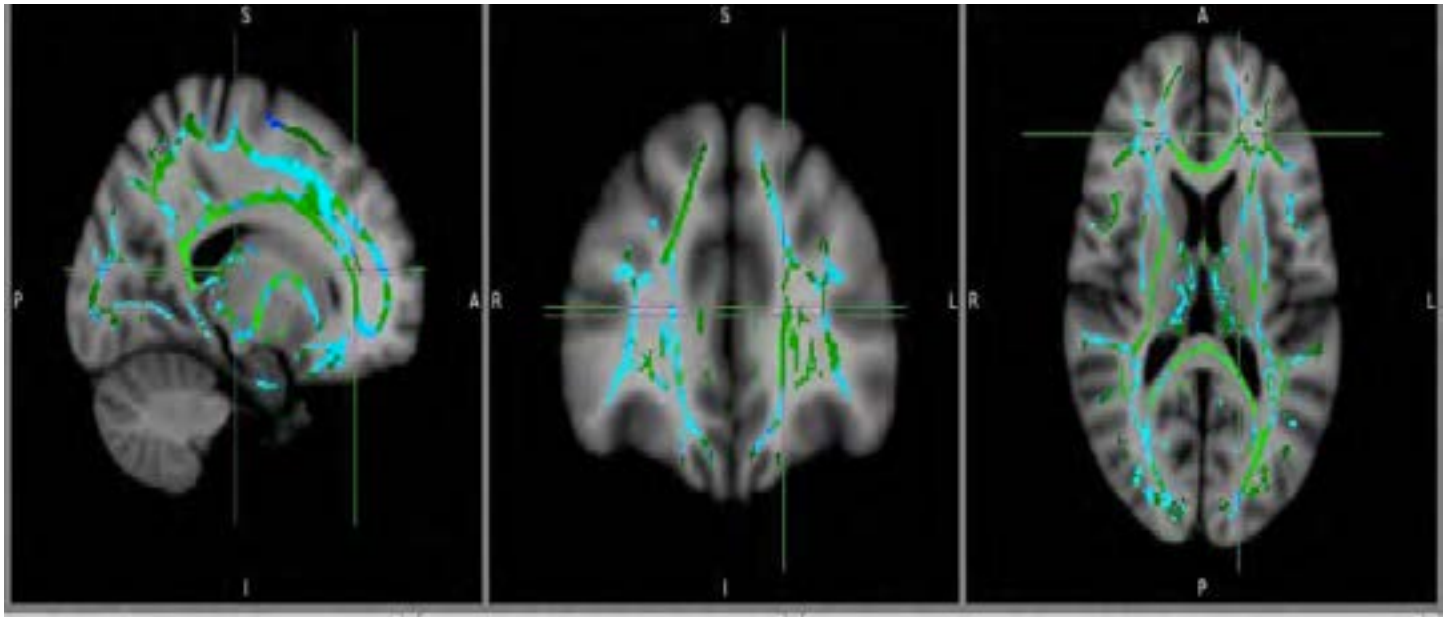


Anisotropic voxel

The Diffusion Tensor Ellipsoid



Regions displaying positive association IQ and Fractional Anisotropy (FA)



Conclusions

- Measurement of personality traits based on choice and neural analysis is more effective than measurement based on survey
- Intelligence has a complex role in strategic behavior:

1. In strictly competitive games higher intelligence brings closer to behavior predicted by game theory
2. In game where efficiency gains are possible, intelligence makes these gains more likely

THANKS