Emotions in a repeated Cournot game

A psychophysiological experiment

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July 14, 2014

Why study emotions in OR?

- To understand behavior in decision and negotiation support
- Are some processes or models emotionally better/worse; or more acceptable/stimulating than others?
- To understand the impact of different ways of communication
- Take into account the role of emotions in developing modeling and decision support approaches

Do emotions play a role in cooperation?

- It is known that subjects cooperate in repeated interactions; two explanations:
  - Reputation seeking: entirely **self-regarding**
  - Reciprocal fairness: **other-regarding** (Sobel, 2005, Bowles and Gintis, 2011)
- Standard methods in experimental economics cannot distinguish other-regarding behavior from self-regarding behavior in repeated interactions (Fehr, 2009)

Measuring emotions can reveal whether cooperation is other-regarding or self-regarding

Emotions

- Changes in **bodily states**, triggered by the brain
- Responses to *actual* or *recalled* perceptions
- Operate alongside cognition
- Not necessarily observable from outside

- Can be studied by
  - Neurophysiology (brain imaging)
  - Self-reports
  - Psychophysiological methods

Arousal

- A bodily response that prepares the subject to act (Bechara and Damasio, 2005)
- Activation of the *autonomic nervous system* leading to a **condition of sensory alertness, mobility and readiness to respond**
- Arousal occurs when a subject *experiences* as well as *anticipates* situations

We measure by the **skin conductance response** (SCR)

Emotional expressions

- Have both functional and communication roles
- Can accompany both *real* and *abstract* stimuli

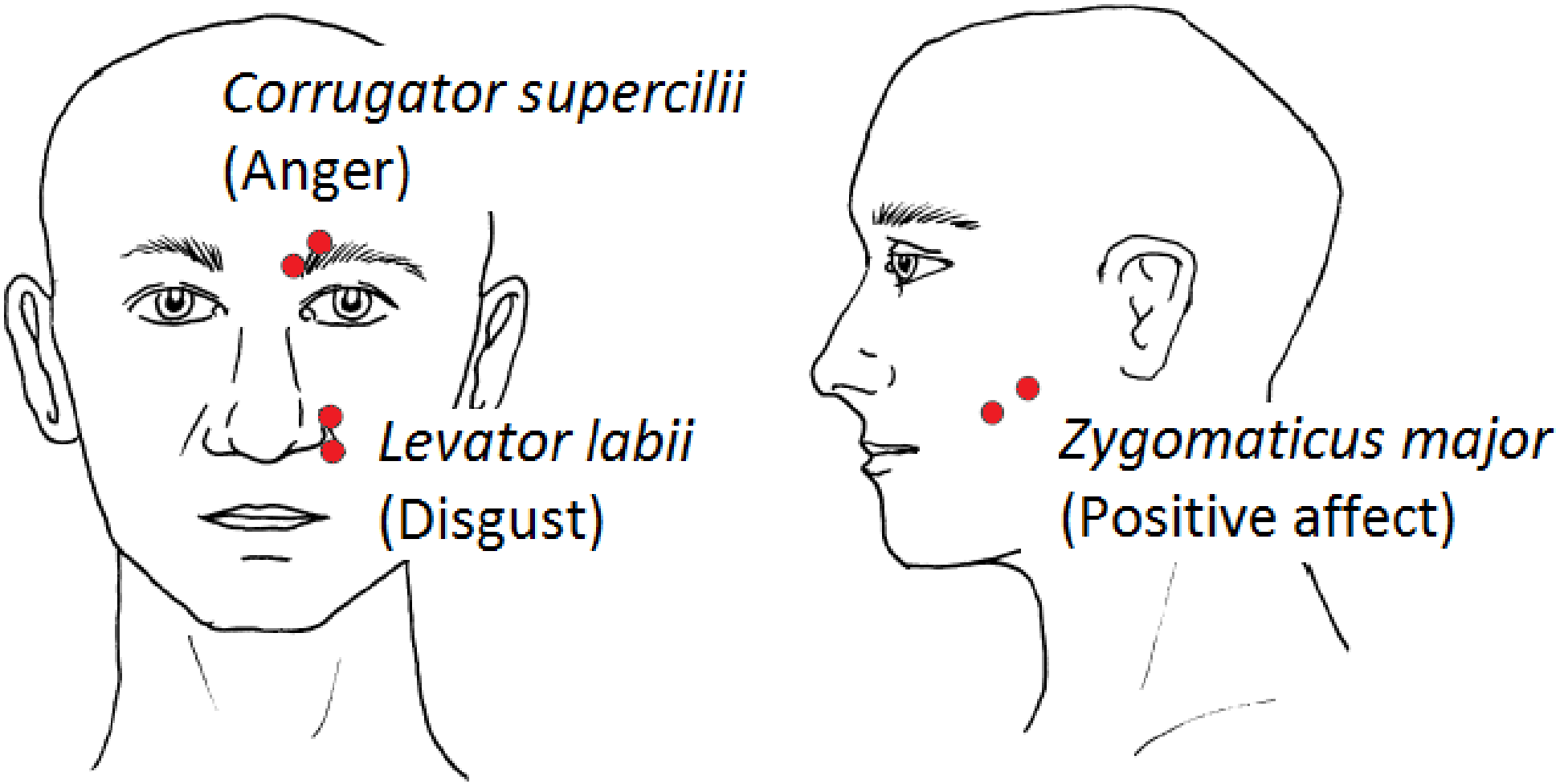
We measure by facial surface **electromyography** (EMG)

Anger

Disgust

Positive affect

Muscles related to emotional expressions



Earlier research on emotions in games

- Ultimatum games:
  - Chapman et al. (2009): the responder's **disgust is higher for unfair offers than for fair offers**
- Public goods games:
  - Joffily et al. (2011): **arousal is higher when the subject does not cooperate** and when the subject learns that he has cooperated less than others
- Other:
  - Ben-Shakhar et al. (2007): **arousal is related to punishments** in a power-to-take game
  - Cannon et al. (2011): **anger, disgust, and positive affect predict moral judgements**

Our experiment: repeated Cournot game

”*Example of human conflict between cooperation and defection*” (Fouraker and Siegel, 1963)

- Step 1: indicate your ideal result
- Step 2: choose your production quantity
- Step 3: view results
- Repeated for 20 rounds, duration not known by the players

Payoff matrix

Payoff increases as the other's production quantity decreases, and vice versa

Production quantity	3	4	5	6	7	8	9	10	11	12	13	14	15
3	54 54	51 68	48 80	45 90	42 98	39 104	36 108	33 109	30 110	27 108	24 104	21 98	18 90
4	68 51	64 64	60 75	56 84	52 91	48 96	44 99	40 100	36 99	32 96	28 91	24 84	19 75
5	80 48	75 60	70 70	65 78	60 84	55 88	50 89	45 90	40 88	35 84	29 78	25 70	20 60
6	90 45	84 56	78 65	72 **J** 72	66 77	60 80	54 81	48 80	41 77	36 72	30 65	24 56	18 45
7	98 42	91 52	84 60	77 66	70 70	63 72	55 71	49 70	42 66	35 60	28 52	21 42	14 30
8	104 39	96 48	88 55	80 60	72 63	64 **N** 64	56 63	48 60	40 55	32 48	24 39	16 28	8 15
9	108 36	99 44	89 50	81 54	71 55	63 56	54 54	45 50	36 44	27 36	18 26	9 14	0 0
10	109 33	100 40	90 45	80 48	70 49	60 48	50 45	40 40	30 33	20 24	10 13	0 0	-10 -15
11	110 30	99 36	88 40	77 41	66 42	55 40	44 36	33 30	22 22	11 12	0 0	-11 -14	-22 -30
12	108 27	96 32	84 35	72 36	60 35	48 32	36 27	24 20	12 11	0 0	-12 -13	-24 -28	-36 -45
13	104 24	91 28	78 29	65 30	52 28	39 24	26 18	13 10	0 0	-13 -12	-26 -26	-39 -42	-52 -60
14	98 21	84 24	70 25	56 24	42 21	28 16	14 9	0 0	-14 -11	-28 -24	-42 -39	-56 -56	-70 -75
15	90 18	75 19	60 20	45 18	30 14	15 8	0 0	-15 -10	-30 -22	-45 -36	-60 -52	-75 -70	-90 -90

J = joint-optimum (72,72), **N** = Cournot-Nash equilibrium (64,64)

Experimental arrangement

Pilot subject demonstrating the equipment

- 44 subjects (24 female)
- Mean age 26.05
- One pair at a time
- Complete anonymity
- Mean reward 22.26 eur

Scoring and analysis of the signals

- **Arousal**: integrated SCR (Benedek and Kaernbach, 2010) over a 5 s time window when the subject sees the results
- **Anticipatory arousal**: sum of SCR amplitudes over a varying-length time window during decision making, divided by the length of the time window
- **Anger**, **disgust**, **positive affect**: mean EMG amplitude over a 5 s time window when the subject sees the results

Explanatory variables

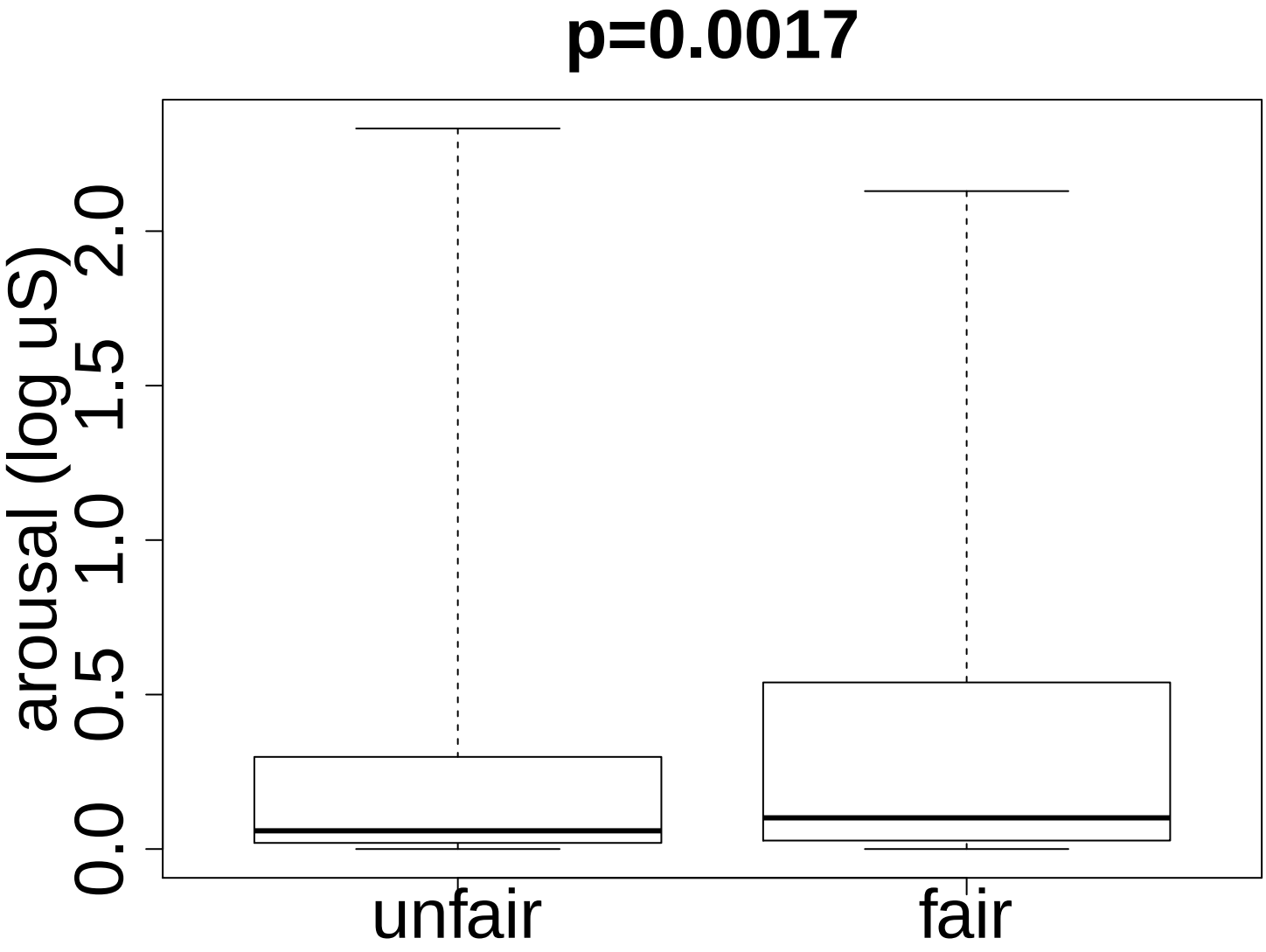
- **Fair result**: own payoff at least as high as the other's payoff
- **Payoff share**: own payoff divided by the sum of own and the other's payoff
- **Own ideal payoff difference**: own payoff minus own ideal payoff
- **Other's ideal payoff difference**: the other's payoff minus ideal payoff to the other
- **Own choice**: if high, the subject is not cooperative
- **Other's previous round choice**: if high, the other is not cooperative
- **Gender**
- **Round of play**

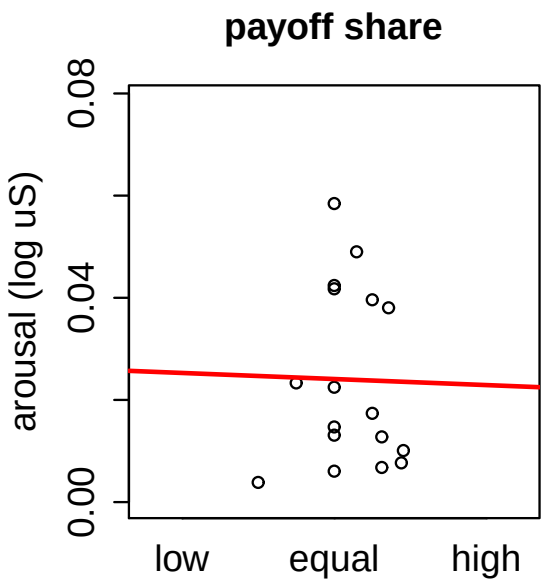
Cournot game: not much cooperation

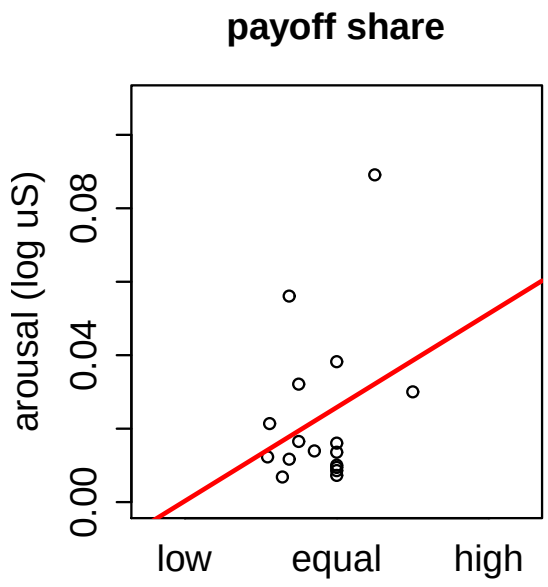
Only two pairs out of 22 cooperate for more than two consecutive rounds

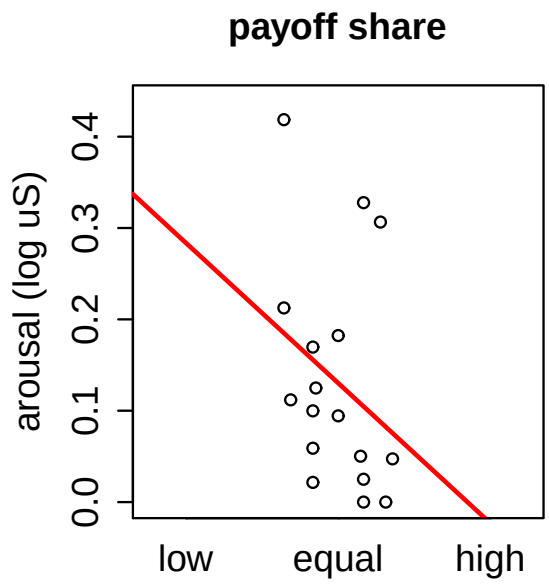
- Mean payoff 55.24, lower than the Cournot equilibrium payoff (64)
- Less cooperation than in similar Cournot duopoly experiments of Huck et al. (2001) and Potters and Suetens (2013)
- Possibly explained by complete anonymity in the experiment

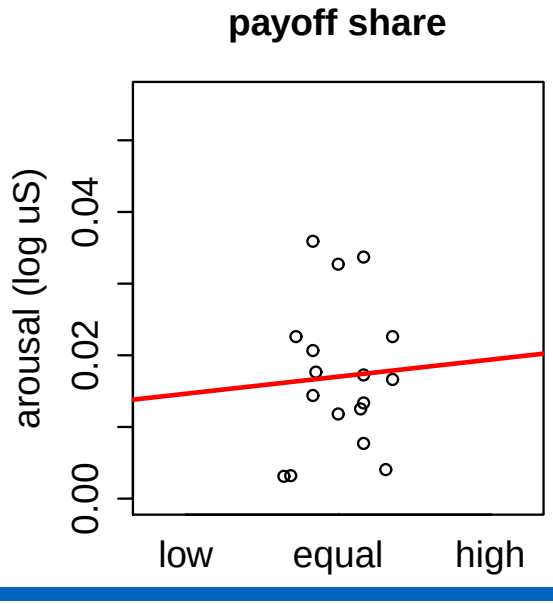
Arousal higher in fair than in unfair results

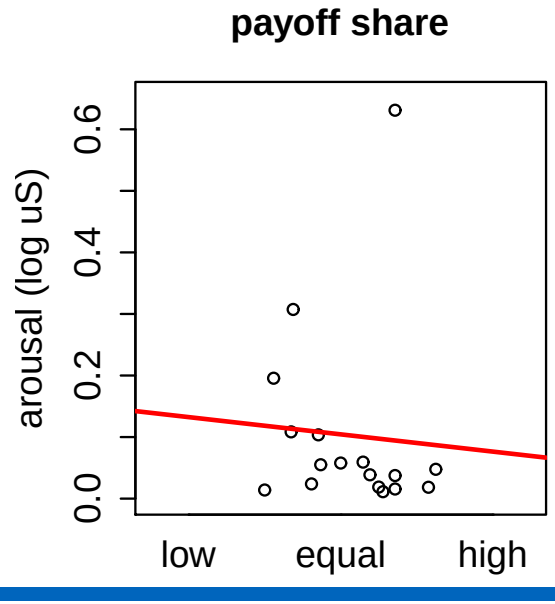


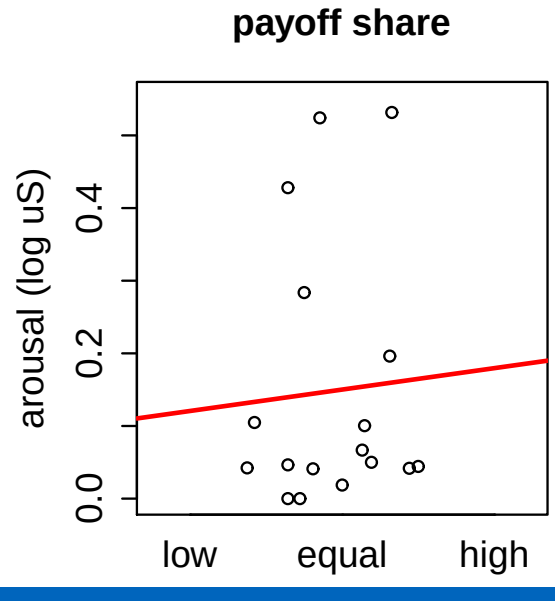

payoff share
arousal (log uS)
0.00
0.04
0.08
low
equal
high

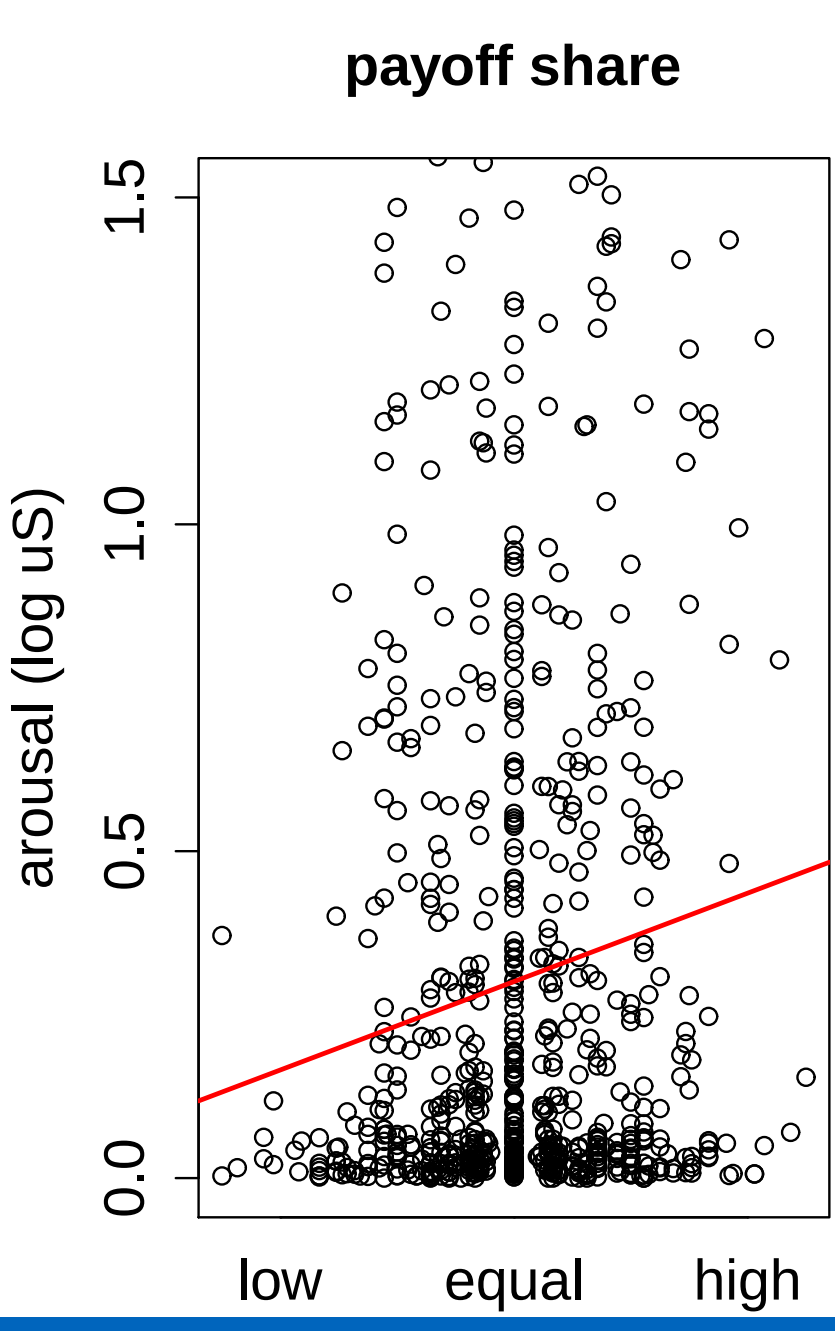

payoff share
arousal (log uS)
0.00
0.04
0.08
low
equal
high

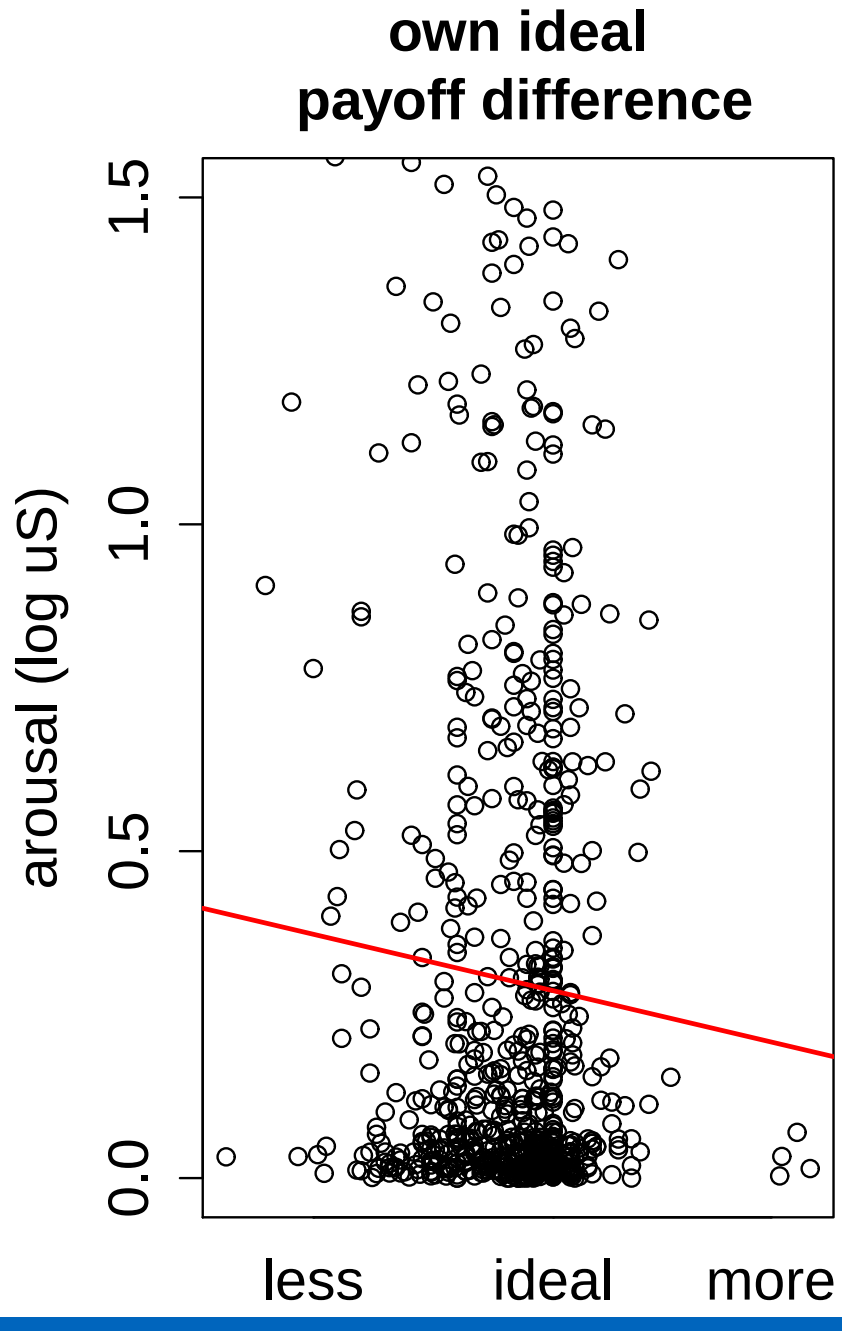

payoff share
arousal (log uS)
0.0
0.1
0.2
0.3
0.4
low
equal
high

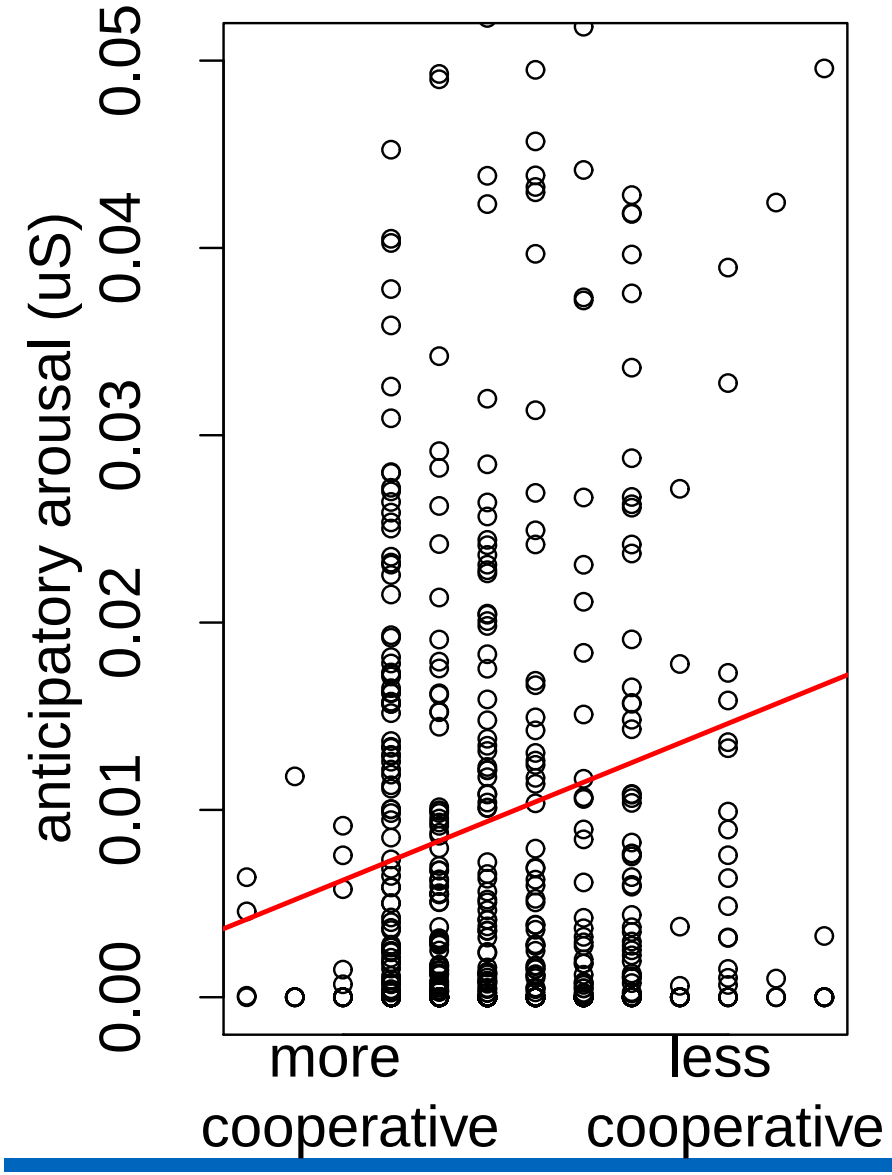

payoff share
arousal (log uS)
0.00
0.02
0.04
low
equal
high

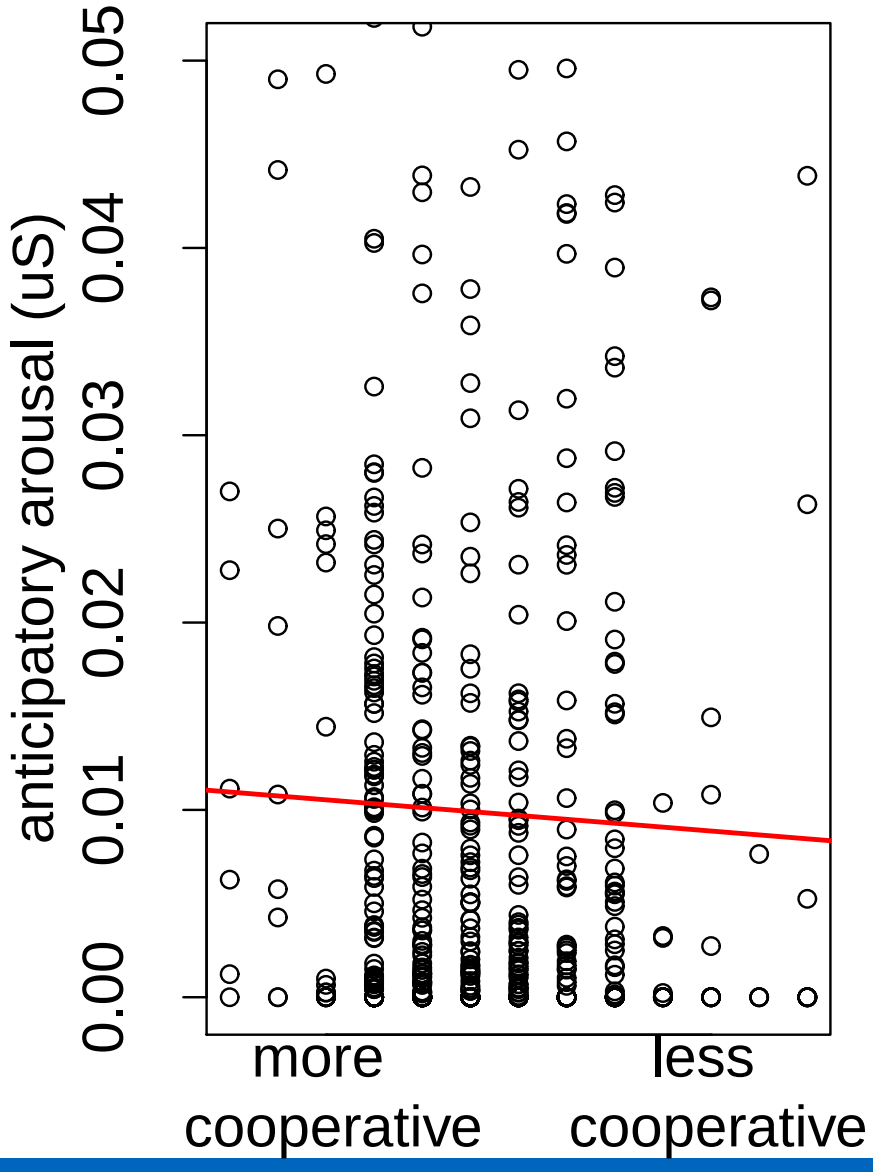

payoff share
arousal (log uS)
0.0
0.2
0.4
0.6
low
equal
high


payoff share
arousal (log uS)
0.0
0.2
0.4
low
equal
high


payoff share
arousal (log uS)
0.0
0.5
1.0
1.5
low
equal
high


own ideal
payoff difference
arousal (log uS)
0.0
0.5
1.0
1.5
less
ideal
more

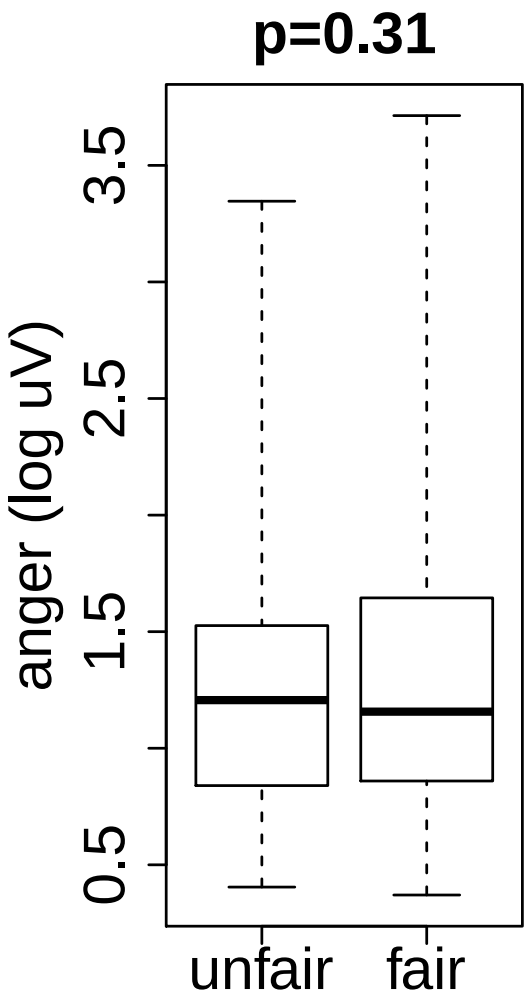

own choice
anticipatory arousal (uS)
0.00
0.01
0.02
0.03
0.04
0.05
more cooperative
less cooperative

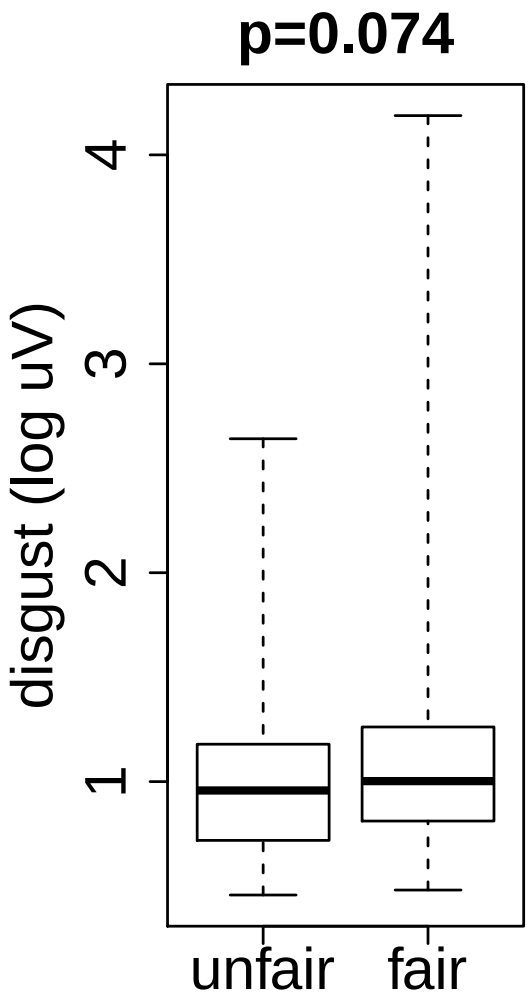

other´s previous round choice
anticipatory arousal (uS)
0.00
0.01
0.02
0.03
0.04
0.05
more cooperative
less cooperative

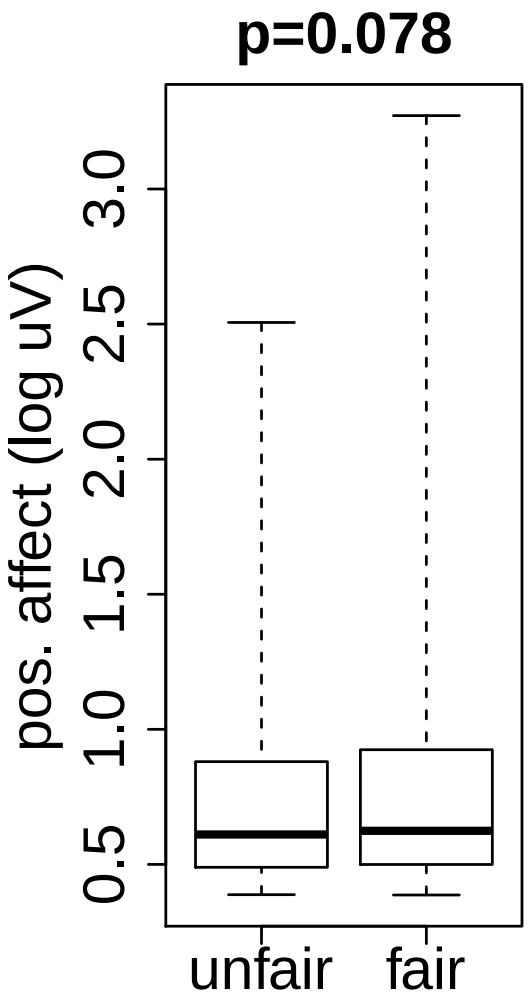
Arousal and anticipatory arousal

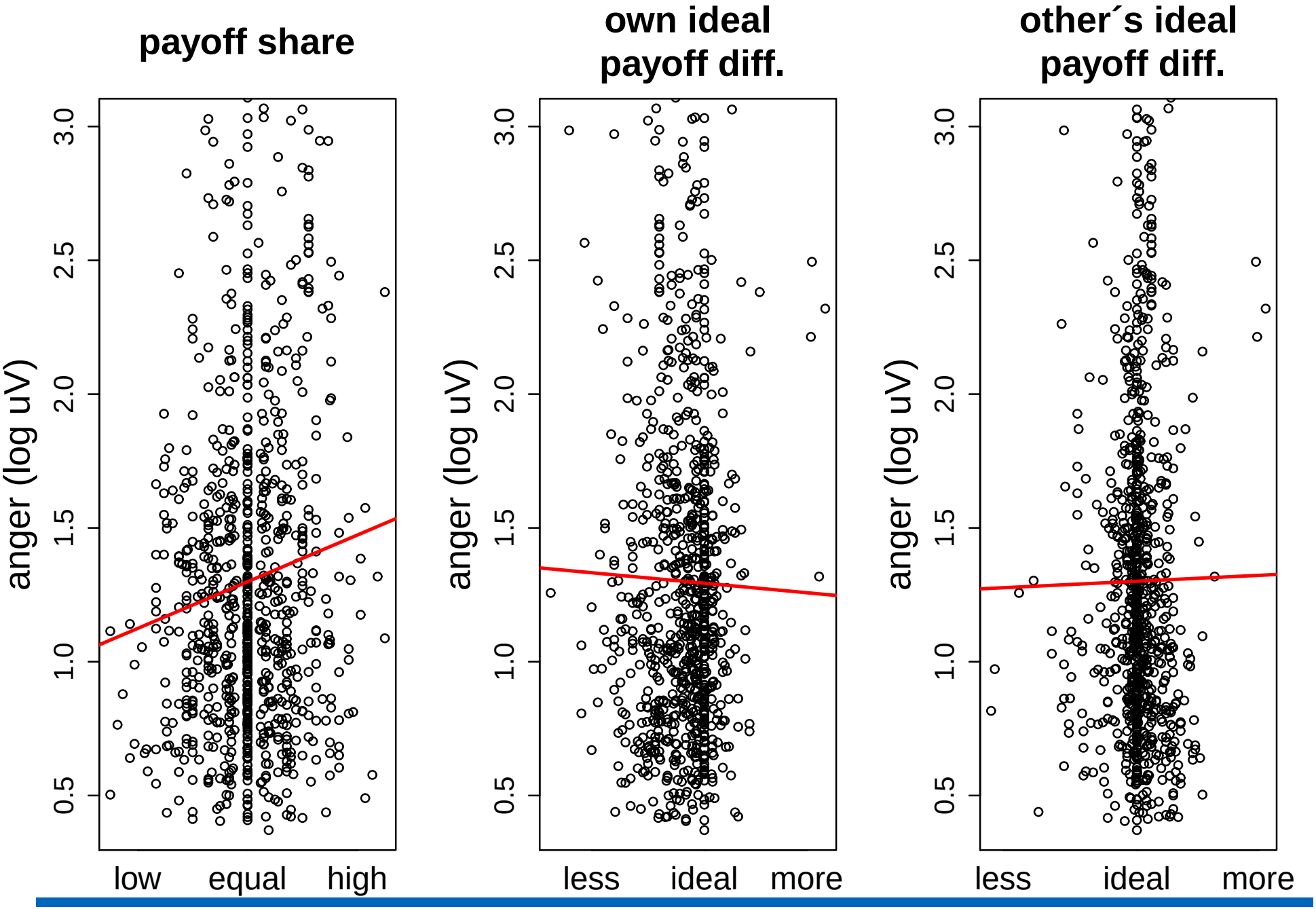
- **Arousal is high in fair results** and with high payoff share, but also when own payoff is less than the ideal payoff
- Anticipatory arousal is high when the **subject makes less cooperative decisions**
- Anticipatory arousal is high when the **other's previous round decisions are more cooperative**
- Gender effect: higher for males
- Habituation: decrease in time

Disgust and pos. affect are higher in fair results



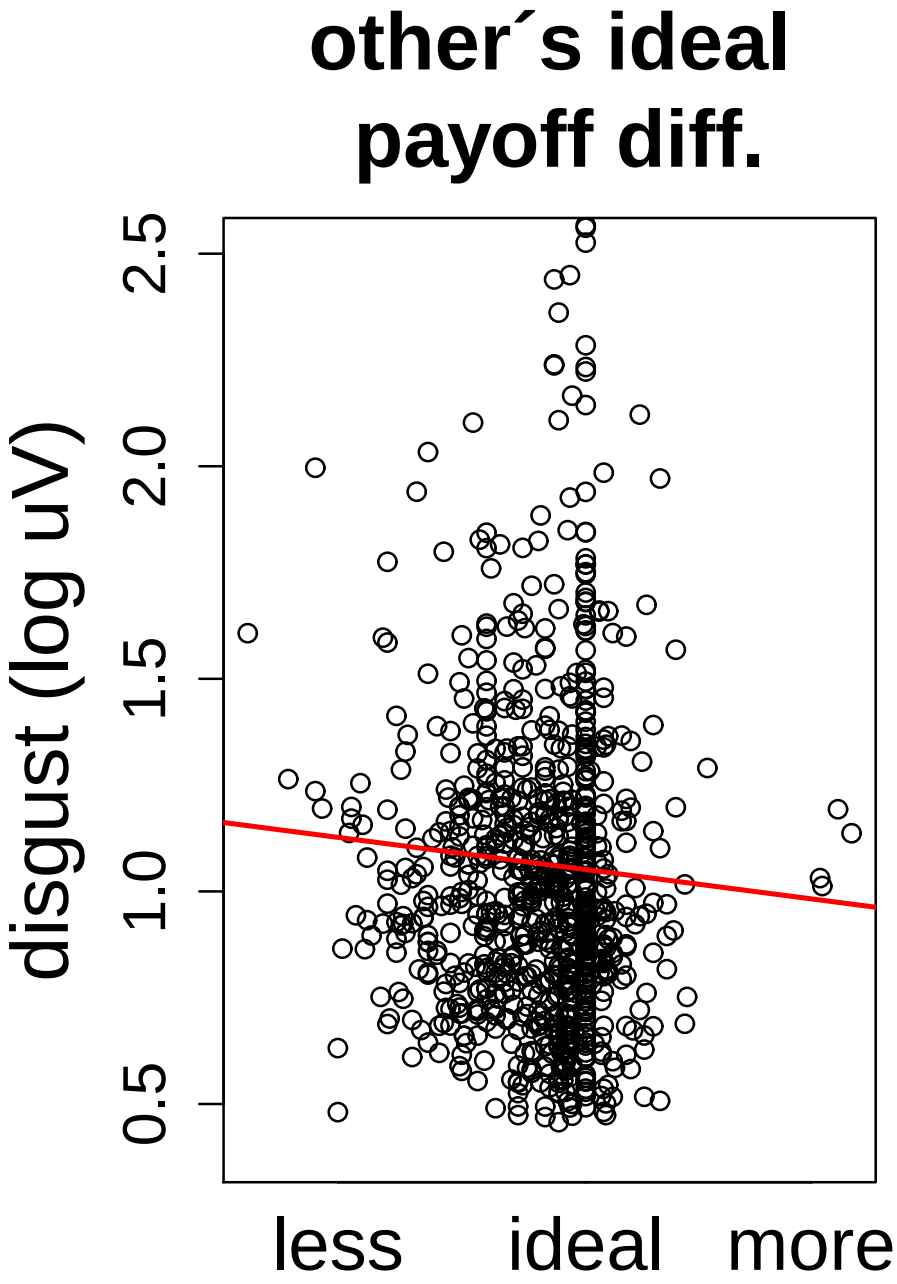


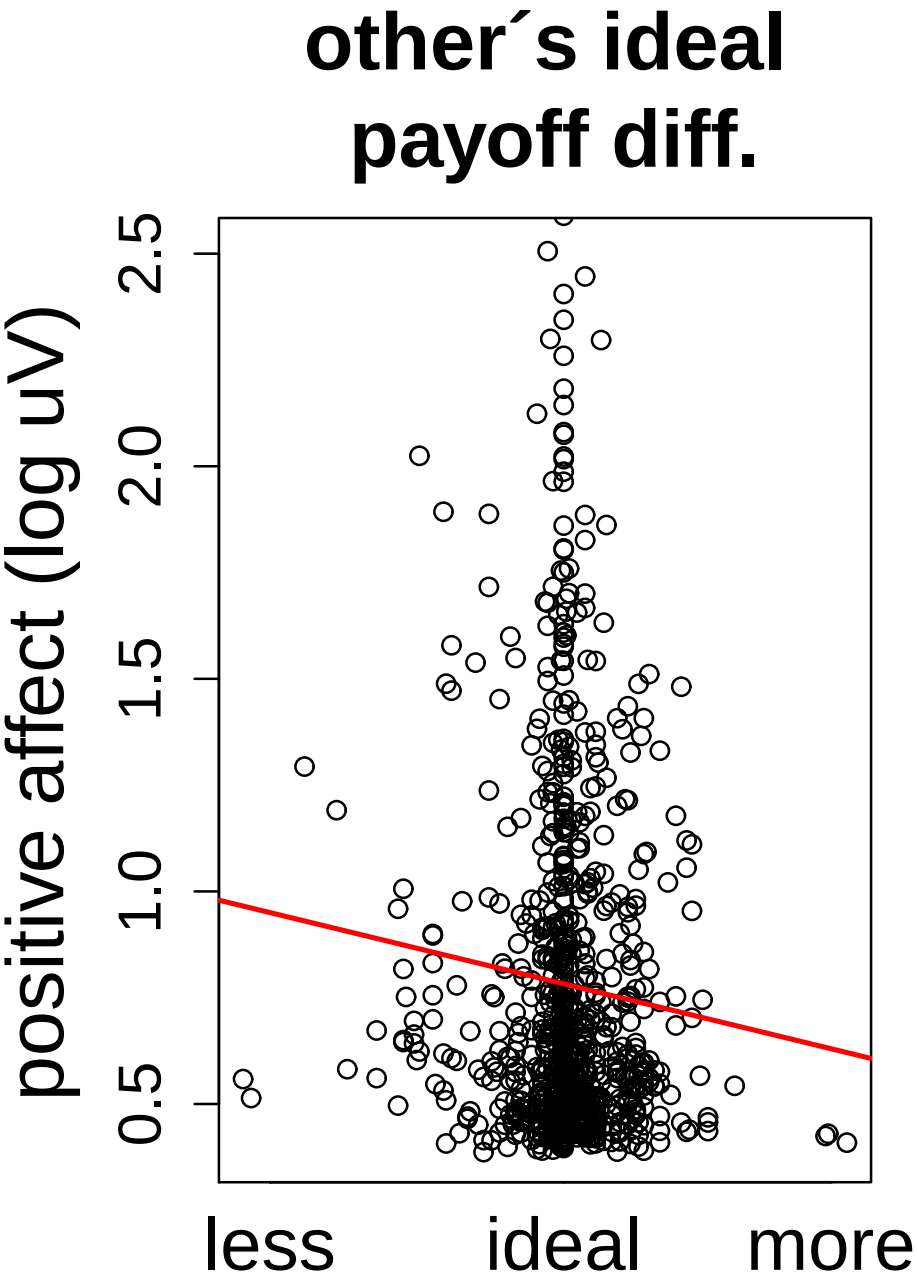



payoff share
own ideal payoff diff.
other´s ideal payoff diff.
anger (log uV)
0.5
1.0
1.5
2.0
2.5
3.0
low
equal
high
less
ideal
more

Anger

- **Increases** as payoff share increases
  - i.e. the higher the relative payoff, the more there is anger
  - Positive *and* negative affect (anger) are not mutually exclusive: the corrugator supercilii muscle can measure both (Ito et al. 1998)
- Increases as the subject gets less payoff than the ideal, and as the other gets more payoff than the ideal


other´s ideal payoff diff.
disgust (log uV)
0.5
1.0
1.5
2.0
2.5
less
ideal
more


other´s ideal payoff diff.
positive affect (log uV)
0.5
1.0
1.5
2.0
2.5
less
ideal
more

Disgust and positive affect

- Do not depend on payoff share
- There is **possibly correlation** between disgust and positive affect
  - Disgust and positive affect are higher in fair results
  - Disgust and positive affect are higher when the other gets less payoff than the ideal

Relationship to earlier studies

- **Anticipatory arousal**: similar results as in Joffily et al. (2011) who find that less cooperative decisions elicit higher anticipatory arousal
- **Disgust** in unfair results: we find opposite results than Chapman et al. (*Science*, 2009)
  - They measure disgust, not positive affect
  - We do not deceive subjects and use fake opponents as they do, and therefore our experiment is more reliable

Conclusions

- Fair behavior of the other player elicits arousal
- Anticipatory arousal is related to own noncooperative behavior
- Subjects get angry if they get less than their ideal payoffs, and when the other gets more than their ideal payoffs
- These results imply that subjects are not entirely self-regarding in cooperative situations

- Emotions **should receive more interest in OR**
- The psychophysiological measurement method suits well for studying emotions in group decision making

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