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However beautiful the strategy, you should occasionally look at the results.

Winston Churchill

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Charting the Type Space: The Case of Linear Public Good Games

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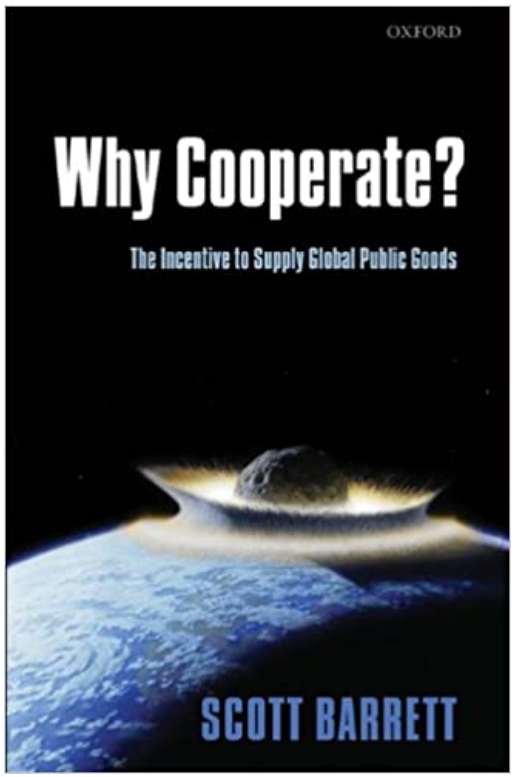
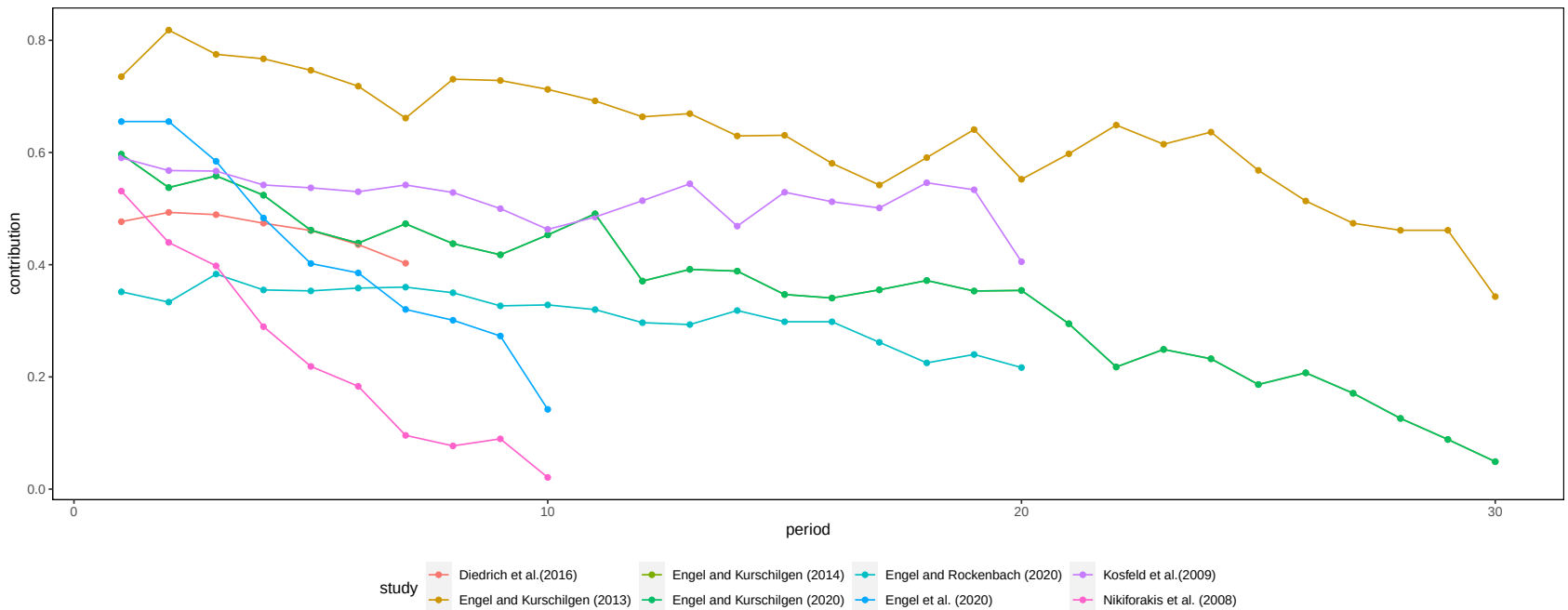
Why Study Public Good Games?

- Global public goods include the prevention of nuclear proliferation, the suppression of pandemics, and climate change mitigation.
- Failure to supply these global public goods exposes the world to dangers; providing them expands human capabilities. (Barrett et al. 2007)



The Tragedy of the Commons

Average contributions typically start above zero but decline over time (Chaudhuri 2011; Ledyard 1995; Zelmer 2003).



The Tragedy of the Commons – Possible Explanations

- Social preferences are part of the utility function (for an excellent overview see Fehr et al. 2002).
- There exist different behavioral types (Fischbacher et al. 2001).
- However, the theorized types are not sufficient to explain the experimental evidence.

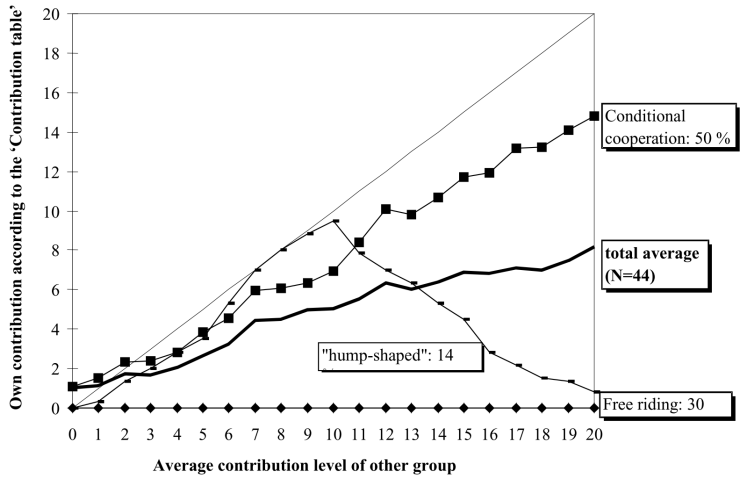


Figure: Player Types Proposed by Fischbacher, Gächter, Fehr (2001)

Research Question

Which reaction functions exist, and how prevalent are they?

Method

- We analyze the data via *clustering*.
- The data are *multivariate time series*, consisting of
  - a participant's own contribution and
  - the group members' average contribution.

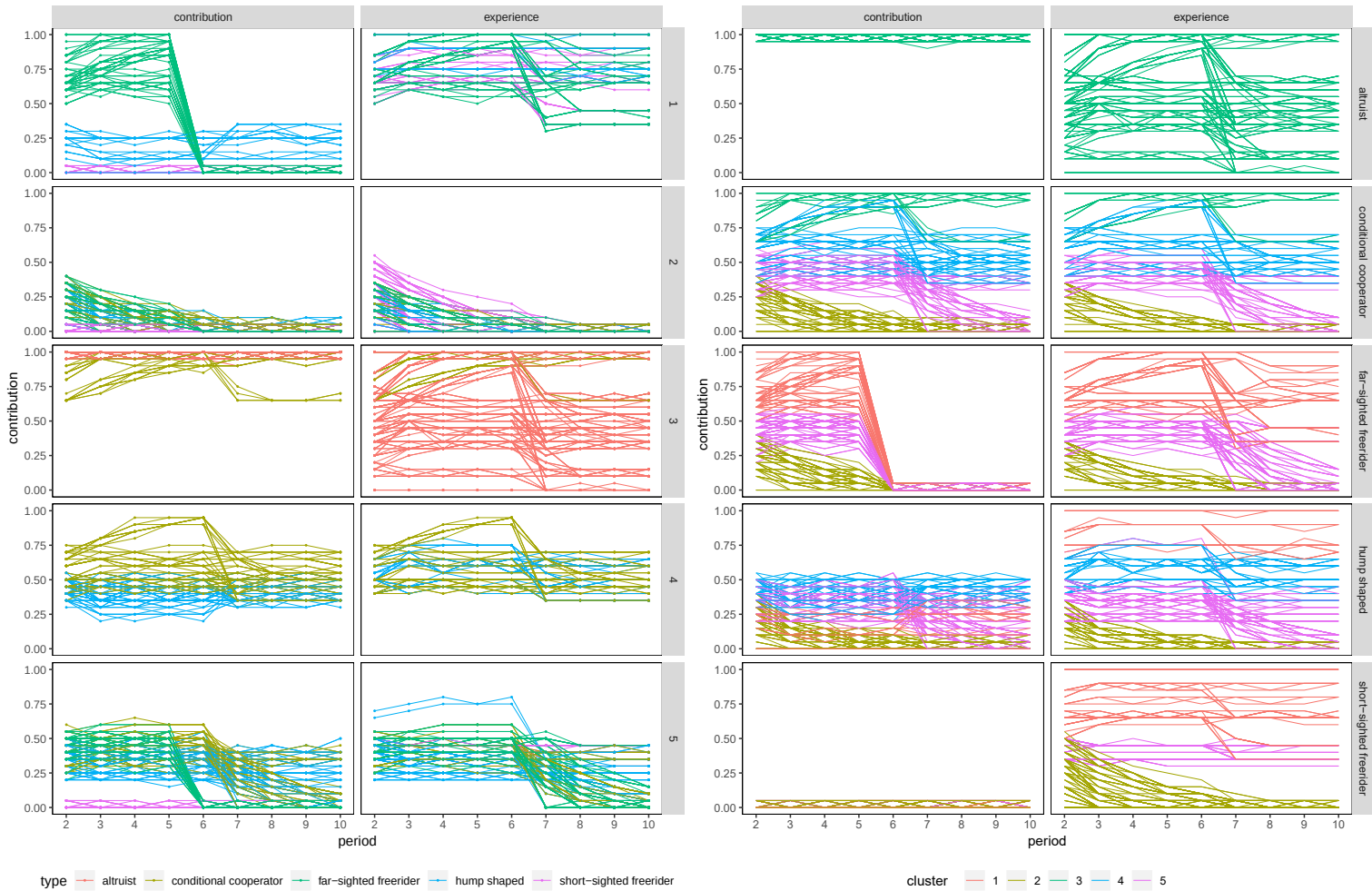
Simulation

Data generating process: $\pi_{it} = e - c_{it} + \mu \sum_{k=1}^{K} c_{kt}$
π profit of individual i in period t; endowment e; contribution c; marginal per capita rate $\mu < 1 < K\mu$.

Table: Simulated Type Space

type	$t = 1$	$t > 1$
short-sighted freerider	0	0
far-sighted freerider	10	$c_{-i,t-1}$ if $t < \tau$ 0 if $t \geq \tau$
conditional cooperator	10	$c_{-i,t-1}$
hump shaped	5	$c_{-i,t-1}$ if $c_{-i,t-1} \leq 10$ $-c_{-i,t-1}$ if $c_{-i,t-1} > 10$
altruist	20	20

Types Versus Patterns



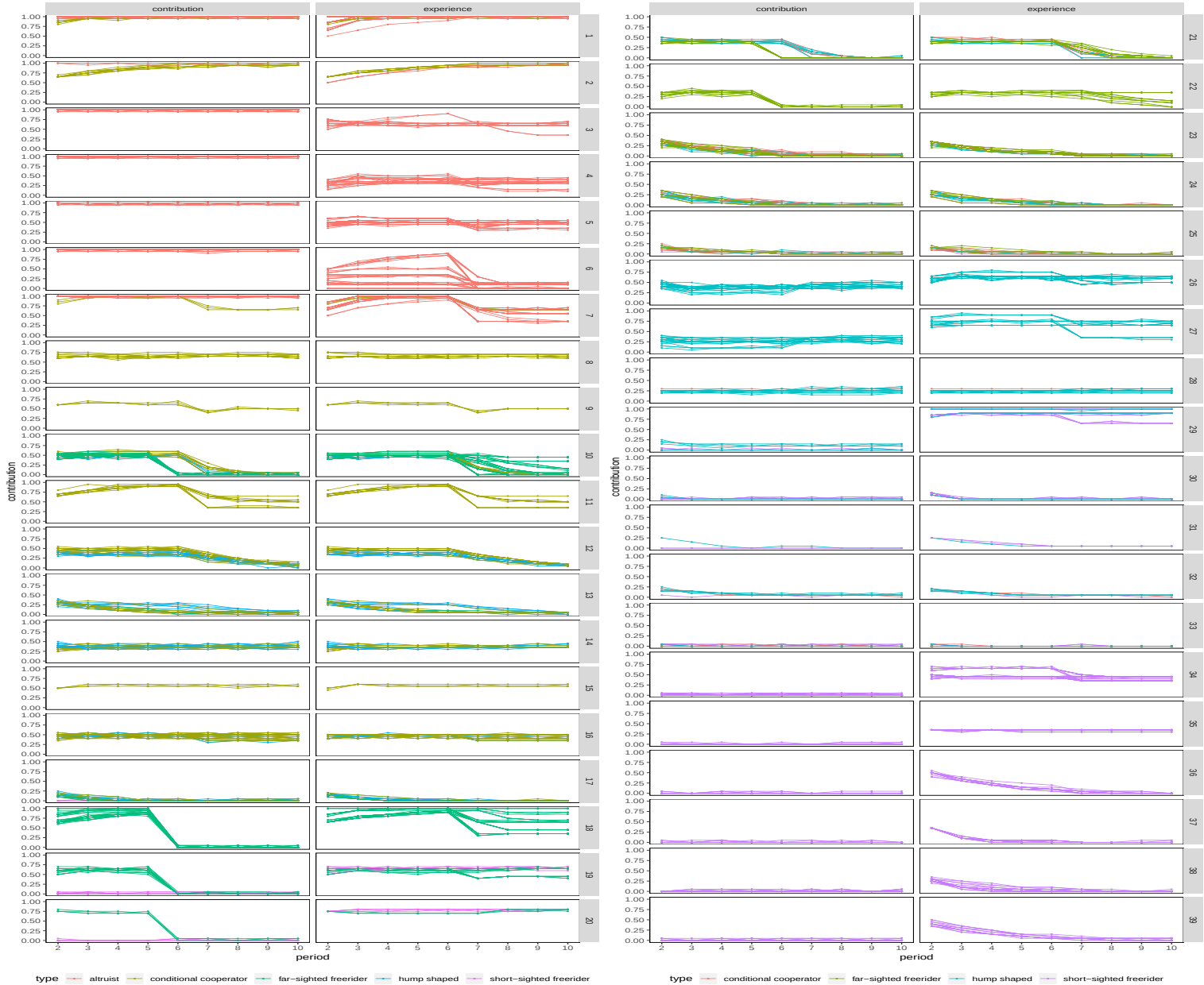
(a) 5 Clusters for 5 Types

(b) 5 Types in 5 Clusters

Internal Cluster Validation Indices

- We face a combined algorithm selection (Rice 1976) and configuration problem (Kotthoff et al. 2017).
- The rankvote of 7 CVIs (chosen based on recommendations by Arbelaitz et al. 2013) decides for:
  - the number of clusters,
  - the prototyping function,
  - the distance function, and
  - the clustering algorithm.
- The best configuration consists of 39 clusters, sdtw centroids & distance, and partitional clustering.

39 Clusters for 5 Types on Simulated Data

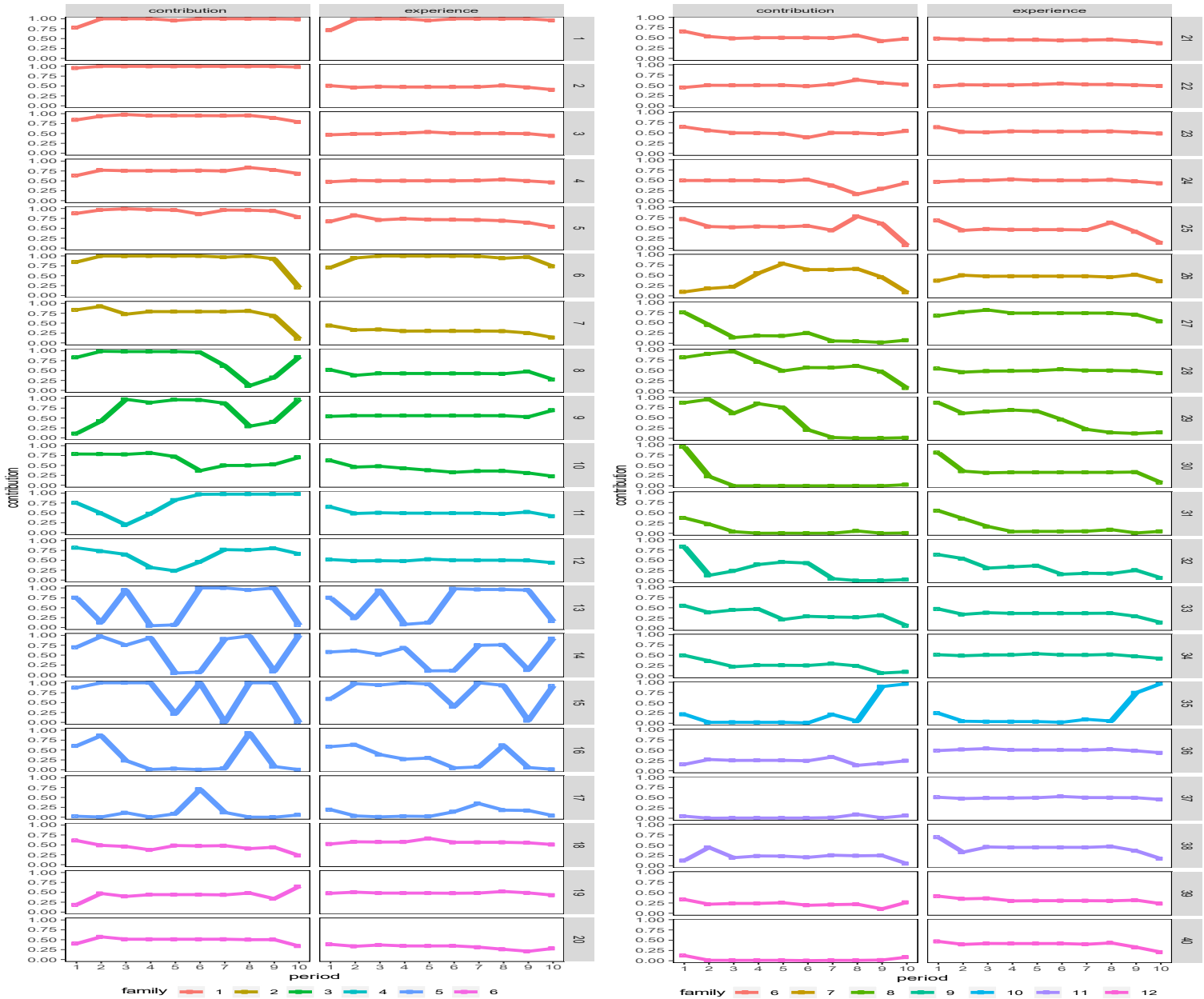


Experimental Data

The data consists of 7 studies, 1,616 participants, 16,474 observations.

study	period	endowment	group size	MPCR	subjects
Diederich et al. (2016)	7	40	10	0.3	360
Diederich et al. (2016)	7	40	40	0.3	200
Diederich et al. (2016)	7	40	100	0.3	500
Diederich et al. (2016)	7	1,000	10	0.3	50
Engel and Kurschilgen (2013)	30	20	4	0.4	44
Engel and Kurschilgen (2014)	30	20	4	0.4	48
Engel and Kurschilgen (2020)	30	20	4	0.4	48
Engel and Rockenbach (2020)	20	20	3	0.4	30
Engel, Kube, et al. (2020)	10	20	4	0.4	96
Kosfeld et al. (2009)	20	20	4	0.4	40
Kosfeld et al. (2009)	20	20	4	0.6	176
Nikiforakis et al. (2008)	10	20	4	0.5	24

Clusters' Centroids in the Experimental Data



Interpretation of the Experimental Data

Few clusters can be theorized with the five types simulated. We find

- almost no altruists,
- very few outright selfish participants,
- very few nearly perfectly conditional cooperators, and
- no hump-shaped types.

Our interpretation:

- Participants try to educate their peers (motivational).
- Participants explore the boundaries of others‘ reactions (cognitive).

Conclusion

- Clustering can be used to infer the composition of the type space.
- Existing theories about the type space only explain a narrow fraction of the data.

Let's Discuss!

- How would you map the clusters to types? (Gerlach et al. 2018)
- How would you explore the parameter space in a more efficient way? (Balietti et al. 2020; Ferrari et al. 2015; Helfmann et al. 2018; Shalamov et al. 2018, e.g.)
- Which alternative evaluation metrics (apart from internal CVIs) would you use?

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