The Consistency Axiom
–An Experimental Study–

Luis G. González* † Werner Güth* ‡ Wiebke Kuklys* §

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Abstract

If a strict equilibrium is suggested as the solution of a strategic game in normal form and if some but not all players are committed to their solution strategy, a reduced game results with only the still non-committed as active players. The reduced game property (or consistency axiom) demands that the solution of the reduced game is given by the original solution strategies of its active players. However, postulating the reduced game property is asking for too much: consistent equilibrium selection in general is not possible if certain other requirements (existence and optimality) are granted (Norde et al., 1996). Does the reduced game property have at least some behavioral appeal? We test this experimentally by confronting players with a solution proposal before letting them decide both for the original game and for its reduced games.

1 Introduction

A problem in interactive decision making involving many players can be that in spite of a general consensus on how to play the game, a subgroup of

*Max Planck Institute for Research into Economic Systems, Strategic Interaction Group, Kahlaische Str. 10, 07745 Jena, Germany

†gonzalez@mpiew-jena.mpg.de

‡gueth@mpiew-jena.mpg.de

§kuklys@mpiew-jena.mpg.de

players would reconsider their choices when others are already committed to the general consensus. The reduced-game property of a solution to a game, or *consistency axiom*, requires such reconsideration not to change behavior: the general consensus should prescribe actions that are voluntarily chosen by any subgroup of players, regardless of other players' commitment to their prescribed actions (or, equivalently, players should not change behavior if the solution behavior of other players remains the same but is coercively imposed instead of freely chosen). Solutions satisfying the consistency axiom therefore have a decentralization property: partitioning the set of players into a subset of committed players and a subset of non-committed players does not change the outcome of the game.

The consistency axiom has been postulated for many concepts in cooperative game theory (e.g. Harsanyi, 1959, Lensberg, 1988, Maschler, 1990, Thompson, 1990). For the equilibrium concept of strategic games (Nash, 1951), the reduced game property is obvious and well-known (see, e.g., Aumann, 1987): since no player can gain by unilaterally deviating from an equilibrium this will be true as well for any non-empty subgroup of players when expecting that all players not in that subgroup stick to the equilibrium. Here we will focus on strict equilibria where "not gaining" is substituted by "losing", i.e., where every player would lose by unilaterally deviating from equilibrium. Unfortunately, postulating the reduced game property for equilibrium refinements or selection theories necessarily violates other obvious rationality requirements (see Norde et al., 1996).

To substantiate this more formally we introduce a few definitions. Let

$$G = (S_1, ..., S_n; u_1(\cdot), ..., u_n(\cdot))$$

denote a finite game in normal form with finite strategy sets S_i and payoff functions $u_i(s)$ assigning player i's payoff to any vector $s = (s_1, ..., s_n)$ in $S = \times_{j=1}^{n} S_j$. Denote by Γ the class of all games G with $n \geq 1$ which are interpreted as their mixed extensions, for which Nash (1951) has proved the existence of equilibria.

A *solution* $\varphi(\cdot)$ defined on the class of games Γ assigns a set $\varphi(G) \subset S$

to any $G \in \Gamma$. For $s^* \in \varphi(G)$ and M with $\varnothing \neq M \subset N := \{1, ..., n\}$ the *reduced game* $G^{s^*,M}$ is simply the normal form game

$$G^{s^*,M} = \left((S_i)_{i \in M}; (\tilde{u}_i(\cdot))_{i \in M}\right)$$

with only players $i \in M$ as active players whose payoffs are given by

$$\tilde{u}_i\left((s_j)_{j \in M}\right) = u_i\left((s_j)_{j \in M}, (s_j^*)_{j \notin M}\right).$$

Thus in $G^{s^*,M}$ the players $j \in N \backslash M$ are committed to their respective solution strategies s_j^* whereas the players $j \in M$ are free to choose any of their available strategies $s_j \in S_j$.

If for $G \in \Gamma, s^* \in \varphi(G)$ and M with $\varnothing \neq M \subset N$ also $G^{s^*,M}$ is contained in Γ , the class Γ of games G is said to be *φ-closed*. Let, for instance, $\varphi(\cdot) = E(\cdot)$, where for all $G \in \Gamma$, $E(G) \subset S$ denotes the equilibrium set of G (i.e., for all $s^* \in E(G)$ and all players $i = 1, \ldots, n$ the strategy s_i^* is a best reply to s^*). Clearly, Γ, the set of finite normal form games G, is E -closed.

The solution function $\varphi(\cdot)$ on Γ is *consistent*, resp. satisfies the reduced game property, if Γ is φ-closed and if for all $G \in \Gamma$ and for M with $\varnothing \neq M \subset N$, $s^* \in \varphi(G)$ implies that $(s_j^*)_{j \in M} \in \varphi(G^{s^*,M})$. The latter obviously means that, although the players $j \in M$ can do whatever they want in $G^{s^*,M}$, their solution strategies $(s_j^*)_{j \in M}$ are in line with the solution $\varphi(G)$ of the original game. In other words: According to $\varphi(\cdot)$ players in M do not modify their choice in $G^{s^*,M}$ compared to what they would have chosen in G. It is straightforward to see that the solution function $E(\cdot)$ on Γ is consistent.

If in addition to consistency of the solution $\varphi(\cdot)$ one also demands

- Non-Emptiness ($\varphi(G) \neq \varnothing$ for all $G \in \Gamma$) and
- Optimality ($\varphi(G) = \arg\max_{s_1 \in S_1} u_1(s_1)$ for $n = 1$),

(both of which appear rather intuitive), then Norde et al. (1996) have shown that $\varphi(\cdot) = E(\cdot)$. Thus, since any *refinement* $E^*(\cdot)$ such that $E^*(G) \subset E(G)$ with $E^*(G) \neq E(G)$ for at least some game $G \in \Gamma$ obviously satisfies optimality, $E^*(\cdot)$ must violate either Non-Emptiness or Consistency. This has inspired some attempts to avoid the impossibility of equilibrium refinement by either weakening the consistency axiom (Dufwenberg et al., 2001) or by accepting non-existence (Güth, 2002/2003).

Since we want to explore the behavioral appeal of the reduced game property, we sacrifice Non-Emptiness rather than Consistency by using strict equilibria as the relevant solution concept. Specifically, the solution concept $\varphi(\cdot) = E^*(\cdot)$ is the set of strict equilibria for all $G \in \Gamma^*$ where $\Gamma^* (\subset \Gamma)$ is the class of games $G \in \Gamma$ with $E^*(G) \neq \varnothing$. If $s^* \in E^*(G)$ and $G^{s^*,M}$ is a reduced game of G, then $(s_j^*)_{j \in M} \in E^*\left(G^{s^*,M}\right)$, since a player $j \in M$ loses by unilaterally deviating from s^* in G as well as in $G^{s^*,M}$. Thus, if $G \in \Gamma^*$, one also has $G^{s^*,M} \in \Gamma^*$, proving that Γ^* is E^*-closed and that $E^*(\cdot)$ is consistent on Γ^*.

For any $G \in \Gamma^*$, any strict equilibrium $s^* \in E^*(G)$, and any subset M with $\varnothing \neq M \subset N$, the reduced game property of $E^*(\cdot)$ requires $\left(s_j^*\right)_{j \in M}$ to be a strict equilibrium in $G^{s^*,M}$. This should render the reduced game property as behaviorally attractive. Nevertheless it will be shown below that there may be violations of Consistency in the sense that players $i \in M$ may want to deviate from $(s_i^*)_{i \in M}$ in $G^{s^*,M}$ (see Güth, 2003/2004, for more details). The reason is that $s^* \in E^*(G)$ has been selected as the solution for $G \in \Gamma^*$ by considering the incentives of all players $j \in N$. But selecting the solution for $G^{s^*,M}$ would be based only on the incentives of the in $G^{s^*,M}$ active players $i \in M$, if $G^{s^*,M}$ has multiple strict equilibria. Those incentives might, furthermore, differ from the incentives in the original game G.

In section 2 we introduce the special class Γ^* of games for which we illustrate the difficulties of consistent equilibrium selection. After describing the experimental procedure (section 3) we analyze the experimental data in section 4. The final section 5 concludes.

2 The games

We only consider three-person games $G = (S_1, S_2, S_3; u_1, u_2, u_3)$ with binary strategy sets

$$S_i = \{X_i, Y_i\} \text{ for } i = 1, 2, 3$$

and payoffs $u = (u_1, u_2, u_3)$ given in the natural order by the trimatrix

X_3:

	X_2	Y_2
X_1	2, 4, z	0, 0, 0
Y_1	0, 0, 0	4, 4, 0

Y_3:

	X_2	Y_2
X_1	3, 3, 0	0, 0, 0
Y_1	0, 0, 0	2, 2, 4

with $z > 0$. Thus the only strict equilibria are $X = (X_1, X_2, X_3)$ and $Y = (Y_1, Y_2, Y_3)$.

To illustrate the difficulty of consistent equilibrium selection for games with multiple strict equilibria, we apply as in Güth (2002/2003) the idea of *unilateral deviation stability*, which prescribes the strict equilibrium that maximizes the product of unilateral deviation dividends. For the game at hand the product of deviation dividends for X is $2 \cdot 4 \cdot z$, whereas it is $2 \cdot 2 \cdot 4$ for Y. This suggests the solution X (resp. Y) if $z > 2$, (resp. $z < 2$). Now, the reduced game $G^{\{1,2\},X} = (S_1, S_2; \tilde{u}_1, \tilde{u}_2)$, which results from committing player 3 to play strategy X_3, has strategies $S_i = \{X_i, Y_i\}$ for $i = 1, 2$ and payoffs $\tilde{u} = (\tilde{u}_1, \tilde{u}_2)$ given in the bimatrix

	X_2	Y_2
X_1	2, 4	0, 0
Y_1	0, 0	4, 4

$M = \{1, 2\}$, $s = X$.

According to the idea of unilateral deviation stability, the solution to this reduced game is (Y_1, Y_2) due to $4 \cdot 4 > 2 \cdot 4$, regardless of the value of z (> 0). Thus, it is clear that for $z > 2$ selecting a solution by unilateral deviation stability violates the reduced game property.

In our experiment, only games of the class described above are used. Furthermore, participants are confronted only with solution proposals X or Y for G and have to decide for G as well as for the non-trivial games $G^{M,s}$ with

$$M = \{1, 2\}, \{1, 3\}, \{2, 3\} \text{ and } s = X, Y.$$

The resulting reduced games $G^{M,s}$ are given by the following bimatrices:

(i) For $M = \{1, 2\}$,

	X_2	Y_2
X_1	2, 4	0, 0
Y_1	0, 0	4, 4

$s = X$

and

	X_2	Y_2
X_1	3, 3	0, 0
Y_1	0, 0	2, 2

$s = Y$

,

which both have multiple strict equilibria, namely, (X_1, X_2) and (Y_1, Y_2). However, if $s = X$ only (Y_1, Y_2) is unilaterally stable, whereas for $s = Y$ the unilaterally stable equilibrium is (X_1, X_2), illustrating again the inconsistency of unilateral deviation stability. For $M = \{1, 3\}$ and $M = \{2, 3\}$, on the other hand, the reduced games derived from $s = X$ and $s = Y$ all have unique strict equilibria and thus do not violate consistency, due to the consistency of $\varphi(\cdot) = E^*(\cdot)$ on Γ^*. Their payoffs are given by the following bimatrices:

(ii) for $M = \{1, 3\}$:

	X_3	Y_3
X_1	2, z	3, 0
Y_1	0, 0	0, 0

$s = X$

and

	X_3	Y_3
X_1	0, 0	0, 0
Y_1	4, 0	2, 4

$s = Y$

.

(iii) for $M = \{2, 3\}$:

	X_3	Y_3
X_2	4, z	3, 0
Y_2	0, 0	0, 0

$s = X$

and

	X_3	Y_3
X_2	0, 0	0, 0
Y_2	4, 0	2, 4

$s = Y$

.

3 Experimental procedure

In the experiment 27 participants were randomly rematched in three-person groups of players (1,2,3), whereby we actually have partitioned the experimental session in three matching groups with 9 participants each. Subjects remained uninformed about this restricted way of rematching in order to discourage repeated game effects. After being seated at a visually isolated computer terminal, participants received a typed version of the instructions (see App. 2), which informed them

1. about the class of three-person games G as defined by the positive payoff parameter z,

2. the concept of strict equilibria, especially its strictly self-enforcing stabilization, and the recommendation procedure establishing some coordination in equilibrium selection,

3. how the reduced games result by committing one of the three players $i = 1, 2, 3$ to his recommended strategy s_i according to the recommendation $s \in \{X, Y\}$,

4. the decision process in each round.

The decision process was as follows. After being randomly assigned to a group of three players and after receiving either role 1, 2, or 3, each participant had to decide between X and Y in the three-person game G. All the strategy choices made by the three players in a group were communicated to its members. Then, one of the three players was committed to his choice, while the two remaining players decided once again in the resulting reduced game. The non-committed players were paid according to the payoffs of the reduced game. The committed player was paid according to his strategy choice in G and the strategies of the non-committed players in the reduced game.

We used a within subjects design for the variation of z, whereby z could only assume the levels $\underline{z} = 1$ and $\overline{z} = 3$. The experiment consisted of 48

	$z = 1$		$z = 3$		Total	
	X	Y	X	Y	X	Y
Role 1	41.4	58.6	47.2	52.8	44.3	55.7
Role 2	72.1	27.9	76.4	23.6	74.2	25.8
Role 3	25.0	75.0	51.9	48.1	38.4	61.6

Table 1: Choice of action by role and value of z (%)

rounds, with the level of z changing every 6 rounds. During the first 24 rounds (phase 1), the recommendation communicated to the participants was alternated between X and Y, while during the last 24 rounds (phase 2) this recommendation was substituted by the suggestion to apply unilateral deviation stability as a solution strategy. Before starting the last 24 rounds, this solution concept was explained to the subjects in a new set of instructions (see App. 2 for the instructions of phase 2).

4 Experimental Results

4.1 Aggregate choice behavior

We begin the analysis of the experimental data by considering aggregate choice behavior in each role. As shown in Table 1, subjects seem to be choosing X and Y equally often in role 1, while they tend to favor the choice of X in role 2. In both cases, the value of z does not seem to affect the aggregate mix of behavior. In contrast, aggregate behavior seems to change with the value of z when playing role 3: in this case, participants tend to favor the choice of Y if $z = 1$, but they tend to choose X and Y equally often if $z = 3$. The Wilcoxon signed-rank test for paired data does not detect any difference in behavior for roles 1 and 2 as the value of z changes, whereas it shows a significant decrease in the frequency with which X is chosen by participants in role 3 when $z = 1$ (see Table 2). Also, we confirm that the choice of X and Y are equally likely only for the roles 1 and 3 with $z = 3$. In all other cases, players seem to favor one action over the other (see Table 3).

	Z statistic*	p-value
Role 1	-1.4861	0.1373
Role 2	-1.216	0.224
Role 3	-2.6063	0.0092

* Signed-rank normal statistic with correction

Table 2: Wilcoxon singed-rank test for differences in choice behavior between $z = 1$ and $z = 3$. H_0: *Frequency of choice of* X *is equal for both values of* z.

	$z = 1$		$z = 3$	
	Z statistic*	p-value	Z statistic*	p-value
Role 1	-2.2649	0.0235	-0.6539	0.5132
Role 2	2.4901	0.0128	2.6086	0.0091
Role 3	-2.6063	0.0092	0.5944	0.5522

* Signed-rank normal statistic with correction

Table 3: Wilcoxon singed-rank test for differences between the frequencies of X and Y. H_0: *The choice of* X *is as frequent as the choice of* Y.

We proceed now to examine how often subjects followed the (deterministic) recommendation given to them during periods 1 to 24. As Figure 1 shows, overall non-compliance was relatively low, although it tended to be higher in later periods. Deviating from the recommendation is understandable, since the recommended strategy was changed between X and Y following an arbitrary alternating rule.[1]

As expected by the fact that the value of z only affects the payoff of the participant in role 3, there seems to be no significant difference in the frequency of compliance as z varies between 1 and 3, regardless of the specific strategy that was recommended to the players (see Table 4). However, the Wilcoxon singed-rank test does reject for player 3 the hypothesis of equal choice frequencies for both values of z, in particular when the recommendation was to play the X strategy (see Table 5.)

[1] A more sophisticated selection principle, like for instance the one proposed by Harsanyi and Selten (1988), is more difficult to apply than the principle of unilateral deviation stability. The recommendation given during the first 24 rounds was not based on any of these two principles.

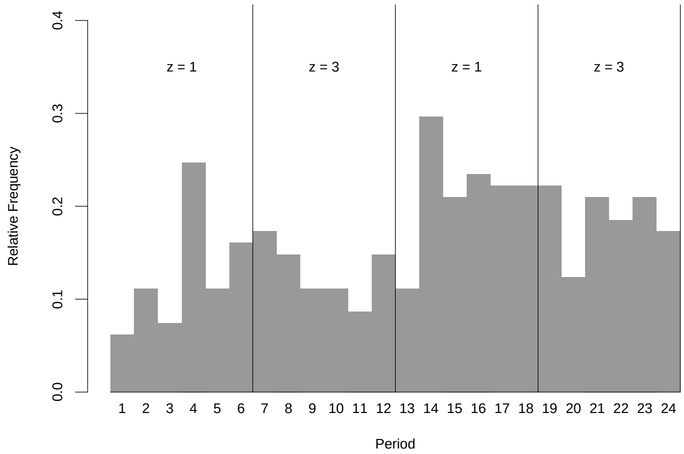

Figure 1: Relative frequency of non-compliance with recommendation

	$z = 1$		$z = 3$	
	X_{rec}	Y_{rec}	X_{rec}	Y_{rec}
Role 1	79.6	89.5	77.8	85.8
Role 2	93.8	73.5	94.4	71.6
Role 3	63	97.5	83.3	92

Table 4: Relative frequency of compliance with recommendations X_{rec} and Y_{rec}

	X_{rec}		Y_{rec}	
	Z statistic*	p-value	Z statistic*	p-value
Role 1	0.4225	0.6727	0.9684	0.3329
Role 2	-0.253	0.8003	0.0609	0.9515
Role 3	-2.382	0.0172	1.4417	0.1494

* Signed-rank normal statistic with correction

Table 5: Wilcoxon singed-rank test for differences in compliance between $z = 1$ and $z = 3$. H_0: *Frequency of compliance is equal for both values of* z.

Finally, from Table 6, it is clear that recommending a particular strategy improves the chances of players to coordinate their initial decisions on a strict equilibrium. Moreover, this effect is not significantly different for the two values of z, as the paired Wilcoxon singed-rank test on the sample of matching groups shows (see Table 7).

$z = 1$		$z = 3$	
rec.	no rec.	rec.	no rec.
56.8	19.1	59.3	27.5

Table 6: Relative frequency of strict equilibrium coordination in first decision

	Z statistic*	p-value
rec.	-0.5345	0.593
no rec.	-0.8322	0.4053

* Signed-rank normal statistic with correction

Table 7: Wilcoxon singed-rank test for differences in strict equilibrium coordination between $z = 1$ and $z = 3$. H_0: *Frequency of coordination is equal for both values of* z*.*

4.2 Consistent Behavior

In order to analyze consistency in behavior using the experimental data, we define two types of consistency: *A-consistency* occurs if all players coordinate their first choice on a strict equilibrium, and the non-excluded players do not deviate from their first choices. Since this definition may be too strict, we also consider the weaker concept of *B-consistency*, which just requires that only the non-excluded players coordinate their first choices and do not deviate. In table 8 we present the relative frequency of consistent behavior using both definitions, by role and value of the z parameter. The data show that there is higher consistency when an alternative has been recommended (instead of the general criterion of unilateral deviation stability), regardless of the role which has been excluded. Furthermore, consistency generally increases with the value of z, with the only exception being the case in which role 3 has been excluded and there was a recommendation.

Excluded Role	With recommendation $z = 1$	$z = 3$	Without recommendation $z = 1$	$z = 3$
A-Consistency				
1	28.62	32.95	8.43	15.77
2	25.25	30.86	10.10	12.90
3	30.65	17.70	7.89	8.06
B-Consistency				
1	31.25	33.38	9.50	16.84
2	29.81	32.82	12.81	14.24
3	39.02	23.62	24.79	28.27

Table 8: Relative frequency of consistent behavior, by role of excluded player

Note that the 3 person-game on which the experiment is based has been designed such that especially players 1 and 2 should question consistent behavior when role 3 is excluded, regardless whether the general consensus was to play X or Y. However, as tables 9 and 10 show, the null hypothesis that A-consistency is *higher* in case that role 3 is excluded cannot be rejected for $z = 1$, and this does not depend on whether a recommendation was provided or not. Also, the analogous hypothesis that B-consistency is higher is generally not rejected, except for the case of $z = 3$ with recommendation.

5 Conclusions

The reduced game property, or consistency of (strict) equilibria has been well understood for a long time and allowed for new and innovative axiomatic characterizations. Together with existence and optimality the axiom of consistency, however, precludes refinements or equilibrium selection except when restricting the class of finite games rather seriously. Thus, consistency seems to be in general a too demanding property. Could it nevertheless have some behavioral appeal in the sense that subgroups of players feel committed to a general equilibrium consensus? This is tested experimentally by informing participants about the strictly self-enforcing expectations of a

	With recommendation		Without recommendation	
	$z = 1$	$z = 3$	$z = 1$	$z = 3$
Compared to Role 1				
Z statistic*	0.415	-2.4879	-0.4183	-1.7208
p-value	0.6609	0.0064	0.3379	0.0426
Compared to Role 2				
Z statistic*	1.3032	-1.6586	-0.83	-2.1325
p-value	0.9037	0.0486	0.2033	0.0165

* Signed-rank normal statistic with correction

Table 9: Wilcoxon singed-rank test for differences in consistent behavior. H_0: *Frequency of A-consistency is higher when role 3 is excluded.*

strict-equilibrium consensus, and by recommending either an arbitrary strict equilibrium which all three players may or may not follow before two players can reconsider their choice in a reduced game or a general selection criterion which is easily applied.

Our first finding is that recommending an arbitrary strict equilibrium improves the degree of coordination (as measured by not deviating in the reduced game from one's initial choice). Suggesting the more elaborate criterion of unilateral-deviation stability without indicating to the players what it implies for the game at hand does not improve coordination in the same way. We can also conclude that the overall tendency to behave consistently is rather low, specially if subjects did not receive any explicit recommendation regarding what equilibrium to choose. Our third, and more important conclusion is that incentives against consistency, as implemented in the experimental game, do not yield a good prediction of actual behavior. More specifically, we would have expected more inconsistency when the player in role 3 rather than one of the other players was excluded; however, inconsistency shows up *less* frequently in this case. Thus not only the normative but also the behavioral appeal of consistency is questionable. It usually will matter whether subgroups of players can reconsider their choices knowing that others rely on the general consensus. Surprisingly, behavioral inertia is

	With recommendation		Without recommendation	
	$z = 1$	$z = 3$	$z = 1$	$z = 3$
Compared to Role 1				
Z statistic*	1.5401	-1.777	2.4879	2.2509
p-value	0.9382	0.0378	0.9936	0.9878
Compared to Role 2				
Z statistic*	2.014	-1.3032	1.6586	2.4879
p-value	0.978	0.0963	0.9514	0.9936

* Signed-rank normal statistic with correction

Table 10: Wilcoxon singed-rank test for differences in consistent behavior. H_0: *Frequency of B-consistency is higher when role 3 is excluded.*

observed in the sense that players stick to an initial consensus for G more often when they have stronger incentives to reconsider their choices.

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Appendix 1

Role	Matching Group	No. obs.				Frequency (%)			
		$z=1$		$z=3$		$z=1$		$z=3$	
		X	Y	X	Y	X	Y	X	Y
1	1	29	43	30	42	40.3	59.7	41.7	58.3
1	2	34	38	28	44	47.2	52.8	38.9	61.1
1	3	28	44	37	35	38.9	61.1	51.4	48.6
1	4	36	36	36	36	50.0	50.0	50.0	50.0
1	5	18	54	22	50	25.0	75.0	30.6	69.4
1	6	27	45	47	25	37.5	62.5	65.3	34.7
1	7	29	43	25	47	40.3	59.7	34.7	65.3
1	8	38	34	46	26	52.8	47.2	63.9	36.1
1	9	29	43	35	37	40.3	59.7	48.6	51.4
2	1	41	31	44	28	56.9	43.1	61.1	38.9
2	2	53	19	52	20	73.6	26.4	72.2	27.8
2	3	53	19	56	16	73.6	26.4	77.8	22.2
2	4	58	14	58	14	80.6	19.4	80.6	19.4
2	5	55	17	55	17	76.4	23.6	76.4	23.6
2	6	35	37	53	19	48.6	51.4	73.6	26.4
2	7	47	25	54	18	65.3	34.7	75.0	25.0
2	8	60	12	58	14	83.3	16.7	80.6	19.4
2	9	65	7	65	7	90.3	9.7	90.3	9.7
3	1	20	52	32	40	27.8	72.2	44.4	55.6
3	2	27	45	38	34	37.5	62.5	52.8	47.2
3	3	17	55	41	31	23.6	76.4	56.9	43.1
3	4	12	60	32	40	16.7	83.3	44.4	55.6
3	5	11	61	34	38	15.3	84.7	47.2	52.8
3	6	14	58	36	36	19.4	80.6	50.0	50.0
3	7	18	54	43	29	25.0	75.0	59.7	40.3
3	8	24	48	45	27	33.3	66.7	62.5	37.5
3	9	19	53	35	37	26.4	73.6	48.6	51.4

Table 11: Choice behavior by role and matching group

Role	Matching Group	No. obs.				Frequency (%)			
		$z=1$		$z=3$		$z=1$		$z=3$	
		X_{rec}	Y_{rec}	X_{rec}	Y_{rec}	X_{rec}	Y_{rec}	X_{rec}	Y_{rec}
1	1	16	18	14	16	88.9	100	77.8	88.9
1	2	16	14	18	16	88.9	77.8	100	88.9
1	3	15	16	15	14	83.3	88.9	83.3	77.8
1	4	18	18	15	15	100	100	83.3	83.3
1	5	8	15	9	16	44.4	83.3	50	88.9
1	6	13	15	16	14	72.2	83.3	88.9	77.8
1	7	13	15	11	17	72.2	83.3	61.1	94.4
1	8	15	17	15	16	83.3	94.4	83.3	88.9
1	9	15	17	13	15	83.3	94.4	72.2	83.3
2	1	15	16	17	17	83.3	88.9	94.4	94.4
2	2	18	16	16	14	100	88.9	88.9	77.8
2	3	16	14	17	15	88.9	77.8	94.4	83.3
2	4	18	12	18	11	100	66.7	100	61.1
2	5	17	14	15	14	94.4	77.8	83.3	77.8
2	6	16	14	18	15	88.9	77.8	100	83.3
2	7	17	15	17	11	94.4	83.3	94.4	61.1
2	8	17	11	17	12	94.4	61.1	94.4	66.7
2	9	18	7	18	7	100	38.9	100	38.9
3	1	17	18	16	18	94.4	100	88.9	100
3	2	15	17	16	18	83.3	94.4	88.9	100
3	3	12	18	16	15	66.7	100	88.9	83.3
3	4	7	18	14	14	38.9	100	77.8	77.8
3	5	9	17	16	15	50	94.4	88.9	83.3
3	6	11	18	17	18	61.1	100	94.4	100
3	7	9	17	15	17	50	94.4	83.3	94.4
3	8	13	18	15	18	72.2	100	83.3	100
3	9	9	17	10	16	50	94.4	55.6	88.9

Table 12: Frequency of compliance with recommendations X_{rec} and Y_{rec}, by matching group

Matching Group	No. obs.				Frequency (%)			
	$z = 1$		$z = 3$		$z = 1$		$z = 3$	
	rec.	no rec.	rec.	no rec.	rec.	no rec.	rec.	no rec.
1	28	11	26	5	77.8	30.6	72.2	13.9
2	24	2	27	4	66.7	5.6	75	11.1
3	22	1	23	11	61.1	2.8	63.9	30.6
4	19	5	19	4	52.8	13.9	52.8	11.1
5	16	3	18	4	44.4	8.3	50	11.1
6	20	19	26	14	55.6	52.8	72.2	38.9
7	18	9	17	8	50	25	47.2	22.2
8	22	7	23	24	61.1	19.4	63.9	66.7
9	15	5	13	15	41.7	13.9	36.1	41.7

Table 13: Frequency of strict equilibrium coordination in first decision, by matching group

Appendix 2

Instruktionen

Herzlich willkommen und vielen Dank für Ihre Bereitschaft, an diesem Experiment teilzunehmen. Bitte lesen Sie diese Instruktionen sorgfältig durch. Von nun an ist jegliche Kommunikation mit anderen Teilnehmern untersagt. Wir bitten Sie, sich auf das Experiment zu konzentrieren. Bei Unklarheiten fragen Sie bitte nicht laut, sondern heben Sie den Arm und warten Sie, bis ein Experimentator zu Ihnen kommt.

Im Experiment werden alle Geldbeträge in Experimental Currency Units (ECU) angegeben. 10 ECU entsprechen dabei 1,00 EUR. Ihr Verdienst plus eine Teilnehmergebühr von 25 ECU (EUR 2,50) werden Ihnen am Ende des Experiments in bar ausgezahlt.

Die Instruktionen sind für alle Teilnehmer identisch. Alle Entscheidungen bleiben anonym, das heisst, Sie erfahren von uns nicht die Identität der anderen Teilnehmer, mit denen Sie interagieren werden.

Sie werden in jeder Runde mit zwei anderen Teilnehmern interagieren: Gruppen von jeweils drei interagierenden Teilnehmern werden in jeder Runde zufällig neu zusammengesetzt. Sie werden also in der Regel von Runde zu Runde mit neuen Teilnehmern interagieren.

Den jeweils drei Teilnehmern werden dann zufällig die Rollen 1, 2 und 3 zugewiesen. In jeder Rolle 1, 2 oder 3 hat man nur die Wahl zwischen einer X- und einer Y-Alternative. Die Auszahlung, die ein Teilnehmer in der zugewiesenen Rolle bekommt, hängt aber nicht nur von seiner eigenen Entscheidung zwischen X und Y ab, sondern auch von den Entscheidungen der beiden anderen Teilnehmer. Diese Abhängigkeit ist in der folgenden Auszahlungstabelle dargestellt:

1 wählt	2 wählt	3 wählt	Geldauszahlung für Rolle 1	Geldauszahlung für Rolle 2	Geldauszahlung für Rolle 3
X	X	X	2	4	z
		Y	3	3	0
	Y	X	0	0	0
		Y	0	0	0
Y	X	X	0	0	0
		Y	0	0	0
	Y	X	4	4	0
		Y	2	2	4

Auszahlungstabelle

Wenn also zum Beispiel die Teilnehmer 1 und 2 ihre Alternative Y wählen, während Teilnehmer 3 sich für Alternative X entscheidet, verdienen die Teilnehmer 1 und 2 jeweils 4 Punkte und Teilnehmer 3 verdient Null Punkte. Wählen hingegen alle drei Teilnehmer die X-Alternative, so verdient Teilnehmer 1 genau 2 Punkte, der Teilnehmer 2 genau 4 Punkte und Teilnehmer 3 genau z Punkte (der Betrag z wird stets positiv sein, aber er kann von Runde zu Runde variieren).

Es gibt Konstellationen der Entscheidungen aller drei Rollen, die eine beträchtliche Attraktivität haben, falls eine solche Konstellation eindeutig von allen drei Entscheidern erwartet und gewählt wird. Falls zum Beispiel alle drei die X-Alternative wählen und das auch allgemein erwartet wird, so würde ein Entscheider verlieren, falls er als einziger Y statt X wählt. Konkret würde die Abweichung eines Einzelnen verursachen, dass er nur Null Punkte verdient statt je nach Rolle 2, 4 bzw. $z(> 0)$ Punkte. Auch wenn sich alle drei für die Y-Alternative entscheiden und dies von allen drei Teilnehmer erwartet wird, würde ein Teilnehmer verlieren, falls er als einziger X statt Y wält. Hier würden Rolle 1 bzw. 2 nur Null statt 2 Punkte verdienen, während Rolle 3 nur Null statt 4 Punkte verdient, falls ein einziger Entscheider X statt Y wählt. Nur Entscheidungkonstellationen gemäß denen alle drei Teilnehmer dieselbe Alternative auswählen (d.h. entweder wählen alle X oder alle wählen Y) ist attraktiv in dem Sinne, dass jeder verliert, falls er als einziger hiervon abweicht.

Um zu ermöglichen, dass alle drei Teilnehmer erwarten, dass alle entweder die generalle Wahl von X oder Y wählen, werden wir zu Beginn jeder Runde eine der beiden folgenden Verhaltensempfehlungen geben:

- X-Empfehlung:

  „Es wird für alle drei Entscheider vorgeschlagen,
  die Alternative X zu wählen."

- Y-Empfehlung:

  „Es wird für alle drei Entscheider vorgeschlagen,
  die Alternative Y zu wählen."

(Natürlich bekommen alle drei Teilnehmer dieselbe Empfehlung. Diese Empfehlung wird abwechselnd X oder Y sein und wird keinerlei von den Teilnehmern selbst beeinflusst.)

Beginnend mit einer X- bzw. Y-Empfehlung wird jede Runde sukzessiv wie folgt ablaufen:

1. Die drei Teilnehmer mit den Rollen 1, 2 und 3 beobachten dieselbe X- oder Y-Empfehlung.

2. Die drei Teilnehmer entscheiden sich in Kenntnis der vorgegebenen Empfehlung für ihre X- oder Y-Alternative, wobei zwei der drei Teilnehmer später die Möglichkeit erhalten, ihre Entscheidung zu revidieren.

3. Einer der drei Teilnehmer wird ausgewählt und auf seine auf Stufe 2 ausgewählte Alternative festgelegt. Diese wird den beiden anderen Teilnehmern mitgeteilt.

4. Die beiden verbleibenden Teilnehmer können nochmals und völlig frei, aber nunmehr endgültig zwischen ihrer X- und Y-Alternative wählen. Hierbei sind sie über die für alle drei Teilnehmer gleiche Verhaltensem-pfehlung sowie über die schon auf Stufe 2 vorgenommene Entscheidung des auf Stufe 4 nicht mehr aktiven Teilnehmers informiert. Es ist mithin auf Stufe 4 möglich, dass keiner, nur einer oder beide der verbleibenden Teilnehmern von ihrer auf Stufe 2 getroffenen Entscheidung abweichen bzw. dieselbe bestätigen.

5. Die drei Teilnehmer werden gemäß der sich letztgültig ergebenen Verhaltenskonstellation bezahlt, d.h. gemäß der auf Stufe 2 getroffenen Entscheidung des (auf Stufe 3) vorzeitig festgelegten Teilnehmers sowie der (auf Stufe 4) endgültigen Entscheidungen der beiden übrigen Teilnehmer.

Danach beginnt eine neue Runde mit einer neu und zufällig zusammengesetzten Gruppe dreier Teilnehmer.

[24 rounds are played]

Instruktionen

Phase 2

Es sei daran erinnert, dass es atraktiv ist, wenn die Teilnehmer einer Gruppe entweder alle X oder Y wählen, da jeder verliert, wenn er als einziger von einer solchen Verhaltenskonstellation abweicht. Bislang wurde Ihnen die Koordination Ihrer Erwartungen, ob nun alle X bzw. Y wählen, durch die Ihnen gegebene X bzw. Y Empfehlung erleichtert. *Diese Empfehlung wird es in den folgenden Runden nicht mehr geben.* Sie müssen in den folgenden Runden also selbst Erwartungen generieren, ob alle Teilnehmer X bzw. Y wählen sollten.

Wie könnte nun ein Kriterium aussehen, gemäß dem alle Teilnehmer in gleicher Weise entscheiden, ob sie alle drei X oder Y wählen sollten? Man könnte möglicherweise darauf abstellen, wieviel jeder verliert, wenn er als einziger von der generellen Wahl von X bzw. Y abweicht. Gemäß der Auszahlungstabelle sind diese Verluste wie folgt:

abweichende	Verlust bei Abweichung, wenn die anderen ...	
Teilnehmer	... X wählen	... Y wählen
1	2	2
2	4	2
3	z	4

Im Lichte dieser Abweichungsverluste könnte z.B. anstreben, dass alle X wählen, wenn das Produkt der individuellen Abweichungsverluste hierbei größer ist als bei Y.

Sie werden in den folgenden Runden wie bisher mit zufällig wächselnden Partnern alternierend für $z = 1$ und $z = 3$ entscheiden müssen, wobei jedoch keine Empfehlung vorgegeben ist. Bitte melden Sie sich per Handzeichen, falls Ihnen unklar ist, was sich in dieser neuen Phase des Experiments geändert hat. Alle öffentlichen Verlautbarungen und Fragen sind zu unterlassen.