# Do All "Bad" Apples Taste the Same? Experimental Analysis of Heterogeneity in Local Public Good Provision

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**Abstract**

In a circular neighborhood, each member contributes repeatedly to two local public goods with the left and the right neighbor. All two-person public good games are structurally independent in spite of their overlapping player sets. Heterogeneity across neighbors is introduced by two randomly selected participants, the "Bad" Apples, either by being less productive or by being excluded from periodic information feedback about their neighbors' contributions. We study how "Bad" Apples affect their neighbors and through them also other group members. Both types of "Bad" Apples spoil the basket, reducing total voluntary contributions compared to a baseline with no "Bad" Apples. Furthermore, we find that "Bad" Apples not only affects their direct neighbors, but also, through behavioral spillovers, the whole neighborhood. However, the two types of "Bad" Apples affect their neighborhood in opposite ways. Whereas less productive "Bad" Apples are least cooperative, "Bad" Apples excluded from feedback information are most cooperative. In the latter case, the reduction of total contributions is caused by the direct neighbors of "Bad" Apples.

**Keywords**: Public goods, behavioral spillovers, experiments, voluntary contribution mechanism, heterogeneity.

**JEL**: C91, C72, H41

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# 1 Introduction

Compared to the field where heterogeneity prevails nearly exclusively, in the experimental economics, psychology and related fields symmetry and homogeneity are encountered surprisingly often. From a methodological point of view, this allows to attribute heterogeneity to idiosyncratic characteristics. Another advantage is that this simplifies the experimental design and reduces the cognitive demand for participants. However, excluding asymmetry or, more generally, heterogeneity, also risks to neglect important aspects of human interaction, for example, how they react to randomly assigned asymmetric roles.[1] It is therefore of interest to analyze how introducing heterogeneity and asymmetry affects social interactions, both in sign and magnitude. A minor deviation from homogeneity, namely by only one member of a possibly large group, can affect the whole group by becoming less cooperative, as effectively synthesized by the metaphor that "one Bad Apple spoils the whole lot".

Our experimental setup is based on structurally independent two-person public games with overlapping player sets in a circular neighborhood. Each member interacts with the left and the right neighbor by choosing two contributions, one for the public good shared with the left, respectively right neighbor. Structural independence on local games may not, however, imply their behavioral independence: subjects often try to align their left and right hand contributions which we describe as intra-personal spillovers. If such intra-personal spillovers also apply to one's neighbors, similar degrees of voluntary cooperation arise via inter-personal spillovers, i. e. inter-personal behavioral spillovers presuppose intra-personal ones. The overall, intra- and inter-personal behavioral interdependence is referred to as purely behavioral spillovers.

Angelovski et al. (2016), in a more homogeneous setup, experimentally confirm such purely behavioral spillovers,[2] focussing on a circular neighborhood with eight members who each plays two structurally independent local public good games with different freeriding incentives in the

[1]Since random role assignement questions entitlement (see Hoffman and Spiter, 1985), participants may abstain from exploiting the chances which their roles provide.

[2]While there exists ample evidence that individuals respond to others' behavior in social interactions (social interaction effects have been analyzed in a variety of social science fields, e.g., by Chartrand and Bargh (1999); Cooper and Rege, (2008); Hong et al. (2004); Falk and Ichino (2006); Topa (2001)), the analysis of behavioral spillovers across structurally independent interactions is still limited.

left and right interaction. Participants do not behave as if playing two separate public good games, with the consequence that the neighborhood evolves as a whole. Moreover, asymmetry in productivities (different Marginal Per Capita Return, MPCR hereafter, in the left and in the right public good game) enhances and stabilizes contributions over time.

The present study introducs additional heterogeneity in this setting by two randomly selected participants, the "Bad" Apples, either being less productive ("productivity gap") or excluded from periodic information feedback about their neighbors' contributions ("information gap"). We try to understand how via intra- and interpersonal spillovers such heterogeneity affects the entire society, i.e. via experimentally implemented constantly interacting group members.[3]. Moreover, we compare how different kinds of heterogeneity influence contributions and then behavioral spillovers.

Both type of "handicaps" are frequent in many collective action tasks like private or commercial endeavors, voluntary contributions to promote the social and natural environment, etc. and both could increase freeriding and thus question voluntary cooperation. Lower productivity in linear public good games is quite generally associated to lower average contributions.[4] Similarly, remaining uninformed about what others contributed and earned renders conditional cooperation impossible and might trigger persistent freeriding.[5] While "Bad" Apples may still decide to cooperate when anticipating that their direct neighbors are conditional cooperators, in both cases they risk becoming "money pumps" for their direct neighbors when contributing.

Considering the asymmetric treatment of Angelovski et al. (2016) as our baseline treatment (with a MPCR of 0.6 on the left side and of 0.8 on the right side for all subjects) we investigate the effects of heterogeneity across members by analyzing and comparing their left and right contributions when interacting repeatedly. Compared to the baseline treatment, the "productivity gap" treatments (hereafter PROD) reduce "Bad"Apples' MPCR to 0.4 on the left and to 0.6 on the right side. The "information gap" treatments (hereafter INFO) maintain the MPCRs of the base-

[3]This kind of heterogeneity differs from that more often adopted in the literature on public goods based on self-sorting, for example when subjects are categorized as free riders, cooperators and conditional cooperators and so on (see as examples Fischbacher et al. (2010), Burlando and Guala (2005), Carpenter (2004) and also, as will be explained more in details hereafter de Oliveira et al. (2015) with whom we share some aspects.

[4]See, e.g., Ledyard (1995) and Chaudhuri (2011).

[5]For evidence on how different information affects contributions to public goods, see Sell and Wilson (1991), Neugebauer et al. (2009), Nikiforakis (2010), Bigoni and Suetens (2010), Grechenig et al. (2010) and Chaudhuri and Paichayontvijit (2010).

line treatment but exclude “Bad” Apples from feedback information about past contributions by their direct neighbors as well as about their own payoff. Both PROD and INFO are implemented between subjects.

Why do we compare two different “Bad” Apple types, one being less productive and one excluded from periodic information feedback but as productive as other society members? “Bad” Apples without periodic information feedback do not allow for behavioral spillovers to pass through them and therefore question, like an “Iron Curtain”, that purely behavioral spillovers affect the whole neighborhood. “Bad” Apples with lower MPCR as such do not hinder the behavioral spillovers, but they may weaken them. Both effects could be reinforced by positioning the two “Bad” Apples most distantly from each-other or directly next to each-other. Actually, two directly interacting “Bad” Apples may be interpreted as one bigger “Bad” Apple, which in the PROD condition additionally allows us to analyze how two “Bad” Apples directly interact. Two distant “Bad” Apples hopefully allows to assess their idiosyncratic different spillover effects.

Similarly to de Oliveira et al. (2015), who investigate how “one bad apple spoils the basket” namely voluntary cooperation of the group, we try to answer the same question by enriching the otherwise homogeneous circular neighborhood of Angelovski et al. (2016) by introducing two heterogeneous members, i.e. two “Bad” Apples.[6] Similarly to Chaudhuri and Paichayontvijit (2010), in the INFO treatments we manipulates feedback information on other members’ contribution to the public good.[7]

Differently from de Oliveira et al. (2015), not all group members are directly in contact with the “Bad” Apples. Another difference, is that de Oliveira et al. (2015) distinguish Bad Apples as poor performers in a pretest, while we experimentally induce “Bad” Apples by lowering their productivity compared to other members or by excluding them from information feedback. Whereas de Oliveira et al. (2015) vary awareness via treatments with and without information

[6] Although one of the main messages is that not all “Bad” Apples taste the same, hereafter we refer to them as “Bad” Apples even when they are not behaving “badly”.

[7] The neighborhood with eight members, each playing two independent 2-person public good games with her direct neighbors, is admittedly stylized and appeals to a circular road. It has the advantage of being easily understood by participants who confront the (compared to Angelovski et al., 2016) additional complexity of two “Bad” Apples and it is worth to investigate not only how “Bad” Apples behave but also how other group members react to different “Bad” Apples.

about the existence of “Bad” Apples, we always induce an awareness that two “Bad” Apples are present, but their exact position in the circular neighborhood is never disclosed.

Our treatments vary in two dimensions, the type of “Bad” Apples and the sequence of their distance (increasing vs. decreasing). With this setting we hope to answer questions like:

- Will the neighborhood evolve as a whole even in presence of “Bad” Apples?
- Will “Bad” Apples without feedback information differ in behavior and behavioral spillovers from “Bad” Apples with lower productivity?
- Will “Bad” Apples trigger different attitudes of the other group members, given that they are aware that they exist but not of their exact location?
- How does voluntary cooperation and its dynamics depend on distance between “Bad” Apples in the neighborhood?

Finally let us point out that metaphors like those of “Bad Apples in basket”may be catchy but also problematic. Neither a circular neighborhood nor a multi-person social dilemma (public goods or Prisoners’ Dilemma) game captures how apples are stored in a basket nor how many of them are rotten. Furthermore, apples are not aware that other apples may be rotten whereas our participants are fully aware of their existence, but not their position. Thus a regular society member, suspecting one direct neighbor to be a less productive “Bad” Apple, may excuse this neighbor’s freeriding as due to stronger freeriding incentives. Similarly, a regular group member, suspecting one direct neighbor to remain uninformed, may try to exploit this neighbor, hoping that this remains unnoticed. Such awareness effects do not exist for apples in baskets but can be crucial when applying the metaphor to human interactions. Furthermore, by allowing for only bilateral and structurally independent interactions, we do allow one side of an apple to be rotten while the other remains healthy.

The paper is organized as follows: Section 2 includes a brief review of literature; Section 3 illustrates the experimental design and Section 4 presents and discusses the main results. We conclude in Section 6 with summary remarks and interpretations. The Appendix includes additional data analysis and the translated instructions of the experiment.

## 2 On the literature

Our study shares several features with other studies on heterogeneity effects of group members and information feedback on group performance and dynamics, but also differs in important others. Our focus on purely behavioral spillover effects across the circular neighborhood due to close or distant "Bad" Apples of different types can be related to evolutionary studies of how the population composition evolves (e.g. Myatt and Wallace, 2008, for a public good game and Eshel et al., 1998, based on a circular neighborhood whose members can behave either pro-socially or opportunistically). As in our setup, the experimental study of Mäs and Nax (2016) assumes a circular network but relies on coordination games with multiple equilibria and mainly investigates whether more costly deviations from a certain equilibrium are less likely. Carpenter (2004) developed a model in which the initial number of type (free riders) affects the growth of freeriding. The review by Felps et al. (2006) considers mainly teamwork, e.g. in commercial enterprises and related organizations, and distinguishes three categories of behavior likely to "spoil the basket": withholding effort (similar to low contributions by PROD group members), being effectively negative (excluded by anonymous interaction in our setup) and violating interpersonal norms; the latter could apply to INFO "Bad" Apples, who fail to reciprocate. Once again in our setup "Bad" Apples' existence and type is commonly known so that other group members may not find violating the reciprocity norm as irritating as when not aware that two group members cannot possibly reciprocate. Moreover, whereas Felps et al. (2006) generally allude to true "bad apples" we investigate heterogeneous groups with two handicapped members without presupposing that handicaps necessarily imply worse behavior. Although according to our data groups with "Bad"Apples altogether fare worse than those without, this can occur even when "Bad"Apples themselves are most cooperative.

Like other studies, reviewed by Felps et al.(2006), we also investigate how other group members react to "Bad"Apples. Actually, in our neighborhood setup there is also heterogeneity in the other group members, namely direct neighbors of "Bad"Apples and more distant group members who do not interact with "Bad"Apples (indirect neighbors). Since we only allow reactions via contribution choices which, furthermore, only affect direct neighbors, reactions like "revenge" can be directly inflicted only on direct neighbors. Altogether Felps et al. (2006) surveys research on groups whose members work together and interact socially whereas we focus on groups whose members interact locally. Grund et al. (2016) present the metaphor of "Bad" Apples in a framing that distinguishes "Bad" Apples as (randomly) migrating individuals across otherwise constant neighborhoods, similar to rented labor in production firms with mainly long-term employees. One finding is that two temporary strangers in an otherwise constant group contribute significantly less. Regarding asymmetry and heterogeneity in productivity, Reuben and Riedl (2009) investigate public-good provision in normal and privileged groups (who have a higher MPCR) and find that the latter are relatively ineffective in using costly sanctions to increase everyone's contributions, showing that privileged groups may not be as privileged as they initially seem.

Regarding information feedback there exists broad literature which analyzes the effects of path dependence, possibly sanctioning or conditionally cooperating, for both homogeneous and heterogeneous groups. For example, Nikiforakis (2010) showed that the feedback format acts as a coordination device and influences the contribution standards which evolve, even though these do not affect incentives. Grechenig et al. (2010) analyze situations with uncertainty about the behavior of the others. Their findings suggest that sufficient information accuracy is crucial for the efficient sanctioning and conclude that when information is inaccurate, precluding sanctions is likely to be optimal. Bigoni and Suetens (2010) report effects of providing additional feedback about individual contributions on the dynamics of contributions in a repeated public good game and find that aggregate contributions decline slower when additional information is provided but also substantial differences across individuals. Chaudhuri and Paichayontvijit (2010) investigate the effect of feedback manipulations in a public good game and classify participants on the basis of their prior belief about others' contributions. To the best of our knowledge none of these studies has looked at public good games with only some group members being excluded from information feedback, but being always aware about the type of "Bad" Apples in their neighborhood but not of their position.

# 3 The experimental design

Participants form a circular neighborhood with eight members. Each player $i = 1, .., 8$ is assigned to two linear public good games, one with the left direct neighbor $i - 1$ (where $i - 1 = 8$ for $i = 1$) and one with the right direct neighbor $i + 1$ (where $i + 1 = 1$ for $i = 8$). Figure 1 locates participant $i$ at the bottom of the circular neighborhood.

For $i = 1, ..., 8$, let $c_i^L$ and $c_i^R$ denote $i$'s left, respectively right, contribution. We restrict $c_i^L$ and $c_i^R$ to integers $(0, 1, ..., 9)$. Individual payoffs are

$$2E - c_i^L - c_i^R + \alpha(c_i^L + c_{i-1}^R) + \beta(c_i^R + c_{i+1}^L) \qquad for \quad i = 1, ..., 8. \tag{1}$$

$E = 9$ is the initial endowment per period and per public good game (on either side), MPCR $\alpha$ applies to $i$'s left game, whose public good level is $c_i^L + c_{i-1}^R$, and $\beta$ to $i$'s right game whith public good level $c_i^R + c_{i+1}^L$. In the baseline treatment, i.e. the asymmetric treatment of Angelovski et al. (2016), $\alpha$ is 0.6 and $\beta$ is 0.8.

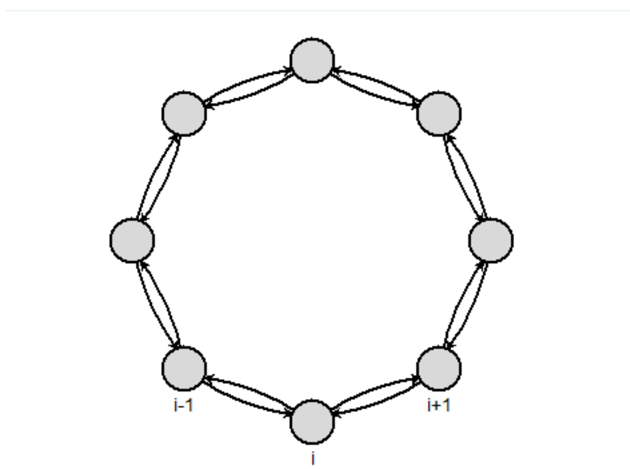


Figure 1: Circular neighborhood with the representative member $i$ at the bottom

When "Bad" Apples have a lower MPCR (PROD treatments), their $\alpha$ is 0.4 and their $\beta$ is 0.6. Thus "Bad" Apples $i$ earn:

$$2E - c_i^L - c_i^R + 0.4(c_i^L + c_{i-1}^R) + 0.6(c_i^R + c_{i+1}^L) \tag{2}$$

while the payoff of other group members $i$ is:

$$2E - c_i^L - c_i^R + 0.6(c_i^L + c_{i-1}^R) + 0.8(c_i^R + c_{i+1}^L) \tag{3}$$

When “Bad” Apples are experimentally induced via no feedback information (INFO treatments), all group members have the same (asymmetric) MPCR structure as the baseline treatment ($\alpha = 0.6$ and $\beta = 0.8$) and payoffs as in (3). There are never efficiency losses from voluntary contributing by both, “Bad” Apples and other members, but freeriding incentives vary between the left and right side for PROD “Bad” Apples.

Subjects play four supergames with random but commonly known finite horizons of either eight (with probability 1/3) or sixteen periods (with probability 2/3). The actual horizon is randomly determined by the computer after the eighth period. Subjects contribute to both, left side and right side public good in every period. Their position is randomly reshuffled after every supergame such that at least one direct neighbor is new.

At the beginning of every supergame the computer randomly selects two members as “Bad” Apples, who are located either next to each other or at maximal distance (see Figure 2) and are informed about their handicap – either lower MPCR or no information feedback, but not about their relative distance. The other members of the neighborhood know about the two “Bad” Apples, their handicap but not their relative distance. Subjects are never informed about the nature of their own neighbors but may, of course, infer it when receiving information about past play.

“Bad” Apples’ distance is held constant for two successive supergames and then changed for the remainig two. We distinguish (within-subjects) an increasing sequence (“Bad” Apples are direct neighbors in the first two supergames and distant in the last two) and a decreasing sequence (“Bad” Apples are distant in the first two supergames and direct neighbors in the last two).

Summing up, our four treatments vary in two dimensions: the “Bad”Apples’ type (PROD and INFO) and “Bad”Apples distance (+ for increasing distance and – for decreasing distance, see Table 1). These treatments are be compared with the asymmetric treatment of Angelovski et al. (2016) without “Bad” Apples.

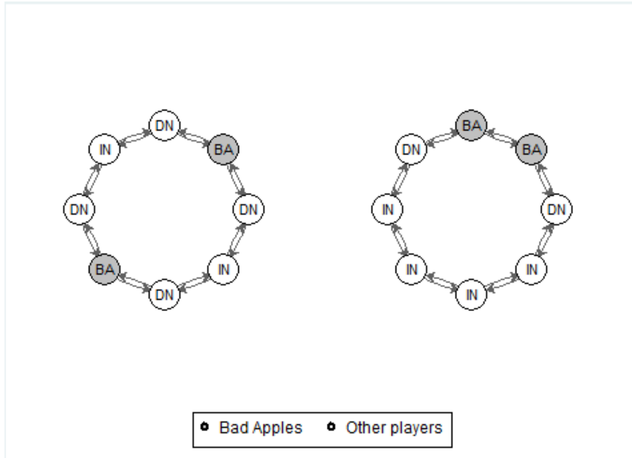


Figure 2: The distance variation of "Bad" Apples. We split group members in three types: "Bad"Apples (BA), their direct neighbors (DN) and the indirect neighbors (IN)

| | | "Bad" Apples' gap | |
|---|---|---|---|
| | | Productivity gap | Information gap |
| Distance | Increasing | PROD + | INFO + |
| | Decreasing | PROD - | INFO - |
| Baseline treatment | | no "Bad" Apples | |

Table 1: 2 × 2−factorial treatment design and the baseline treatment

The experiment was run at CESARE lab at Luiss Guido Carli (Rome, IT) with 272 subjects participating in the four treatments, divided into 34 groups of 8 participants each. No subject participated in more than one session. An experimental session included two or three such groups. The average earning was 20€. The baseline treatment employed 96 subjects, divided in 12 groups of 8. The experiment was conducted using Z-Tree (Fischbacher, 2007) and we used Orsee (Greiner, 2015) for recruitment of participants.

# 4 Results

By investigating the contribution behavior let us try to answer to the following research questions:

($i$) Do "Bad" Apples have a negative impact on voluntary contribution, i.e. do they "spoil the basket"?

($ii$) Are there behavioral spillovers, even in presence of "Bad" Apples? Do PROD and INFO

"Bad" Apples behave differently?

Table 2 reports average individual contributions to the public good (left and right side pooled) in comparison with the baseline treatment without "Bad" Apples and shows that, irrespective of handicap type (PROD and INFO) and distance sequence (increasing vs. decreasing), average contributions are persistently (across supergames) lower than in the baseline and that average contributions are significantly lower in both treatments than in baseline (2.81 in PROD and 2.748 in INFO versus 3.478 in baseline). Sequence (increasing versus decreasing) reveals the same pattern with a greater reduction in contribution in decreasing INFO treatments and a lower in decreasing PROD, compared to the baseline. This confirms that "Bad" Apples spoil the basket.

| | Baseline | PROD | INFO | PROD + | PROD - | INFO + | INFO - |
|---|---|---|---|---|---|---|---|
| Averages: | 3.478 | 2.861 | 2.748 | 2.742 | 3.000 | 2.883 | 2.614 |
| Difference: | | -0.617*** | -0.730*** | -0.736*** | -0.478*** | -0.596*** | -0.865*** |
| P - value: | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Periods 1 to 4 | 3.871 | 3.499 | 3.234 | 3.375 | 3.639 | 3.384 | 3.101 |
| | | -0.371*** | -0.637*** | -0.496*** | -0.231*** | -0.487*** | -0.769*** |
| | | (0.000) | (0.000) | (0.000) | (0.001) | (0.000) | (0.000) |
| Periods 5 to 8 | 3.340 | 2.895 | 2.795 | 2.725 | 3.056 | 2.965 | 2.644 |
| | | -0.505*** | -0.605*** | -0.674*** | -0.314*** | -0.434*** | -0.756*** |
| | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Periods 9 to 12 | 3.492 | 2.485 | 2.449 | 2.380 | 2.616 | 2.609 | 2.253 |
| | | -1.007*** | -1.043*** | -1.112*** | -0.874*** | -0.882*** | -1.239*** |
| | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Periods 13 to 16 | 2.862 | 2.174 | 2.141 | 2.182 | 2.163 | 2.307 | 1.939 |
| | | -0.688*** | -0.720*** | -0.680*** | -0.699*** | -0.555*** | -0.923*** |
| | | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |

Table 2: Average contributions by treatment and difference from the baseline treatment (p-values in parenthesis for two-independent sample t tests)

Finding 1: Irrespective of handicap type (PROD, INFO) and distance sequence (+, −), average contributions with "Bad" Apples are lower than in baseline (at $p < 1\%$ level), what persists across periods.

Further indirect evidence of this effect is provided by Tables 9 and 10 in the appendix. Table 9 shows that even when you take away the contributions from public good games in which the bad apples are involved in, the remaining contributions are still significantly lower than the baseline treatment. This result takes the notion of "spoiling the basket" a step further from what previous studies have done by confirming that the basket isn't spoiled only through conditional cooperation. It proves that the negative behavior spreads, through behavioral spillovers, to parts of the society in which no "Bad" Apples are present. Table 10 shows that initial contributions (first period of first supergame) in PROD and INFO do not differ significantly from baseline. To confirm that "Bad" Apples influence behavior of the others independently of their own behavior, the lower part of Table 10 reports average contributions in period one of supergame one when excluding the public good games in which BA were involved, and confirms that they are also not significant from the baseline. This further indicates that the difference in contributions from the baseline (d)evolves dynamically over time due to behavioral spillovers, and is not solely due to the knowledge of "Bad" Apples being present.

Therefore neighborhood with "Bad" Apples are indeed spoilt. But is that due to "Bad" Apples? More specifically, are "Bad" Apples freeriding and causing negative behavioral spillovers? Let us investigate "Bad" Apples' choices and, since intra-personal spillovers are a precondition of inter-personal ones, verify if individual contributions on either side are influenced by past contributions of direct neighbors on the opposite side. Table 3 reports the results of this analysis through a panel tobit regression of left-hand side and righ-hand side contributions showing that in PROD and INFO individual contributions are affected not only by past contributions of direct neighbors on the same side, but also by past contributions of direct neighbors on the other side.[8] More specifically, the effect of one-period lagged left neighbor contribution (labelled L neighbor $(t-1)$) and of one-period lagged right neighbor contribution (labelled R neighbor $(t-1)$) on the current own right, respectively left, contribution is statistically significant. Even though one's left and right game with the respective neighbor are structurally independent, they are behaviorally linked due to intra-personal behavioral spillovers as participants correlate how they play their two games.

Finding 2: In a neighborhood with "Bad" Apples intra-personal spillovers exist in both PROD

[8]The difference in observations is due to the random horizon rule, which implied that subjects played less often for sixteen periods in the treatment INFO.

and INFO treatments.

| | Left contributions at time $t$ | | | Right contributions at time $t$ | | |
|---|---|---|---|---|---|---|
| | Baseline | PROD | INFO | Baseline | PROD | INFO |
| Left contribution $(t-1)$ | 0.511*** | 0.533*** | 0.514*** | | | |
| | (0.021) | (0.017) | (0.017) | | | |
| Right contribution $(t-1)$ | | | | 0.547*** | 0.577*** | 0.571*** |
| | | | | (0.020) | (0.017) | (0.016) |
| Supergame | -0.078* | -0.301*** | -0.404*** | -0.197*** | -0.247*** | -0.379*** |
| | (0.044) | (0.036) | (0.033) | (0.044) | (0.037) | (0.034) |
| Period | -0.076*** | -0.079*** | -0.051*** | -0.076*** | -0.072*** | -0.059*** |
| | (0.011) | (0.009) | (0.008) | (0.011) | (0.009) | (0.008) |
| L neighbor $(t-1)$ | 0.308*** | 0.287*** | 0.181*** | 0.051*** | 0.073*** | 0.054*** |
| | (0.018) | (0.015) | (0.014) | (0.017) | (0.015) | (0.014) |
| R neighbor $(t-1)$ | 0.083*** | 0.044*** | 0.048*** | 0.374*** | 0.339*** | 0.189*** |
| | (0.018) | (0.015) | (0.015) | (0.019) | (0.016) | (0.015) |
| **Ref. Category: indirect neighbors (IN)** | | | | | | |
| “Bad” Apples (BA) | | -0.612*** | 0.390*** | | -0.598*** | 0.534*** |
| | | (0.115) | (0.097) | | (0.118) | (0.100) |
| Direct neighbors of BA (DN) | | -0.070 | -0.116 | | -0.232** | 0.055 |
| | | (0.099) | (0.084) | | (0.101) | (0.086) |
| Observations | 4288 | 6560 | 6365 | 4288 | 6560 | 6365 |
| Subjects | 96 | 136 | 136 | 96 | 136 | 136 |

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 3: Panel tobit regression of left-hand side and right-hand side contributions

Table 3 also reveals decay across supergames and periods (in line with the standard decay pattern of repeated public goods experiments) as well as path dependence of both, left and right side contributions (since current contributions are positively affected by one-period lagged own contributions on the same side). More importantly, it shows that on both sides “Bad” Apples are significantly less cooperative than other members in PROD whereas they are most cooperative in INFO. In the former case, the average contributions are lower than in baseline, in the latter they are higher on both sides.

Finding 3: In PROD “Bad” Apples are actual “bad” contributors whereas they are the highest contributors in INFO.

The different behavior of “Bad” Apples types, in spite of generally spoiling the basket (Finding 1), can be explained when investigating the contribution behavior of their (in)direct neighbors.

Let us analyze the contribution choices of different neighborhood members, namely "Bad" Apples (BA) and their neighbors, where we distinguish direct neighbors (DN) and indirect neighbors (IN).[9] Since extending the analysis of behavioral spillovers and path dependence to all member types (see Table 11 in Appendix) confirms the respective findings, we try to answer to the following further questions:

(*i*) Do BA's behave differently from DN, DN from IN and BA from IN?

(*ii*) How do such differences depend on whether the two BA are close or far apart?

(*iii*) Do "Bad" Apples with lower productivity differ from those without feedback information?

(*iv*) Do supergame, period, "Bad" Apples' distance, and its sequence affect the whole neighborhood?

Table 4 compares the contribution of "Bad" Apples (BA), their direct (DN) and indirect neighbors (IN) in PROD and INFO: "Bad" Apples behave differently in the two treatments and contribute significantly less in PROD and more in INFO. Specifically, PROD "Bad" Apples are lowest contributors (2.221), followed by their direct (2.767) and indirect neighbors (3.379). This mainly question voluntary cooperation of direct neighbors (DN) whereas indirect neighbors (IN) have the highest contributions in PROD. In INFO "Bad" Apples are the highest contributors and their direct neighbors (DN) are the lowest contributors.

Apparently, being less productive first prompts "Bad" Apples to free-ride what affects their direct neighbors and via intra-personal spillovers also indirect neighbors, although their average contributions do not significantly differ from baseline. In contrast, blind "Bad" Apples are more cooperative than the less productive ones which renders them exploitable and actually exploited by their direct neighbors (DN) with the lowest average contribution (2.578). Via behavioral spillovers also the indirect neighbors (IN) contribute significantly less than BA (2.744 vs. 3.012) in INFO.[10]

[9]Recall that, when "Bad" Apples are next to each other, there exist two direct and four indirect neighbors, whereas, when "Bad" Apples are far apart, there are four direct and two indirect neighbors (see Figure 2)

[10]The opposite effect, negative for PROD and positive for INFO treatments, can be also confirmed separately for Left and Right contributions of BA and DN, when compared to baseline contributions of IN group members (see Table 11 in the Appendix).

The average contribution of IN in PROD is highest (and does not differ much from baseline) what is in line with spillover dynamics in this treatment. The low DN and IN contributions in INFO seem to indicate possible "Iron Curtain" effects of "Bad" Apples. Altogether presence and awareness of "Bad" Apples always spoils the basket but the process leading to this is very different. Figure 3 compares the dynamics of average contributions (across sequence, left and right contributions, and supergames) in PROD, INFO and baseline (without BA) what illustrates that DN and IN contribution dynamics differ more (are more condensed) between types in PROD (INFO) treatments. However, it reveals contribution decays for all group member types.

| | PROD | INFO |
|---|---|---|
| "Bad" Apples (BA) | 2.221 | 3.012 |
| Direct Neighbors (DN) | 2.767 | 2.578 |
| Indirect Neighbors (IN) | 3.379 | 2.744 |
| Total | 2.861 | 2.748 |

Table 4: Average contributions by treatment type and member type

Summing up, there is a distinct difference in behavior between PROD and INFO neighborhoods. Whereas BA are and remain throughout all periods the lowest contributors in PROD (followed by their direct neighbors and then by their indirect neighbors), in INFO their contributions are and remain highest across all periods (with their direct neighbors contributing the least). Therefore the INFO "spoiling the basket" is triggered by the direct neighbors (DN) who suspect a BA neighbor and try to exploit this neighbor what via spillovers also infects indirect neighbors, IN, and possibly the whole neighborhood. Figure 3 also reveals higher (lower) variability in contributions across group member types in PROD (INFO) treatments.

Let us categorize participants into broad groups (high vs. low contributors) and analyze how many subjects of each type (BA, DN, and IN) qualify as low or high contributors.[11] Low (high) contributors are subjects whose sum of left and right contributions is on average 4 tokens or less (14 or more) across all periods. Table 5 lists the percentage shares of low and high contributors for all three group member types (BA, DN, and IN), separately for both BA types.

[11] We excluded periods 8 and 16 to avoid possible end-game effects.

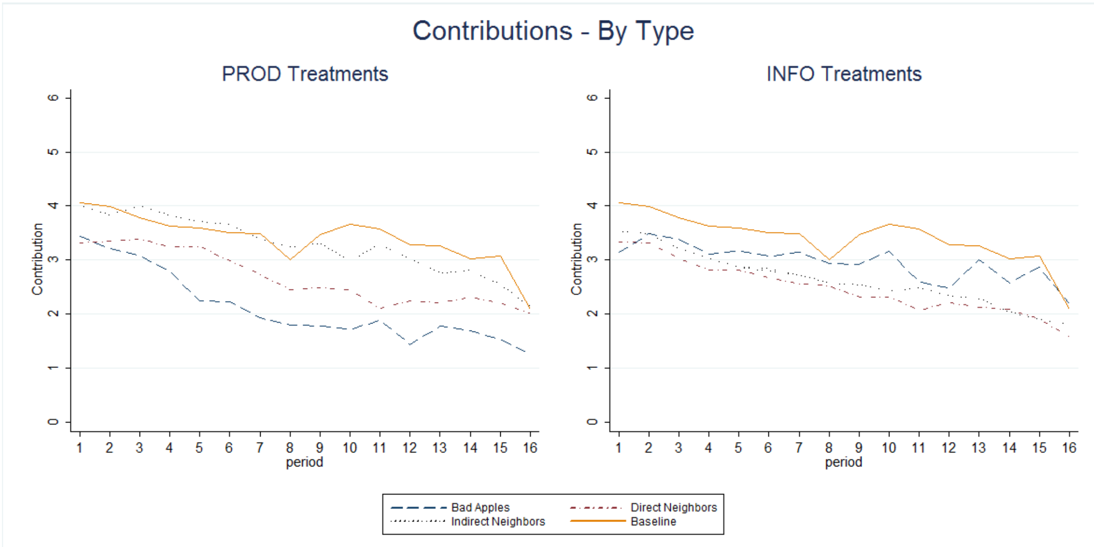


Figure 3: Contribution dynamics in the PROD (left panel) and INFO (right panel) treatments vs. the baseline treatment

<u>Finding 5</u>: Direct neighbors (DN) of "Bad" Apples constitute a large low contributor share and a small high contributor share in both PROD and INFO (41% and 39%, resp. 17% and 12%). In PROD, direct neighbors reciprocate low contributions of "Bad" Apples, while in INFO treatments they seem to exploit "Bad" Apples.

| | Low contributors | | High contributors | |
|---|---|---|---|---|
| | PROD | INFO | PROD | INFO |
| "Bad" Apples (BA) | 0.34 | 0.22 | 0.17 | 0.38 |
| Direct Neighbors (DN) | 0.41 | 0.39 | 0.17 | 0.12 |
| Indirect Neighbors (IN) | 0.25 | 0.39 | 0.66 | 0.50 |
| TOTAL | 100% | 100% | 100% | 100% |

Table 5: Shares of BA, DN and IN within low (left panel) and high (right panel) contributors

Thus the high contributing group members are typically either "Bad" Apples or indirect neighbors, revealing that "Bad" Apples are only really bad only in PROD whereas direct neighbors (DN) are bad in both conditions, PROD and INFO. The fact that for indirect neighbors there are no great differences in low and high contributing shares between treatments (PROD and INFO) reveals that behavioral spillovers due to BA fade out as the distance from them increases.

Table 6 reports the results of a multilevel regression on how contributions depend on own and neighbors' types. Using contributions from indirect neighbors (IN) to direct neighbors (DN) as the reference category, the average contributions of BA to BA is lower in PROD and higher in INFO. The same pattern occurs when BA contributes to DN: it seems that BA in INFO treatments trust blindly that direct neighbors will not exploit them. Further, in INFO treatments direct neighbors contribute less to indirect ones (IN) than they receive from them what is in line with intra-personal spillovers (of bad behavior). So DN members also exploit IN members and ultimately spoil the basket via intra- and interpersonal spillovers. Controlling for period and supergame confirms that contributions decrease over time in both treatments. The Right dummy variable captures the significantly positive effect of higher productivity (MPCR) in one's right game what proves participants fully understand and react to freeriding incentives.

| | PROD | INFO |
|---|---|---|
| **Ref. Category: IN to DN** | | |
| BA to BA | -1.032*** | 0.310*** |
| | (0.097) | (0.092) |
| BA to DN | -0.756*** | 0.240*** |
| | (0.071) | (0.068) |
| DN to BA | -0.424*** | -0.177*** |
| | (0.069) | (0.065) |
| DN to IN | -0.024 | -0.149** |
| | (0.069) | (0.065) |
| IN to IN | 0.208*** | -0.183*** |
| | (0.066) | (0.066) |
| Supergame 2 | -0.840*** | -0.655*** |
| | (0.055) | (0.053) |
| Supergame 3 | -1.172*** | -1.173*** |
| | (0.055) | (0.054) |
| Supergame 4 | -1.360*** | -1.661*** |
| | (0.056) | (0.051) |
| Period | -0.103*** | -0.070*** |
| | (0.004) | (0.004) |
| Right | 0.353*** | 0.411*** |
| | (0.038) | (0.036) |

Table 6: Multilevel regression on individual contribution

Figure 4 illustrates the distance effect of "Bad" Apples on the average contribution dynamics for all group members types in PROD and INFO separately for near and distant "Bad" Apples. Results drawn from this descriptive analysis are statistically confirmed via the econometric analysis reported in Table 7.

In PROD treatments "Bad" Apples perform worse when they are next to each other; direct neighbors do not seem affected by the distance between BA while indirect neighbors' contributions are higher when BA are close. In INFO "Bad" Apples' contributions are unaffected by their distance, which is due to their inability to reciprocate and to infer their neighbor's type. Contributions of direct neigbhors is the lowest in both cases (BA at maximum vs. minimum distance). Altogether, in INFO one should rather speak of "Bad" Neighbors than of "Bad" Apples.[12]

[12]Note also that, in the presence of BA, both Figure 3 and 4 reveal a less pronounced restart effect when participants learn that the supergame will continue in period 9.

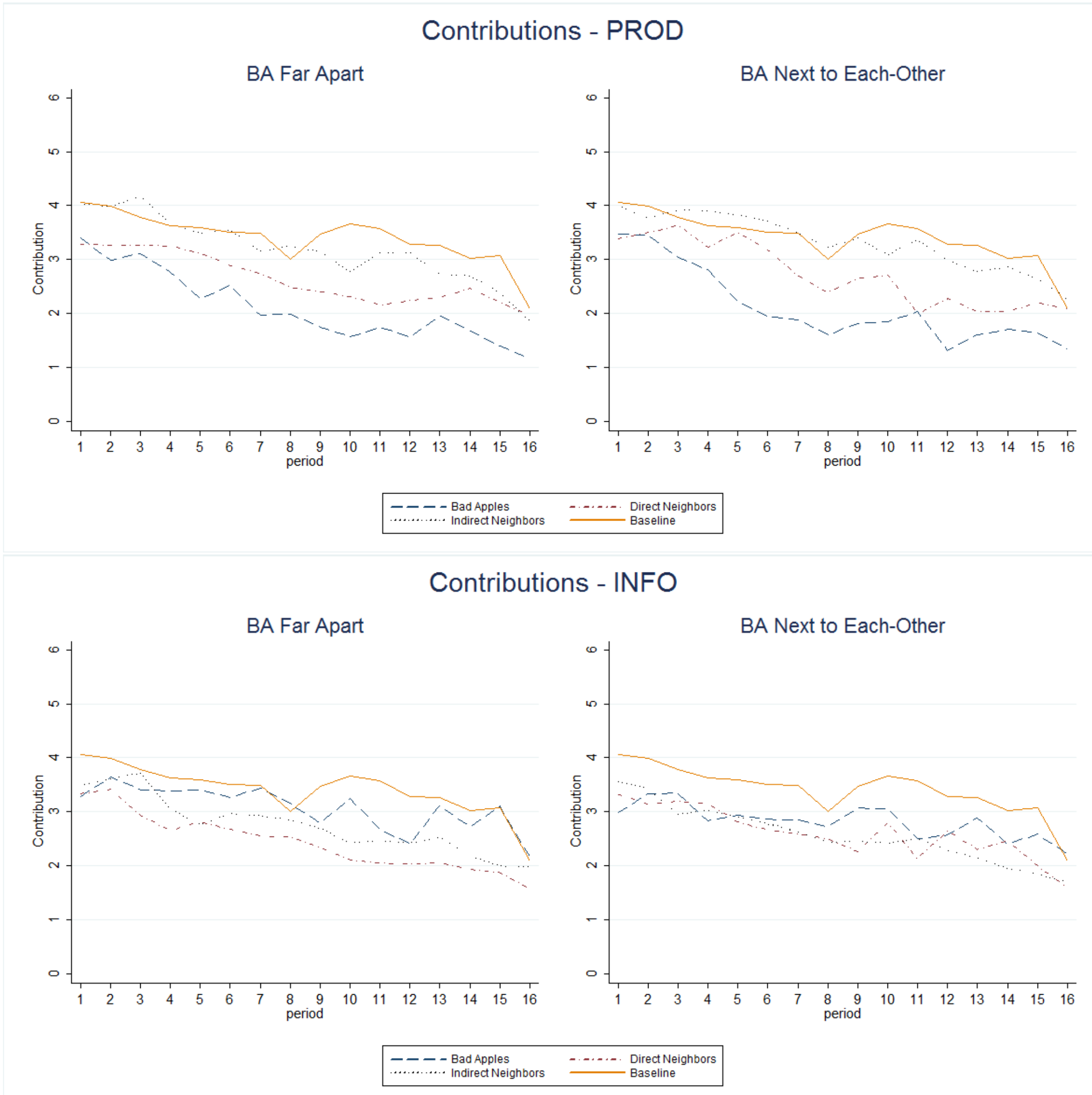


Figure 4: Average contributions across periods when “Bad” Apples are at the maximum (left panel) and minimum (right panel) distance in PROD (above panel) and INFO (below panel) treatments

Since distance between “Bad” Apples seems to matter, Table 7 presents a regression analysis on PROD and INFO average contributions by BA, DN and IN using as explanatory variables (apart from supergame and period dummies), “Bad” Apples’ distance (1 if close, 0 if distant) and distance sequence (1 for decreasing and 0 for increasing). The estimates show that the distance between “Bad” Apples significantly reduces the average individual contributions of “Bad” Apples in PROD while it increases those of the most distant group members (IN). In INFO distance between “Bad” Apples has not significant effect on their contribution but significantly reduces those of more distant members (IN).

| PROD, average contributions at time $t$ | | | |
|---|---|---|---|
| | *BA* | *DN* | *IN* |
| Supergame 2 | -1.050*** | -0.899*** | -0.632*** |
| | (0.238) | (0.149) | (0.157) |
| Supergame 3 | -2.300*** | -1.577*** | -0.502*** |
| | (0.251) | (0.156) | (0.164) |
| Supergame 4 | -2.849*** | -2.054*** | -0.874*** |
| | (0.271) | (0.171) | (0.162) |
| Period | -0.190*** | -0.122*** | -0.129*** |
| | (0.013) | (0.010) | (0.010) |
| BA are next to each other | -0.624*** | 0.010 | 0.367*** |
| | (0.177) | (0.111) | (0.113) |
| Distance is decreasing | 0.253 | 0.540 | 0.476 |
| | (0.476) | (0.477) | (0.511) |

| INFO, average contributions at time $t$ | | | |
|---|---|---|---|
| | *BA* | *DN* | *IN* |
| Supergame 2 | -0.702*** | -0.431*** | -1.026*** |
| | (0.260) | (0.163) | (0.176) |
| Supergame 3 | -0.916*** | -1.085*** | -1.689*** |
| | (0.247) | (0.160) | (0.167) |
| Supergame 4 | -1.411*** | -1.596*** | -2.807*** |
| | (0.223) | (0.142) | (0.168) |
| Period | -0.044*** | -0.107*** | -0.117*** |
| | (0.012) | (0.009) | (0.010) |
| BA are next to each other | -0.275 | 0.192* | -0.482*** |
| | (0.172) | (0.103) | (0.125) |
| Distance is decreasing | 0.477 | -0.067 | -0.493 |
| | (0.548) | (0.358) | (0.382) |

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 7: Panel tobit regression of individual left (upper subtable) and right (lower subtable) by subject types and pooled for all types

Thus “Bad” Apples’ closeness has a significant effect on their own contributions only in PROD. Given that INFO “Bad” Apples receive no feedback on neighbors’ contributions, the non-effect of their distance in INFO is obvious. That distance of “Bad” Apples has a different effect (sign) on the indirect neighbors (IN) for the two “Bad” Apple types is due to the fact that close “Bad” Apples in PROD treatments can affect IN less via negative behavioral spillovers because of their larger average distance from “Bad” Apples. Behavioral spillovers become weaker the further away two group members are located in the circular neighborhood (see Angelovski et al., 2016, for related results). The sequence in which the distance of the position of the BA varies, decreasing versus increasing, has no significant effect on contributions of all three member types and for both treatments.

Finding 6:

- Voluntary contributions, on average, decrease across supergames and periods;
- PROD "Bad" Apples mutually reinforce free-riding if next to each other;
- distance between "Bad" Apples (BA) affects contributions of indirect neighbors (IN) positively in PROD and negatively in INFO treatments.

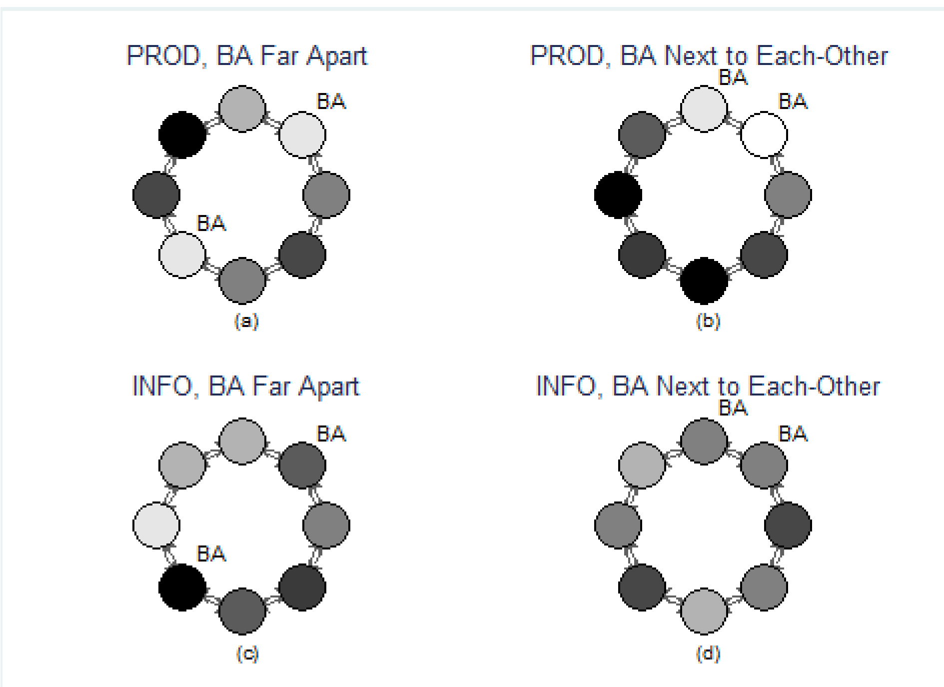


Figure 5: Individual average contributions by position in the neighborhood: PROD treatments when Bad Apples are far (panel $a$) and next to each other (panel $b$) and INFO treatments when Bad Apples are far (panel $c$) and next to each other (panel $d$)

This finding is visually represented in Figure 5. A darker shade represents higher average contribution and a lighter shade lower one. The analysis has been split by "Bad" Apples type and their distance. Neighborhoods (a) and (b) rely on PROD "Bad" Apples and (c) and (d) on INFO ones. In neighborhoods (a) one clearly sees that "Bad" Apples contribute least, whereas their indirect neighbors contribute most. In neighborhoods (b) close "Bad" Apples have the lowest contributions and their indirect neighbors the highest. Interestingly, "Bad" Apples with a non-"Bad" Apple neighbor on their more productive right side contribute more than the other "Bad" Apple.

Type (c) neighborhoods show that "Bad" Apples contribute more in that setting, but display heterogeneity. It indicates that behavior can evolve differently when considering the two sub-neighborhood with three "non-handicapped" members each between which no spillovers can occur due to the "Iron Curtain" effect. If "Bad" Apples are far apart, due to their asymmetric MPCR they can affect either neighborhood with a different intensity. Type (d) neighborhoods seem to display the highest heterogeneity of contributions of all four neighborhood types of Figure 5.

Finally, how do supergame, period, "Bad" Apples' distance, and its sequence affect the society with eight members as a whole? Table 8 presents a regression analysis of average group contribution showing that PROD groups do better when "Bad" Apples are next to each other. While PROD "Bad" Apples contribute very little and even less when they are close, the group as a whole does better. Apparently other participants, separated from "Bad" Apples, overcompensate the decrease of BA contributions. Distance of INFO "Bad" Apples has no effect on group efficiency.

| | PROD | INFO |
|---|---|---|
| Supergame 2 | -0.837*** | -0.653*** |
| | (0.065) | (0.066) |
| Supergame 3 | -1.168*** | -1.169*** |
| | (0.065) | (0.067) |
| Supergame 4 | -1.355*** | -1.663*** |
| | (0.065) | (0.063) |
| Period | -0.103*** | -0.070*** |
| | (0.005) | (0.005) |
| BA are next to each other | 0.133*** | -0.037 |
| | (0.045) | (0.046) |
| Distance is decreasing | 0.213 | -0.208 |
| | (0.380) | (0.406) |
| Observations | 888 | 864 |
| Number of groups | 17 | 17 |

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 8: Panel tobit regression on group-level average contributions

Finding 7:

- group performance is differently affected by BA distance: their distance is enhancing group performance in PROD but not in INFO;
- experience, measured by supergame as well as periods, reduce group performance;
- sequence of distance (increasing or decreasing) has no significant effects on group performance.

# 5 Conclusions

Ai of this analysis has been to analyze if introducing additional heterogeneity (by two different types of "Bad" Apples) in the same circular neighborhood as in Angelovski et al. (2016) affect both voluntary contribution and behavioral spillovers. This research has done an exhaustive heterogeneity analysis, which is not restricted to only distinguishing "Bad" Apples from other group members and how they mutually affect each other. We take into consideration that in bilateral interactions participants do not always have the same productivity, hence the different MPCR on the left and right side for each individual. Our setup further distinguishes between different handicaps that "Bad" Apples might have (productivity gap vs. information gap) and how the specific type of handicap affects the dynamic of our circular society.

The setup also allows for the differentiation between the proximity of non-handicapped members to "Bad" Apples (direct and indirect neighbors), the sequence of "Bad" Apples' position (increasing or decreasing), the experience effect of periods with possibly heterogeneous lengths, and reshuffling of positions between the four supergames. Such analysis permits to address to the main questions posed in the Introduction:

• even when "Bad" Apples are present neighborhoods evolve as a whole. Therefore "Bad" Apples do not impede behavioral spillovers from spreading out, but may reduce voluntary cooperation.

• PROD and INFO “Bad” Apples behave very differently: the former are the least and the latter the most cooperative group members. Moreover, they trigger very different attitudes of other group members: direct neighbors of “Bad” Apples become more cooperative in PROD treatments and least cooperative in INFO treatments; therefore “spoiling of the basket” has very different roots in both treatments. PROD treatments directly lower “Bad”Apples’ contributions whereas INFO mainly affect their direct neighbors, who in turn spread this behavior to the indirect ones.

• distance of “Bad” Apples only matters for the PROD but not for the INFO treatments. Circular neighborhoods where the Bad” Apples are positioned next to each other lead to higher contributions.

Altogether the comparison with the baseline treatment (without “Bad”Apples) show that, “Bad”Apples are a curse rather than a blessing.[13] But their effects on the basket depend on some aspects of the environment, captured in our setup via treatments, which across the board do not crowd out behavioral spillovers.

In spite of structurally independent games, purely behavioral spillovers are reduced but not eliminated by either type of “Bad” Apple in the circular neighborhoods with eight members each. Less productive (PROD) “Bad” Apples trigger a lower efficiency loss, compared to Baseline, than less informed “Bad” Apples (INFO). However none of this questions purely behavioral spillovers. Strategically positioning “Bad” Apples may help to promote voluntary cooperation. In particular, spread-out PROD “Bad” Apples seem detrimental to contributions, which does not apply to spread-out INFO “Bad” Apples. Thus our conclusion: not all “Bad” Apples taste the same!

**Acknowledgement.** We would like to thank the Max Planck Institute of Bonn for funding and supporting this research.

[13]As also underlined, in a rather different setting, by Bigoni and Suetens (2010).

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# Appendix

| | Baseline | PROD | INFO |
|---|---|---|---|
| Averages: | 3.478 | 3.176 | 2.688 |
| Difference: | | -0.302*** | -0.790*** |
| P - value: | | (0.000) | (0.000) |
| Periods 1 to 4 | 3.871 | 3.721 | 3.252 |
| | | -0.149** | -0.619*** |
| | | (0.014) | (0.000) |
| Periods 5 to 8 | 3.340 | 3.283 | 2.718 |
| | | -0.116** | -0.682*** |
| | | (0.043) | (0.000) |
| Periods 9 to 12 | 3.492 | 2.882 | 2.372 |
| | | -0.610*** | -1.119*** |
| | | (0.000) | (0.000) |
| Periods 13 to 16 | 2.862 | 2.441 | 1.981 |
| | | -0.421*** | -0.880*** |
| | | (0.000) | (0.000) |

Table 9: Average contribution by BA type and their difference with the Baseline excluding all PGG where BA are involved (p-values in parenthesis for one-tailed two-independent sample t tests)

| All members | | | |
|---|---|---|---|
| | Baseline | PROD | INFO |
| Averages: | 4.208 | 4.390 | 3.989 |
| Difference: | | 0.181 | -0.219 |
| P - value: | | (0.557) | (0.448) |
| All members except "Bad" Apples | | | |
| | Baseline | PROD | INFO |
| Averages: | 4.208 | 4.299 | 3.947 |
| Difference: | | 0.090 | -0.261 |
| P - value: | | (0.715) | (0.271) |

Table 10: Average contributions in the first period of the first supergame and difference from the baseline (two-independent sample t tests)

Define $\delta L$, resp. $\delta R$ the absolute value of the change in left, resp. right contribution between period $t$ and period $t-1$. In this table we present how many times we observe a $\delta$ greater or equal than 3 in the first quarter of periods, by and across supergames. We compare this frequency with the total number of observations.

Same results are obtained if we increase the threshold to 4. Too few observations if we increase it further.

| Left-hand side contributions at period $t$ | PROD | | | INFO | | |
|---|---|---|---|---|---|---|
| | BA | DN | IN | BA | DN | IN |
| Left contribution $(t-1)$ | 0.286*** | 0.534*** | 0.481*** | 0.298*** | 0.487*** | 0.424*** |
| | (0.041) | (0.029) | (0.030) | (0.036) | (0.029) | (0.030) |
| Supergame | -0.893*** | -0.352*** | -0.086 | -0.404*** | -0.414*** | -0.394*** |
| | (0.124) | (0.072) | (0.068) | (0.081) | (0.062) | (0.071) |
| period | -0.164*** | -0.067*** | -0.079*** | -0.042*** | -0.052*** | -0.067*** |
| | (0.021) | (0.014) | (0.015) | (0.015) | (0.013) | (0.014) |
| L neighbor $(t-1)$ | 0.185*** | 0.314*** | 0.258*** | 0.004 | 0.244*** | 0.265*** |
| | (0.037) | (0.024) | (0.024) | (0.029) | (0.024) | (0.026) |
| R neighbor $(t-1)$ | 0.040 | 0.016 | 0.056** | 0.044 | 0.034 | 0.076*** |
| | (0.038) | (0.024) | (0.027) | (0.032) | (0.024) | (0.026) |

| Right-hand side contributions at period $t$ | PROD | | | INFO | | |
|---|---|---|---|---|---|---|
| | BA | DN | IN | BA | DN | IN |
| Right contribution $(t-1)$ | 0.366*** | 0.475*** | 0.594*** | 0.294*** | 0.508*** | 0.548*** |
| | (0.039) | (0.029) | (0.029) | (0.035) | (0.029) | (0.030) |
| Supergame | -0.497*** | -0.403*** | -0.024 | -0.270*** | -0.397*** | -0.506*** |
| | (0.117) | (0.075) | (0.069) | (0.084) | (0.066) | (0.075) |
| period | -0.101*** | -0.070*** | -0.085*** | -0.057*** | -0.085*** | -0.057*** |
| | (0.020) | (0.015) | (0.015) | (0.016) | (0.014) | (0.015) |
| L neighbor $(t-1)$ | 0.057 | 0.062** | 0.087*** | 0.015 | 0.058** | 0.066** |
| | (0.036) | (0.025) | (0.025) | (0.030) | (0.025) | (0.026) |
| R neighbor $(t-1)$ | 0.392*** | 0.294*** | 0.317*** | 0.033 | 0.190*** | 0.275*** |
| | (0.037) | (0.026) | (0.028) | (0.033) | (0.025) | (0.027) |
| Observations | 1,640 | 2,452 | 2,468 | 1,592 | 2,420 | 2,353 |
| Subjects | 90 | 114 | 112 | 97 | 128 | 128 |

Table 11: Panel tobit regression of left-hand side and right-hand side contributions by BA, DN and IN

# Instructions

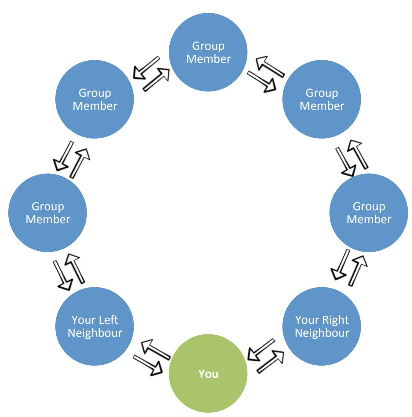
Welcome. You are participating in an experiment about economic decision-making. During the experiment, you can earn money. Your earnings will depend on your decisions and the decisions of others. These instructions describe the decisions you and other participants should take and how your earnings are calculated. Therefore, it is important to read them carefully.

During the experiment, all interactions between the participants will take place through computers. It is forbidden to communicate with other participants by any other means. If you have any questions, please raise your hand and one of us will come to answer it. Keep in mind that the experiment is anonymous, i.e., your identity will not be disclosed.

During the experiment, your earnings will be calculated in points. At the end of the experiment, the points will be converted to euros at the following exchange rate:

$$1 \text{ point} = 1€.$$

In the experiment, you will be a member of a group containing a total of eight members, including you. For the purpose of this experiment, you and the rest of the members in the group are positioned in a circular manner. This means that each member has a neighbour to the left and a neighbour to the right.




During the experiment, each of you will interact with your two neighbors. These two neighbors will be the same two individuals for one supergame. In the experiment, there will be a total of four supergames. One supergame lasts either eight or sixteen periods (as will be explained later). Therefore, you will have to make either eight or sixteen decisions before the supergame ends. At the end of each supergame, your group consisting of eight members will be reshuffled randomly. For every member, at least one neighbor will be different from the previous supergame. *Keep in mind that you do not know the identity of your neighbors so you will not know if both of your neighbors are new, or just one of them.*

How many periods a supergame lasts depends on chance. A supergame will last for 8 periods with a probability of 1/3, and 16 periods with probability of 2/3.

In each period, you and your two neighbors will be endowed with points. More specifically, nine (9) points will be assigned to you for the interaction with your left neighbor, and nine (9) points will be assigned to you for the interaction with your right neighbor. The same number of points will be assigned to both of your neighbors, and all other members in your group.

In each period, you will have to decide, individually and independently, how many of the nine points you are endowed with you will want to contribute to a project with your left neighbor. In what follows, this is referred to as Project L. Similarly, in each period you will have to decide, individually and independently, how many of the nine points you are endowed with you will want to contribute to a project with your right neighbor. In what follows, this is referred to as Project R.

Keep in mind that you can invest a maximum of nine points to Project R and a maximum of nine point to Project L; moreover, you cannot invest your points for Project R into Project L, and vice versa.

You will retain for yourself the points that you decide not to invest in either project. Therefore, you will keep for yourself $9-$Your contribution to Project L; similarly you will keep for yourself $9-$Your contribution to Project R. For example, you can invest eight points in project R, and keep $9 - 8 = 1$ for yourself, or invest three points in Project L and keep $9 - 3 = 6$ to yourself.

Every member is going to make the decisions simultaneously.

<u>PAYOFFS</u>

Your payoff in each supergame will depend only on your own choices and on those of your two neighbors.

Six out of the eight members of your group will be informed, at the end of every period, about their own payoff and their neoghbors' contributions; the remaining two members will not receive any feedback (as will be explained later.)

At the end of each period, your payoff is computed in the following manner:

**For Project R**: $(9 -$Your contribution$) + 0.8 *$ (Your contribution + Your right neighbor's contribution)

**For Project L**: $(9 -$Your contribution$) + 0.6 *$ (Your contribution + Your left neighbor's contribution)

EXAMPLE: Let's try to compute your payoff in the following case. For the purpose of the example we imagine that both your right and left side neighbors contribute 8 points. If you contribute 8 points into Project R, your payoff will be $(9-8)+0.8*(8+8) = 1+0.8*16 = 1+12.8 = 13.8$. Similarly, if you contribute 3 points into Project L, your payoff will be $(9-3)+0.6*(3+8) = 6 + 0.6 * 11 = 6 + 6.6 = 12.6$.

In each of the successive periods, all group members will simultaneously choose their contributions to Project R and to Project L. *Keep in mind that you will play multiple periods with the same participants and that you will choose how much to contribute before knowing the contributions of your neighbors, if you are one of the members receiving feedback information.*

At the end of each period, six group members will be informed about own payoffs from Project L and from Project R, contributions by both left and right neighbors, and accumulated earnings from both projects. The remaining two members will not receive any information and the following period will start directly.

What you will actually earn is:

At the end of the experiment the computer will randomly select the average payoff you obtained in one of the four supergames as a final payment. Thus your payment will be equal to the average payoff of supergame 1, or to the average payoff of supergame 2, or to the average payoff of supergame 3, or to the average payoff of supergame 4. Such a payoff will be converted to euros at the exchange rate of 1 point = 1 €.