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# Does heterogeneity spoil the basket? The role of productivity and feedback information on public good provision

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ABSTRACT

In a circular neighborhood of eight, each member contributes repeatedly to two local public goods, one with the left and one with the right neighbor. All eight two-person games provide only local feedback information and are structurally independent in spite of their overlapping player sets. Heterogeneity is induced intra-personally by asymmetric productivity in left and right games and inter-personally by two randomly selected group members who are less privileged (LP) by being either less productive or excluded from end-of-period feedback information about their payoffs and neighbors' contributions. Although both LP-types let the neighborhood as a whole evolve less cooperatively, their spillover dynamics differ. While less productive LPs initiate "spoiling the basket" via their low contributions, LPs with no-end-of-round information are exploited by their neighbors. Furthermore, LP-positioning, closest versus most distant, affects how the neighborhood evolves.

## 1. Introduction

The existence and evolution of behavioral spillovers have been analyzed in different experimental settings (see e.g. Savikin and Sheremeta, 2013; Bednar et al., 2012; Cason et al., 2012; Cason and Gangadharan, 2013; Falk et al., 2013, for coordination and competitive games; Bernasconi et al., 2009 and Falk et al. 2013 for public good games).[1] Most studies assume symmetry and homogeneity, what may imply an implicit demand effect for correlating behavior across structurally independent games and question whether behavioral spillovers can also be robustly confirmed in situations with intra- and inter-personal heterogeneity.

Excluding asymmetry and heterogeneity simplifies the experimental setting at the cost of external validity since behavior in the field crucially depends on the heterogeneity of group members and on their relative positioning. So external validity of behavioral spillovers specifically requires robustness also in cases of heterogeneity which may not only be intra- but also inter-personal.

Circular neighborhoods with overlapping two-player sets involving bilateral linear public good games are convenient paradigms to explore local, e.g. bilateral, interaction embedded in a more global setup. Each group member confronts only one left and one right neighbor in two structural independent bilateral interactions. Such bilateral interaction is typical for neighborhoods in the field, even though local interaction can be more widespread. An example would be two neighbors who have to agree how to separate their gardens by a fence or wall. In a circular neighborhood each member has to agree independently with each neighbor how nicely and costly to divide their gardens. We capture this experimentally by letting both neighbors contribute voluntarily assuming that the sum of their contributions determine (linearly) the size or quality of their common fence or wall.

Asymmetry, i.e. intra-personal heterogeneity, is captured by different productivities in one's left and right bilateral interaction, smaller in the former and larger in the latter. This feature is common to all treatments and in the Baseline treatment is the only type of heterogeneity which we allow for.[2]

We additionally allow for inter-personal heterogeneity by considering two (randomly selected) less privileged group members, referred to as LP-members (LPs). We focus on two very different types of

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[1] Most of this literature focus on how an individual, successively facing multiple independent games, correlates behavior across them. Falk et al. (2013), instead, investigate social interaction effects when two identical public good games are played simultaneously with different sets of opponents.

[2] See (Angelovski et al., 2018) where we allow only for intra-personal heterogeneity.

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heterogeneity: one in free-riding incentives and the other in feedback information.[3] Compared to the Baseline treatment, in the "low productivity" treatment (hereafter PROD) LPs are less productive on both sides. In the "no information" treatment (hereafter INFO) LPs are excluded from end-of-period feedback information about their neighbors' contributions and their own payoff while maintaining the same productivities of the Baseline treatment. Relative positioning of the two same-type LPs in the neighborhood is either close or maximally distant.

Structural independence of all two-person public good games is induced by local feedback information and separate individual endowments for both games.[4] Structural independence implies that, when both choice tasks are played once, free-riding is strictly dominant.[5] Nevertheless, structural independence of local games does not guarantee their behavioral independence. Intra-personal spillovers can occur if agents link own left and right contributions. Furthermore, due to overlapping player sets, conditional cooperation may imply inter-personal spillovers and more or less co-evolving contributions. This interplay of intra- and inter-personal spillovers may trigger contribution dynamics to which we refer as (purely) behavioral spillovers. Based on the analysis and results of Angelovski et al. (2018),[6] we expect most group members to be discrimination averse (by not wanting to treat equals unequally) and reciprocators (in the sense of conditional cooperation) even when inducing inter-personal heterogeneity across group members.

Since LPs may weaken conditional cooperation, we predict inter-personal heterogeneity to moderate the coevolving contributions in the neighborhood but not to question purely behavioral spillovers. Thus we predict and hope to confirm behavioral spillovers as robust to both, intra- as well as inter-personal heterogeneity.

Furthermore, we analyze how purely behavioral spillovers depend on LP-type. Specifically, we expect less productive LPs to contribute less and LPs excluded from end-of-period feedback information to inspire their neighbors' free-riding. Since participants are aware of LPs and their type but not of their positions in the neighborhood, regular members, suspecting a less productive LP neighbor, may contribute less when unwilling to excuse their neighbor's lower contribution by the higher free-riding incentive. Similarly, a regular member, suspecting an uninformed LP, may try to exploit his/her neighbor, hoping that this remains unnoticed. Finally, we investigate if close or distant positioning of LPs trigger different dynamics of voluntary cooperation.

According to our data both LP types reduce voluntary cooperation compared to the Baseline. Nevertheless, while behavioral spillovers prevail in both treatments, voluntary cooperation differs across LP types. Less productive LPs contribute less what contaminates the whole neighborhood. LPs with no end-of-period information feedback, on the contrary, are on average the highest contributors but often, as expected, exploited by their neighbors. Furthermore, the relative distance of LPs can affect how the neighborhood evolves as whole.

Our approach to robustly assess the effects of intra-personal asymmetry and inter-personal heterogeneity on purely behavioral spillovers seems novel and quite different from the existing literature. We, however, share some insights with studies examining within-group heterogeneity in free-riding incentives, ranging from Fisher et al. (1995) to contributions like Noussair and Tan (2011), Reuben and Riedl (2009), Reuben and Riedl (2013), Fischbacher et al. (2014) and Kölle (2015). Specifically, we confirm results concerning the effects of different marginal per capita returns (MPCR hereafter). So far only de Oliveira et al. (2015) allow for heterogeneity in group composition via "selfish Bad Apples" (i.e. subjects identified as freeriders in a pretest) and analyse how their presence affects others and reduces group efficiency, while Grund et al. (2018) form heterogeneous groups in a public good game by varying the number of stranger versus partner participants in each group.

Our INFO treatment is related to studies varying feedback information in symmetric public good games (Marwell and Ames, 1981; Sell and Wilson, 1991; Chan et al., 1999; Neugebauer et al., 2009; Bigoni and Suetens, 2010; Grechenig et al., 2010 and de Oliveira et al. 2015. We confirm that participants without feedback information contribute significantly more than participants with feedback information.

Circular networks have been frequently compared to other networks (see for example Eckel et al., 2010; Suri and Watts, 2011 and Carpenter et al., 2012). However, our circular neighborhood is hardly comparable as it implements structurally independent bilateral games (Eckel et al., 2010, and Carpenter et al., 2012, provide local feedback but all participants contribute to and benefit from a single public good). Suri and Watts (2011) and Carpenter et al. (2012) vary the network structure. Falk et al. (2013) let each participant confront two independent three-player public good games with homogeneous productivities.

Section 2 illustrates the experimental design and states our hypotheses. Section 3 presents and discusses the main results. We conclude in Section 4 with summary remarks and interpretations. The translated instructions are reported in the Appendix.

## 2. Experimental design and hypotheses

Participants form a circular neighborhood with eight members. Each member $i = 1, ...,8$ is involved in two linear public good games, one with the left neighbor $i-1$ (where $i-1=8$ for $i=1$) and one with the right neighbor $i+1$ (where $i+1=1$ for $i=8$). Fig. 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 $(0, 1, ...,9)$ to strengthen structural independence of one's left and right game via independent choice sets as well as by game specific endowments. Individual payoffs are:

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

where $E = 9$ is the periodic initial endowment per public good game (on either side). MPCR $\alpha$ applies to $i$'s left game, whose total public good contribution is $c_i^L + c_{i-1}^R$, and $\beta$ to $i$'s right game with total public good contribution $c_i^R + c_{i+1}^L$.

The asymmetric treatment of Angelovski et al. (2018) with $\alpha = 0.6$ and $\beta = 0.8$ is the Baseline treatment. In addition to its intra-personal heterogeneity, we add inter-personal heterogeneity via two LP-members, both of the same type, PROD and INFO.

For the PROD type we assume $\alpha = 0.4$ and $\beta = 0.6$ letting a less privileged member $i$ 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 a regular member $i$ is:

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

INFO LP-members have the same productivities as in the Baseline

[3] The literature on public goods experiments partly considers other forms of heterogeneity, for example in wealth and income (see Buckley and Croson, 2006; Chan et al., 1996, 1999) capabilities and valuation (see Kölle, 2015) and in group composition (see Burlando and Guala, 2005; Smith, 2011; Grund et al., 2018), consider partners-strangers group composition, whereas Bardsley and Sausgruber, 2005; Fischbacher and Gächter, 2010; de Oliveira et al., 2015, consider composition of conditional cooperators and selfish players).

[4] For a study with overlapping player sets in a circular neighborhood without structurally independent local games, meaning that all group members are strategically interacting, see Boosey (2017).

[5] A commonly known upper bound for the number of successive periods justifies free-riding even for finite horizon games.

[6] Our companion study shows that participants anchor intra-personally behavior on the higher marginal per capital return and that this enhances and stabilizes voluntary cooperation across the whole neighborhood.