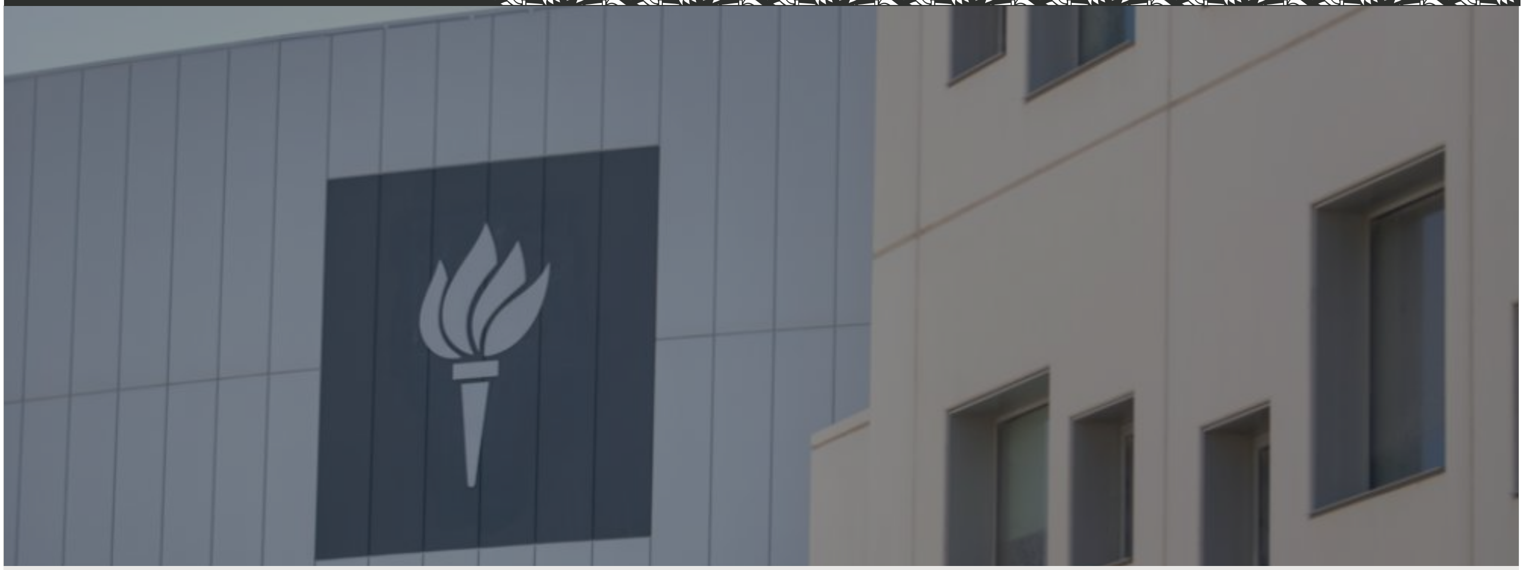

Integration and Diversity

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Integration and Diversity

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Frédéric Moisan[§] Manuel Muñoz-Herrera[¶] Angel Sánchez[‖]

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Abstract

We study a setting where individuals prefer to coordinate with others but they differ on their preferred action. Our interest is in understanding the role of link formation with others in shaping behavior. So we consider the situation in which interactions are exogenous and a situation where individuals choose links that determine the interactions. Theory is permissive in both settings: conformity (on either of the actions) and diversity (with different groups choosing their preferred actions) are both sustainable in equilibrium. We conduct an experiment to understand how link formation affects equilibrium selection.

Our experiment reveals the powerful effect of linking on equilibrium selection: with an exogenous complete network, subjects choose to conform on the majority's preferred action. By contrast, with endogenous linking – irrespective of the costs of linking – subjects always opt for diversity of actions.

JEL Codes: D85, D03, C72, C92

Keywords: Networks, equilibrium selection, social coordination, experiment

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1 Introduction

> *Predicting which of the many equilibria will be selected is perhaps the most difficult problem in game theory* (Camerer 2003)

In 2017, in a widely publicized incident in the Netherlands, a coach company Qbuzz refused to interview an immigrant who had applied for a job because he said that he would not shake hands with female clients (due to his religious beliefs). The coach company felt that the behaviour of the driver went against social norms in the Netherlands (and would probably put off potential customers). This incident brings out the point that individuals may have different rankings over norms – physical contact between a man and woman is the accepted norm in some communities, while it is entirely prohibited in other communities. A relatively common tension also arises in the context of language: members of different communities each prefer their mother tongue to be the common language of communication. Language is a central concern in knowledge based and communication intensive societies. These differences in preferences on norms create the following tension: individuals would like to coordinate on actions with others, but their preferences over these actions may be different.[1] This paper studies how individuals choose actions and arrive at norms of coordination in such settings.

To clarify the key considerations, we start by defining a social game in which a set of individuals play the 'Battle of the Sexes' game. Everyone prefers to coordinate on one action but individuals differ in the action they prefer: there are two groups, group U prefers action *up*, group D prefers action *down*. An individual chooses a single action for all her interactions. The payoffs are the sum of payoffs from her interactions with the other players.[2] It is easy to see that with these preferences, conformism on either action is a Nash equilibrium. We consider a baseline setting in which everyone is obliged to interact

[1] A similar tension also arises in the context of markets with network externalities in which consumers prefer a particular standard/platform, but there is social value of everyone being on the same standard.

[2] For concreteness, in the two person game, suppose individuals of type U earn 4 from coordinating on action *up*, and they earn 2 from coordinating on action *down*. The payoffs of the type D go the other way: D types earn 4 from coordinating on *down* and only earn 2 from coordinating on *up*. Finally, both players earn zero if they miscoordinate.

with everyone else, and a setting in which individuals choose with whom to interact. In the former setting, all players know they are located in a complete network. In the latter setting, players observe the network that is created, and then choose between action *up* and *down*. The theoretical analysis reveals a rich set of possibilities.

Consider the case where everyone interacts with everyone else.[3] There exist three equilibria: everyone conforming to a single action, *up* or *down*, and diversity with everyone choosing their preferred action (i.e., group U members choosing *up*, and group D choosing *down*). Next, consider the setting with endogenous linking, and suppose that the costs of linking are zero. Now the outcomes take two forms: one, every individual connects to everyone else and the action profile corresponds to the three equilibria described above. The other situation exhibits partial connectivity: an interesting special case arises when the network fragments into two distinct components and individuals in each component choose a different action. Moreover, we show that, under our parameter assumptions on costs of linking, in both the exogenous and endogenous interaction setting, conforming to the majority's preferred action maximizes aggregate welfare.[4] Thus, there are multiple equilibrium outcomes, in both the exogenous and the endogenous linking case, and there is a tension between diversity and aggregate welfare. We conduct a laboratory experiment to better understand how players choose actions and how these choices are affected by whether the network is exogenous or endogenous.

The experiment involves groups of 15 subjects who play the game repeatedly, over 20 rounds. In each group, there is a majority sub-group with 8 subjects (who prefer action *up*) and a minority sub-group with 7 subjects (who prefer action *down*). We find that, with exogenous interaction, conformity on the majority's preferred action obtains in 5 out of 6 groups. By contrast, with endogenous linking, individuals form most of the possible links (roughly 95 out of a possible 105), and yet in all groups they rapidly converge on diversity. Thus, the freedom to create links has a powerful effect on behavior and on

[3] We refer to this as the exogenous complete network.

[4] Specifically, we assume that the cost of linking is smaller than the payoff from successful coordination on the less preferred action.

aggregate welfare.[5]

To test the robustness of endogenous linking, we vary the costs of linking. Different costs of linking lead to different networks: we study if the effects of endogenous linking seen with zero cost are robust to this change. We first turn to negative linking costs (or link subsidy): our next finding is that, in all the 6 groups we studied, subjects form dense (and almost complete) networks but that they choose diverse actions. Finally, we consider the case with positive costs. Our final finding is that, in all the 6 groups we studied, subjects select the outcome with segregation and diversity.

To summarize, our experiment reveals the powerful effect of linking on equilibrium selection: with an exogenous complete network, subjects choose to conform on the majority's preferred action. By contrast, with endogenous linking – irrespective of the costs of linking – subjects always opt for diversity of actions.

One reason that the diversity outcome is surprising is that the payoffs in this equilibrium are Pareto dominated by the conformism outcome. So we examine the experimental payoffs more closely. We find, somewhat surprisingly, that average minority payoffs under the exogenous complete network are *not* significantly different from the average payoffs obtained with the diversity outcome under the endogenous treatment. The main reason for this is the differential rate of convergence: minority subjects converge significantly more quickly to the steady state action profile in the endogenous linking treatment (as compared to the exogenous treatment).[6] Taking these observations together leads us to the view that endogenous linking by creating a distinct set of groups facilitates a quicker resolution of the coordination problem.

Our paper is a contribution to the study of social coordination. Following the early contributions of Schelling (1960) and Lewis (1969), there is now a large body of research on coordination problems. Blume (1993) and Ellison (1993) drew attention to the role

[5] We also considered an experimental treatment with a minority of 3 members, and a majority of 12: when the minority is so small we find that the freedom to form links makes no difference. Subjects choose to conform with the majority's preferred action both in the exogenous complete network as well as when links are endogenous. This treatment is presented in the Supplementary Material.

[6] Majority group subjects choose their preferred action and persist with that action from early on, in both treatments.

of interaction structures in shaping coordination, while Goyal and Vega-Redondo (2005) and Jackson and Watts (2002) developed models in which players choose partners and also actions in a coordination game. In more recent years, a number of researchers have introduced heterogeneity of preferences in these models as a way to think about culture and identity, see e.g., Advani and Reich (2015), Bojanowski and Buskens (2011), and Ellwardt et al. (2016) and Neary (2012). Our paper conducts an experimental investigation on the role of endogenous linking in such a setting.

There is a large experimental literature on social coordination, see e.g. Charness et al. (2014), Crawford (1995), Isoni et al. (2014). Specifically, there is a strand of work on coordination games on networks (Choi and Lee 2014; Antonioni et al. 2013; Kearns et al. 2012) and a strand of work on network formation (Bernasconi and Galizzi 2005; Goeree et al. 2009).[7] We combine network formation with coordination in the current paper. The early paper by Corbae and Duffy (2008) presents an experiment where subjects form links in the first stage and play the stag hunt game in the second stage. The players in their experiment are ex-ante identical and the authors abstract from size effects, by considering average payoffs (across interactions). By contrast, in our paper, players belong to different preference groups and the key tension turns to the size of interaction group. In a recent paper, Riedl et al. (2016) brings out the positive role of endogenous linking in facilitating social welfare. That paper studies linking in a minimum effort game and it finds that endogenizing the choice of partners has a dramatic effect on behavior: players converge to the most efficient Nash equilibrium. By contrast, in our paper, introducing endogenous links leads to play converging to a Pareto-dominated outcome. Thus, our work shows that endogenizing linking can have very different consequences for social welfare, depending on

[7]The present paper reports an experiment with human subjects; there is also a literature that studies simulations of complex network dynamics. For a recent paper in this line of work, that studies network linking and segregation, see Lipari et al. (2019).

whether individuals have heterogeneous or similar preferences.[8]

The paper is organized as follows. Section 2 presents the model and the theoretical analysis. Section 3 presents our experimental design and Section 4 the experimental findings on endogenous versus exogenous networks. Section 5 concludes. Appendix A contains some of the proofs, Appendix B provides additional analyses of the experimental data, while Appendix C contains the instructions for the experiments.

2 Theory

We study a game of network formation and action choice in which individuals benefit from selecting the same action as their neighbours. However, individuals differ on their preferred action. There are thus two types of individuals. We study networks that are stable and describe the corresponding equilibrium actions.

2.1 The model

Let $N = \{1, 2, \ldots, n\}$ with $n \geq 3$. The game has two stages. In the first stage, every player $i \in N$ chooses a set of link proposals g_i with others, $g_i = (g_{i1}, \ldots, g_{ii-1}, g_{ii+1}, \ldots, g_{in})$, where $g_{ij} \in \{0, 1\}$ for any $j \in N \backslash \{i\}$. Let $G_i = \{0, 1\}^{n-1}$ define i's set of link proposals. The induced network $g = (g_1, g_2, \ldots, g_n)$ is a directed graph. The closure of g is an undirected network denoted by $\overline{g}$ where $\overline{g}_{ij} = g_{ij}g_{ji}$ for every $i, j \in N$. We define the finite set of all undirected networks $\overline{g}$ as $\overline{G}$. Player i's strategy in the second stage is defined through a function x_i mapping every undirected network $\overline{g}$ that can result from the first stage to an action in $A = \{up, down\}$. Formally, $x_i : \overline{G} \to A$, and we define X_i as the set of all such strategies for player i. We denote the set of overall strategies of player i in the full game as $S_i = G_i \times X_i$, and the set of overall strategies for all players as $S = S_1 \times \ldots \times S_n$. A

[8] Kearns et al. (2012) and Kearns et al. (2009) study voting behaviour by biased voters. In this game, players must coordinate on the same vote to earn a payoff. Individuals differ on their preferred outcome. Kearns et al. (2009) show that with exogenous networks subjects are quite successful in achieving coordination. By contrast, Kearns et al. (2012) show that with endogenous linking, subjects form rich networks but fail to reach coordination. This finding is in the same spirit as our work: with conflicting preferences, endogenous linking can lead to a decrease in welfare.

strategy profile $s = (x, g)$ specifies the link proposals made by every player in the first stage through $g = (g_1, g_2, \dots, g_n)$, and the choice functions made by each player in the second stage through $x = (x_1, x_2, \dots, x_n)$. We define $N_i(\overline{g}) = \{j \in N : \overline{g}_{ij} = 1\}$ as the set of i's neighbours in the network $\overline{g}$.

Moreover, for every player i, let $\theta_i \in \{up, down\}$ define i's type. This leads us to define $N_{up} = \{i \in N : \theta_i = up\}$ and $N_{down} = \{i \in N : \theta_i = down\}$ as the groups of players preferring action *up* and *down*, respectively ($N_{up} \cup N_{down} = N$). If $|N_{up}| \neq |N_{down}|$, we refer to the largest group of players sharing the same type/preferences as the *majority* and the other group as the *minority*. Furthermore, we define

$$\chi_i(\overline{g}, x) = \{j \in N_i(\overline{g}) : x_j = \theta_i\} \tag{1}$$

as the set of i's neighbours who play i's preferred action ($\chi_i(\overline{g}) \subseteq N_i(\overline{g})$). In what follows, we shall write $\overline{g} - \overline{g}_{ij}$ (resp. $\overline{g} + \overline{g}_{ij}$) to refer to an undirected network $\overline{g}'$ such that $\overline{g}'_{ij} = 0$ (resp. $\overline{g}'_{ij} = 1$) and $\overline{g}'_{kl} = \overline{g}_{kl}$ if $k \notin \{i, j\}$ or $l \notin \{i, j\}$.

Given strategy profile s, the utility for player i is defined as:

$$u_i(x, \overline{g}) = \lambda^{\theta_i}_{x_i}(1 + \sum_{j \in N_i(\overline{g})} I_{\{x_i = x_j\}}) - |N_i(\overline{g})|k \tag{2}$$

where $I_{x_j = x_i}$ is the indicator function of i's neighbour j choosing the same action as player i. The parameter λ is defined as follows: $\lambda^{\theta_i}_{x_i} = \alpha$ if $x_i(\overline{g}) = \theta_i$ (i chooses his preferred action), and $\lambda^{\theta_i}_{x_i(\overline{g})} = \beta$ if $x_i(\overline{g}) \neq \theta_i$ (i chooses his least preferred action) with $\beta < \alpha$. This payoff function is taken from Ellwardt et al. (2016). We note that the utility is additive across interactions with neighbours. Thus the size of the neighbourhood is an important factor in our setting.

To focus on the interesting cases, we will assume a cost of forming a link $k < \beta$. Observe that if $\beta < k$, then no player will benefit from playing their less preferred action. Moreover, if $\alpha < k$, then no player benefits from forming any link.

2.2 Equilibrium analysis

This section studies equilibrium networks and behavior. We solve backwards, starting with behavior in a given network. We then move to stage 1 and solve for stable networks.

For ease of exposition, we will drop the argument $\overline{g}$ and simply refer to strategies by x_i (instead of $x_i(\overline{g})$) whenever possible. Player i's payoff from choosing θ_i is $\alpha(|\chi_i(\overline{g})| + 1)$ and from choosing the other action is $\beta(N_i(\overline{g}) - |\chi_i(\overline{g})| + 1)$. So he is strictly better off choosing θ_i if and only if

$$\alpha(|\chi_i(\overline{g})| + 1) > \beta(|N_i(\overline{g})| - |\chi_i(\overline{g})| + 1). \tag{3}$$

This inequality can be rewritten as

$$|\chi_i(\overline{g})| > \frac{\beta}{\alpha + \beta}|N_i(\overline{g})| - \frac{\alpha - \beta}{\alpha + \beta} \tag{4}$$

Intuitively, a player is better off selecting his preferred action if and only if the proportion of his neighbours in $\overline{g}$ selecting the same action is sufficiently large. To illustrate the implications of this inequality, we consider a complete network. This network is interesting as it captures a situation of full integration where every player interacts with every other player.

Proposition 1. *Fix a complete network g. Everyone choosing the same action is an equilibrium if and only if $n \geq \alpha/\beta$. Every player choosing their preferred action is an equilibrium if and only if $|N_{up}|, |N_{down}| \geq \frac{\beta(n+1)}{\alpha+\beta}$.*

We sketch the proof here. To fix ideas, consider conformity on the majority's preferred action *up*. The payoff to a majority individual is $n\alpha$ and the payoff to a minority individual is $n\beta$. Since a deviating minority individual would obtain a payoff of α, it then follows that conformity is an equilibrium if $n \geq \alpha/\beta$. Similar computations also hold for the conformity on the minority preferred equilibrium (on action *down*).

Turning to the diversity outcome, player i's payoff from choosing the preferred action θ_i is $\alpha|N_{\theta_i}|$, and from choosing the other action is $\beta(n - |N_{\theta_i}| + 1)$. Since no player of either type $\theta_i \in \{up, down\}$ can benefit from choosing the least preferred action, it then follows that diversity is an equilibrium if:

$$\alpha|N_m| \geq \beta(n - |N_m| + 1) \tag{5}$$

for $m \in \{up, down\}$. This inequality can be rewritten as

$$|N_m| \geq \frac{\beta(n+1)}{\alpha + \beta} \tag{6}$$

for any $m \in \{up, down\}$. This completes the proof.

In a complete network there are three equilibrium outcomes: *conformity* where every player coordinates on the same action, *up* or *down*, and *diversity* where every player chooses their preferred action. Observe that conformity outcomes are always equilibria, regardless of the fraction of different types. On the other hand, the existence of the diversity outcome is contingent on a sufficiently large minority. Figure 1 illustrates these equilibrium outcomes in a society with 15 individuals divided into two types: 8 players are represented by *"circles"* and the remaining 7 individuals are represented by *"triangles"*. The circles prefer action *up*, while the triangles prefer action *down*. In all the figures throughout the article, action *up* is represented by color *"blue"* while action *down* is represented by color *"red"*.

We now solve the two stage game with link formation and action choices. We adapt the pairwise stability notion from Jackson and Wolinsky (1996) to our setting. In the spirit of their definition, we say that a network and corresponding equilibrium action profile is stable if no individual can profitably deviate either unilaterally or with one other individual. Given a network action pair $(\overline{g}, x(\overline{g}))$, $x_{-ij}(\overline{g})$ refers to the choices of all players, other than players i and j.

Definition 1. *A network-action pair $(\overline{g}, x(\overline{g}))$ is pairwise stable if:*

- $x(\overline{g})$ *is an equilibrium action profile given network* $\overline{g}$.
- *for every* $\overline{g}_{ij} = 1$, $u_i(x, \overline{g}) \geq u_i(x', \overline{g} - \overline{g}_{ij})$ *and* $u_j(x, \overline{g}) \geq u_j(x'', \overline{g} - \overline{g}_{ij})$, *where*

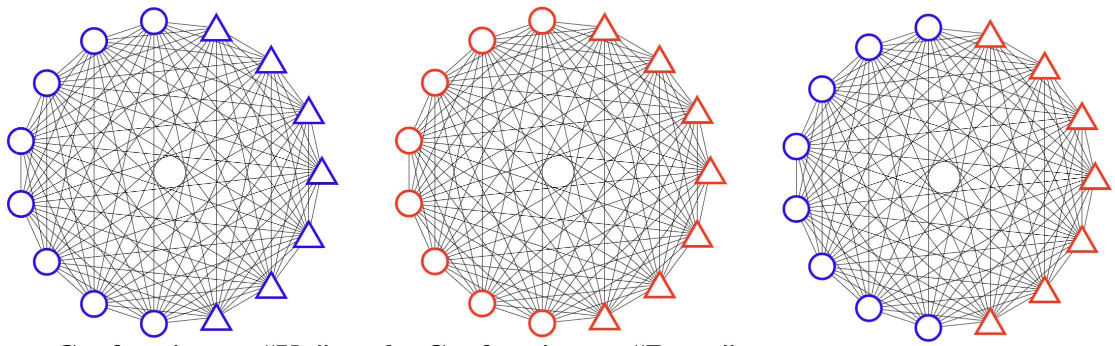


Figure 1. Nash equilibria in the complete network.

Note: A *circle* node represents a player in the majority and a *triangle* a player in the minority. Majority players prefer action *up* represented by color **blue**, while minority players prefer action *down* represented by color **red**. The border color of a node displays its chosen action.

$x'(\overline{g}-\overline{g}_{ij})$ and $x''(\overline{g}-\overline{g}_{ij})$ are some equilibrium action profiles given network $\overline{g}-\overline{g}_{ij}$.

- *for every $\overline{g}_{ij}=0$, $u_i(x,\overline{g}) \geq u_i(x',\overline{g}+\overline{g}_{ij})$ or $u_j(x,\overline{g}) \geq u_j(x',\overline{g}+\overline{g}_{ij})$ where $x'(\overline{g}+\overline{g}_{ij})$ is some equilibrium action profile given network $\overline{g}+\overline{g}_{ij}$.*

In this definition, part (2) says that no player can delete an existing link and profit, while part (3) says that no pair of players can form an additional link and increase their payoffs. In both cases, note that we allow for the action profiles that would result from different networks to be independent (and therefore possibly distinct) of each other. In that sense, a single linking change can lead all players (not only those affecting the linking change) to re-optimize their actions. Our aim here is to show that conformity and diversity can both be supported in a pairwise stable outcome; moreover, these outcomes can be supported by fairly different network structures. We believe that this general observation is robust in the sense that it does not depend on specific details of the definition above.

Proposition 2. *Suppose $k=0$. Then $(\overline{g}^*, x^*(\overline{g}^*))$ is pairwise stable if one of the following obtains:*

(i) $\overline{g}^*$ is a complete network and $x_i^*(\overline{g}^*)=m$ for all $i \in N$ and $n \geq \alpha/\beta+1$, where $m \in \{up, down\}$.

(ii) $\overline{g}^*$ *is a complete network and* $x_i^*(\overline{g}^*) = \theta_i$ *for all* $i \in N$, *and* $|N_{up}|, |N_{down}| \geq \frac{\beta n}{\alpha+\beta} + 1$.

(iii) $\overline{g}^*$ *contains two complete components,* $C_u = N_{up}$ *and* $C_d = N_{down}$ *where every player in* C_u *chooses up, while every player in* C_d *chooses down.*

This result provides a partial characterization of pairwise stable outcomes. It highlights three types of equilibrium outcomes.[9] Proposition 2(i) describes *Integration with conformity*, which arises when the network is complete and everyone chooses the same action. The corresponding proof follows from the fact that conformity on any action is an equilibrium for the complete network and any network with only one missing link if the population is large enough, i.e., $n \geq \alpha/\beta + 1$. Since the pair of players deleting a link would earn strictly less in the subgame where they conform on the same action, the complete network is pairwise stable.

Proposition 2(ii) describes *Integration with diversity*, which arises when the network is complete and everyone chooses their preferred action. It is easy to see that such a diversity outcome is an equilibrium in any network with only one missing link between two players of different types. Moreover, such an outcome is an equilibrium in any network with only one missing link between two players of the same type if the total number of such players is sufficiently large, i.e., $|N_{up}|, |N_{down}| \geq \frac{\beta n}{\alpha+\beta} + 1$. Given every player selects their preferred action, disconnecting any pair of same type players can only decrease their payoff.

Proposition 2(iii) describes *Segregation with diversity*, which arises when the network contains two components where all individuals choose their preferred action, and members of the same component share the same type. In this case, choosing the same actions would still clearly be optimal for all if only two players of the same component were disconnected, or if two players of different types became connected with each other. Fixing the same action profile, deleting a link is clearly decreasing the corresponding players' payoffs, and adding a link has no consequences on any player's payoffs.

We illustrate these outcomes with our example ($n = 15$, $|N_{circle}| = 8$, and $|N_{triangle}| = 7$). The conformity and diversity outcomes with integration are illustrated in the top half

[9] The detailed proof is provided in Appendix A

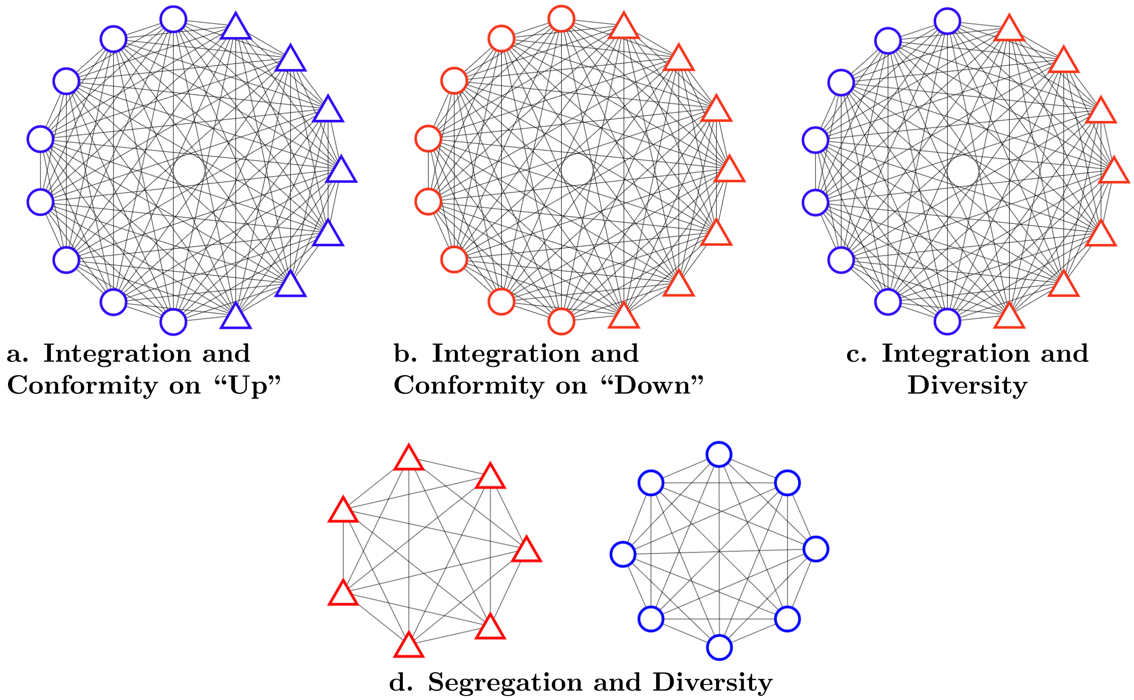


Figure 2. Pairwise stable outcomes for $k = 0$.

Note: A *circle* node represents a player in the majority and a *triangle* a player in the minority. Majority players prefer action *up* represented by color **blue**, while minority players prefer action *down* represented by color **red**. The border color of a node displays its chosen action.

of Figure 2, while the segregation is illustrated in the bottom half of Figure 2.

We now turn to social welfare which we define as the sum of payoffs of all players. An outcome is said to be socially efficient if it maximizes aggregate welfare. We show that both with the complete network and with endogenous networks, conformity on the majority's preferred action maximizes social surplus.

Proposition 3. *In a complete network, conformity on the majority's preferred action is socially efficient. In the game with linking and action choice, the socially efficient outcome entails a complete network and conformity on the majority's preferred action.*

The proof is presented in Appendix A. The result says that in our setting diversity is never socially desirable. To develop some intuition for the result, consider the complete network. Fixing the behavior of one group, the total aggregate payoffs can only decrease when the other group mixes actions. This follows from the coordination externalities inherent to our model. We therefore only need to compare the two outcomes: one, where everyone conforms to action *up*, and two, where everyone conforms to action *down*. The concluding step then shows that conformity on *up* is better if and only if the group that prefers *up* constitutes a majority.[10] Thus with exogenous complete network, the socially efficient outcome corresponds to Figure 1(a). Similarly, in the endogenous linking treatment, the unique socially efficient outcome is presented in Figure 2(a). Note that this socially efficient outcome is invariant with respect to value of the linking cost k (so long as it is below β).

In some circumstances, we may wish to consider Pareto-domination. It is easy to see that the majority group is always better off when everyone conforms to the majority's preferred action, but the minority may or may not be better off. Assuming that the network is complete, it is easy to verify that conformity on the majority's preferred action Pareto-dominates diversity in actions if $n/min\{N_{up}, N_{down}\} > \alpha/\beta$.

We summarize the theoretical analysis as follows: in the exogenous complete network there exist multiple equilibria exhibiting conformity and diversity. The conformity equilibria exist regardless of the group size, while the diversity equilibria can only arise if the minority group is not too small. With endogenous linking, there exist multiple equilibria exhibiting full integration with conformity, full integration with diversity, and segregation with diversity. Those equilibria hold regardless of the group size. In both the exogenous complete network and the endogenous network setting, conformity on the majority's preferred action maximizes aggregate social welfare.

We now report on laboratory experiments to examine the role of network formation in shaping patterns of social coordination.

[10]It is worth noting that this argument holds for arbitrary values of α and β. Thus conformity is preferred even if α is much larger than β: this is because the minority collectively gains less than what the majority losses when the minority switches away from conformism to diversity.

3 Experiment design

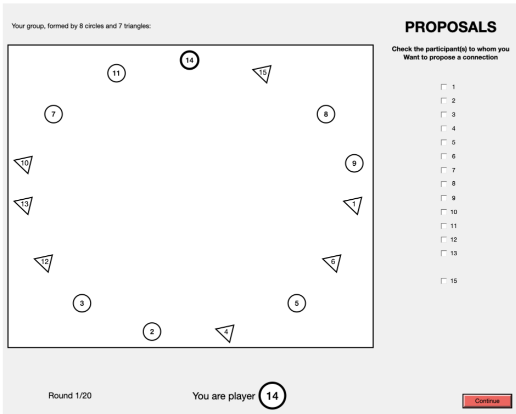
3.1 Experimental game

The experimental game follows the basic setup of the theory model. First, we describe the game where networks are endogenous, which refers to the two stage model of linking and action choice. Subsequently, we highlight the specific differences for the game with exogenous networks.

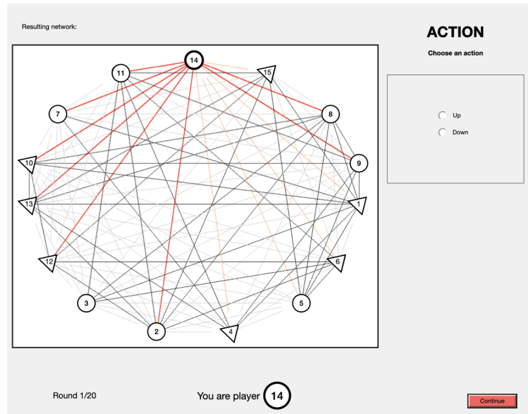
In either case, we consider groups of 15 participants, who interact repeatedly within the same group for 20 rounds (plus 5 unpaid trial rounds). Prior to the start of play, participants are informed of a symbol, either a circle or a triangle, and an identification number, from 1 to 15, assigned to them. Groups are composed of 8 circles (the majority group) and 7 triangles (the minority group). Figure 3a presents the screen that participants see at the start of the game (note that the positions of circles and triangles are mixed to avoid potential visual biases). Every participant knows his symbol, number and the symbol and number of the 14 others in his group. *Both symbol and number are kept fixed for the entire 20 rounds of play.*

There are two stages in the game with endogenous networks: first, players simultaneously make linking proposals to any of the other 14 in their group. Reciprocated proposals lead to the creation of links. In the second stage, players are informed of the links proposed and formed in stage 1. After observing the created network, players choose one of two actions: *up* or *down*. Figure 3b illustrates information about the network that players observe, at this point; in this picture, reciprocated (bilateral) proposals are represented as dark and 'complete' links, while proposals that are not reciprocated are represented as light shorter 'incomplete' edges.[11] Reciprocated and unreciprocated links involving the decision maker are highlighted in red, while any other link is depicted in grey. For example, in the screenshot in Figure 3b, player 14 has links with 2, 7, 8, 9, 10, 11, 12 and 13. He does not reciprocate proposals from 5 and 6, while he makes unreciprocated proposals to 1, 4 and

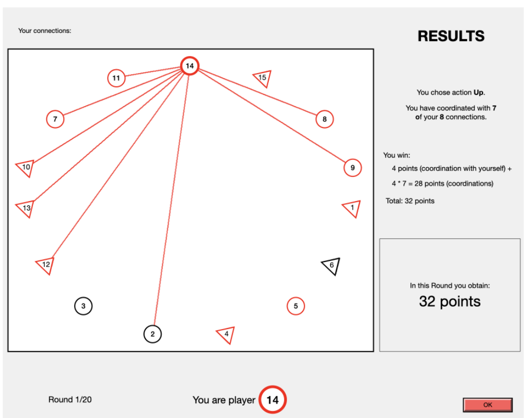
[11] An edge departing from node i towards node j without connecting j means that player i proposes a link to player j but j does not propose a link to i



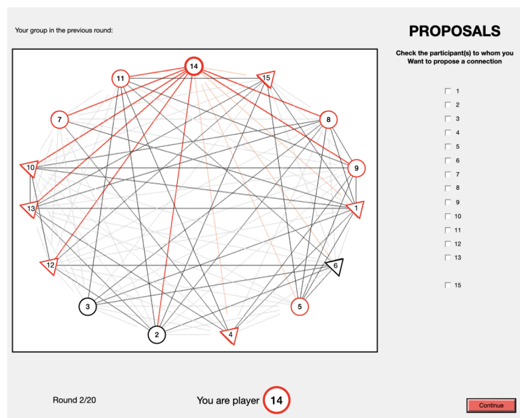
a. Network formation



b. Action choice



c. Results



d. Network formation in round > 1

Figure 3. Screens in the experiment.

Note: (a) Stage 1 in round 1: choosing proposals. The network display illustrates the type and identity number of each player in a group. The decision maker's identity marker is also presented at the bottom of the screen. (b) Stage 2 in any round: choosing *up* or *down*. In the network display, unreciprocated proposals are represented as light 'incomplete' edges, whereas reciprocated proposals are represented as dark 'complete' edges. The decision maker's proposals are highlighted in **red**. (c) End of any round. The decision maker observes own links, and which player(s) chose the same action (in **red**). Payoffs of the decision maker are summarized on the right hand side of the screen. (d) Stage 1 in round $r > 1$: choosing proposals. The decision maker observes a summary of proposals, links, and actions from round $r - 1$.

15. The reciprocated links lead to the relation of being neighbours.

The values of the key parameters are as follows:

- $\alpha = 4$: payoff for coordinating on one's *most* preferred action,
- $\beta = 2$: payoff for coordinating on one's *less* preferred action,
- $k = 0$: cost of any bilateral link.

For a player with symbol circle (triangle), his preferred action is *up* (*down*). Every player sees the outcome of the game and his net payoffs on the screen, as in Figure 3c. The figure shows that player 14's neighborhood includes 2, 7, 8, 9, 10, 11, 12 and 13. He coordinates successfully on his preferred action with players 7, 8, 9, 10, 11, 12 and 13, and he fails to coordinate with 2. Thus his net payoff is $8 \times 4 = 32$. Finally, at the beginning of any subsequent round, in stage 1, every player receives information about every other player's links and actions in the previous round, as shown through Figure 3d.

The second version of the experimental game is one with exogenous networks. In this case, unlike the game with endogenous networks, there is no network formation stage. Instead, a complete network of interaction is exogenously imposed, so that all players interact with every member of the group. Therefore, participants' first screen already portrays the links between nodes (see Figure 3b). After observing the complete network, players choose one of two actions: *up* or *down*.[12] Given that there is no linking decision, there are also no linking costs. For this reason, and to make payoffs comparable, the parameters in the game with exogenous networks are $\alpha = 4$ and $\beta = 2$.

3.2 Treatments with endogenous and exogenous networks

In what follows, we introduce the two main treatments in our study: ENDO and EXO. By varying the way networks are formed, the main purpose of these treatments is to investigate the role of endogenous linking on emerging outcomes. Details on these and other treatments

[12] The complete network is shown as it would be in game with endogenous networks, had the complete network emerged. See the instructions in Appendix C.

are presented in Table 1. The last two columns refer to additional treatments, that are described in Section 4.4 below.

Table 1. Experimental treatments.

Note: Description of the initial network structure and parameters of the game by treatment, as well as summary of aggregate payoffs (social welfare) in equilibrium for conformity and diversity.

	Endogenous Networks			**Exogenous Networks**		
	ENDO	SUBSIDY	COST	EXO	EXOSYM	EXOASYM
Links						
Linking costs (k)	0.0	-0.3	0.5	NA	NA	NA
Number of initial links	0.0	0.0	0.0	105.0	97.0	97.0
Payoffs per coordination						
Preferred action (α)	4.0	4.0	4.5	4.0	4.0	4.0
Non-preferred action (β)	2.0	2.0	2.5	2.0	2.0	2.0
Aggregated payoffs						
Conformity	690.0	711.0	697.5	690.0	654.0	656.0
Diversity	452.0	465.4	459.5	452.0	452.0	452.0

The first treatment in our study is ENDO, which refers to the situation in which networks are formed endogenously, but the cost of links is zero. ENDO starts with an empty network and participants play the two-stage game as describe above. From the theory, Propositions 2 and 3 tell us that the complete network with conformity on the majority's preferred action is an equilibrium and also socially efficient: see Table 1. Moreover, given our parameters, every individual in the minority group earns more by conforming to the majority's preferred action than by choosing his preferred action. Given these efficiency advantages, it seems reasonable to postulate the following hypothesis.

Hypothesis 1. *In the* ENDO *treatment subjects select the Pareto-dominant equilibium – the network outcome is the complete network and the coordination game outcome is conformity on the majority's preferred action.*

The second treatment in our study is EXO. This is a direct comparison with ENDO where players are located in an exogenously given network, from which they simply choose between two coordination actions. In EXO, the efficient equilibrium involves *conformity* on the majority's preferred action, *up* (see Propositions 1 and 3). As in ENDO, given our parameters, a minority individual earns more in this conformity outcome than he would in the diversity outcome where different preference types abide by their preferred actions. We conjecture that behaviour in the game will be indistinguishable from ENDO where subjects coordinate on the socially efficient outcome. Our second hypothesis is:

Hypothesis 2. *In the treatment* EXO *subjects select the Pareto-dominant outcome – the coordination game outcome is conformity on the majority's preferred action.*

The detailed instructions handed out to subjects in both treatments, ENDO and EXO, are presented in Appendix C.

3.3 Treatments with varying cost of linking

The first two treatments are designed to explore how linking affects coordination and efficiency. For that purpose, we deliberately isolated confounding factors such as the costs associated with establishing a link between two nodes. Yet, the dynamics of link formation in ENDO may realistically generate network structures that differ, even slightly, from the complete network. For example, subjects may choose to not propose links with players who did not previously propose a link with them, or select their preferred action (e.g., in the previous period). Alternatively, subjects may choose to use their linking activity in the first stage to signal their intended action in the second stage (e.g., disconnecting from players with a different type signals one's intent to not select their preferred action).

As a result of generating incomplete networks, such scenarios can create coordination problems in the second stage that are distinct from that in EXO. As a means to better understand the role that linking plays in resolving the coordination problem in the second stage, we manipulate the cost associated with linking in two new treatments varying the cost of linking: SUBSIDY and COST.

Treatment SUBSIDY is a treatment with endogenous network formation, and it is different from ENDO in that there is a *small negative* cost for forming links. We set the parameters as

- $\alpha = 4$: payoffs from coordinating on preferred action.

- $\beta = 2$: payoff from coordinating on less preferred action.
- $k = -0.3$: negative cost of a link.

These parameter values lead to a departure from the net payoffs in the treatment ENDO. They have been chosen so as to ensure that conformity on majority's preferred action remains the Pareto dominant action. For more details see Appendix A.1. Negative linking costs can allow the absence of links to work as signals of intent. As not forming a link is costly, we conjecture that the pressures towards a complete network would be even greater in this setting. Taking this together with the discussion on efficiency in the baseline ENDO and EXO treatments, strengthens the case for the complete network and the conformity outcome. This leads to our next hypothesis.

Hypothesis 3. *In the treatment* SUBSIDY*, subjects select the Pareto-dominant outcome – the network outcome is the complete network and the coordination game outcome is conformity on the majority's preferred action.*

The next treatment is COST, in which the cost for forming links is *positive*, unlike SUBSIDY. The parameter values are set as follows:

- $\alpha = 4.5$: payoffs from coordinating on preferred action.
- $\beta = 2.5$: payoff from coordinating on less preferred action.
- $k = 0.5$: positive cost of a link.

Observe that being connected with a player who plays one's most preferred action is worth $\alpha = 4$ in EXO and $\alpha - k = 4$ in COST and ENDO. Similarly, for the payoffs from the less preferred action, the payoff is 2 in all three treatments. We have noted the efficiency arguments in favour of the outcome with complete network and conformism on the majority's preferred action. That efficiency argument still has force in the setting with positive costs of linking. This suggests our next hypothesis.

Hypothesis 4. *In the treatment* COST*, subjects select the Pareto-dominant outcome: the network outcome is the complete network and the coordination game outcome is conformity on the majority's preferred action.*

The equilibrium outcomes associated with these two treatments are presented in the Appendix A.1 and A.2. As reported in Table 1, the integration with conformity outcome remains socially efficient in these two treatments, as under treatment ENDO.

3.4 Procedures

The experiment was conducted in the Laboratory for Research in Experimental and Behavioural Economics (LINEEX) at the University of Valencia. A total of 540 subjects participated in the study. For each of the 6 treatments, we conducted two sessions with 3 groups of 15 participants in each. Participants interacted through computer terminals and the experiment was programmed using z-Tree (Fischbacher 2007).

Each session lasted between 90 and 120 minutes. Upon arrival, subjects were randomly seated in the laboratory. At the beginning of the experiment subjects received printed instructions, which were read out loud to guarantee that they all received the same information (see Appendix C).

After reading the instructions, participants played 5 trial rounds to familiarize with the experiment and payoffs in the game. Trial rounds were not paid and groups were rematched at the beginning of the 20 rounds of actual play. At the end of the experiment each subject answered a debriefing questionnaire.

Earnings were calculated as the total sum of all points accumulated across the 20 rounds of play, using the exchange rate of 50 points = 1 euro. On average participants earned 18 euros, including a 5 euro show-up fee.[13] The standard conditions of anonymity and non-deception were implemented in the experiment, and no one participated in more than one session.[14]

[13] Earnings for minority players are not significantly different across treatments. Similarly, for the majority earnings are not significantly different across treatments, except for ENDO where they earn about 50% more than in the rest. In all treatments, majority participants earn more than those in the minority.

[14] Regarding the demographics, female participants represent 47% of all subjects in ENDO, and 51% in EXO. All participants are undergraduate students, and the average age is 23 years old. Participants' academic backgrounds are in law, finance, business, economics, pedagogics, tourism, and nursing.

4 Experimental results

In this section, we report findings on the effect that network formation has on coordination, equilibrium selection and efficiency, by comparing settings with *endogenous* and *exogenous* networks.

The data in our experiment consists of the decisions made over 20 periods by groups of 15 participants. In each of the 4 main treatments there are 6 groups, resulting in a total of 480 observations at the group level. Throughout the paper, we test the role of network formation, by running random effects GLS regressions, clustering standard errors on groups. We use dummy variables for treatments as the independent variables. We report two-sided p-values in the text and provide all regressions in Appendix B.[15]

Table 2 reports summary statistics of the main variables of analysis by treatment. Recall the first choice in the game is to create network links (in the endogenous formation treatment). There are two classes of links. Links within-types (WT) are those connecting minority players to other minority players (21 possible links) or majority players to other majority players (28 possible links). The second class of links are between-types (BT), which connect minority players to majority players (56 possible links). The table reports the fraction of links formed out of the maximum possible for each case. Conformity reports the fraction of players in the majority (out of 8) and in the minority (out of 7) choosing the action preferred by the majority: action *up*. Finally, efficiency reports the fraction of total points earned in the network divided by the maximum attainable payoff (conformity in the complete network) when the integration with conformity outcome is chosen.

[15] We also analyzed the data using Wilcoxon-Mann-Whitney tests and group averages as the unit of observation. The regression' results are consistent with those of the non-parametric tests.

Table 2. Summary statistics across treatments

Note: Average fractions (percentages) for each of the main variables summed over rounds. Standard deviations in parenthesis. There are no standard deviations for treatments with exogenous networks as links are imposed by design. Links within types (WT-links) as well as Conformity are reported separately for the minority and the majority, while links between types (BT-links) are the same for the majority and the minority.

	Endogenous Networks			**Exogenous Networks**		
	ENDO	SUBSIDY	COST	EXO	EXOSYM	EXOASYM
WT-links						
Minority	0.98	0.99	0.88	1.00	1.00	1.00
	(0.06)	(0.05)	(0.14)	-	-	-
Majority	0.98	0.99	0.97	1.00	1.00	1.00
	(0.04)	(0.04)	(0.06)	-	-	-
BT-links	0.83	0.94	0.13	1.00	0.44	0.44
	(0.11)	(0.07)	(0.11)	-	-	-
Conformity						
Minority	0.06	0.03	0.07	0.69	0.31	0.52
	(0.10)	(0.06)	(0.10)	(0.37)	(0.39)	(0.39)
Majority	0.97	0.99	0.99	0.99	0.94	0.98
	(0.05)	(0.04)	(0.03)	(0.03)	(0.18)	(0.06)
Efficiency	0.64	0.68	0.62	0.85	0.76	0.80
	(0.26)	(0.02)	(0.04)	(0.15)	(0.12)	(0.13)

4.1 Endogenous versus exogenous links

Consider the network formation stage in treatment ENDO.[16] We observe that networks are highly connected from round 1 onward and the high rates of connectivity continue over time without much variation. Specifically, subjects create roughly 94.5 links (about 10% of total links are missing), individual degree is on average 12.59 (out of 14 possible links) and there are no differences in connectivity between majority and minority players ($p = 0.673$). For such densely connected networks as in ENDO, it is more illuminating to portray the fraction of links missing instead of the fraction of links formed.

Figure 4 depicts the fraction of links missing within-types (WT) for the majority (solid

[16] We note that the treatments require a group of 15 subjects to play the same game repeatedly (20 times). In principle, therefore, we should also be considering repeated game effects. In our setting, equilibria of the repeated game will include a sequence of the static game equilibrium, and possibly other more complicated patterns of behavior. In the experiments, subjects converge fairly quickly and behave very much in line with a static equilibrium. The key finding is the contrast in outcomes between the exogenous and the endogenous linking setting. As both these treatments involve repeated interactions, repeated game effects are not central to understanding this difference.

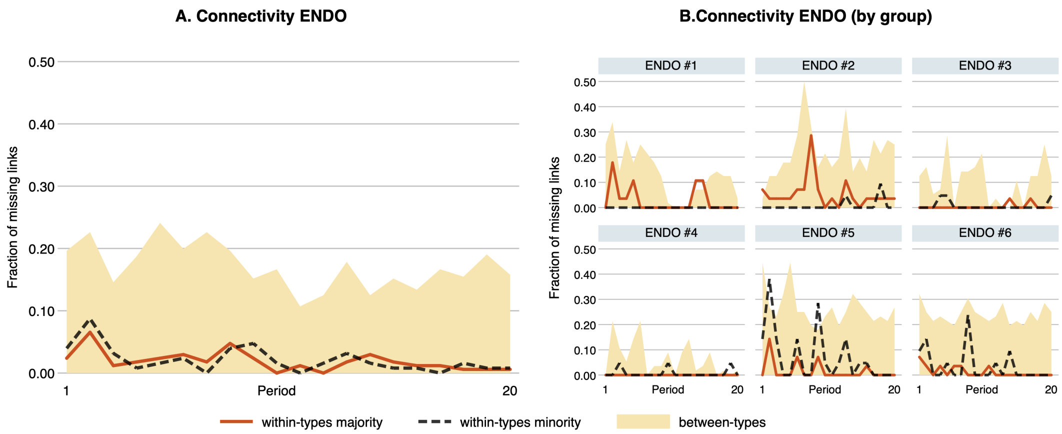


Figure 4. Fraction of missing links in treatment ENDO.

Note: The figure depicts the fraction of between-types missing links (**light area**), as well as the fraction of within-types missing links for the majority (**solid line**) and for the minority (**dashed line**), across the 20 periods of play. Panel A illustrates outcomes pooled at the treatment level and Panel B discriminates by groups.

line) and for the minority (dashed line), as well as the fraction of between-types (BT) missing links (light area). We observe that almost all WT-links are formed both for the majority and for the minority, and the fractions are not different between them ($p = 0.872$). Thus, most of the missing connections are BT-links. Moreover, taking a deeper look into the intentions to connect (i.e., proposals made), we find that the likelihood that a proposal is reciprocated and turns into a link is not distinguishable between minority and majority players, neither for WT-proposals ($p = 0.828$) or for BT-proposals ($p = 0.464$). This means that both types of players were equally invested in proposing links and the few missing connections are not caused by a particular type reciprocating less than the other.[17]

We next look at the actions chosen in the coordination game under the two treatments.[18] The main finding is that subjects conform significantly more under treatment EXO than ENDO ($p < 0.0001$): the average number of subjects choosing the majority's action are 12.68

[17]In the Supplementary Material, we report detailed measures on the likelihood of successfully turning proposals into links, by type of player for all endogenous treatments.

[18]Note that conformity on either action is an equilibrium as long as all agents have at least one connection and $\alpha \leq 2\beta$. These conditions are satisfied for all networks endogenously created in ENDO. See details in the Supplementary Material.

and 8.18, respectively. This is illustrated in Figure 5: the fraction of majority participants (solid line) and minority subjects (dashed line) conforming by choosing the majority's preferred action *up*, across periods. In particular, in five out of the six groups, subjects reached full conformity in treatment EXO (see Figure 5B), while none of the groups in treatment ENDO reaches full conformity even once (see Figure 5D). Thus the experiment rejects Hypothesis 1 but strongly supports Hypothesis 2.

Furthermore, an inspection of the figure reveals that the main source of the difference between the treatments comes from the choice of the minority, who conform significantly under treatment ENDO ($p < 0.000$); on the other hand, there were no significant differences in the choices of the majority across these two treatments ($p = 0.149$). Finally, note that in treatment ENDO, subjects choose actions in line with their preferences and diversity in actions obtains: this translates into significantly lower level of efficiency as compared to outcomes under treatment EXO ($p < 0.0001$).

These observations constitute the main finding of the paper:

Result 1. ***Endogenous versus exogenous linking***. *In an exogenous complete network, subjects conform to the majority's preferred action; this leads to high levels of efficiency. By contrast, in the endogenous linking game, subjects create an incomplete but dense network, and every subject chooses his preferred action. This leads to diversity in actions and significantly lower level of efficiency than in the exogenous case.*

How is it that subjects form densely connected networks in ENDO, that are very similar to those in EXO, and yet choose diversity in actions? Recall, that the theory predicts that the minority is strictly worse off under diversity as compared to conformity, when the network is complete. The networks that subjects created are dense but not complete: a natural question is whether conformity is still efficient and desirable for the minority subjects in these networks?

To examine this question, we look at the payoffs that would arise if subjects were to conform fully on the majority's action in the created networks and compare these payoffs with the payoffs that subjects actually earn under diversity. We find that efficiency would have been higher had all subjects conformed ($p = 0.000$) to the majority's preferred action

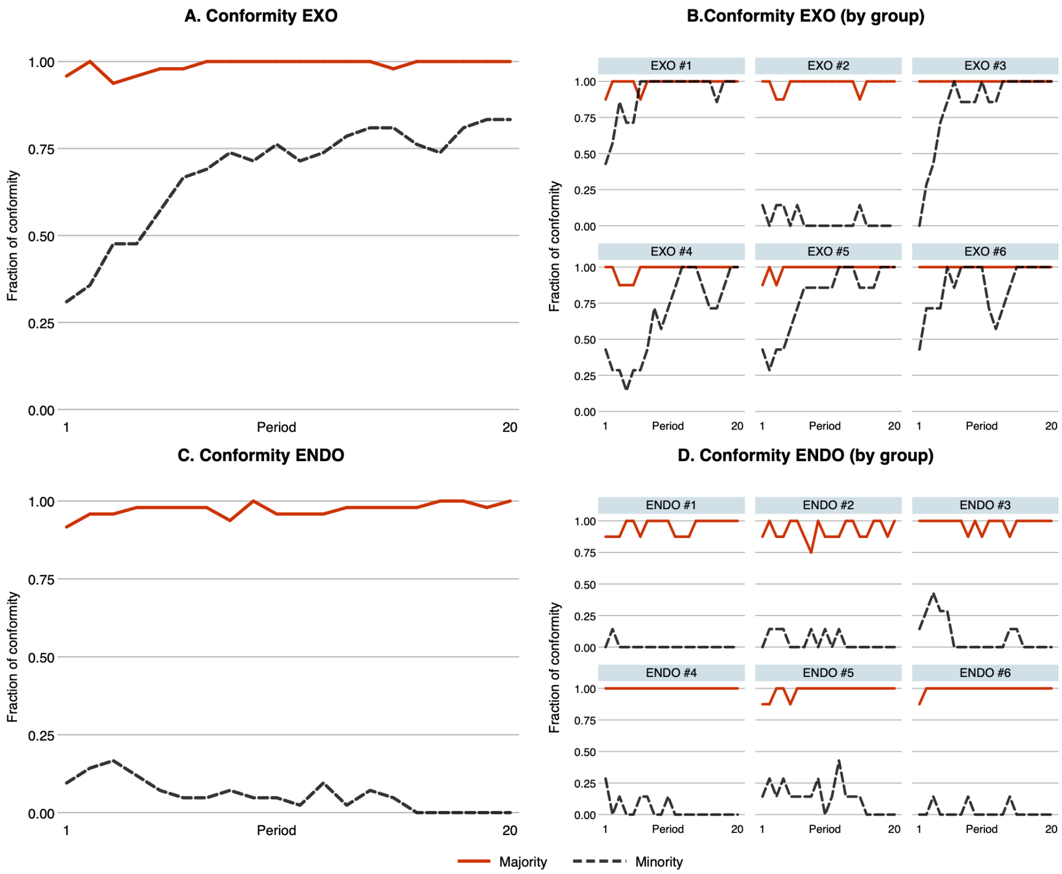


Figure 5. Fraction of subjects choosing conformity (action *up*) in treatments EXO and ENDO.

Note: The figure depicts the fraction of majority (**solid line**) and minority (**dashed line**) subjects choosing action *up*, across periods. Panel A (C) illustrates outcomes pooled at the treatment level and Panel B (D) discriminates by groups for EXO (ENDO).

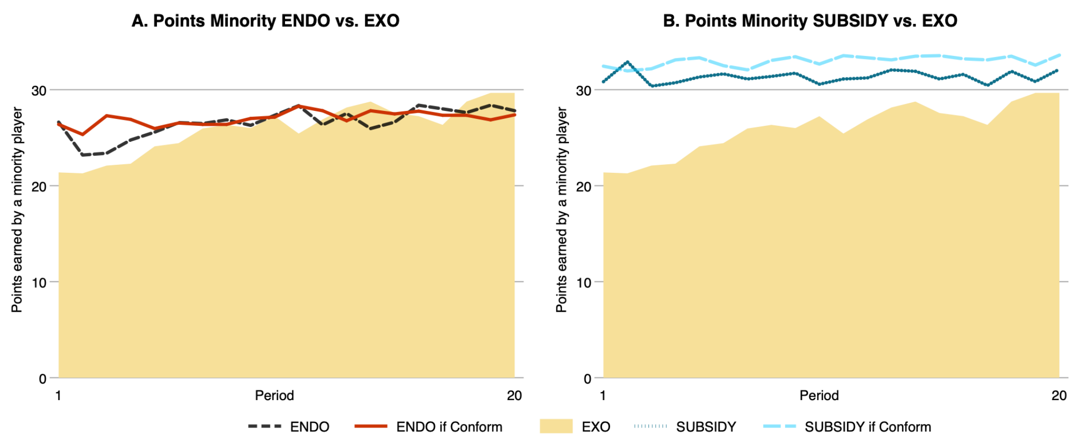


Figure 6. Average payoff for minority players in EXO, ENDO and SUBSIDY.

Note: The **light area** represents the average earnings in EXO in both panels. In Panel A, the **solid line** represents average earnings in ENDO if conformity had been chosen, and the **dashed line** represents the actual average earnings in ENDO. In Panel B, the **long-dashed line** represents average earnings in SUBSIDY if conformity had been chosen, and the **dotted line** represents the actual average earnings in SUBSIDY.

in these created networks. This would have especially benefited the majority players who would have earned on average 54 points instead of 31 points. However, minority players would not have seen a significant improvement in earnings: they would have earned on average 27 points instead of 26.3 points ($p = 0.647$). Figure 6 illustrates the earnings for the minority players under three scenarios: one, under treatment ENDO (dashed line), two, if players had chosen conformity (solid line), and three their earnings under treatment EXO (light area).

This shows us that the minority players are not worse off by choosing diversity compared to choosing conformity, in the incomplete networks that arise under ENDO. We next compare their payoffs under ENDO with their payoffs under treatment EXO. Although efficiency is significantly lower at the network level in ENDO ($p < 0.001$), the actual payoffs attained by the minority in ENDO are not statistically different from what they earn under EXO ($p = 0.462$). The reason for this, as illustrated in Figure 6, is that coordination on the diversity outcome in ENDO is faster than coordination on the conformity outcome in EXO. The absence of difference in attained payoffs is therefore due to the speed of convergence to conformity under treatment EXO as compared to the rate of convergence to diversity under treatment ENDO. This is best seen if we compare the time trend between treatments in the first and second half of the experiment (i.e., blocks of 10 periods), and find that the time trend is positive and significant for EXO in the first half ($p = 0.003$) but it is not significant for ENDO ($p = 0.221$). It is not significant for the second half for either of the two treatments.

These results are consistent with the following view: this is a very complex coordination problem, due to the large number of individuals and the heterogeneity in preferences. Individuals try and use cues from the environment and instruments that they have available to simplify the coordination problem. In our experiment, relatively greater linking with own types correlates strongly with rapid convergence to choosing preferred actions, i.e., to diversity in actions.

We now explore the robustness of this correlation.

4.2 Endogenous incentivized links: the role of negative costs

In this section, we explore more deeply the role of endogenous linking by conducting a treatment with a small negative cost, i.e. a subsidy. In treatment SUBSIDY, any two players can strictly increase their payoffs by 0.3 points when forming a link, regardless of whether they subsequently coordinate their actions. Therefore, we expected this to reduce the fraction of missing links compared to ENDO. If conformity were chosen in the resulting networks, it would suggest that the freedom to choose links does not necessarily lead to different behavior but merely imposes an additional layer of complexity that is hard to solve (thus the missing links), compared to the exogenous case. However, if diversity were chosen, this would provide additional support to our claim that endogenous linking per se affects the way subjects behave in otherwise equivalent social networks.

Figure 7A shows that connectivity is high and that it is higher than under treatment ENDO, $101.3 > 94.5$ ($p = 0.005$). Note that both minority and majority players have high degrees, 13.5 and 13.6, respectively. This is because, on average, both types of players again are indistinguishable in creating all their WT-links ($p = 0.538$). The few missing connections are BT-links, for which the rate of proposals is also indistinguishable between

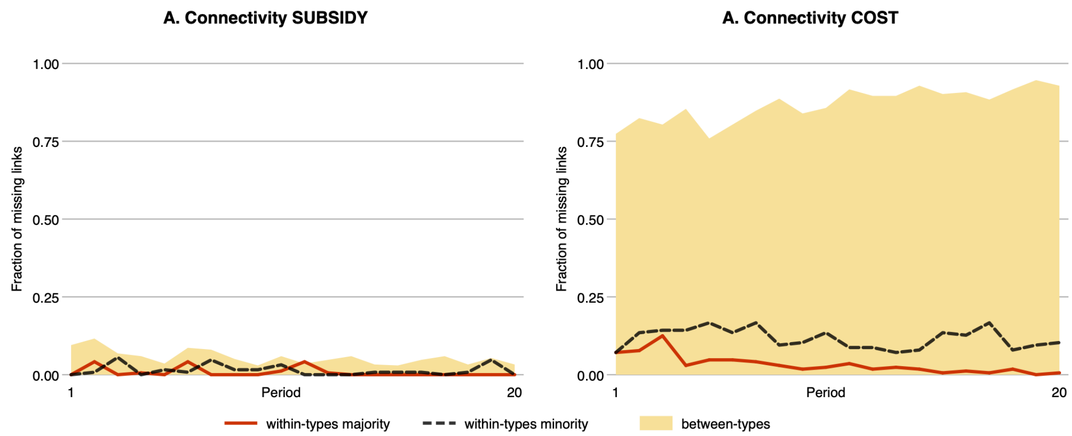


Figure 7. Fraction of missing links in treatment SUBSIDY(Panel A) andCOST (Panel B)

Note: The **light area** represents the fraction of missing links between players with different types. The **solid line** represents the fraction of missing links within players in the majority, and the **dashed line** represents the fraction of missing links within players in the minority.

majority and minority (p = 0.912). This means that both types of players responded similarly to the incentives to connect and were highly involved in actively proposing and reciprocating to links.

Turning to action choice in the coordination game, the striking result is that, subjects in SUBSIDY create densely connected networks – in fact they created the complete network in 50% of the cases, and yet not even once did a group reach full conformity. Thus subjects converged to diversity in all the cases. Figure 8A presents patterns of choice in the coordination game. The level of conformity is statistically not distinguishable from ENDO when looking at the choices of the majority (p = 0.207) or the minority (p = 0.108). The experiment therefore rejects Hypothesis 3 for SUBSIDY.

One point to note is that under treatment SUBSIDY, the network was sufficiently dense so that choosing conformity wuld have actually yielded all subjects strictly higher earnings – so, efficiency would have been higher at the aggregate level (p = 0.000), for the majority (p = 0.000) as well as for the minority (p = 0.012). This suggests that even when the network formation challenge is successfully resolved, the freedom of linking leads to dramatically different behavior in the coordination game.

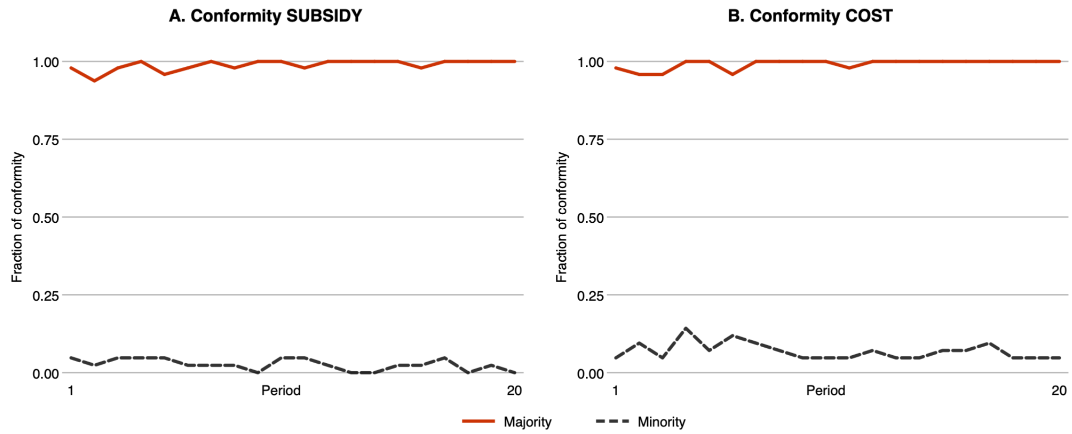


Figure 8. Fraction of subjects choosing conformity (action *up*) in treatments COST and SUBSIDY

Note: The figure depicts the fraction of majority (**solid line**) and minority (**dashed line**) subjects choosing action *up*, across periods.

Result 2. ***Negative linking cost.*** *When the cost of linking is negative, subjects choose a dense network – in 50% of the cases, they actually chose the complete network – and yet always also chose diversity of actions.*

4.3 Endogenous links: the role of positive costs

To further understand the role of the cost of linking, we also, as a control to the role of linking, conduct a treatment with a positive linking cost. In treatment COST, unlike treatment ENDO, two players should only form a link if they intend to choose the same action in the coordination game. This treatment provides insights into the intentions of majority players. That is, in both ENDO and SUBSIDY, the behavior of the majority players should have been the same if conformity had been chosen, thus the minority was driving outcomes. However, in COST, if majority players want to drive outcomes towards conformity, they should promote BT-links. However, if diversity in actions is chosen, we should see a significant decrease in BT-links compared to ENDO.

Networks in COST are actively created from early on, but this linking activity is mostly focused on WT-links. Thus we see the emergence of (almost) complete segregation in Figure 7B. Subjects created an average of 53 links out of 105, so that 50% of all possible links are missing. This is justified by the fact that BT-links are very limited at the start, and become rarer over time. The majority forms on average the same number of WT-links in COST and ENDO ($p = 0.259$), while the minority is less successful in forming WT-links when linking is costly than when it is free ($p = 0.029$). However, the main difference is in the BT-links: the rate of missing links increases from 17% in ENDO to 87% in COST ($p < 0.0001$). Moreover, the intention to connect, i.e. fraction of BT-proposals, is not distinguishable between the majority and the minority in COST ($p = 0.775$), which indicates that players in both types are deliberately avoiding connecting between them. Thus, networks converge to two distinct complete components that have virtually no links between them.

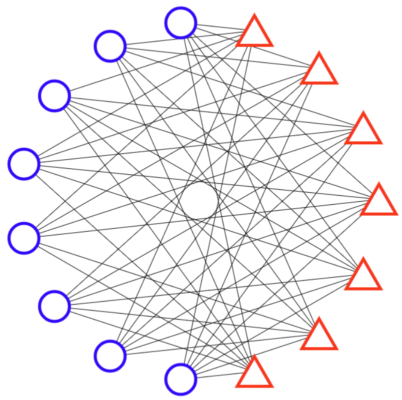
We now turn to actions: The main observation is that subjects, in these segregated structures, choose their own preferred action. Moreover, there is convergence to diversity in actions, and the level of conformity is not distinguishable from ENDO ($p = 0.441$). This is illustrated in Figure 8B. Thus Hypothesis 4 is rejected.

Result 3. ***Positive linking cost.*** *When the cost of linking is positive, subjects create a network almost completely segregated by preference type and everyone chooses their preferred action, leading to diversity in actions.*

Positive linking costs allow links to work as signals of intent. For example, for a minority player to form a link with a majority player might be seen as an indication of a willingness to go along and conform with the majority's preferred action, while not forming a link can signal an intention to stick to one's own preferred action. This line of reasoning suggests a closer relation between networks and action choice in COST, than under ENDO and SUBSIDY. The outcome in treatment COST may be seen as supporting this line of reasoning.

4.4 Robustness

The previous experimental results suggest a strong effect of choosing links on the selection of the outcome. However, since the endogenously formed networks in the treatment ENDO are not perfectly matching the complete network, there remains the possibility that the existence of a few missing links itself causes the breakdown of efficient coordination in the second stage.



a b

Figure 9. Illustrations of networks in (a) EXOSYM and (b) EXOASYM .

Note: The graphs display the between-types links connecting majority and minority players. For clarity in the illustration, we omit all within-types links, connecting minority to minority players or majority to majority players.

In order to verify this hypothesis, we provide an alternative examination of the role of endogenous linking compared to exogenous networks. The strategy here is to take dense networks similar to those that were created by subjects in the treatment ENDO, set them up as exogenous networks and have the subjects play coordination games on these networks. We take two distinct network configurations with 7 missing links in both, leading to an 87.5% connectivity across types.[19] We consider one symmetric and one asymmetric pattern of missing links in order to cover extreme cases of the distribution of such missing links.[20]

Treatment EXOSYM captures a case where the 7 missing links are evenly distributed across the minority players. That is, every minority player has exactly *one* missing link with a majority player (see Figure 9a). After observing the network, as in ENDO, subjects choose one of two actions: *up* or *down*.

[19]This design choice is justified by the minimal variations in the network structures observed in ENDO, which closely resemble the static nature of the fixed structures considered here. However, we realize this is not the unique option to investigate the role of endogenous linking. For example, an alternative would consist in setting the exact sequences of networks as created in ENDO, and ask a new group of subjects to play coordination games on those networks (which would then exogenously change over time). While such a method may offer a closer comparison with ENDO, we believe it would not uncover significantly more insights.

[20]As in the design presented above, each of these new treatments consists of 6 groups of 15 subjects whose decisions are made over 20 periods, resulting in a total of 240 observations at the group level.

Treatment EXOASYM is different from EXOSYM in that the 7 missing links are unevenly distributed. The network is such that only one minority player is missing all but one links with the majority players, while the remaining six minority players are connected to all the majority players (see Figure 9b where the filled triangle node represents the minority player with missing links with all but one majority player).

We investigate if the behavior of subjects remains unchanged or if it is different from the behavior in ENDO. If behavior is markedly different, then that would suggest that the act of linking *per se* is important. While this is the general strategy, we would like to note that there are confounding factors that need to be borne in mind. One important factor is that we are not varying the exogenous networks across the periods. So the analogy of exogenous networks with the dynamics of endogenous networks is not exact. So, the evidence we present on the differences between treatments ENDO and EXOSYM and EXOASYM should only be seen as suggestive.[21]

The equilibrium characterization for treatments with exogenous-incomplete networks is presented in Appendix A.3. Table 1 summarizes the experimental design and the predicted aggregated payoffs (efficiency) in equilibrium.

Our corresponding hypothesis is summarized as follows.

Hypothesis 5. *In the treatments* EXOSYM *and* EXOASYM*, the absence of endogenous linking choices will create significantly different choices of action in the coordination games, as compared to treatment* ENDO*.*

We find that conformity is chosen significantly more by the minority under treatments EXOSYM ($p = 0.05$) and EXOASYM ($p = 0.001$) compared to treatment ENDO. This supports Hypothesis 5. Specifically, under treatment EXOSYM and EXOASYM, four groups (out of twelve) converge to conformity on the majority's preferred action.[22] The diversity outcome

[21] Treatments EXOSYM and EXOASYM are aimed to resemble linking patterns as in ENDO, while imposing the network exogenously. Potentially, other forms of linking patterns can induce differences in outcomes and discourage conformity even more, but this was not part of our aim in this robustness check. For examples of studies exploring the effects of different linking patterns (network structures) on outcomes see Choi and Lee (2014); Antonioni et al. (2013); Kearns et al. (2012).

[22] In EXOSYM, one of the remaining groups converges to conformity on the minority's action and the remaining four groups converge to diversity. In EXOASYM, the remaining three groups converge to diversity.

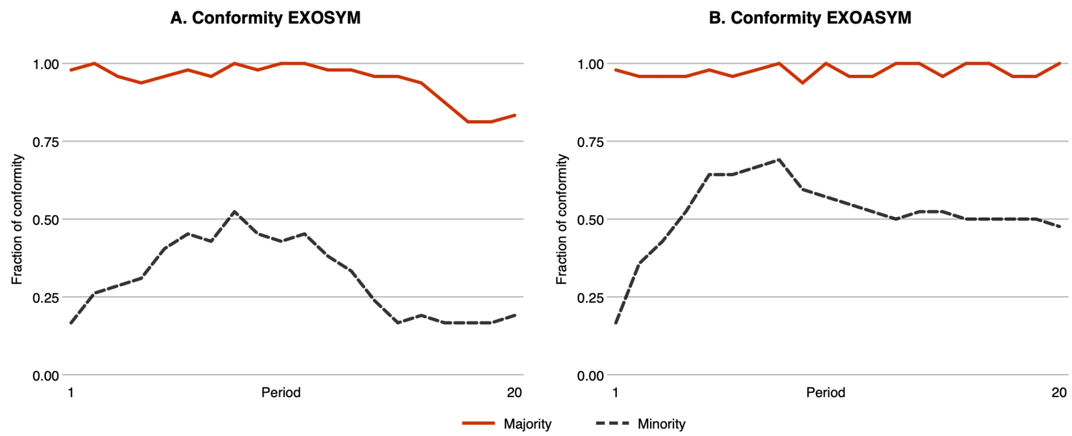


Figure 10. Fraction of subjects choosing conformity (action *up*) in treatments EXOSYM and EXOASYM.

Note: The figure depicts the fraction of majority (**solid line**) and minority (**dashed line**) subjects choosing action *up*, across periods.

was reached in all 100% of the groups under ENDO, but it was attained in only 58% of the groups (7 out of 12) under EXOSYM and EXOASYM. This leads to significantly higher levels of efficiency under EXOSYM ($p = 0.001$) and EXOASYM ($p < 0.001$).

To summarize:

Result 4. ***Exogenous incomplete networks.*** *When networks are incomplete but exogenously imposed, subjects choose conformity significantly more than in equivalently incomplete but endogenously formed networks. This leads to higher levels of efficiency.*

This sharp difference in outcomes supports the view that the choice of linking *per se* is important in shaping behavior.

5 Conclusion

This paper studies social coordination in a setting where individuals prefer to coordinate with others but they differ on their preferred action. Our interest is in understanding the role of the choice of linking with others in shaping individual choice.

To clarify the key considerations, we start by setting out a theoretical model. There is a group of individuals who each choose between two actions *up* or *down*. Everyone prefers to coordinate on one action but individuals differ in the action they prefer. We consider a baseline setting in which everyone is obliged to interact with everyone else and a setting in which individuals choose with whom to interact. In the latter setting, everyone observes the network that is created and then chooses between action *up* and *down*. The theoretical analysis reveals a rich set of possibilities.

In the case where everyone interacts with everyone else, there exist three equilibria: everyone conforming to one action, everyone conforming to the other action, and diversity with the two groups choosing their preferred actions. In the setting with endogenous linking the outcomes take two forms: either every individual connects to everyone else and the action profile corresponds to one of the three equilibria described above, or the network is only partially connected. In the latter case, the network may fragment into two components and individuals in each component choose a different action. Finally, we show that in both the exogenous and endogenous interaction setting, conforming to the majority's preferred action maximizes aggregate welfare. Thus there is multiplicity in outcomes both in the exogenous and the endogenous linking case and there is a tension between diversity and aggregate welfare.

Our experiments reveal that, in an exogenous complete network, subjects choose to conform to the majority's preferred action. By contrast, when linking is free and endogenous, subjects form dense networks but choose diverse actions. The networks are biased in favour of linking within same preferences type. An examination of the dynamics of action choice reveals that convergence to the steady state with diverse actions is faster under endogenous linking as compared to the convergence to conformity on the majority's preferred action under the exogenous complete network. Thus our experiments suggest that individuals use links – selectively – to resolve the coordination problems they face.

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Appendix A Proofs and additional propositions

Proof of Proposition 2:

Proof. Let us first demonstrate (i). We know from Proposition 1 that conformity is an equilibrium in the complete network if $n \geq \alpha/\beta$. Similarly, conformity is an equilibrium in any network with $n(n-1)/2-1$ links (i.e., the complete network minus one link) if $n \geq \alpha/\beta + 1$. Since the players with one missing link would earn strictly less in the latter equilibrium (because of the missing link), it directly follows that the complete network with conformity (on either action) is pairwise stable according to Definition 1.

Let us now demonstrate (ii). We know from Proposition 1 that diversity is an equilibrium in the complete network if $|N_{up}|, |N_{down}| \geq \frac{\beta(n+1)}{\alpha+\beta}$. Let us also consider the same network with exactly one extra missing link. If this link is between two players of different types, then it follows that diversity is an equilibrium if none of those players can benefit by choosing a different action, i.e., $\alpha|N_m| \geq \beta(n-|N_m|)$, which can be rewritten as $|N_m| \geq \frac{\beta n}{\alpha+\beta}$, for any $m \in \{up, down\}$. If the link is between two players of the same type, then diversity is an equilibrium if none of those players can benefit by choosing a different action, i.e., $\alpha(|N_m|-1) \geq \beta(n-|N_m|+1)$, which can be rewritten as $|N_m| \geq \frac{\beta n}{\alpha+\beta}+1$, for any $m \in \{up, down\}$. In both cases, the missing link yields strictly lower payoffs for the players unlinked with each other. It directly follows that if $|N_{up}|, |N_{down}| \geq \frac{\beta n}{\alpha+\beta}+1$, the complete network where all players choose their preferred action is pairwise stable according to Definition 1.

Finally, let us demonstrate (iii). It is easy to see that segregation in two complete components where all players of the same component share the same type, and where every player chooses their preferred action is an equilibrium (because $\alpha > \beta$). It directly follows that such an outcome is also an equilibrium if one extra link is missing in the network (between players of the same type). However, this outcome yields strictly lower payoffs for the players unlinked with each other. Similarly, the diversity outcome is an equilibrium if there is one extra link added between two players of different types, in which case all payoffs remain unchanged (because the extra link incurs no cost). It therefore follows that the segregation network with diversity is pairwise stable according to Definition 1.

□

Proof of Proposition 3:

Proof. Let x and y be the number of players playing *down* in N_{up} and N_{down}, respectively. The sum of individual payoffs is

$$W(x, y) = (n - x - y)(\alpha(|N_{up}| - x) + \beta(|N_{down}| - y)) + (x + y)(\beta x + \alpha y). \tag{7}$$

For fixed y, social welfare is decreasing in x if $x < x^*$ and increasing in x for $x > x^*$, where

$$x^* = \frac{\beta(|N_{down}| - 2y) + \alpha(|N_{up}| - 2y) + \alpha(n)}{2(\alpha + \beta)}. \tag{8}$$

Similarly, for any x, social welfare is decreasing in y if $y < y^*$, and increasing in y for $y > y^*$, where

$$y^* = \frac{\alpha(|N_{up}| - 2x) + \beta(|N_{down}| - 2x) + \beta(n)}{2(\alpha + \beta)} \tag{9}$$

Since $0 \leq x \leq |N_{up}|$ and $0 \leq y \leq |N_{down}|$, it follows that $W(x, y)$ is maximized for some $x \in \{0, |N_{up}|\}$ and some $y \in \{0, |N_{down}|\}$. Note that $W(0, |N_{down}|) = \alpha(|N_{up}|^2 + |N_{down}|^2)$, and $W(|N_{up}|, 0) = \beta(|N_{up}|^2 + |N_{down}|^2)$, which directly implies that $W(0, |N_{down}|) > W(|N_{up}|, 0)$ (because $\alpha > \beta$). Furthermore, since $W(0, 0) = n(\alpha|N_{up}| + \beta|N_|)$, we have that $W(0, 0) > W(0, |N_{down}|)$ if and only if

$$\frac{|N_{up}|}{|N_{down}|} > \frac{\alpha - \beta}{\alpha + \beta} \tag{10}$$

This inequality holds whenever $|N_{up}| > |N_{down}|$.

Similarly, since $W(|N_{up}|, |N_{down}|) = n(\beta|N_{up}| + \alpha|N_{down}|)$, we have that $W(|N_{up}|, |N_{down}|) > W(0, |N_{down}|)$ if and only if

$$\frac{|N_{down}|}{|N_{up}|} > \frac{\alpha - \beta}{\alpha + \beta} \tag{11}$$

This inequality holds whenever $|N_{down}| > |N_{up}|$. Furthermore, note that equations (10) and (11) hold for $|N_{up}| = |N_{down}|$ as long as $\beta > 0$. To summarize, we always have that either $W(0,0) > W(0,|N_{down}|)$ or $W(|N_{up}|,|N_{down}|) > W(0,|N_{down}|)$ as long as $|N_{up}| \neq |N_{down}|$ or $\beta > 0$.

Finally, consider the case where $x = |N_{up}|$ and $y = |N_{down}|$: this implies that $x + y = n$. Since $\alpha > \beta$, it can be shown that $W(0,0) > W(|N_{up}|,|N_{down}|)$ so long as $|N_{up}| > |N_{down}|$. Moreover, $W(0,0) < W(|N_{up}|,|N_{down}|)$ holds as long as $|N_{up}| < |N_{down}|$. Finally, $W(0,0) = W(|N_{up}|,|N_{down}|)$ if $|N_{up}| = |N_{down}|$.

We now show that with endogenous interaction, social welfare is maximized under integration and conformity on the majority's action. The argument is as follows: Start from any network g and any configuration of actions x. Now add all missing links and obtain the complete network. Since $k = 0$ the aggregate payoff remains unchanged. But we know from the first part of the proof that, in the complete network, aggregate payoffs are maximized under conformity on the majority's preferred action. This completes the proof. □

A.1 Treatment SUBSIDY

We start with the case where linking has a negative cost. We obtain the following result.

Proposition 4. *Suppose $k < 0$. Then $(\overline{g}^*, x^*(\overline{g}^*))$ is pairwise stable if one of the following conditions obtain:*

(i) $\overline{g}^*$ is complete and conformity obtains, $\forall i \in N$, $x_i^*(\overline{g}^*) = m$, where $m \in \{up, down\}$.

(ii) $\overline{g}^*$ is complete and diversity obtains, $x_i^*(\overline{g}^*) = \theta_i$ for all $i \in N$, and $|N_{up}|, |N_{down}| \geq \frac{\beta n}{\alpha+\beta} + 1$.

(ii) $\overline{g}^*$ contains two complete components, $C_u = N_{up}$ and $C_d = N_{down}$ where players in C_u choose up, while players in C_d choose down, if $|N_{up}|, |N_{down}| \geq \max(\frac{\alpha-\beta}{\beta}, \frac{\beta-k}{\alpha-\beta})$.

The proofs of (i) and (ii) are identical to Proposition 2. The proof of (iii) is however slightly different. The same action profile would still be an equilibrium if only two players of the same component were disconnected, and as a result, such disconnection is not beneficial. However, if two players of different types became connected with each other, the same action profile would still be an equilibrium, but since $k < 0$, both players adding the link would earn strictly more. Conformity on the minority's preferred action would also be an equilibrium in this alternative network (with one link added across types) if $\max(|N_{up}|, |N_{down}|) \geq \frac{\alpha-\beta}{\beta}$. In this case, the majority player adding the link would earn $(\max(|N_{up}|, |N_{down}|) + 1)(\beta - k)$. The payoff for that player in the original segregated network with diversity is $\max(|N_{up}|, |N_{down}|)(\alpha - k)$. Therefore, if $\max(|N_{up}|, |N_{down}|) \geq \frac{\beta-k}{\alpha-\beta}$, such a player would not benefit from adding a link. A similar argument shows that a minority player cannot benefit from adding a link (because the alternative network may reach conformity on the majority's preferred action). Note that the set of outcomes that are pairwise stable according to Proposition 4 ($k < 0$) are also pairwise stable according to Proposition 2 ($k = 0$). However, the reverse is not true. More specifically, *segregration with diversity* does not always hold for $k < 0$ and specific values for the parameters (see Proposition 4(iii)).

A.2 Treatment COST

Let us now consider the case with costly links. We obtain the following result.

Proposition 5. *Suppose $k > 0$. Then $(\overline{g}^*, x^*(\overline{g}^*))$ is pairwise stable if one of the following outcomes obtains:*

(i) *$\overline{g}^*$ is a complete network and conformity obtains, $\forall i \in N$, $x_i^*(\overline{g}^*) = m$, where $m \in \{up, down\}$.*

(ii) *$\overline{g}^*$ is complete and diversity obtains, $x_i^*(\overline{g}^*) = \theta_i$ for all $i \in N$, and $|N_{up}|, |N_{down}| \geq \frac{\beta(n-1)+k}{\alpha}$.*

(iii) *$\overline{g}^*$ contains two complete components, C_u and C_d; every player in C_u chooses up, while every player in C_d chooses down.*

The proofs of (i) and (iii) are identical to Proposition 2. The proof of (ii) differs slightly. The same action profile (diversity) would still be an equilibrium if only two players of the same type were disconnected, and as a result, such disconnection is not beneficial. Conformity on the majority's preferred action would be an equilibrium in the alternative network where one link is deleted between players of different types. The payoff for the minority player deleting the link would then be $(n-1)(\beta-k)$. The payoff for that player in the original complete network with diversity is $\min(|N_{up}|, |N_{down}|)\alpha - nk$. Therefore, if $\min(|N_{up}|, |N_{down}|) \geq \frac{\beta(n-1)+k}{\alpha}$, then this player does not want to delete the link. The same argument can be made for the majority player deleting the link (assuming the alternative network leads to conformity on the minority's preferred action). Note that the set of outcomes that are pairwise stable according to Proposition 5 ($k > 0$) are also pairwise stable according to Proposition 2 ($k = 0$). However, the reverse is not true. More specifically, *integration with diversity* does not hold for $k > 0$ and specific parameters.

A.3 Treatments EXOSYM and EXOASYM

Finally, we present the equilibrium analysis of the coordination game in these treatments.

Proposition 6. *Suppose $|N_{up}| > |N_{down}|$. Fix an incomplete network g in which only $|N_{down}|$ links are missing between minority and majority players, and the degree of any majority player is at least $n-2$. Suppose x^* is a Nash equilibrium. Then the following outcomes are possible:*

(i) conformity on $m \in \{up, down\}$ if $n \geq \alpha/\beta + |N_{down}|$.

(ii) diversity with every player choosing their preferred action, if $|N_{up}|, |N_{down}| \geq \frac{\beta(n+1)}{\alpha+\beta}$.

Proof. Suppose any conformity outcome in (i). Since the number of missing links between minority and majority players is $|N_{down}|$, any player must have at least a degree $n - |N_{down}| - 1$ (lowest degree for a minority player missing all $|N_{down}|$ links). All players who select their preferred action can clearly not improve their payoff through any deviation. However, the payoff for players selecting their least preferred action is at least

$(n - |N_{down}|)\beta$. Any individual deviation from such players instead yields α. As a result, conformity is an equilibrium whenever $(n - |N_{down}|)\beta \geq \alpha$, which can be rewritten as $n \geq \alpha/\beta + |N_{down}|$.

Suppose the diversity outcome in (ii). Since the number of missing links between minority and majority players is $|N_{down}|$ and $|N_{up}| > |N_{down}|$, there must exist at least one majority player with a degree $n - 1$ (linked with everyone else). There may also be some minority player(s) with a similar degree (e.g., if some other minority player is missing more than one link). It then directly follows that any such player will earn $|N_y|\alpha$ where $y \in \{u, d\}$. Any unilateral deviation however yields $(n - |N_y| + 1)\beta$. As a result, such a player is not better off deviating if $|N_y|\alpha \geq (n - |N_y| + 1)\beta$, which can be rewritten as $|N_y| \geq \frac{\beta(n+1)}{\alpha+\beta}$. Since other players can only be less connected with the opposite type, they can also not benefit by deviating under this condition. Thus, diversity is an equilibrium. □

The main point to note is that conformity (on *up* or *down*) and diversity both remain equilibrium outcomes under EXOSYM and EXOASYM.

Appendix B Regression tables

The data in our experiment consists of the decisions made over 20 periods by groups of 15 subjects. In each of the 6 treatments there are 6 groups, resulting in a total of 720 observations at the group level. The tables below report the results associated to random effects GLS regressions with standard errors clustered on groups.

Table B1. Effect of types on network connectivity in ENDO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category is the MINORITY type. The dependent variable is the share of formed links by types in column I, the fraction of missing links within types in column II, the fraction of failed proposals within types in column III, and the fraction of failed proposals between types in column IV. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	II	III	IV
Majority	0.0119	−0.0022	−0.0017	0.0228
	(0.0282)	(0.0139)	(0.0077)	(0.0312)
Period	0.0026*	−0.0019	−0.0011	−0.0023
	(0.0014)	(0.0015)	(0.0009)	(0.0016)
Majority × Period	−0.0003	0.0005	0.0004	0.0004
	(0.0018)	(0.0016)	(0.0009)	(0.0021)
Constant	0.8917***	0.0219**	0.0121*	0.0735***
	(0.0219)	(0.0114)	(0.0065)	(0.0105)
χ^2	7.63*	9.08**	9.26**	5.08
# Obs.	240	240	240	240

Table B2. Effect of endogenous linking on conformity: ENDO vs. EXO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category is the treatment EXO. The dependent variable is the level of conformity the network in column I, the level of conformity of the majority in column II, and the level of conformity of the minority in column III. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	II	III
ENDO	-0.2931^{***}	-0.0168	-0.6088^{***}
	(0.0610)	(0.0117)	(0.1274)
Period	0.0119^{***}	0.0019^{***}	0.0233^{***}
	(0.0032)	(0.0006)	(0.0067)
ENDO × Period	-0.0139^{***}	0.0003	-0.0300^{***}
	(0.0034)	(0.0010)	(0.0069)
Constant	0.8391^{***}	0.9886^{***}	0.6681^{***}
	(0.0599)	(0.0036)	(0.1259)
χ^2	29.50^{***}	18.15^{***}	39.77^{***}
# Obs.	240	240	240

Table B3. Effect of endogenous linking on efficiency: ENDO vs. EXO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category in columns I and II is treatment ENDO-IF, and the dependent variable is the level of efficiency and the aggregate earnings of the minority, respectively. The omitted category in columns III to VI is treatment EXO, and the dependent variable is the level of efficiency in column III, the aggregate earnings of the minority in the first 10 periods in column IV, the aggregate earnings of the minority in the last 10 periods in column V, and the aggregate earnings of the minority in column VI. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	II	III	IV	V	VI
ENDO	-0.2698^{***}	-0.4625	-0.2048^{***}	-0.2216	0.8127	0.7328
	(0.0185)	(1.0092)	(0.0415)	(2.0275)	(2.2152)	(0.9968)
Period	0.0022^{**}	-0.0715^{*}	0.0130^{***}	0.7266^{***}	0.3209	0.4098^{***}
	(0.0011)	(0.0392)	(0.0028)	(0.2386)	(0.2178)	(0.0593)
ENDO × Period	-0.0007	0.1154	-0.0115^{***}	-0.4038	-0.2118	-0.2228^{**}
	(0.0013)	(0.0770)	(0.0029)	(0.3299)	(0.2925)	(0.0889)
Constant	0.9067^{***}	26.9689^{***}	0.8417^{***}	27.3342^{***}	26.0825^{***}	25.7737^{***}
	(0.0176)	(0.6117)	(0.0411)	(1.7254)	(1.4532)	(0.5909)
χ^2	215.65^{***}	14.90^{***}	32.76^{***}	19.92^{***}	2.88	58.04^{***}
# Obs.	240	240	240	120	120	240

Table B4. Effect of types on network connectivity in SUBSIDY

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category is the MINORITY type. The dependent variable is the share of formed links by types in column I, the fraction of missing links within types in column II, the fraction of failed proposals within types in column III, and the fraction of failed proposals between types in column IV. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	II	III	IV
Majority	0.0062	−0.0062	−0.0029	0.0029
	(0.0203)	(0.0101)	(0.0053)	(0.0271)
Period	0.0017***	−0.0004	−0.0002	−0.0019***
	(0.0005)	(0.0003)	(0.0001)	(0.0006)
Majority × Period	0.0001	−0.0004	−0.0003	0.0013
	(0.0008)	(0.0007)	(0.0003)	(0.0008)
Constant	0.9614***	0.0141	0.0074	0.0267**
	(0.0166)	(0.0097)	(0.0051)	(0.0145)
χ^2	17.93***	5.15	5.23	14.26***
# Obs.	240	240	240	240

Table B5. Effect of negative linking cost on network connectivity: SUBSIDY vs. ENDO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category is the treatment ENDO. The dependent variable is the fraction of missing links within types for the majority in column I, and for the minority in column II, the fraction of failed proposals within types for the majority in column III, and for the minority in column IV, the fraction of failed proposals between types for the majority in column V, and for the minority in column VI. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	II	III	IV	V	VI
SUBSIDY	−0.0119	−0.0079	−0.0060	−0.0048	−0.0667*	−0.0469***
	(0.0084)	(0.0149)	(0.0045)	(0.0082)	(0.0373)	(0.0179)
Period	−0.0014***	−0.0019	−0.0008***	−0.0011	−0.0019	−0.0023
	(0.0005)	(0.0015)	(0.0003)	(0.0009)	(0.0013)	(0.0016)
SUBSIDY × Period	0.0006	0.0015	0.0003	0.0009	0.0013	0.0003
	(0.0008)	(0.0015)	(0.0004)	(0.0009)	(0.0015)	(0.0017)
Constant	0.0198**	0.0219*	0.0105**	0.0121*	0.0964***	0.0735***
	(0.0079)	(0.0114)	(0.0042)	(0.0065)	(0.0294)	(0.0105)
χ^2	9.61**	7.70*	9.71**	6.76*	5.85	34.99***
# Obs.	240	240	240	240	240	240

Table B6. Effect of negative linking cost on conformity: SUBSIDY vs. ENDO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category is the treatment ENDO. The dependent variable is the level of conformity of the majority in column I, the level of conformity of the minority in column II, the level of conformity in the network in column III, and the total earnings of the minority players in column IV. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	II	III
SUBSIDY	0.0159	−0.0324	−0.0066
	(0.0126)	(0.0201)	(0.0122)
Period	0.0022***	−0.0068***	−0.0019*
	(0.0008)	(0.0019)	(0.0012)
SUBSIDY × Period	−0.0005	0.0052**	0.0022
	(0.0011)	(0.0023)	(0.0014)
Constant	0.9718***	0.0593***	0.5459***
	(0.0111)	(0.0193)	(0.117)
χ^2	14.60***	18.58***	3.81
# Obs.	240	240	240

Table B7. Effect of endogenous linking on efficiency: SUBSIDY vs. EXO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category in columns I and II is treatment SUBSIDY-IF, and the dependent variable is the level of efficiency in column I, and the aggregate earnings of the minority in column II. The omitted category in columns III and IV is treatment EXO, and the dependent variable is the level of efficiency in column III, and the aggregate earnings of the minority in column IV. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	II	III	IV
SUBSIDY	−0.2929***	−1.6173**	−0.1669***	5.5667***
	(0.0126)	(0.6401)	(0.0412)	(0.6881)
Period	0.0016***	0.0532***	0.0129***	0.4098***
	(0.0006)	(0.0155)	(0.0028)	(0.0593)
SUBSIDY × Period	−0.0010*	−0.0417	−0.0124***	−0.3983***
	(0.0006)	(0.0591)	(0.0028)	(0.0823)
Constant	0.9677***	32.9577***	0.8417***	25.7727***
	(0.0124)	(0.5341)	(0.0411)	(0.5909)
χ^2	540.83***	17.52***	30.93***	86.25***
# Obs.	240	240	240	240

Table B8. Effect of positive linking cost on network connectivity: COST vs. ENDO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category is the treatment ENDO. The dependent variable is the fraction of missing links within types for the majority in column I, and for the minority in column II, the fraction of failed proposals within types for the majority in column III, and for the minority in column IV, the fraction of failed proposals between types for the majority in column V, and for the minority in column VI. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	**II**	**III**	**IV**	**V**	**VI**
COST	0.0150	0.0950**	0.0076	0.0461**	0.4825***	0.4573***
	(0.0133)	(0.0434)	(0.0069)	(0.0209)	(0.0895)	(0.0767)
Period	−0.0014***	−0.0019	−0.0008***	−0.0011	−0.0019	−0.0023
	(0.0005)	(0.0015)	(0.0003)	(0.0009)	(0.0013)	(0.0016)
COST × Period	−0.0027	0.0004	−0.0014	0.0005	0.0086***	0.0094
	(0.0017)	(0.0035)	(0.0009)	(0.0019)	(0.0028)	(0.0078)
Constant	0.0198**	0.0219*	0.0105**	0.0121*	0.0964***	0.0735***
	(0.0079)	(0.0114)	(0.0042)	(0.0065)	(0.0294)	(0.0105)
χ^2	14.52***	20.64***	14.88***	23.71***	41.49***	71.87***
# Obs.	240	240	240	240	240	240

Table B9. Effect of positive linking cost on conformity: COST vs. ENDO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category is the treatment ENDO. The dependent variable is the level of conformity of the majority in column I, the level of conformity of the minority in column II, the level of conformity in the network in column III, and the total earnings of the minority players in column IV. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	**II**	**III**
COST	0.0191*	0.0105	0.0151
	(0.0116)	(0.0379)	(0.0196)
Period	0.0022***	−0.0068***	−0.0019*
	(0.0008)	(0.0019)	(0.0012)
COST × Period	−0.0006	0.0051**	0.0021
	(0.0011)	(0.0023)	(0.0012)
Constant	0.9718***	0.0593***	0.5459***
	(0.0111)	(0.0193)	(0.0117)
χ^2	12.93***	25.99***	6.21
# Obs.	240	240	240

Table B10. Effect of incomplete (symmetric) exogenously-fixed networks on conformity: EXOSYM vs. ENDO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category is the treatment ENDO. The dependent variable is the level of conformity of the majority in column I, the level of conformity of the minority in column II, the level of conformity in the network in column III. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	II	III
EXOSYM	−0.0235	0.2536**	0.1058*
	(0.0311)	(0.1291)	(0.0622)
Period	0.0022***	−0.0069***	−0.0019*
	(0.0008)	(0.0019)	(0.0012)
EXOSYM × Period	−0.0093	−0.0024	−0.0061
	(0.0086)	(0.0103)	(0.0075)
Constant	0.9718***	0.0593***	0.5459***
	(0.0111)	(0.0193)	(0.0117)
χ^2	8.75**	19.81***	8.74**
# Obs.	240	240	240

Table B11. Effect of incomplete (asymmetric) exogenously-fixed networks on conformity: EXOASYM vs. ENDO

Note: GLS regressions with group random effects and standard errors clustered on groups (in parenthesis). The omitted category is the treatment ENDO. The dependent variable is the level of conformity of the majority in column I, the level of conformity of the minority in column II, the level of conformity in the network in column III, and the total earnings of the minority players in column IV. ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels.

	I	II	III	IV
EXOASYM	0.0027	0.4581***	0.2152***	
	(0.0159)	(0.1343)	(0.0688)	
Period	0.0022***	−0.0068***	−0.0019*	
	(0.0008)	(0.0019)	(0.0012)	
EXOASYM × Period	−0.0012	0.0099	0.0040	
	(0.0016)	(0.0112)	(0.0054)	
Constant	0.9718***	0.0593***	0.5459***	
	(0.0111)	(0.0193)	(0.0117)	
χ^2	7.76*	38.35***	18.54***	
# Obs.	240	240	240	

Appendix C Instructions

All treatments:

You are participating in an economic experiment where you have to make decisions. For participating in this experiment, you will receive a minimum payment of 5€. Please, read carefully these instructions to find out how you can earn **additional money**.

All interactions between you and the other subjects take place through the computers. Please, do not talk to the other subjects or communicate with them in other way. If you have questions, raise your hand and an experimentalist will come to you to answer it.

This experiment is **anonymous**. Therefore, your identity will not be revealed to the other subjects nor theirs to you.

In this experiment, you can earn points. At the end of the experiment, those points will be converted to Euros using the following exchange rate: 50 points = 1€. You will receive your earnings in cash.

This experiment is composed by 2 identical stages. The first stage is a trial stage, it lasts 5 rounds and the points you earn will not be exchanged for Euros. The second stage is the real experiment, it lasts 20 rounds, and the points you earn will be exchanged for Euros at the end of the experiment. Next, you will be informed of the decisions to you can make in each round.

Decisions in each round

At the beginning of each round, all subjects are randomly assigned to groups of size 15. You will be in a group with the same people for an entire stage. Please, remember that the first stage is a trial stage (5 rounds), and the second is the experiment (20 rounds).

Each subject in a group is randomly assigned a symbol (**circle or triangle**) and a number (**between 1 and 15**). You will be informed about your number and your symbol at the bottom of your screen, which will not change within a stage. That is, your number and your symbol might change from the trial stage to the experiment stage, but not between the rounds of a given stage.

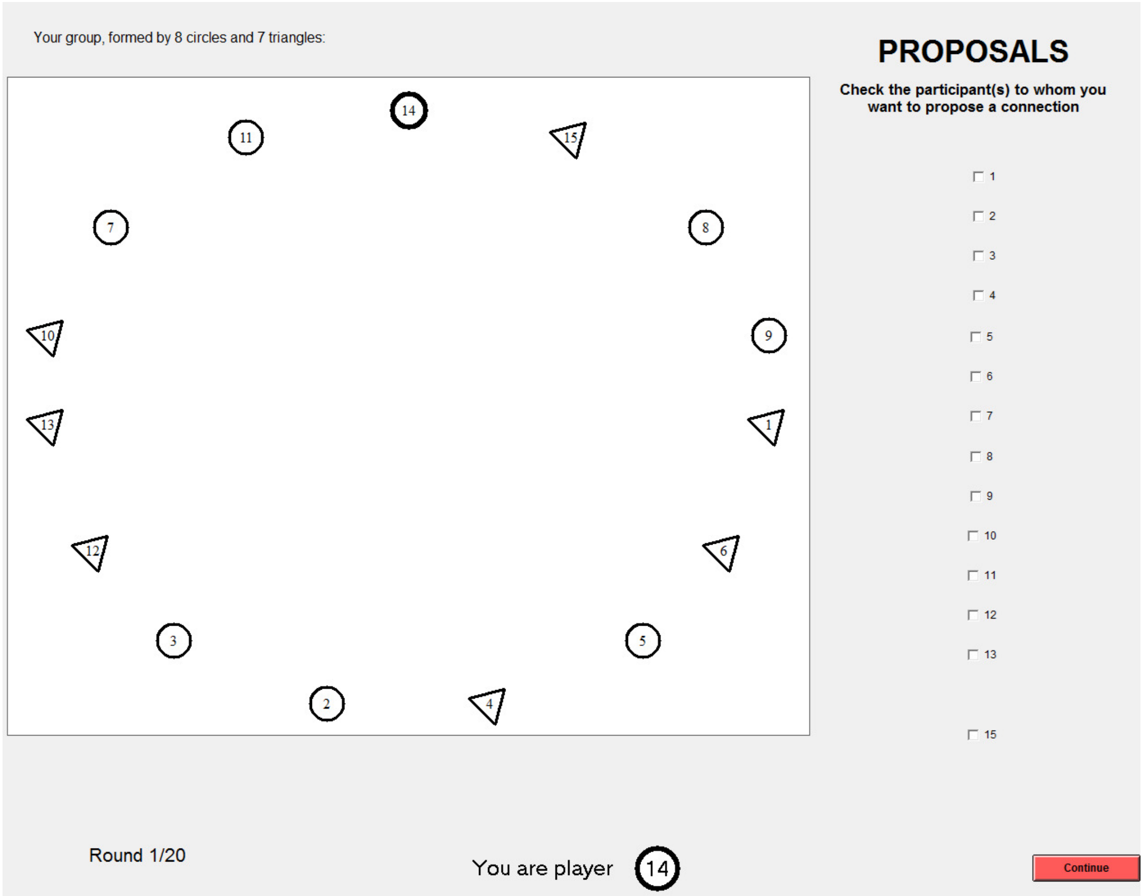
Specific to Treatment ENDO only:

Each round consists of 3 phases: (1) Linking, (2) Action and (3) Earnings.

Phase 1. Linking

At the beginning of the first round you will see the interaction network formed in the previous round. Naturally, in round 1 you will see an empty network. You will see your number and your type, and the numbers and types of the other subjects, as illustrated in the image below. You will be highlighted with a thicker border, to facilitate that you can identify yourself in the screen.

The first decision you make regards whom you want to propose a connection to. You can propose between 1 and 14 connections. To do so, you have to click the checkbox next to a subject's number, in the list on the right hand side of the screen. Once you checked all the proposals you want to make, click the Continue button.



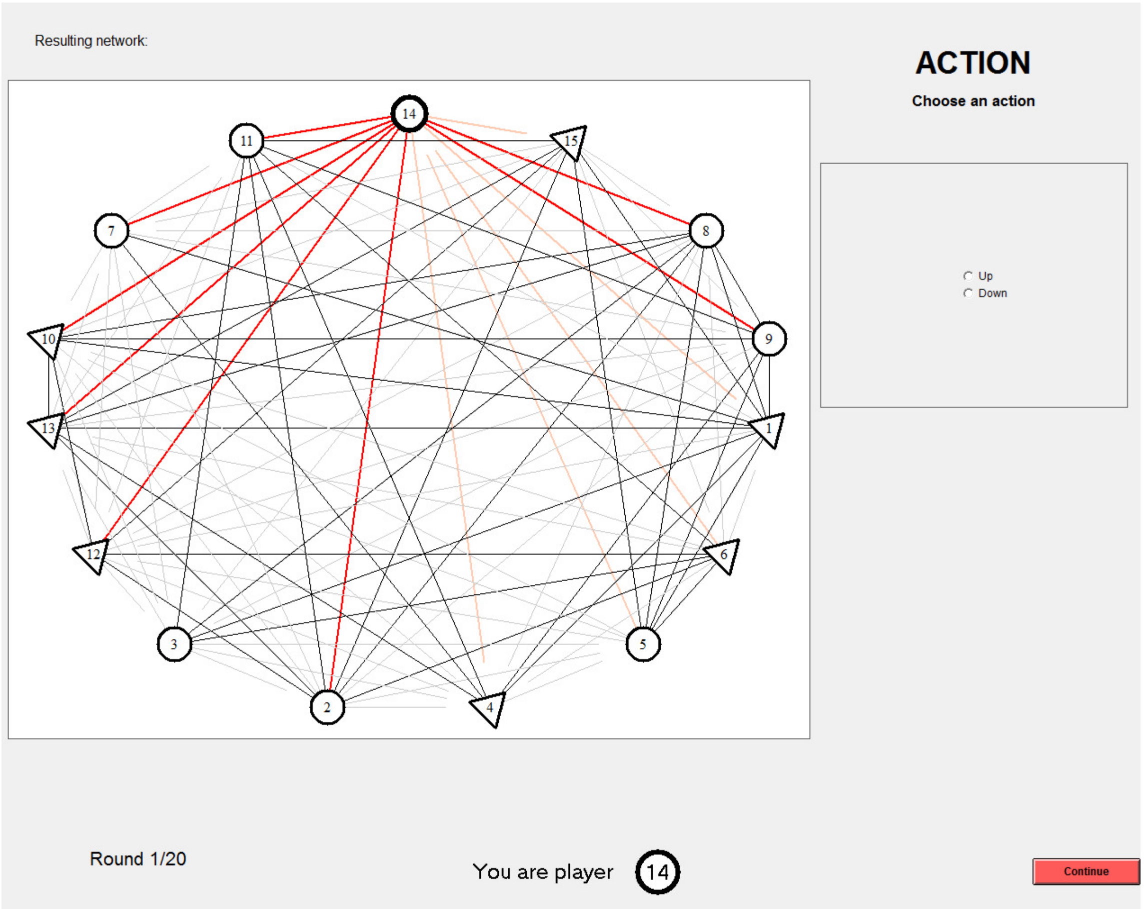
A connection is formed if 2 subjects propose to each other. In Phase 2 (Action) you will interact only with the subjects to whom are connected.

Phase 2. Action

Once all subjects have made all their proposals, you will see the resulting network of interactions. A line starting from you and reaching another subject represents a connection between you and the other subject. A thinner line starting from you, directed to another subject, without reaching him, represents a proposal you made to the such subject, which he did not reciprocate. Similarly, a line starting from other subject, directed to you without reaching you, represents a proposal the other subject made you but you did not reciprocate.

The red lines represent your relations, and the black lines represent the relations between the other subjects.

On the right-hand side of the screen you can choose between two actions: **up** or **down** (you must choose one of them). Depending on your symbol and the decisions made by the subjects you linked to in the first stage, you can earn points. This is explained as follows:



If you are **circle** and you:

- choose **up**, you receive **4 points for each** of your connections choosing **up**
- choose **down**, you receive **2 points for each** of your connections choosing **down**

If you are **triangle** and you:

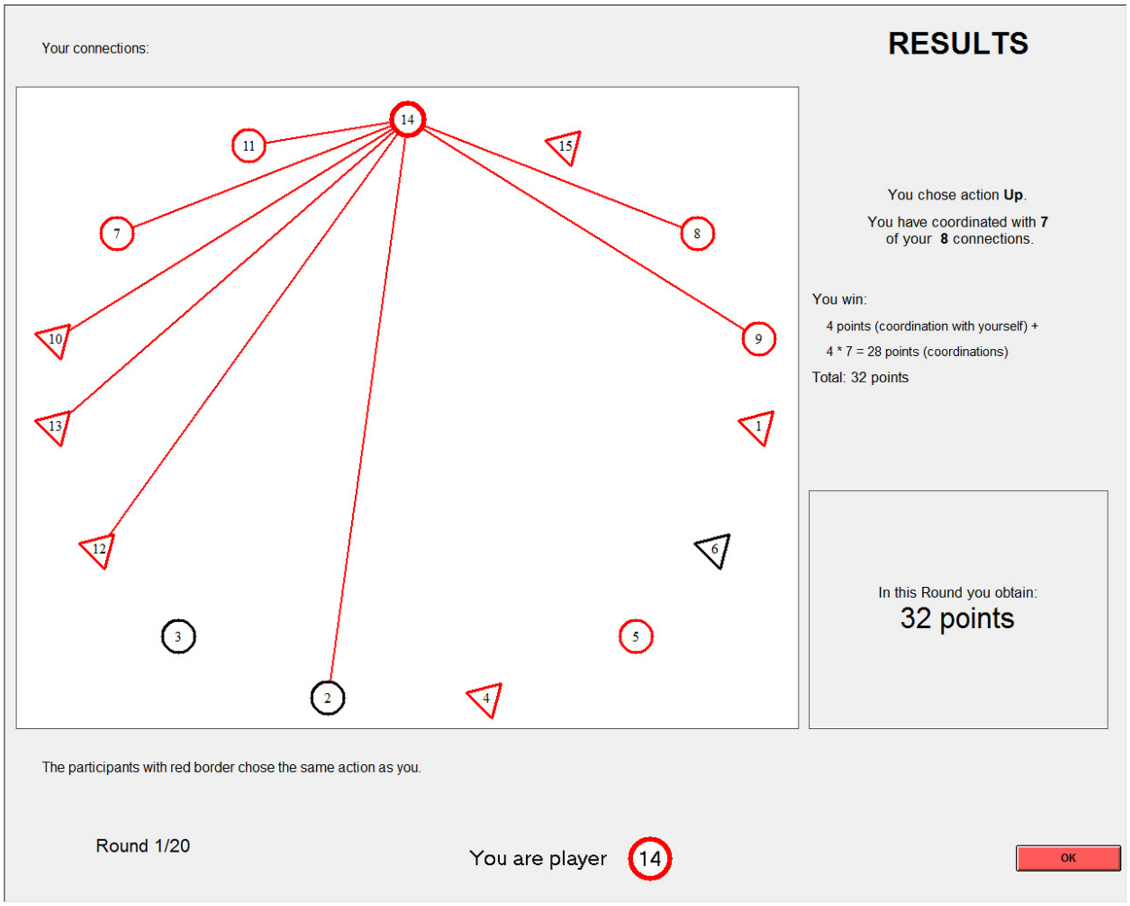
- choose **down**, you receive **4 points for each** of your connections choosing **down**
- choose **up**, you receive **2 points for each** of your connections choosing **up**

Phase 3. Earnings

In the last phase of each round you will see the points you earned given your interactions. On the left-hand side of the screen you will see the connections you formed. Those subjects choosing the same action as you will be displayed with a red border, otherwise they will have a black border. This will allow you to easily calculate the points you earn in the current round.

Please, bear in mind that you earn points for each subject you are linked to who chooses the same action as you (displayed with a red border). The exact amount of points (4 or 2) will depend on your symbol and the action you chose (as explained in Phase 2 (Action).

The total amount of points you earn will be the sum of the points you obtained during the 20 rounds of the experiment (the second stage).



Next, we present two examples:

Example 1: You are a circle, you are linked to 10 subjects, you have chosen *up* and 4 of your connections have chosen *up* as well (6 have chosen *down*). Therefore, you earn 4 points for coordinating with yourself (you always coordinate with yourself), and 16 (4×4=16) points for coordinating with the other 4. Your earnings in the round are 20 points in total.

Example 2: You are a circle, you are linked to 10 subjects, you have chosen *down* and 6 of your connections have chosen *down* as well (4 have chosen *up*). Therefore, you earn 2 points for coordinating with yourself (you always coordinate with yourself), and 12 ($2 \times 6 = 12$) points for coordinating with the other 6. Your earnings in the round are 14 points in total.

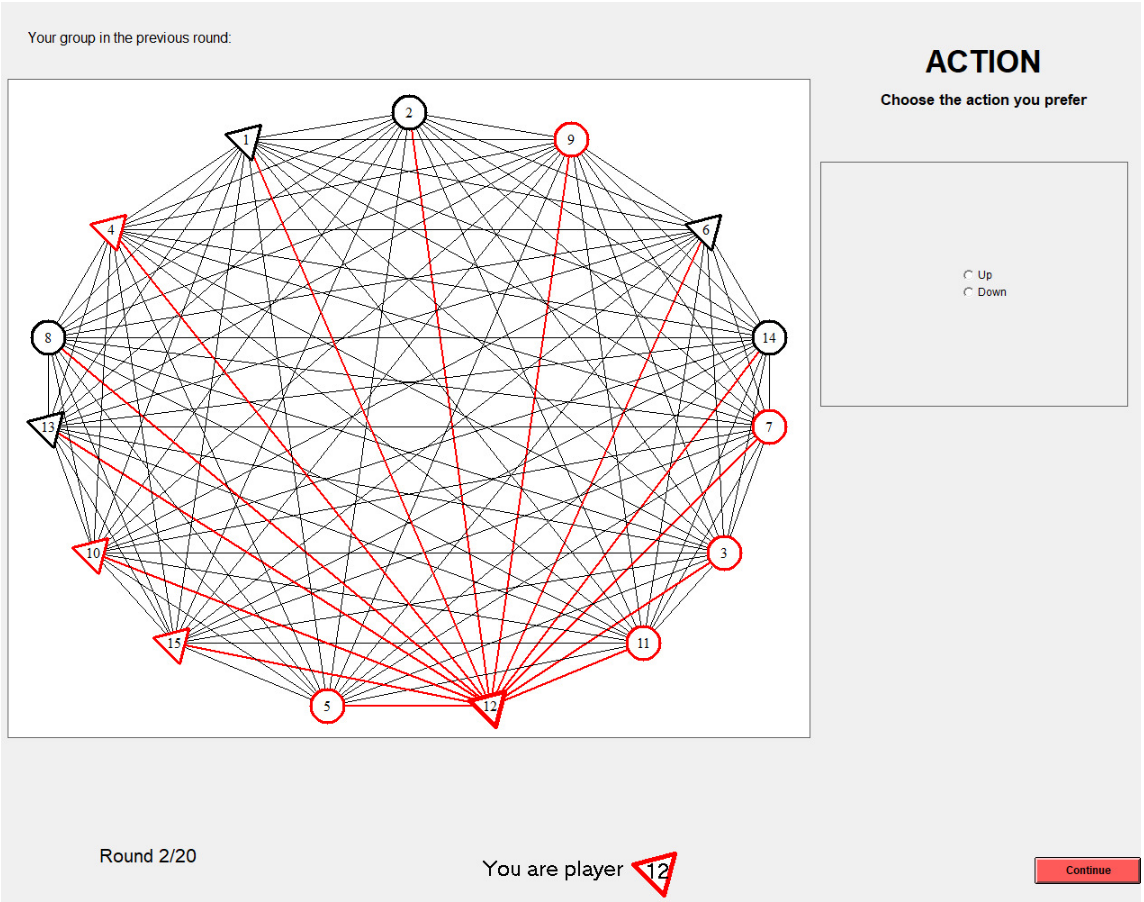
Specific to Treatment EXO only:

Each round consists of 2 phases: (1) Action and (2) Earnings.

Phase 1. Action

At the beginning of each round you will see the group of subjects you interact with and their choices in the previous round (in the first round you will see the subjects without any previous decision). You will see your number and your type, and the numbers and types of the other subjects, as illustrated in the image below. You will be highlighted with a thicker border, to facilitate that you can identify yourself in the screen.

On the right-hand side of the screen you can choose between two actions: **up** or **down** (you must choose one of them). Depending on your symbol and the decisions made by the subjects you linked to in the first stage, you can earn points. This is explained as follows:



If you are **circle** and you:

- choose **up**, you receive **4 points for each** of your connections choosing **up**
- choose **down**, you receive **2 points for each** of your connections choosing **down**

If you are **triangle** and you:

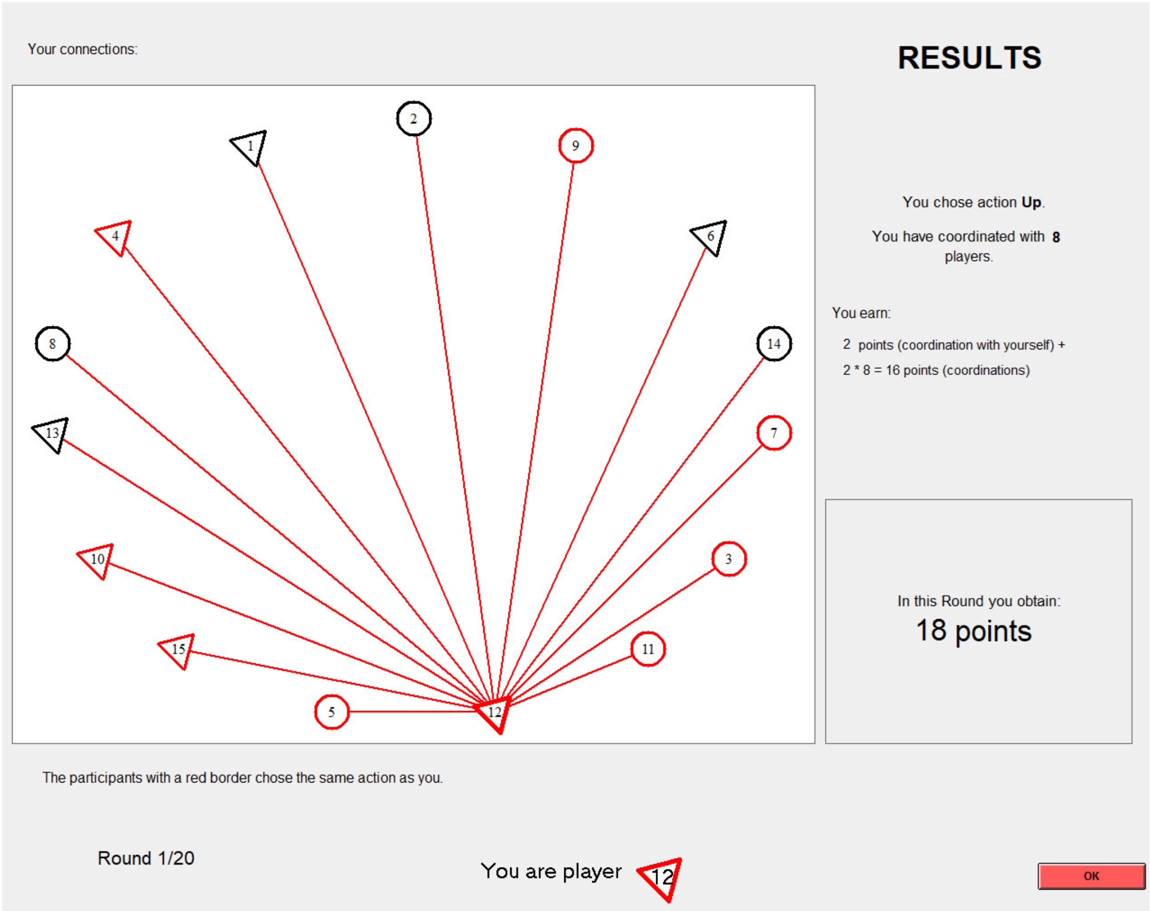
- choose **down**, you receive **4 points for each** of your connections choosing **down**
- choose **up**, you receive **2 points for each** of your connections choosing **up**

Phase 2. Earnings

In the last phase of each round you will see the points you earned given your interactions. On the left-hand side of the screen you will see the connections you formed. Those subjects choosing the same action as you will be displayed with a red border, otherwise they will have a black border. This will allow you to easily calculate the points you earn in the current round.

Please, bear in mind that you earn points for each subject you are linked to who chooses the same action as you (displayed with a red border). The exact amount of points (4 or 2) will depend on your symbol and the action you chose (as explained in Phase 1 (Action).

The total amount of points you earn will be the sum of the points you obtained during the 20 rounds of the experiment (the second stage).



Next, we present two examples:

Example 1: You are a circle, you have chosen *up* and 4 other subjects have chosen *up* as well (10 have chosen *down*). Therefore, you earn 4 points for coordinating with yourself (you always coordinate with yourself), and 16 (4×4=16) points for coordinating with the other 4. Your earnings in the round are 20 points in total.

Example 2: You are a circle, you have chosen *down* and 10 other subjects have chosen *down* as well (4 have chosen *up*). Therefore, you earn 2 points for coordinating with yourself (you always coordinate with yourself), and 20 (2×10=20) points for coordinating with the other 6. Your earnings in the round are 22 points in total.

All treatments:

Summary In each round, you can create connections. You will earn points from those subjects you are connected to who chose the same action as you (coordinate with you). The session consists of 2 stages, the first is a trial stage, which lasts 5 rounds, and the latter is the experiment and lasts 20 rounds. You will participate with the same 15 subjects for a whole stage (trial or experiment), but your group, symbol and number, and those of the other subjects, might change between stages.