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S1 Model

The model can be divided into four parts: (1) initialization, (2) interaction, (3) gossip, (4) reaction to gossip. The simulation terminates after 10^4 rounds.

S1.1 Initialisation

Let us consider a population of $N \in \{1, 2, ..., n\}$ agents where $n = \{50, 100, 200\}$. Each agent is assigned a gossip motive (either always-true or always-negative) and an initial value of cooperation $c_{i,0}$ drawn from a normal distribution $\mathcal{N}(0.5, 0.05)$:

$$c_i = c_{i,0} \quad \forall i \in N. \tag{1}$$

The initial cooperation $c_{i,0}$ represents the baseline cooperation level of each agent and is kept constant throughout the entire simulation. Note that the distribution was not truncated to only have values greater than 0.

Each agent has a reputation of the other agents as interaction partners $r_{i,j} \in \mathbb{R}$, that is, the reputation that agent i holds of agent j as an interaction partner. Further, for the double reputation mechanism, each agent has a reputation of the other agents as information provider $g_{i,j} \in [0, 1]$, which indicates how reliable agent i expects the gossip shared by agent j to be. Both $r_{i,j}$ and $g_{i,j}$ were initialised to 0 to indicate that agents had no previous knowledge of other group members.

S1.2 Interactions

Each round, agents are randomly matched in pairs and interact with one another, and each agent can either cooperate (C) or defect (D). Their likelihood to cooperate depends on their baseline cooperation $c_{i,0}$ and the reputation they hold of their interaction partner $r_{i,j} \in \mathbb{R}$ (the reputation that agent i holds of agent j as an interaction partner).

$$c_{i,j,t} = c_{i,0} + r_{i,j} \tag{2}$$

After each interaction, agents update their reputation of agent j, $r_{i,j}$, upwards by a value ω_d if agent j cooperated, and downwards if agent j defected. $c_{i,0}$ indicates the agent's baseline cooperation level, that is not affected by their interactions with other group members. The impact that interactions have on agent's likelihood to cooperate is embedded in $r_{i,j}$.

The reputation agents have of each other ranges in $\mathbb{R}$ in order for positive and negative reinforcement loops to emerge. That is, let us consider agent i with a low baseline cooperation. If agent i interacts several times with agent j, and agent j often cooperates with agent i, then agent i will be more and more likely to cooperate with agent j over time, even if agent i's baseline cooperation is very low (positive reinforcement loop). Similarly, let us consider agent i with a high baseline cooperation. If agent i interacts several times with agent j, and agent j often defects with agent i, then agent i will be more and more likely to defect with agent j over time, even if agent i's baseline cooperation is very high (negative reinforcement loop).

S1.3 Gossip

Once all agents interacted and updated their reputation of their interaction partners, each agent shares x gossip statements (default: $x = 2$, $x = \{1, 5\}$) about their most recent interaction partners with their current interaction partner. That is, if agent i and agent j interact, agent i will communicate to agent j x gossip statements about are the last x agents with which agent i interacted. Similarly, agent j will communicate to agent i x gossip statements about the last x agents with which agent j interacted. The content of the gossip depends on the gossip motive the agent has been initiated with:

- *Always-true motive*: Agents always gossip truthfully, sharing whether the target cooperated or defected in the previous interaction.
- *Always-negative*: Agents always report that the target defected, no matter whether the target cooperated or defected.

From the perspective of the gossip receiver, each gossip statement affects the reputation of the target as interaction partner and can also affect the reputation of the sender, as either an interaction partner or a gossiper.

S1.4 Reaction to gossip

In this model, we explored three different mechanisms of reaction to gossip.

In the next single and double reputation mechanisms, receivers first interpret the senders' motive to gossip. Receivers can correctly interpret the gossiper's motive (always-true and always-negative) with a certain probability $\rho \in \{0, 0.25, 0.5, 0.75, 1\}$. While the gossip motive is assigned to the agents during the initialization stage and it remains fixed throughout the entire simulation, agents are aware that two different motives to gossip exist. Hence, they need to determine whether the gossip received was shared by a gossiper with always-true motive or always-negative motive. The percentage ρ represents the likelihood that agents correctly interpret the motive of the gossiper.

S1.4.1 Complete acceptance (Baseline)

Receivers take the gossip at face value. Agents either increase/decrease their reputation of the target as an interaction partner by a value $\omega_{g,t}$ depending on whether the target cooperated/defected. Agents do not update the reputation of the sender. This mechanism is the most used to operationalise gossip, i.e., as an information exchange about a third agent, without any further psychological specification or reputational consequences for gossipers.

After each gossip instance received, the gossip receiver updates its reputation of the gossip target z, $r_{i,z}$, upwards if the gossip reports that agent z cooperated, and downwards if defected.

S1.4.2 Single reputation

After interpreting the senders' motive, receivers increase/decrease their reputation of the sender as an interaction partner by a value $\omega_{g,s}$ depending on whether the gossip is interpreted as always-true/always-negative. Receivers also increase/decrease their reputation of the target as interaction partner by a value $\omega_{g,t}$ if the target cooperated/defected. That is, gossip impacts not only the likelihood with which the receiver cooperates with the target, but also the likelihood that the receiver cooperates with the sender.

S1.4.3 Double reputation

Agents hold two separate reputations: one as interaction partner ($r_{i,j}$, which reflects the likelihood, in the eyes of agent i, that agent j will cooperate) and one as gossiper ($g_{i,j} \in [0, 1]$, which indicates how reliable agent i expects the gossip shared by agent j). After interpreting the senders' motive, receivers increase or decrease their reputation of the sender as a gossiper ($g_{i,j}$) by a value $\omega_{g,s}$ if the gossip is interpreted as driven by always-true or always-negative motives. The senders' reputation as gossipers does not affect the likelihood that the receiver will cooperate with the sender in future interactions but affects how the receiver uses the gossip to inform future interactions with the target: receivers increase/decrease their reputation of the target as interaction partner by a value $g_{i,j} * \omega_{g,t}$ if the target cooperated/defected. In other words, gossip impacts the likelihood with which the receiver cooperates with the target proportionally to the sender's reputation as gossiper and does not impact the likelihood that the receiver cooperates with the sender. In order to avoid single gossip statements to have an overwhelming impact on the sender's likelihood to cooperate with the target, we constrained $g_{i,j} \in [0, 1]$. This way, each gossip statement can have an impact ranging between 0 (if $g_{i,j} = 0$) and $\omega_{g,t}$ (if $g_{i,j} = 1$).

S2 Parameters

Table S1 reports the parameters used in the model and experiments.

Table S1: Model's parameters.

Parameter description	Variable	Range
Group size	N	$\{50, 100, 200\}$
Distribution for initial level of cooperation	$\mathcal{X}$	$\mathcal{N}(0.5, 0.05); U[0, 1]$
Number of gossip statements exchanged per interaction	x	$\{1, 2, 5\}$
Size of the update following direct interaction	ω_d	$\{0.1, 0.3, 0.5\}$
Size of the update following gossip for senders	$\omega_{g,s}$	$\{0.1, 0.3, 0.5\}$
Size of the update following gossip for targets	$\omega_{g,t}$	$\{0.1, 0.3, 0.5\}$
Probability of correctly interpreting gossip motives	ρ	$\{0, 0.25, 0.5, 0.75, 1\}$
Number of model replicas	I	100

S3 Additional analysis

S3.1 Impact of ρ

To have a better understanding of the impact of ρ on the results, we tested how cooperation changed as ρ slightly increases from 0 to 100%. Results showed we identified that cooperation progressively increases as ρ increases (see Figure S1, S2).

Figure S1: Final percentage of cooperation for always-true and always-negative gossip motives for different values of interpretation ρ. Reaction mechanism: single reputation. The error bars indicate the 95% confidence intervals, calculated over 100 independent runs.

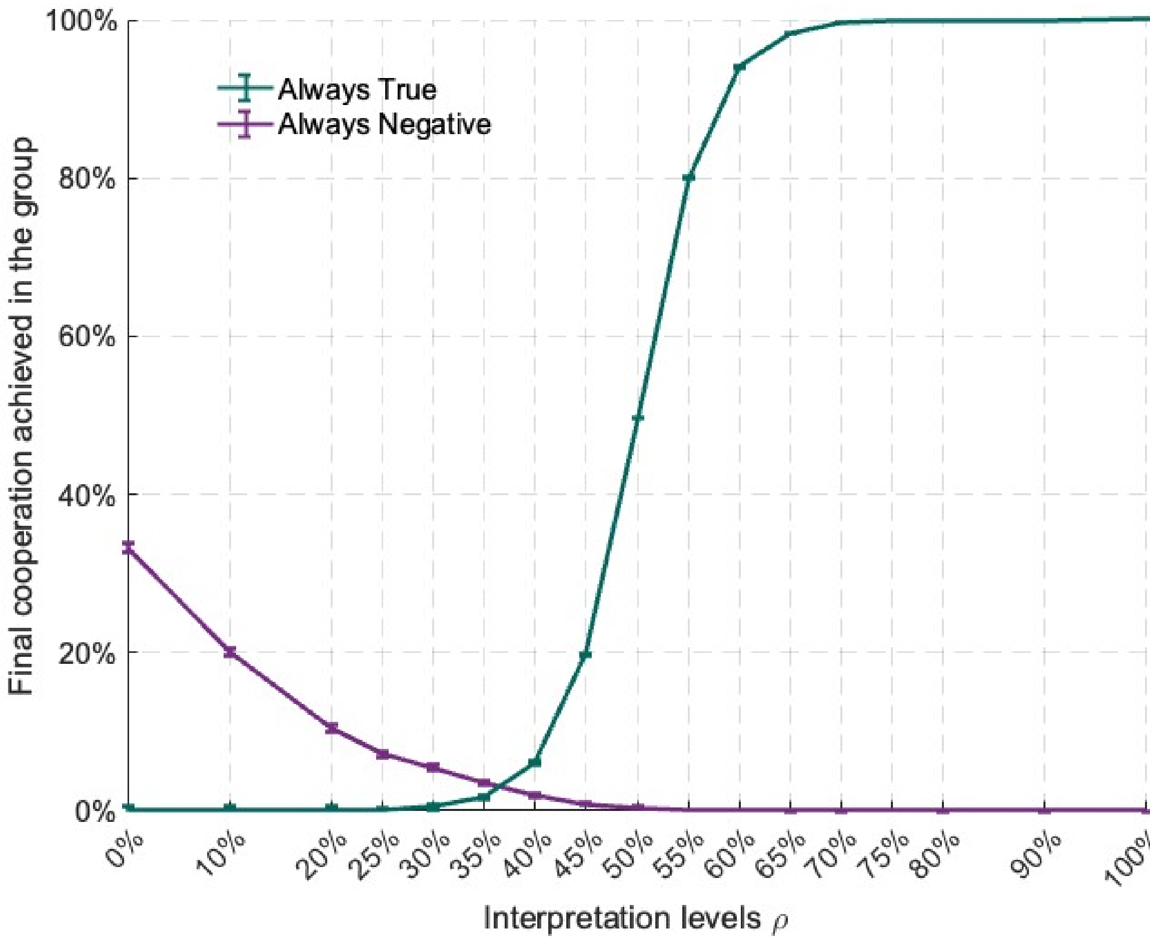
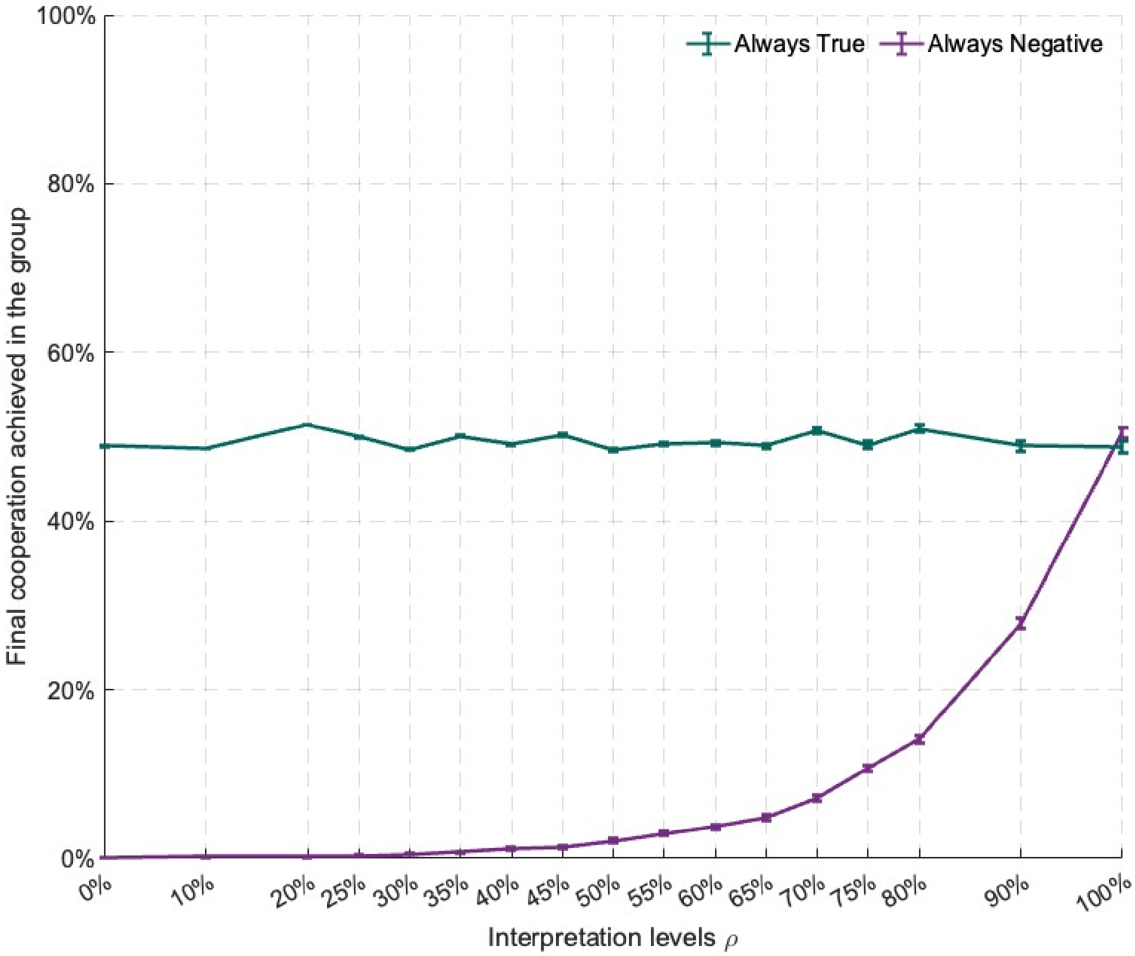


Figure S2: Final percentage of cooperation for always-true and always-negative gossip motives for different values of interpretation ρ. Reaction mechanism: double reputation. The error bars indicate the 95% confidence intervals, calculated over 100 independent runs.



S3.2 Initial cooperation

To analyse more diverse population compositions, we tested the impact of a different initialization for agents' baseline cooperation. Having a uniform initial cooperation allowed us to control whether results hold when extending the range of initial cooperation among agents. This way, we allow agents to embody both high cooperators and high defectors. Figures

S3, S4, and S5 show similar patterns to those discussed in the main manuscript, suggesting that our results are robust given a uniform initialisation of the baseline cooperation.

Figure S3: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Agent's initial cooperation level drawn from a uniform distribution $U[0,1]$. Reaction mechanism: complete acceptance. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

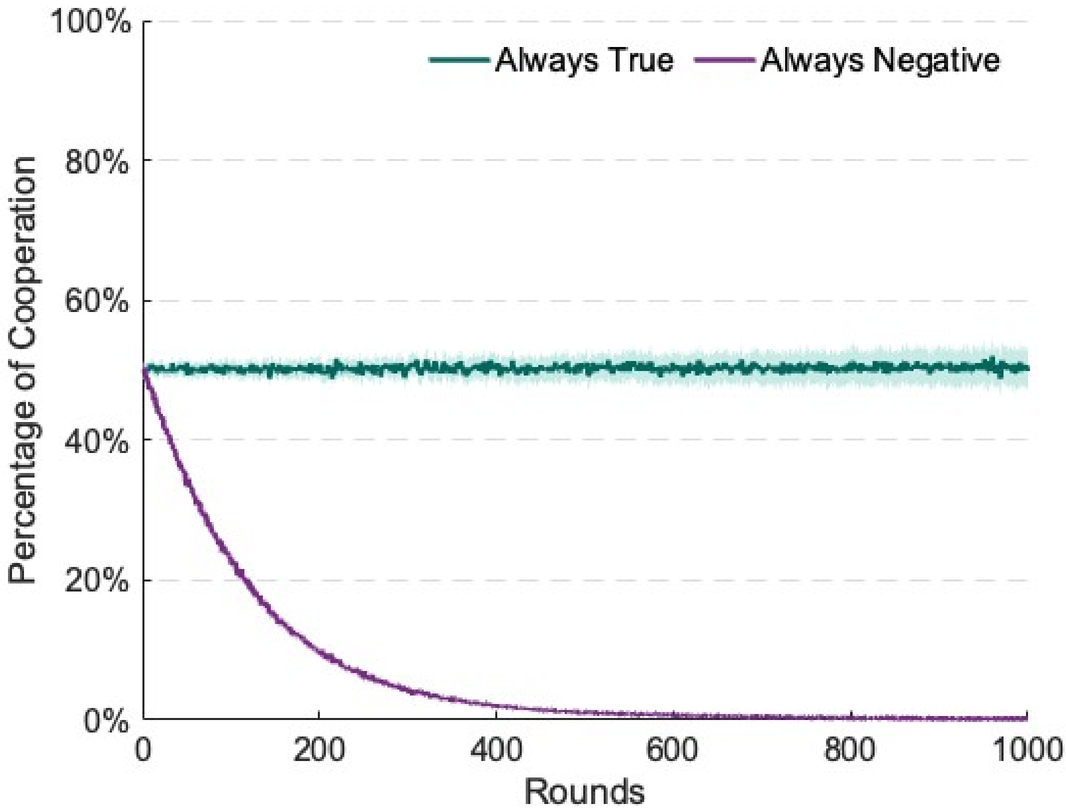


Figure S4: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Agent's initial cooperation level drawn from a uniform distribution $U[0, 1]$. Reaction mechanism: single reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

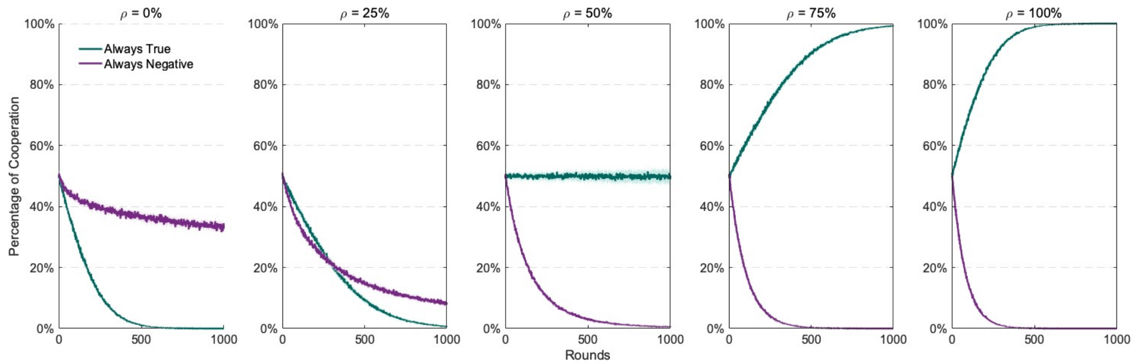
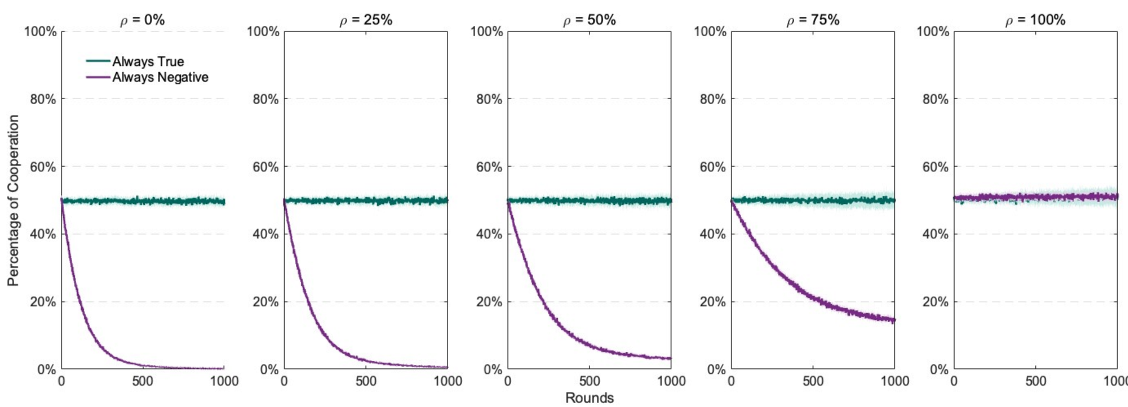


Figure S5: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Agent's initial cooperation level drawn from a uniform distribution $U[0, 1]$. Reaction mechanism: double reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.



S3.3 Gossip motives

Furthermore, we were interested in exploring whether the dynamics would change when agents would gossip for different motives within a population. For this, we run simulations for populations composed of:

1. 30% always-true, 70% always-negative gossipers
2. 50% always-true, 50% always-negative gossipers
3. 70% always-true, 30% always-negative gossipers.

Results are shown for populations where (A) agents accepted gossip at face value (see Figure S6), (B) single reputation was used by agents (see Figure S7), and (C) double reputation was used by agents (see Figure S8)

When agents accept gossip at face value (Figure S6), cooperation declines. While always-truthful gossipers support the initial cooperation, the presence of always-negative gossip depletes the group initial cooperation, which slowly declines to zero.

The presence of always-negative gossipers depletes cooperation also when other mechanisms are used to interpret gossip (see Figures S7, S8). Nevertheless, if agents correctly interpret gossip motives ($\rho = 100\%$), (1) the initial cooperation can still be sustained when double reputation is employed, (2) cooperation can be fostered if the majority of agents share always-truthful gossip and single reputation is used to react to gossip.

Figure S6: Percentage of cooperation over rounds for groups with both always-true and always-negative gossipers. Different percentages of gossip motives within the population. Reaction mechanism: complete acceptance. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

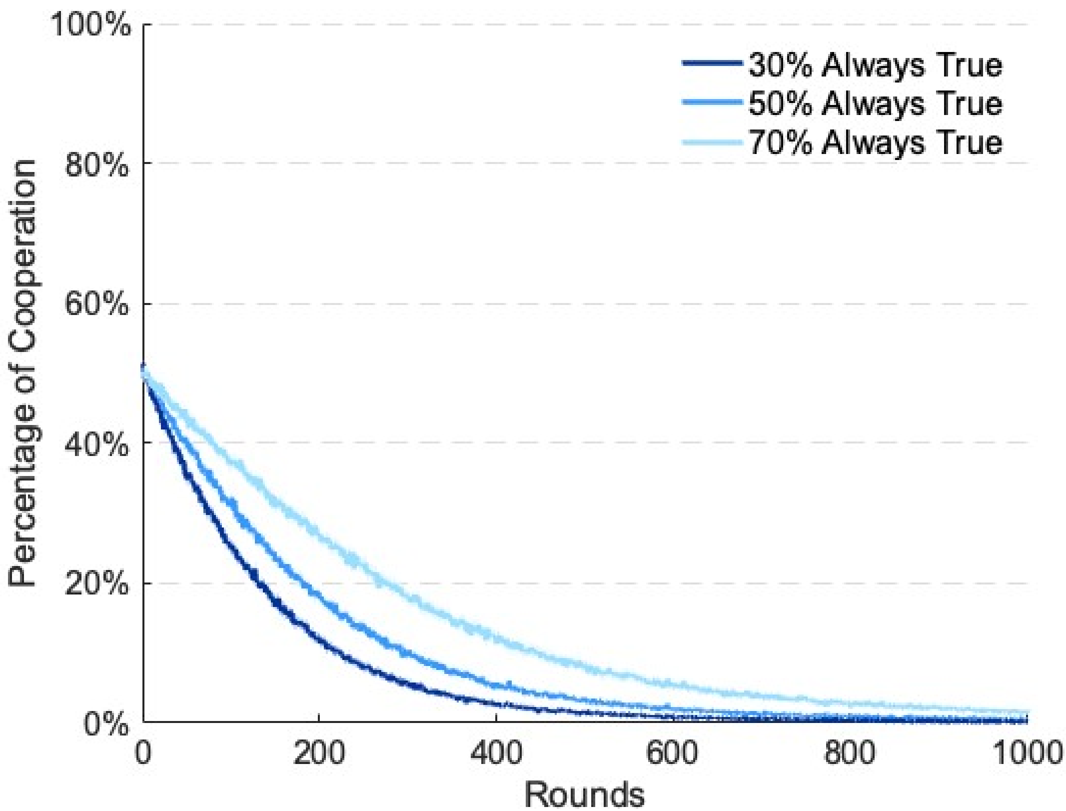


Figure S7: ercentage of cooperation over rounds for groups with both always-true and always-negative gossipers. Reaction mechanism: single reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

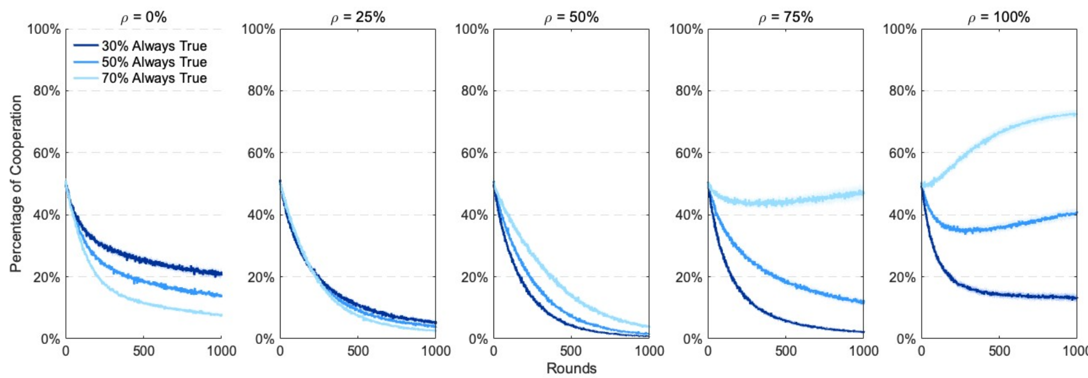
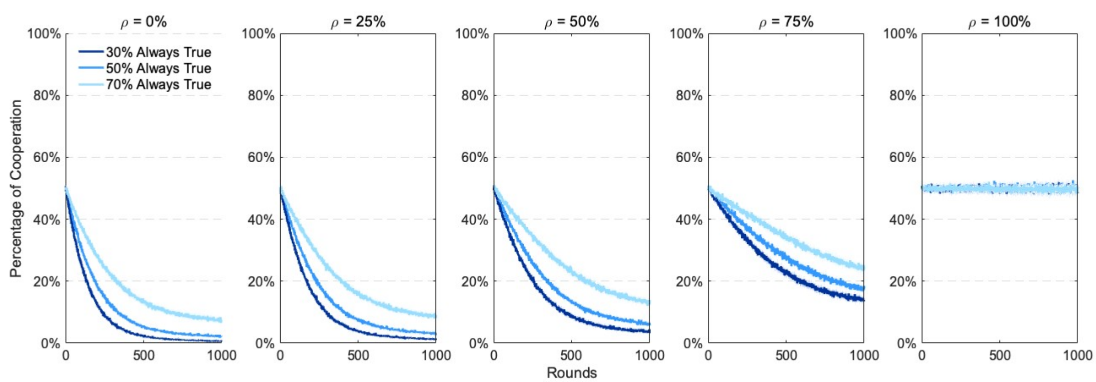


Figure S8: ercentage of cooperation over rounds for groups with both always-true and always-negative gossipers. Reaction mechanism: double reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.



S4 Sensitivity analysis

S4.1 Group size

We tested the model for different population sizes $N = 50, 100$. Results are consistent with our main findings, suggesting that the dynamics discussed in the main paper hold also for larger populations.

Figure S9: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Population size $N = 50, 100$. Reaction mechanism: complete acceptance. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

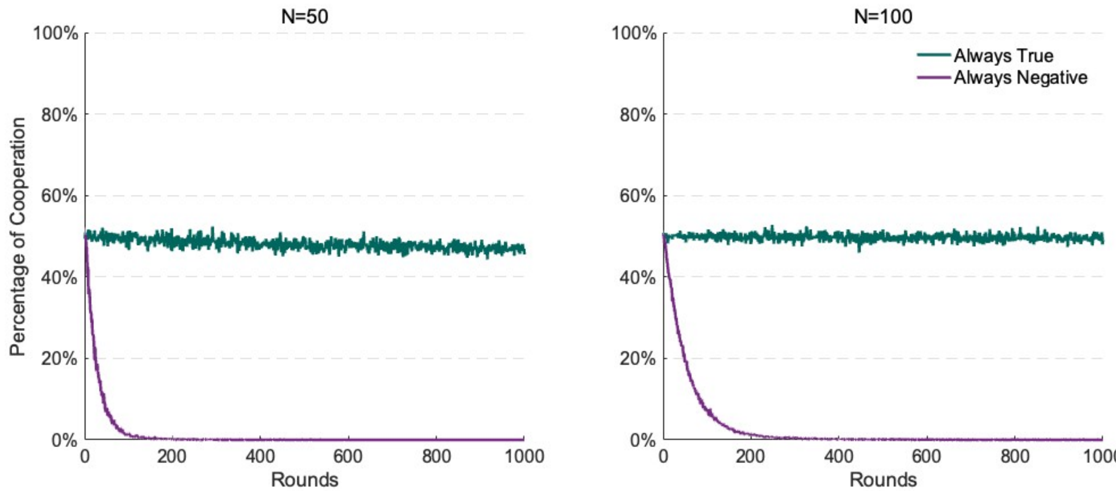


Figure S10: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Population size $N = 50$. Reaction mechanism: single reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

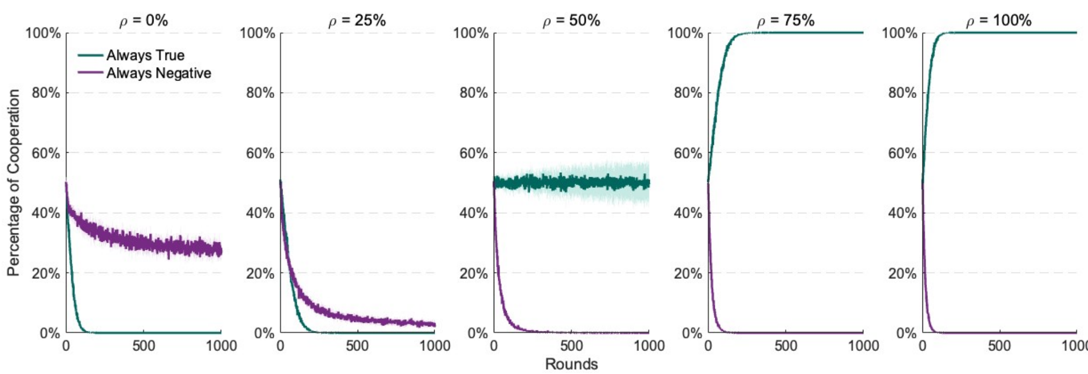


Figure S11: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Population size $N = 100$. Reaction mechanism: single reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

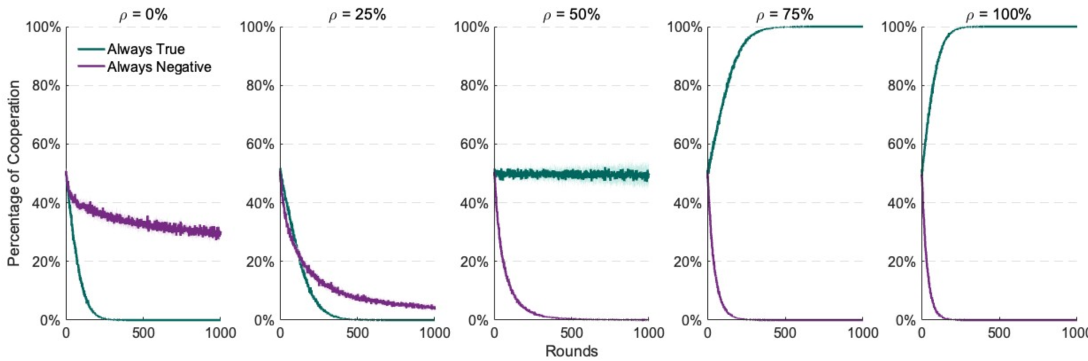


Figure S12: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Population size $N = 50$. Reaction mechanism: double reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

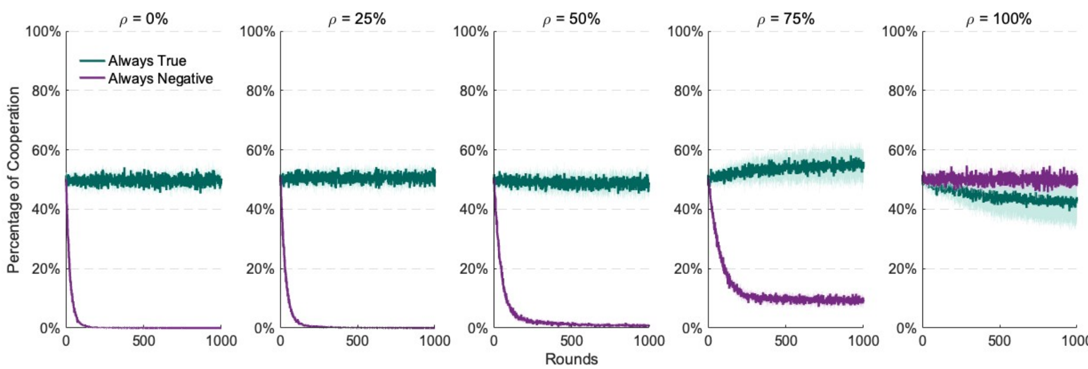
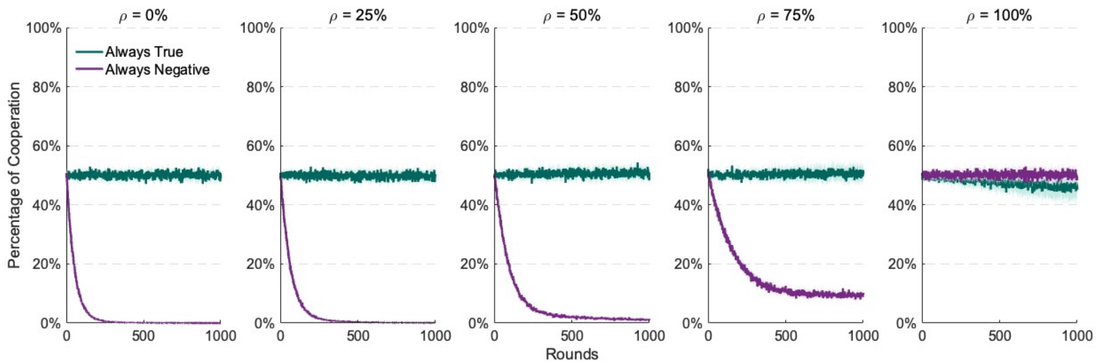


Figure S13: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Population size $N = 100$. Reaction mechanism: double reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.



S4.2 Weights of the reputations' updates

Furthermore, the size $(\omega_d, \omega_{g,s}, \omega_{g,t})$ of the increase/ decrease of agent's reputation $R_{i,j}$ and $G_{i,j}$ do not significantly impact the groups dynamics (see Figure S14, S15, S16, S17, S18). That is, the extent to which agents update their reputation of the other agents as interaction partners and as gossipers following a direct interaction or a gossip does not lead to any substantial difference in the cooperation dynamics analysed.

Figure S14: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Agent's weights for update $\omega_d, \omega_{g,s}, \omega_{g,t} = 0.1, 0.3$. Reaction mechanism: complete acceptance. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

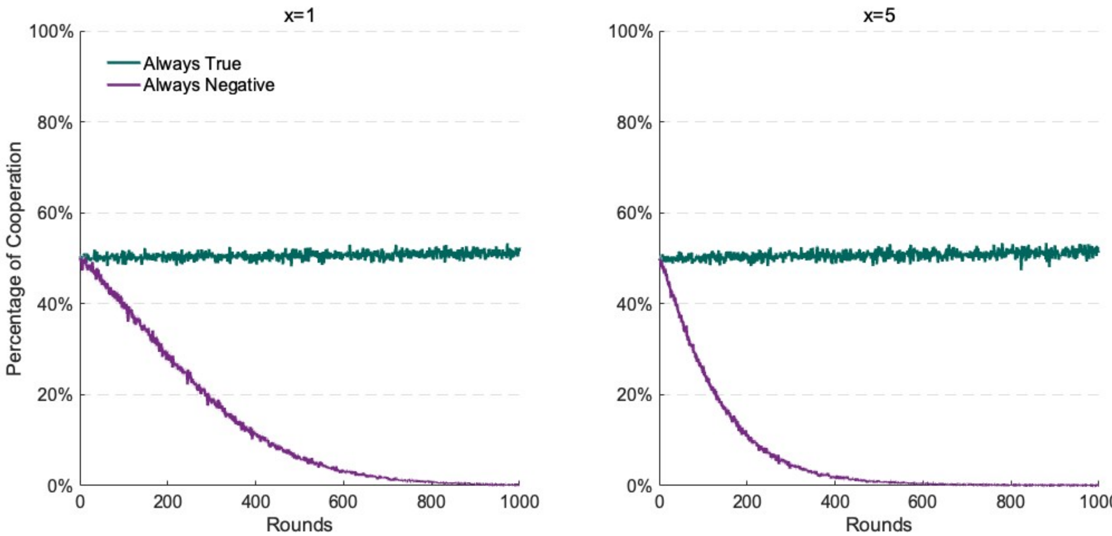


Figure S15: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Agent's initial baseline cooperation $\omega_d, \omega_{g,s}, \omega_{g,t} = 0.1$. Reaction mechanism: single reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

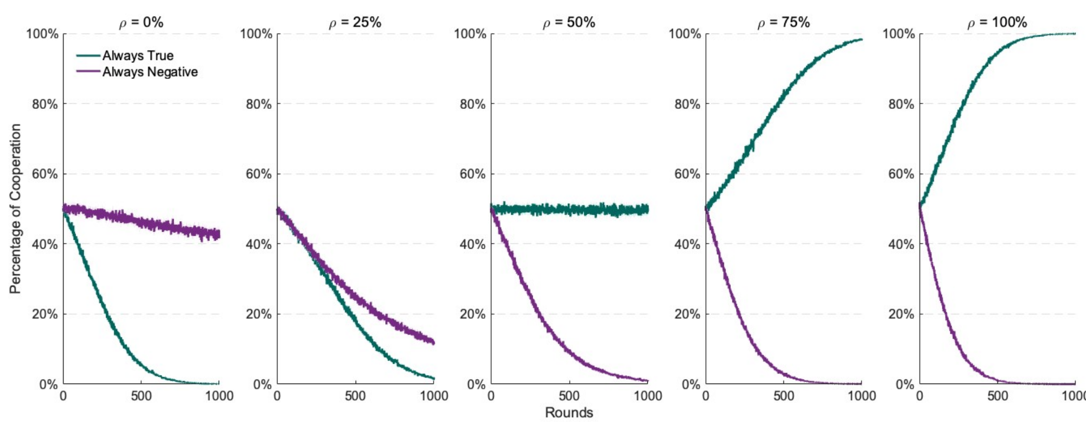


Figure S16: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Agent's initial baseline cooperation $\omega_d, \omega_{g,s}, \omega_{g,t} = 0.3$. Reaction mechanism: single reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

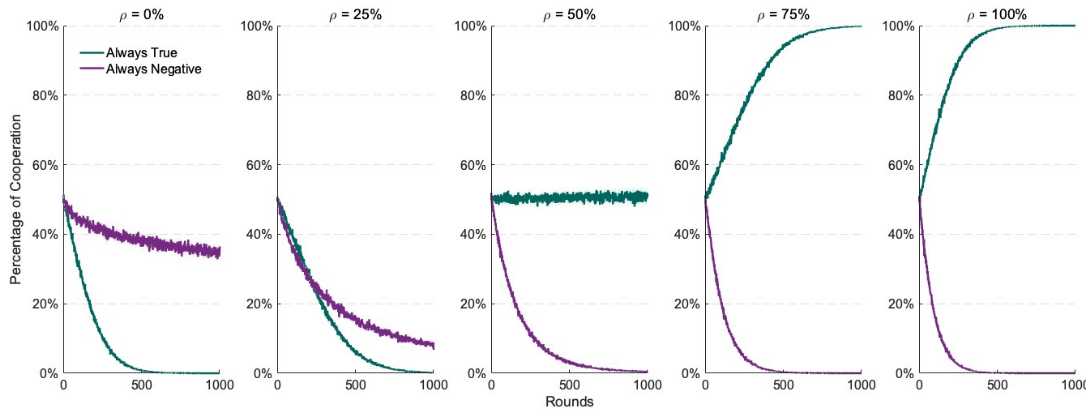


Figure S17: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Agent's initial baseline cooperation $\omega_d, \omega_{g,s}, \omega_{g,t} = 0.1$. Reaction mechanism: double reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

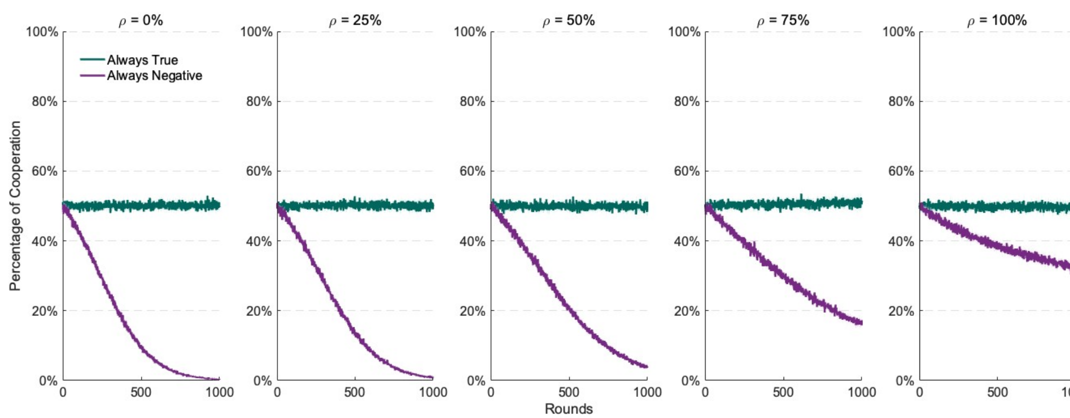
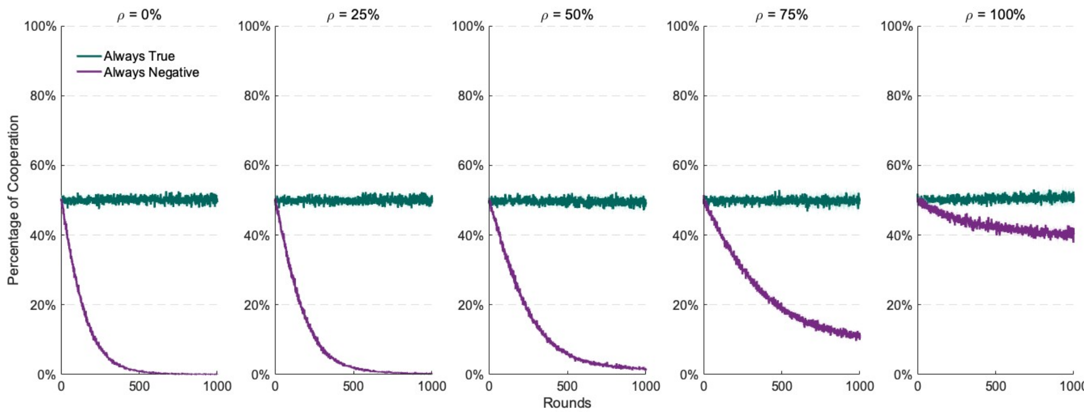


Figure S18: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Agent's initial baseline cooperation $\omega_d, \omega_{g,s}, \omega_{g,t} = 0.3$. Reaction mechanism: double reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.



S4.3 Gossip statements $x = 1, 5$

Finally, the number of gossip statements exchanged during each interaction ($x = 1, 2, 5$) does not impact the groups dynamics (see Figure S19 , S20 , S21 , S22 , S23).

Figure S19: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Gossip statements $x = 1, 5$. Reaction mechanism: complete acceptance. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

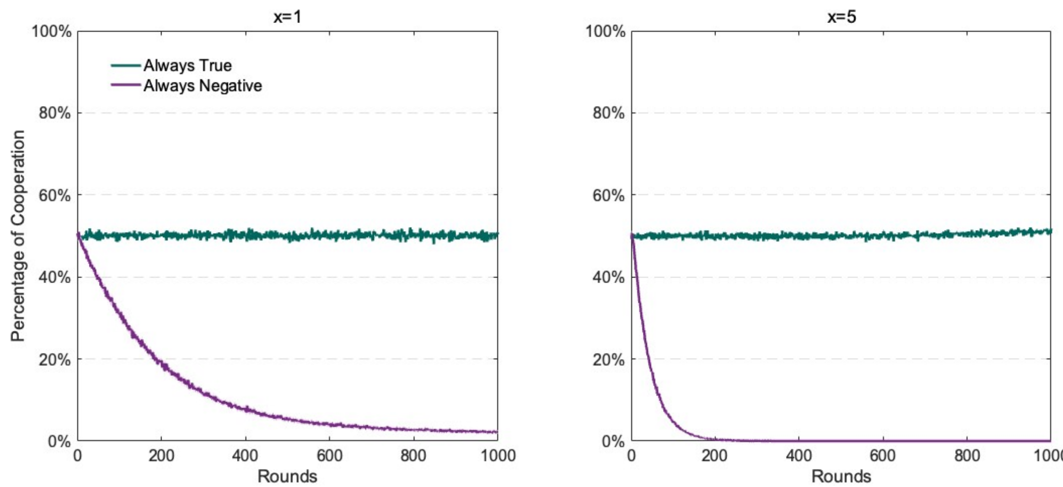


Figure S20: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Gossip statements $x = 1$. Reaction mechanism: Single reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

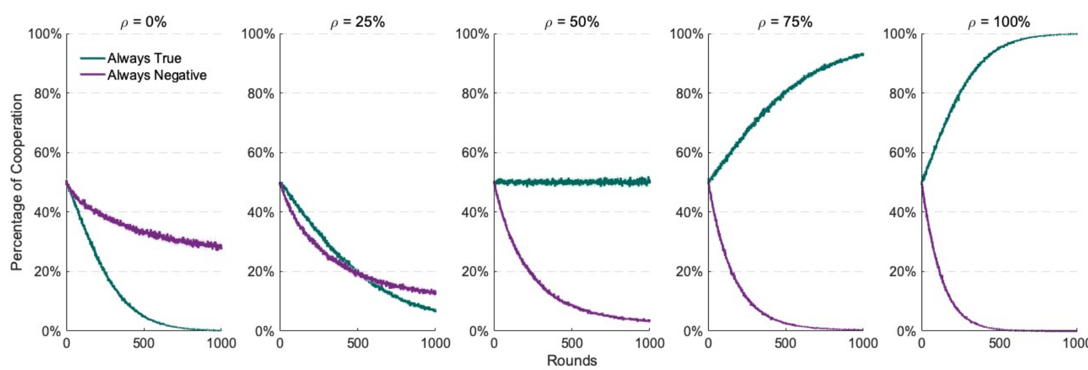


Figure S21: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Gossip statements $x = 5$. Reaction mechanism: Single reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

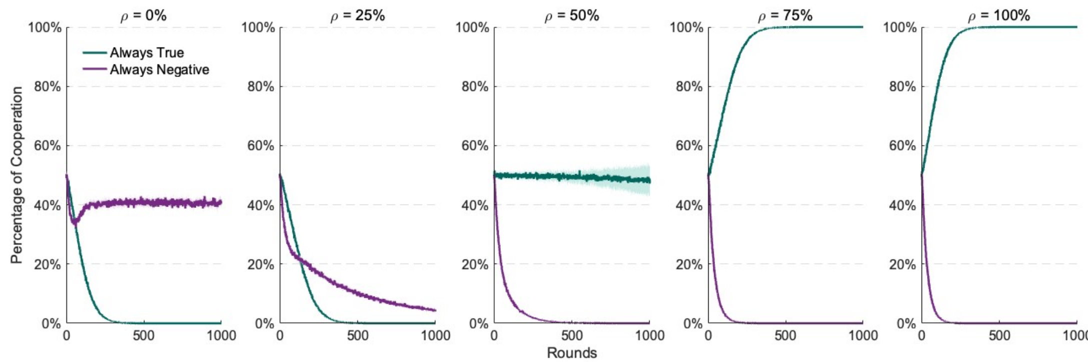


Figure S22: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Gossip statements $x = 1$. Reaction mechanism: Double reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.

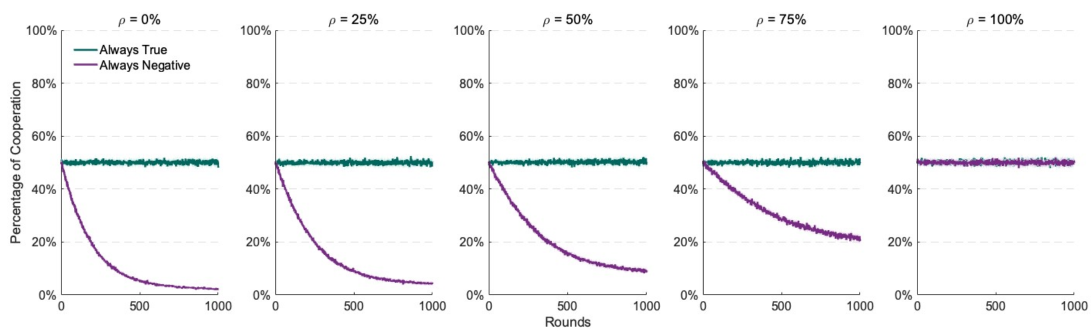


Figure S23: Percentage of cooperation over rounds for always-true and always-negative gossip motives. Gossip statements $x = 5$. Reaction mechanism: Double reputation. The shadows indicate the 95% confidence intervals, calculated over 100 independent runs.