Breeding Cooperation: Cultural Evolution in an Intergenerational Public Goods Experiment

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Abstract

This paper investigates the evolution of cooperation across multiple laboratory generations in an experimental public goods game. Theories of cultural evolution show how cooperative equlibria can be supported by the transmission of behavioral norms across generations. These types of cultural evolutionary processes are important for political science topics ranging from public policy to political participation. One of the best-established findings in the massive literature on experimental social dilemmas is that within-game communication increases cooperation. We find that it is possible to breed cooperation by selectively exposing later generations of subjects to cooperative messages from previous generations. We propose a number of potential reasons for the fact that between-generation communication (or advice) is at least as strong as within-game communication.

Key Words
Culture, evolution, cooperation, public goods, experiments, social dilemma

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Breeding Cooperation: Cultural Evolution in an Intergenerational Public Goods Experiment

This paper investigates the evolution of cooperation in an intergenerational public goods experiment. Theories of cultural evolution show how cooperative equlibria can be supported by the transmission of behavioral norms across generations. These types of cultural evolutionary processes are important for political science topics ranging from public policy to political participation because they are an important process by which behaviors and attitudes are transmitted among interacting individuals. One of the best-established findings in the massive literature on experimental social dilemmas is that within-game communication increases cooperation. We find that it is possible to breed cooperation by selectively exposing later generations of subjects to cooperative messages from previous generations. The effects of cultural transmission are at least as strong as within-game communication.

The concepts of cultural transmission and social learning are at the heart of theories of cultural evolution (Richerson and Boyd 2005; Boyd and Richerson 1988). These models rely on a simple definition of culture as the social transmission of beliefs and behaviors among individuals, which in combination with individual learning, produces the variation in beliefs and behaviors seen across different societies. Specific forms of cultural transmission include vertical transmission from parent to offspring, oblique transmission from older adults to younger people, and horizontal transmission among same-generation peers. Importantly for our experiments, several models demonstrate how cultural transmission can support cooperation across generations (Henrich and Boyd 2001; Boyd and Richerson 1985). A key intuition of these models is that norms of reciprocity and punishment of non-cooperators are passed across generations, reducing the costs of learning how to cooperate in each subsequent generation.

Such patterns of cultural transmission are crucial to the stability of cooperation in real-world societies and political systems, although the concepts of cultural evolutionary models have received little attention in political science. Cultural evolution is implicated in broad-scale processes of political socialization and citizen behavior, including cooperation problems of voting and tax compliance. Within formal political institutions such as Congress, norms of reciprocity are passed down from senior legislators to junior legislators in order to support various forms of bargaining, committee structures, and coalition-building. One of the current hot topics in public policy is the role of collaborative institutions for building cooperation in complex conflicts involving multiple issues and organizations (O'Leary et al. 2006; Sabatier et al. 2005; Lubell et al. 2002). A major challenge of collaborative institutions is maintaining agreement and cooperation in the face of high levels of turnover among participants; overcoming this challenge requires cultural transmission of cooperative norms. Ongoing cooperation games in the real world nearly always involve multiple generations of participants, and thus it is critical to understand how social learning and cultural transmission supports different behavioral norms. Our experimental design creates a situation that mirrors this real-world situation and examines how norms of cooperation are passed among individuals in a simpler setting.

It is difficult to stake out new territory in the mature (with early experiments dating to the 1950s) and vast literature on experimental social dilemmas (Komorita et al. 1992;

Kollock 1998); researchers who claim to be covering new ground will often find similar examples among the thousands of experimental papers. Intergenerational experiments are no exception—although relatively new in this literature, some initial studies have been conducted using a variety of types of social dilemmas and methods of cultural transmission. One set of experiments finds that advice from previous generations has the strongest effect when it is announced publicly to all experimental subjects and generally recommends cooperative behavior (Ananish et al. 2009; Chaudhuri et al. 2006). Another series of experiments suggest that while cultural transmission has an extremely strong influence on behavior in later generations, there are some interesting asymmetric effects such as perpetuating unequal divisions of gains from cooperation (Schotter and Sopher 2003), decreasing levels of trust among senders in a trust game but increasing levels of trustworthiness among receivers (Schotter and Sopher 2006), and considerations of fairness being more important for receivers than senders in an ultimatum game (Schotter and Sopher 2007). A common thread in these experiments is that many of the findings would not emerge without the use of an intergenerational experiment.

Our experiment contributes to this literature by thinking about breeding cooperation in a manner similar to Darwin's observations on breeding pigeons. In particular, we aim to *direct* the cultural evolution of cooperation by selectively exposing future generations to the most positive cooperative advice. Breeding cooperation in this manner has direct implications for real-world games such as collaborative policy, where program designers make choices about who to include in future games, and also select among past examples as models for current collaborations. We next turn to the design and results of our initial experiments.

Experimental Design and Procedures

Undergraduate student subjects in group sizes ranging from 3 to 9 played an N-Person public goods game. Individuals could contribute between zero and 20 tokens to a common fund. Contributions to the common fund were doubled and returned to all members of the group regardless of whether or not they contributed. Subjects began the game with an endowment of between 50 and 150 tokens, although the vast majority of subjects began with an endowment of 100 tokens. (After an initial period of testing to calibrate final payments to average around $15, we settled on an initial endowment of 100 tokens.) Each token was worth $.05 in US dollars. Subjects accumulated or lost tokens over the course of the experiment, and were paid in cash at the end of the game in proportion to the amount of tokens they had accumulated, plus a $5 show-up payment. Subjects earned on average $15 and between $10-20. In the baseline progenitor generation (F0 generation in lab breeding jargon), some groups were allowed to communicate in each round (via computer messages) while other groups had no-communication. The communication versus no-communication conditions were designed to reproduce the best-established finding in the social dilemma literature that communication increases cooperation (Dawes et al. 1977; Orbell et al. 1988; Sally 1995; Balliet 2009). Each game lasted 20 rounds, although subjects were not told this at the outset of the experiment. We did have some unpaid subjects in these pilot experiments, which we describe in more detail later and control for in the analysis. All experiments were run via a computer network, using the Gameweb browser-enabled software developed by Richard McElreath and colleagues (http://sourceforge.net/projects/gameweb/).

All subjects initially read a series of instructions informing them of the payoff structure and details of the game operation. Subjects were informed that interactions in the game and payment amounts would be anonymous. Subjects were provided with an introductory screen in which they could test how different levels of contribution amounts would affect the payoff distributions. Subjects could experiment with this screen for as long as they wanted. We did not explicitly test subject understanding of the game by requiring them to correctly answer a series of questions because we wanted to increase the potential strength of social learning and reduce the strength of individual learning.

In each round, subjects contributed an amount to the common fund, and then were able to view (anonymously) the contributions, per-round, and cumulative payoffs for each individual in the game. After viewing these, subjects were able to send a message to other participants (if they were in a session that included within-game communication, and then read (anonymously) the comments of other players.

To make the game intergenerational, each subject was asked to provide written advice (between generation communication) to the next group of subjects at the end of the game. This advice was then provided to the next generation (successor generation; or F1) of subjects that came into the lab. In particular, we selected the most cooperative advice from the set of F0 groups to provide to the F1 generation. We provide the details for this process below. Unlike the Chaudhuri and Schotter et. al. experiments, we did not pay past generations for the performance of future generations, which provides an incentive for previous generations to leave good advice. Our subjects have no incentive to improve the performance of future generations, although we do select the most cooperative advice as discussed later. This pilot experiment only includes one F1 generation; later experiments will extend the number of generations although the results show that intergenerational effects are strong even in one generation. The F1 generations are also run under two conditions, one with communication and one without communication. Table 1 summarizes the number of groups and subjects in each combination of conditions: F0-no communication, F0-communication; F1-no communication; F1-communication.

[Table 1 about here]

The key question is the level of cooperation (contributions to the public good by round) in the successor generations relative to the progenitor generations. As with past experiments, we expect within-generation communication to substantially increase cooperation, and we also expect a gradual decline in cooperation in later rounds of the game as end game and boredom effects materialize. If intergenerational cultural transmission is strong, we expect cooperation to be much higher in the F1/no communication condition (in which there is only intergenerational transmission) relative to the F0/communication condition (in which there is only within-generation transmission). The combined effects of cultural transmission and communication should produce the highest levels of cooperation in the F1/communication condition.

The communication conditions also provide the opportunity to content code the advice given to other subjects in the round. We coded the content of messages into the following categories:

1) Full Cooperation: messages encouraging other players to contribute the full amount possible (10 experimental tokens)
2) Irrelevant: either blank or game-irrelevant communication
3) Praise or positive moral: messages praising other individuals for contributing or that framed contributions as a moral imperative in a positive light (e.g. “do the right thing)
4) Disapprove or negative moral: messages disapproving of other individuals for defecting or that sanctioned other individuals morally for not contributing (e.g. “if you don’t give 10 you’re a bad person)

Each message sent could have multiple phrases and thus might be coded in more than one category. The coding scheme is best conceptualized as quantifying different "bits" of each message. We double-coded a random sample of the advice, and there is an acceptable level of intercoder reliability.

Thus we can analyze the "tone" of the messages in the progenitor and successor generations where communication is occurring. This provides some insight into whether or not the advice from the previous generation shifted the dialog among subjects in ways that go beyond just exhorting higher levels of cooperation.

The content coding also allows us to demonstrate the tone of the advice that we selected to provide to future generations. For example, of the 5 pieces of advice provided to the successor generation in this experiment, 4/5 specifically advocated full cooperation, 2/5 contained positive moral statements, 1/5 contained negative moral sanctions against cooperation, and 3/5 contained group building statements the explicitly mentioned words like "we" and other team-oriented comments (remember that each piece of advice was coded for multiple elements). This was by far the most cooperative set of advice from all the progenitor groups. Note however that the most cooperative advice did not come from the most cooperative progenitor group in terms of cooperation. While cooperative advice and behavior are positively correlated (see below), there is enough variation that they are not the same rank ordering. Also, a group that experiences non-cooperation may provide more cooperative advice in an attempt to help future generations obtain better results.

Results

Figure 1 reports the mean contribution by round for each of our conditions and clearly shows the effect of cultural transmission. As expected, communication substantially increases cooperation within the progenitor generation. However, cooperation in the successor generation (even without communication) is higher than cooperation in the progenitor generation with communication. In other words, the advice from previous generations alone transmits cooperative norms in a strong enough way to maintain cooperation when subjects cannot talk to one another within the game. In fact, the effect of advice alone produces nearly as much cooperation as seen in the successor generation with communication. Communication does enhance cooperation a small amount relative to the no-communication successor generation a small amount, but does not have nearly the same magnitude of effect as in the progenitor generation. The benefits of within-game communication are reduced in the successor generation because subjects are relying on the advice from their predecessors. This is a very similar effect to Schotter and Sopher (2003), where advice locks subjects into one of two possible cooperative equilibriums in a Chicken game.   One caveat for this pilot study is the F1-no communication condition consists of entirely unpaid subjects; we control for this in the regression below although the effect of advice alone may be less dramatic if all subjects were paid.

[Figure 1 about here]

Figure 2 provides further insights into contribution behavior by reporting histograms of contribution frequency by condition. It is interesting to see that contribution behavior is generally bi-modal, with subjects either deciding to contribute the full amount (cooperate) or nothing at all (defect), with relatively few partial contributions. The progenitor/no communication condition has the highest frequency of defection, while the progenitor/communication condition has about an equal split of cooperation and defection. Both of the successor generations, on the other hand, have a high level of full cooperation. This suggests that intergenerational advice is acting to effectively weed out very low levels of contributions from chronic defectors.

[Figure 2 about here]

Figures 3 through 6 provides some corroborating evidence in terms of the tone of communication in the progenitor and advice conditions. Within-game communication in the successor generation appears to follow the cooperative advice given by the progenitor generation, with higher levels of exhortations for "full" cooperation (e.g. “Contribute all 10 tokens people”; Figure 3) and higher levels of praise (Figure 4). The increases in cooperative messages are concentrated in early rounds of the games, suggesting that cultural transmission provides later generations a "head start" in the evolution of cooperation. Circumstantial evidence for this conjecture is in Figure 1, where cooperation is actually fairly low in the initial rounds of the F0/communication condition, suggesting that it took some time for subjects to coordinate. Cultural transmission essentially reduces the costs of this early learning period.

Reflecting the disappearance of chronic defectors, the level of disapproval is consistently lower throughout the rounds of the successor generation (Figure 4). Interestingly, the level of irrelevant communication increases in both conditions over time, and may be linked to the typical end-game effects seen in most social dilemma experiments. Irrelevant communication may reflect boredom and people not caring as much about establishing cooperation.

[Figure 3-6 about here]

Table 1 provides a statistical analysis using a linear regression model of contributions and also an ordered logit model where the dependent variable is coded as (0=No contribution; 1=Greater than zero, less than full; 2=Full contribution). The ordered logit is appropriate for the non-normal distribution of contribution behaviors. The independent variables are 1/Round (the inverse of game length, to capture the gradual decline in cooperation), group size, a dummy variable for unpaid subjects, a dummy variable for communication condition, a dummy variable for successor generation, and an interaction term between successor generation and communication. The combination of dummy variables means the intercept captures the baseline progenitor condition without communication for paid subjects. All results are statistically significant, and the model explains about 28 percent of the variance in contribution behavior.

[Table 1 about here]

The estimated coefficients on the treatment dummy variables in the linear regression model essentially reinforce the graphical display in Figure 1. Compared to the progenitor generation without communication, the linear regression results predict that subjects in the progenitor game with communication will contribute 2.45 more units in the average round. Culturally transmitted advice alone increases the predicted contribution by 4.5 in the successor generation without communication; even if paid subjects reduce their contribution by the predicted .81 units, cultural transmission is having at least as strong an effect on cooperation as in-game communication. The model predicts the highest level of cooperation in the successor generation with communication, but the negative interaction effect means that intergenerational advice and communication are substitutes instead of complements. The negative interaction means communication does not have as much of an effect on the successor generations as in the progenitor generation, or conversely, intergenerational advice does not have as much of an effect when communication is ongoing across generations. If communication and intergenerational advice were complements, there would be a positive interaction effect such that intergenerational advice enhances the marginal benefits of communication.

Conclusion

Even in this pilot study with some unpaid subjects, the experiments reported here clearly show that it is possible to breed cooperation in the short-term by selectively exposing later generations to advice that recommends cooperation. The effect of intergenerational advice is strong enough to effectively substitute for in-game communication as a promoter of cooperation. Cultural evolution models suggest that vertical and oblique social learning reduces the cost of individual learning, such as that seen when subjects are attempting to coordinate in the progenitor games with communication. Put simply, people perform better when you tell them how to succeed. Cultural transmission may also be particularly strong because the previous generation is seen as experts with previous experience; they have prestige that should be appreciated regardless of the informational content of their advice. In addition, advice from the previous generation may be viewed as more trustworthy than current generation advice because the previous generation is not competing for the same resources, and has no incentive to send deceptive messages of cooperation and then defect privately.

The results open up a whole host of interesting questions about intergenerational transmission and cooperation that deserve serious exploration. Further experiments should be done to see what types of experimental treatments influence the strength of cultural transmission and the persistence of cooperative norms over time. For example, Schotter and Sopher (2003) run their experiments for enough generations to observe punctuated equilibria where some groups have much lower levels of cooperation. We suspect a similar story would happen here if we had enough generations, because there is always a probability of a group of non-cooperators joining the experiment and ignoring the advice of previous generations. So the question is really how long-lasting are periods of cooperation, and how frequent and long-lasting are periods of defection. It would also be interesting to examine the effect of intergenerational advice in the absence of selecting for a particular type (e.g. cooperative) of advice. There is a difference between the content of the advice (e.g.; cooperative versus non-cooperative) and the mode of transmission (e.g.; within-generation versus intergenerational), and there are some reasons to expect that intergenerational advice may have a stronger effect independent of message content.

It is also interesting to think about the possibility of breeding different lineages of behavior, for example it should be possible to breed defection by exposing later generations to the most non-cooperative advice. A particularly interesting possibility in this vein is there may be an asymmetry such that it is easier (or harder) to breed cooperation versus defection. Finally, we need to understand how such intergenerational processes interact with institutional arrangements such as the potential to punish defectors and reward cooperators. Are institutions complements or substitutes for institutional mechanisms like punishment, that are known to increase cooperation (Fehr and Gachter 2000; Fehr and Gachter 2002)? Similar to norms for contributing to public goods, can cultural transmission accelerate the development of institutional norms like altruistic punishment; e.g., how frequently people use punishment and under what conditions.

Answers to these questions have real-world implications for the design of institutions to solve real-world cooperation problems ranging from the broad to the narrow scale. Our experimental manipulations are analogous to policy decisions that expose new generations of people to particular types of information and behaviors from previous generations. This of course happens all the time in the real world as people channel the information available to their successors in all kinds of different human enterprises. Pinpointing the mechanisms through which cultural transmission most effectively promotes cooperation in the lab should help inform those choices in the field.

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Table 1: Number of Groups and Individuals by Treatment and Payment Condition			
		Communication	
		No	Yes
Generation	Progenitor (F0)	9 (11) groups 47 (57) individuals	8 (10) groups 41 (52) individuals
	Successor (F1)	0 (8) groups 0 (39) individuals	7 (13) groups 36 (65) individuals
Note: First number is paid groups, individuals. In parentheses is total groups, individuals. Number of decisions (unit of analysis in the statistical analysis) is #individuals multiplied by 20 rounds.			

Table 2: Regression Models of Contributions

	Linear	*Ordered Logit*
Independent Variables	Coefficient (S.E.)	Coefficient (S.E.)
1/Round	1.46 (0.26)*	0.85 (0.15)*
Group Size	-0.16 (0.06)*	-0.12 (0.04)*
Unpaid Subject	0.81 (0.15)*	0.51 (0.08)*
Successor Generation	4.14 (0.21)*	1.83 (0.12)*
Communication	2.46 (0.16)*	1.14 (0.09)*
Successor X Communication Interaction	-1.24 (0.25)*	-0.30 (0.14)*
Intercept	3.14 (0.36)*	
F-statistic	6, 4253 d.f. = 274.1*	
Adjusted R^2	0.28	0.31 (pseudo)

Note: Cell entries are unstandardized regression coefficients with standard errors in parentheses; *Reject null hypothesis of coefficient =0, p<.05; N=4260 contribution decisions

Figure 1: Mean Contribution by Round and Treatment Condition

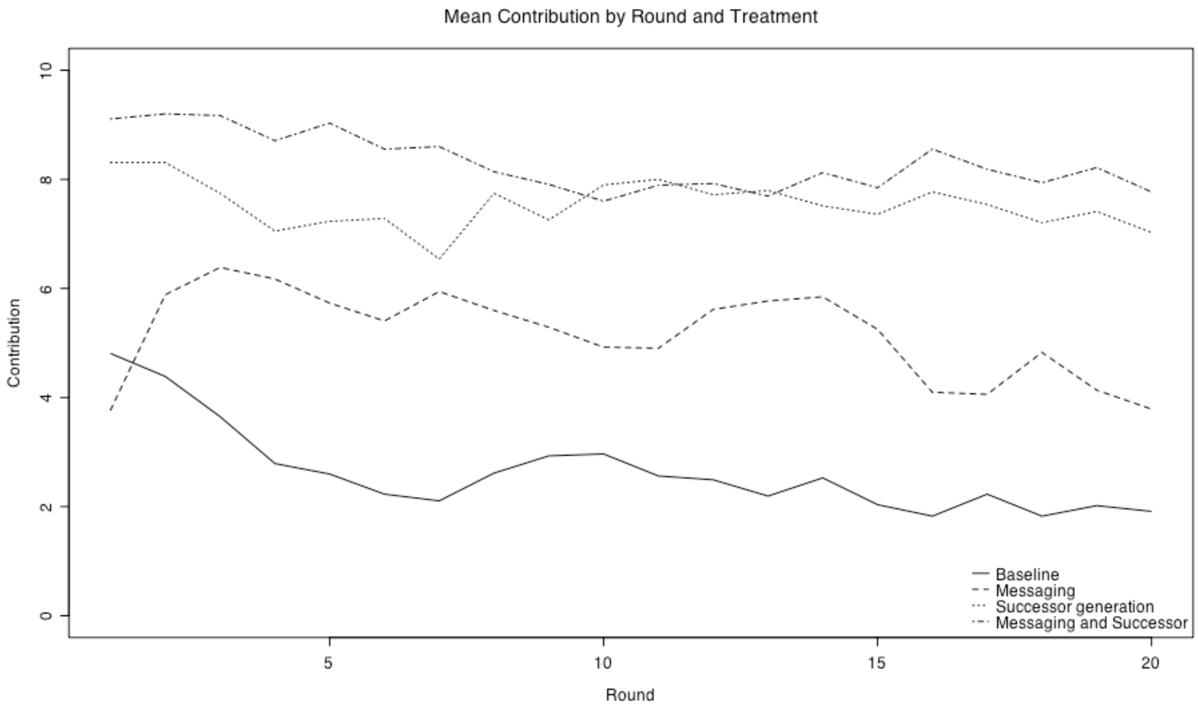

Figure 2: Frequency Distributions of Contributions by Condition

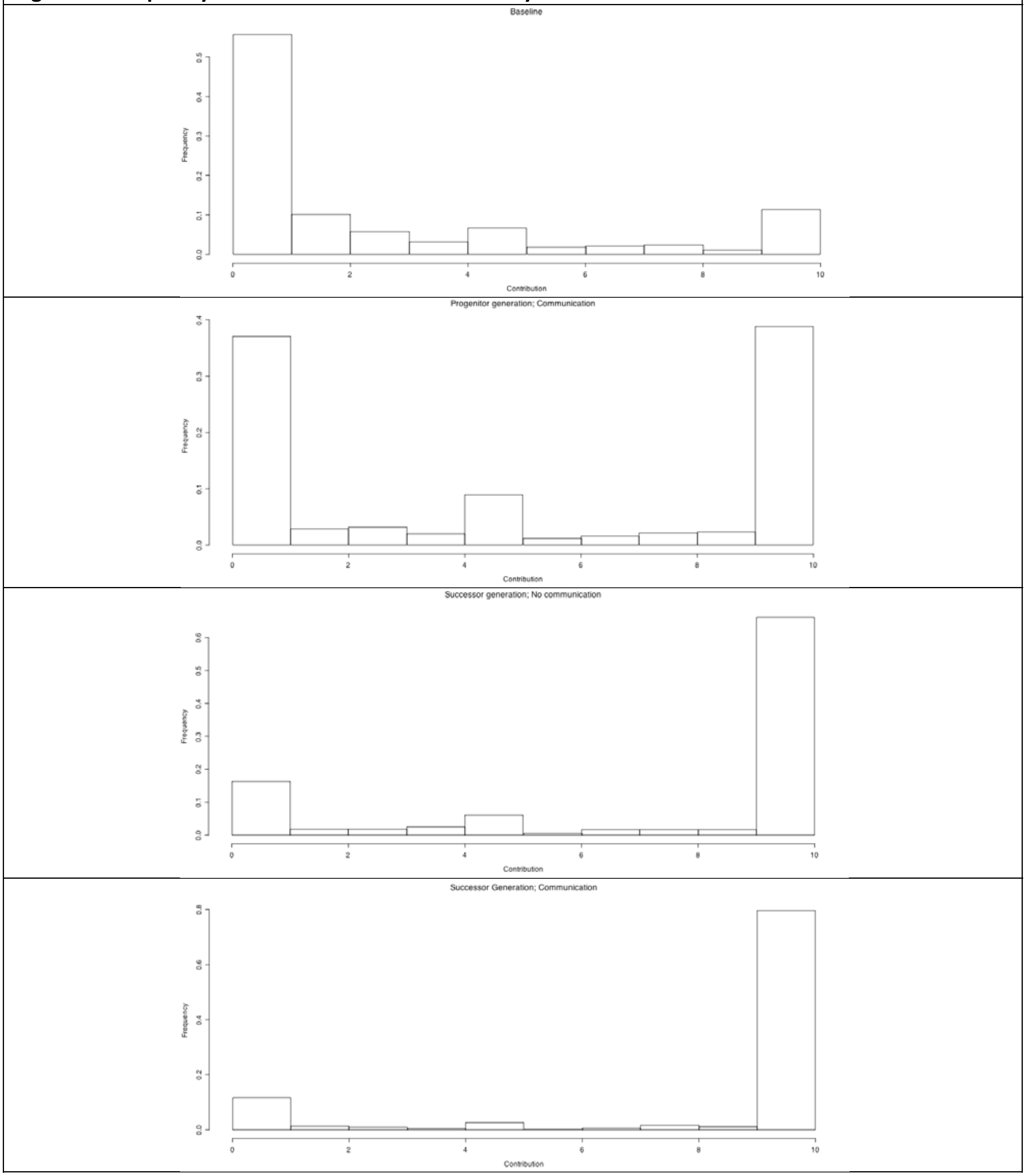

Figure 3: Proportion of Total Messages Specifying Full Cooperation by Round and Treatment

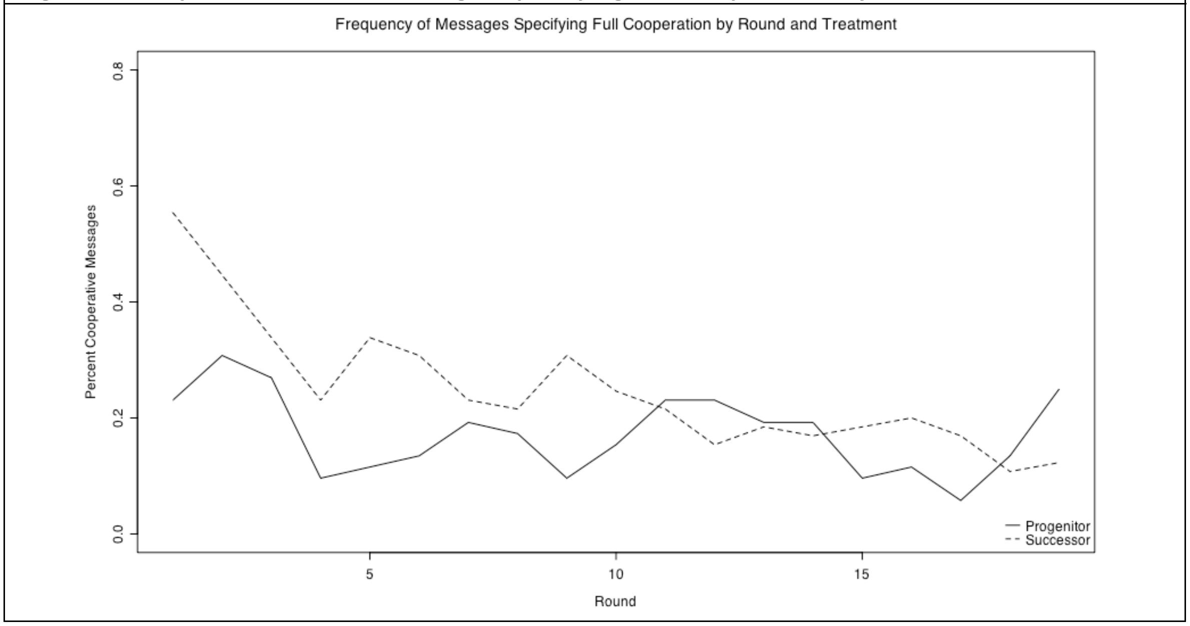

Figure 4. Proportion of Total Messages Specifying Praise by Round and Treatment

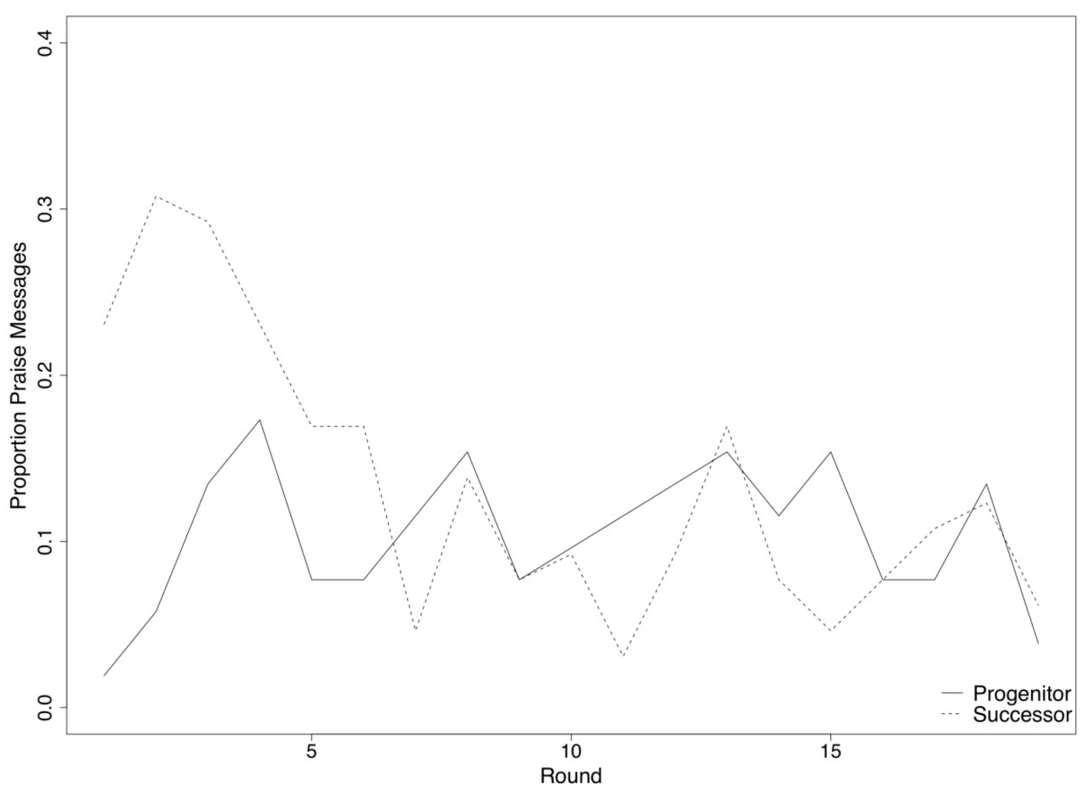

Figure 5. Proportion of Total Messages Specifying Disapproval by Round and Treatment

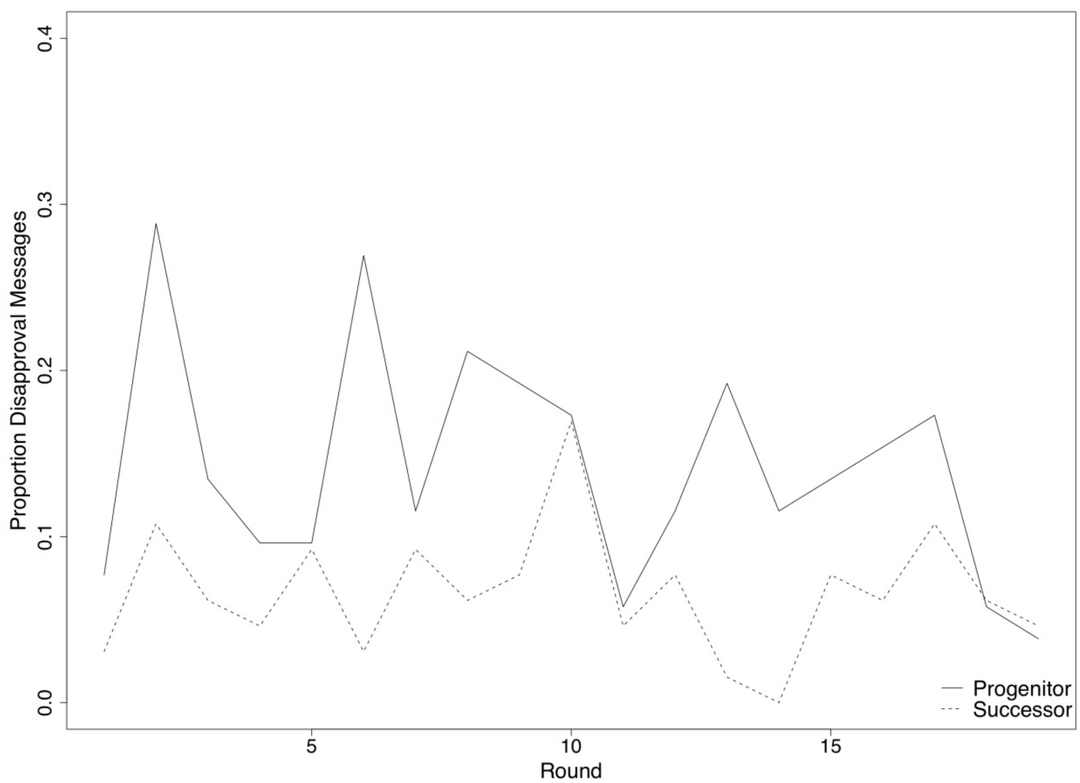

Figure 6. Proportion of Total Messages that are Irrelevant by Round and Treatment