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■ *Research Paper*

Post-disaster Cooperation Among Aid Agencies

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Natural and anthropogenic disasters affect ever-larger populations. Effective cooperation among aid agencies is key to post-disaster recovery. Studies in evolutionary game theory suggest two motives for one agency to cooperate with another: the other agency's reputation and the perceived probability of working together again in the future.

This mixed method study collected data from decision makers in 30 aid agencies. The quantitative instrument, itself an evolutionary game, showed cooperation heavily influenced both by reputation and by interaction potential, with probable frequency of future interaction being a better predictor. Qualitative interviews affirmed the importance of both and showed learning, directives and reviews are subsidiary determinants of cooperation.

This study answers—for the population of disaster aid managers—a controversial question in the evolution of cooperation. It offers guidance for agencies allocating training budget between technical skills (e.g. distributing medicines) and cooperation skills, with the aim of quickly aiding disaster victims. Copyright © 2017 John Wiley & Sons, Ltd.

Keywords cooperation; trust; disaster response; evolutionary game theory; inter-agency

INTRODUCTION

Disaster management assumes greater importance as changing weather patterns and insufficient safeguards more frequently expose larger populations to hazards both natural (e.g. earthquakes and tsunamis) and anthropogenic (e.g. nuclear accidents and terrorist acts).

Effective cooperation among the several aid agencies that typically respond to disasters is key to post-disaster recovery and remediation. In the context of tsunami response at a school in Washington State, US National Academy of Sciences president Marcia McNutt (2016) remarks, 'Success at Ocosta depended on partnerships' among many helpers from diverse scientific, educational, non-governmental organization (NGO) and governmental cultures.

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Prior studies in evolutionary game theory suggest two alternative motives for one agency to cooperate with another in the post-disaster situation: the other agency's reputation and the perceived probable frequency of working again with that agency in the future.

This mixed method study collected data from experts and decision makers in 30 aid agencies across the world. Quantitative results showed inter-agency cooperation heavily influenced both by reputation and by interaction potential of the agencies, with probable frequency of future interaction being a slightly better predictor. Qualitative interviews supported the importance of both and showed agency learning, directives and reviews are subsidiary but still influential determinants of cooperation among agencies. The quantitative instrument, itself an evolutionary game, proved to be a useful focus for experts' thoughts and qualitative responses.

This study answers—at least for the specialized population of disaster aid managers—a controversial question in the evolution of cooperation. It offers guidance for agencies allocating training budget between technical skills (e.g. distributing medicines) and soft cooperation skills, both with the ultimate aim of aiding disaster victims.

In this paper, we further characterize disasters, and their apparent growing frequency and severity. We describe the common phenomena of post-disaster cooperation and dis-coordination among aid agencies. We briefly review literature on the evolution of cooperation and its open question of whether indirect reciprocity (essentially, the other's reputation) or estimation of future encounters with the other is the prime driver for initiating cooperative action. We mention other research pertinent to inter-organizational cooperation in the disaster context, noting that there is not much of it.

We then describe the methodologies and results obtained by the quantitative and qualitative investigations. The research shows that among aid agency managers, the perceived frequency of working with a particular other agency in the future is a stronger driver of cooperation (on any given occasion) than the other agency's reputation. We mention the limitations of the present research and show implications of the research for aid agencies.

DISASTERS

Natural geological, hydrological and meteorological events may put humans at risk. Man-made disasters like oil spills and financial meltdowns do the same. Some disasters are hybrid, for example, when builders have constructed homes in areas prone to mudslides, or when, as in Hurricane Katrina (Needle, 2011) or the sinking of the Titanic, official ineptitude made the harmful consequences of a natural occurrence even worse.

The apparent recent increase in incidence and severity of disasters may be due to better global communication and news coverage and to the media's preference for reporting frightening news. The increase may be real, a result of climate change, more jobseekers migrating to regions that are at risk from rising sea levels or crop diseases or the limits to the manageability of complex systems such as nuclear generators. In any case, the human and dollar costs of disasters are very significant.

The reinsurance company Swiss Re indicated that US losses suffered from natural and man-made disasters accounted to approximately $140bn in 2012 (Pearce, 2012). It is estimated that the welfare cost associated with large economic disasters can rise to as much as 20 per cent of the annual gross domestic product of a country (Cavallo and Noy, 2009).[1]

Heetun's (2015) dissertation catalogues natural disasters occurring in 2013 alone. These included earthquakes, typhoons, floods, cyclones, extreme weather episodes, tropical storms, tornados, rockslides, wildfires, droughts and sinkholes. (The list did not include 2013's unnatural disasters: nuclear accidents, toxic spills, epidemics and oil platform blowouts.)

On 8 November 2013, Typhoon Haiyan struck the Philippines affecting 9.7 million people, leaving 3 million with no shelter, killing 3637

[1] The International Insurance Institute publishes statistics on worldwide disasters. http://www.iii.org/fact-statistic/catastrophes-global

and destroying 384 000 acres of crops including rice and corn worth $105m (Hodal, 2013). The World Risk Report ranks the Philippines third out of 173 countries in terms of vulnerability to disasters. Even though Japan faces the same level of *risk* for the same kinds of weather, the *hazard* is greater in the Philippines, as it is believed that 17 times more people in the Philippines could be harmed, as the poorer country offers fewer opportunities for mobility away from at-risk or affected areas, and less emergency equipment (Alliance Development Works, 2012).

Figure 1 illustrates how an affected locale recovers from a disaster, rebuilds and prepares for the next extreme event. The response and recovery stages are the ones carrying the most urgency following any given disaster. These are the stages we address in the present paper.

DISASTER RELIEF AND PROBLEMS OF INTER-AGENCY COOPERATION

When disasters strike and aid agencies converge on the affected area, they lack understanding concerning how the other agencies operate. They fail to understand other agencies' organization, culture and emotional rewards, the way they use their information systems and the quality of those systems. They fail to identify relevant information that should be passed on to other agencies. Depending on the size of the population and the level of development of the country, the economic outcomes, policies and institutional arrangements may be different in each country where a disaster strikes (Barrionuevo, 2010). All this affects the quality of inter-agency cooperation (Bharosa *et al.*, 2010).

Figure 1 The disaster cycle. Adapted from Ishak et al. (2004)

Aid agencies are dedicated to their relief mission. However, when interacting with like agencies, even the most dedicated and altruistic organizations may engage in jurisdictional disputes, quests for glory and budget, spats over precedence, liability-avoidance behavior and refusal of accountability. Moreover, NGOs compete for donor funds. They attract these funds by showing mission leadership and success. See Petrucci (2012).

Phillips (2011) provided philosophical context, using a multiple-perspectives systems schema. He showed how the ideas of moral hazard, externalities, adverse selection, responsibility, integrity, breach of trust, accountability, moral authority and transparency apply to high-performance inter-agency interaction in the post-disaster environment.

Grace *et al.* (2011) emphasized the dysfunction characterizing agencies and departments of Federal Government when responding to disasters and overseas contingencies. These authors note there is much discussion, angst and frustration about the lack of cooperation and coordination among the different agencies during disasters, both natural and man-made.

Other entities, not of an aid organization nature, are involved in disasters, further complicating the picture and delaying restitution to victims. In the Exxon Valdez spill, Exxon Corp., the State of Alaska, US Department of the Interior, US Environmental Protection Agency and the Alyeska Corporation argued over who was responsible for what (Linstone and Mitroff, 1994). When the collapse of the World Trade Towers propelled toxic dust into the neighbouring Deutsch Bank building, the bank, its insurors, New York citizen groups, local and state governments and courts, the Environmental Protection Agency and a number of construction companies engaged in buck-passing and litigation, keeping the building uninhabitable for several years (Varchaver, 2008).

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The 2010 Haiti earthquake left 300 000 injured, 225 000 killed and 1.5 million people homeless. One aid worker called it 'the most complex emergency to date'.

> Over 900 NGOs responded to the Haiti earthquake, each with its own priorities, suppliers, and work style: 'They compete with one another for resources, duplicate one another's efforts, and generally get in one another's way', *Wired* wrote of the relief effort. The job of coordinating the response in Haiti fell to two major groups: the United Nations …, and the U.S. military, which became a *de facto* coordinator through its control of the airport. The two failed to work together, leading to what one NGO termed 'a situation of utter chaos' (http://insidedisaster.com/haiti/response/relief-challenges).

THE EVOLUTION OF COOPERATION

Delton *et al.* (2011), in *Proceedings of the National Academy of Sciences*, showed the incidence of altruistic (cooperative) behavior depends on the actor's assessment of the chances of meeting the other party in future and the actor's assessment of the probable frequency of meeting the other party again.

Nowak's (2006) *Science* article and subsequent book (2012) reported on the evolution of cooperative behavior in prisoners-dilemma type games. Many 'generations' of plays showed the emergence of cooperative behavior. Nowak distinguished five basic cooperative strategies: direct reciprocity, spatial selection, indirect reciprocity, kin selection and tribal selection.

Among Nowak's remarkable findings was the 'evolution of forgiveness', that is, the survival value of going beyond tit-for-tat, to cooperate even when the other player has shown betrayal behavior. Nowak's spatial selection may be compared with the probability assessment idea of Delton *et al*., as one may assume that contact with spatially close players is more frequent than with distant players.

'Indirect reciprocity' means the decision to cooperate is based on the other player's reputation for helpfulness. Nowak notes: 'Humans, more than any other creature, offer assistance based on indirect reciprocity, or reputation'. This is because we have language (and Facebook and credit-scoring agencies) to make a person's reputation widely known.

Of the five general strategies for cooperation, we focus on 'probability assessment' and 'indirect reciprocity'. Although kin selection and tribal selection are conceivably operative in a disaster aid situation, the global nature of many aid efforts—and the fact of personnel and management turnover in the aid agencies—means kin and tribal selections are unlikely to be useful levers for managing disaster response. Direct reciprocity seems more likely to be exercised between individuals, rather than between organizations, and individuals frequently leave their employing organizations. In the present research, we follow Nowak's view that indirect reciprocity is more worthy of our first attention.

The high-profile question, still open, is which of these strategies is most instrumental in engendering cooperative behavior among humans. We answer this question for a particular population, that is, disaster aid managers.

OTHER PRIOR RESEARCH

Various aspects of disaster management have drawn the attention of systems researchers, journals and conferences. See, for example, Chroust and Ossimitz (2011), Chroust *et al.* (2011) and Linstone and Mitroff (1994).

Management journals are replete with research on what individual organizations do in ordinary times and in crisis times. Inter-organizational actions in ordinary times are also well researched, as reflected in the literatures of alliances, accounting rules and negotiation (Phillips, 2011). Phillips noted the sparsity of research on inter-organizational actions in crisis times, the little there is tending to focus on game theory and on developing 'swift trust' (Zolin, 2002; Zolin and Dillard, 2005; Zolin and Hinds, 2004; Zolin *et al.*, 2004; Tatham and Kovács, 2010) when circumstances prohibit a long courtship between cooperating parties.

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Gross (2010) used game theory in a simulation to find responses to crisis from social networking sites. Coles and Zhuang (2011) report a game theory study supported by the National Center for Risk and Economic Analysis of Terrorism Events to explore cooperative interaction between international and local agencies.

Hamari *et al.* (2014) document the benefits of gamification—representing questionnaires and training exercises in the form of games—for this and related purposes.

THE QUANTITATIVE RESEARCH

Methodology

We designed and programmed a spreadsheet-based game to determine which is the dominant mechanism: indirect reciprocity or probable future interaction. The game also tests whether an agency's response strategy is evolutionary, that is, whether the agency finds it best to shift resources between technical training (e.g. firefighting) and training in inter-agency coordination.

The game assumes an inverted u-shaped function of aid efficacy versus per cent of training budget spent on learning cooperation. Too little spent in this way means the agency cannot cooperate with others; too much means essential technical skills go wanting.

In an action-oriented profession like humanitarian aid, the morale of employees—and to some extent the agency's external image—depends on the visible expertise in firefighting or medicine distribution and not on invisible and less glamorous cooperation skills. Nonetheless, the leader knows the latter must be developed if the agency is to achieve its mission. Our game, to be described in the following paragraphs, offers the agency manager an opportunity to exercise this leadership by changing the budget after an initial run of plays, that is, to display double-loop learning (Argyris and Schön, 1974). This opportunity comprises the evolutionary aspect of the game.

In the game, an agency head must make the budget decision and then participate in 12 hypothetical disaster scenarios. In each scenario, the Agency 1 decision maker will interact with a different 'Agency 2'. The Agency 1 decision maker will know Agency 1's probability of interacting with Agency 2 in the future and will know the 'reputation' of Agency 2 for cooperation. She or he will then choose a level of cooperation to extend to Agency 2. The cooperation level ranges from low to very high, although the stipulated budget may disallow one or more of the higher cooperation levels. The game responds by showing the level of cooperation the other agency offers. The payoff to victims will be visible—a table of these payoffs is shown at the lower left of Figure 2—as is the cumulative mean and standard deviation of payoffs in all completed plays. The rightmost two columns of Figure 2 are shown to the player only after she or he has chosen 'Level of Cooperation You Extend to this Agency'.

After 12 plays, the Agency 1 director/player is offered an opportunity either to stop or to modify the budget decision and proceed to another 12 scenarios.

As the 'under the hood' details of the game were laid out in Phillips *et al.* (2014),[2] they are summarized in an Appendix to the present article, likewise for the instructions given to respondents/players.

The units for statistical analysis were the hypothetical disaster scenarios, lines 1–12 under 'Play #' in Figure 2, and the optional additional scenarios or 'plays' 13–24. (Plays 13–24, not shown in Figure 2, are revealed by scrolling down or clicking a hyperlink in the spreadsheet.) These were pooled across all respondents. The dependent variable was 'Level of Cooperation You Extend to this Agency', and the independent variables were 'Probability You Will Interact with this Agency again' and 'This Agency's Reputation'. Because the expert sample was purposive and not random, and the dependent variable was ordinal, we chose the relatively robust chi-squared test of association to assess the variate relationships. The relationships were assessed separately; no multivariate analysis was attempted.

[2] This was a conference proceedings paper published before the data were collected. It reported on the mechanics and beta tests of the game.

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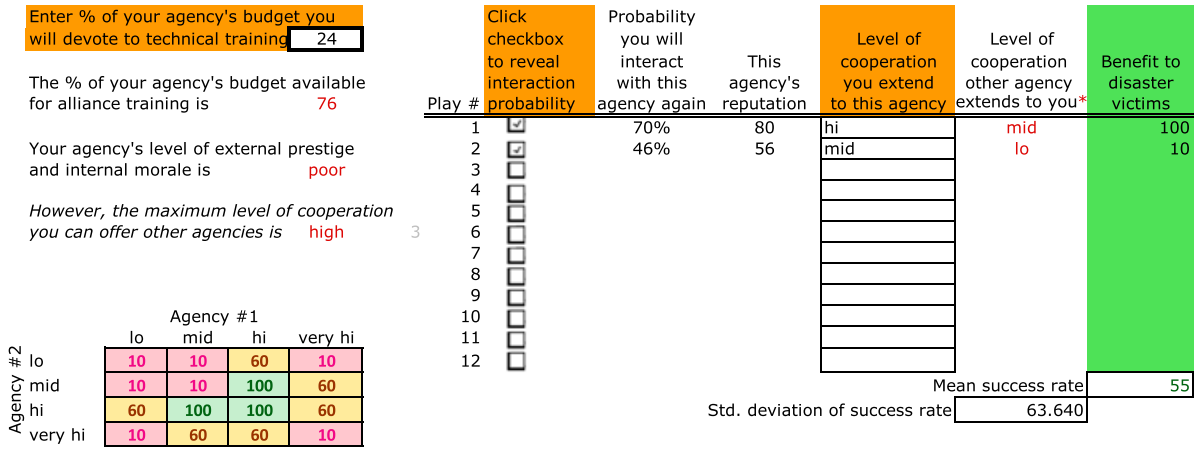

Figure 2 Screenshot of game, first phase. Source: Phillips et al. (2014) [Colour figure can be viewed at wileyonlinelibrary.com]

Results

Both independent variables showed significant relationships with the dependent variable. However, the chi-squared tests showed a stronger relationship between propensity to cooperate and 'Probability You Will Interact with this Agency again' than between cooperation propensity and other agency's reputation.

The chi-squared results are shown in Appendix 3. They shed experimental light on the interaction probability versus indirect reciprocity debate, but in retrospect, the result is sensible. At our workplaces, most of us cut some slack for uncooperative co-workers if we believe we will have to work with them for months or years. The result also reinforces Nowak's (2006) idea of occasional forgiveness as a superior strategy.

Two of the 30 participants opted to alter their budgets and play a second round of 12 scenarios.

The qualitative interviews filled out this picture further. Several participants remarked that the game sharpened their focus and vocabulary for discussing their management task and had potential as a training tool. This focus informed the qualitative interview responses.

THE QUALITATIVE RESEARCH

In semi-structured interviews, all respondents stated that it is beneficial to cooperate and elaborated on the benefits of cooperation. All participants affirmed that they work with other agencies during disasters and that reputation and interaction probability are primary determinants of cooperation.

There was general agreement that if agencies have not interacted before, the decision to cooperate rests on the other's reputation—what is perceived through the news media, social media, or what trusted others think of the agency. However, if the agencies have interacted before, then it is more likely that the agencies will base their decision to cooperate both on the reputation and interaction potentials of the other agencies.

If they have cooperated before, then the secondary factors of learning, directives and reviews come into play in forming the decision to cooperate. These three factors take on no particular order of importance, although all are subsidiary to reputation and interaction potential. Detailed discussions[3] suggested why they are subsidiary considerations: there is ambiguity in all three.

Learning and Cooperation

Learning comes from what an agency has gained through its interactions with other agencies and what their officers have reported. It learns of other agencies' expertise based on past direct

[3] Greater detail on the qualitative interviews may be found in Heetun's (2015) dissertation.

interactions and indirectly from the opinions of third agencies.

All our participants stated that they learn from other organizations they interact with. However, Le Coze (2013) reflects on how often agencies do not retain lessons learnt during disasters and do not take corrective action after to enhance cooperation.

Learning during disasters may include crowd-sourced geographic information systems such as those highlighted following the Haiti earthquake (Zook *et al*., 2010). However, Goodchild and Glennon (2010) claim the risks associated with faulty information that volunteers provide outweigh the potential benefits of using this information. Zook *et al*. also note that volunteer GIS is 'not without problems'.

On the other hand, scandals have battered Red Cross, the most prominent international aid agency,[4] casting doubt on the veracity of some of the information it disseminates (Komp, 2006). Our data were collected just before the 2014 accusations[5] against Red Cross (CBS, 2014); we regret not knowing our respondents' opinions on them.

Directives and Cooperation

Inter-agency cooperation is influenced by directives that run each agency. However, aid workers may observe directives 'in the breach' as unique conditions on the ground emerge, as successive disasters become more complex, or simply through ineptitude and poor communication. Col (2007) analysed the roles of local governments during Hurricane Katrina in the USA and the Tangshan earthquake in China. In the USA, national, state and local officials generally argued with each other; in Tangshan, government workers worked together in greater harmony. In China, higher levels of government supported what the local government was doing, resulting in more efficiency. In the USA, officials were not familiar with National Response Plan.

Reviews and Cooperation

According to Noji (2005), in the past, agencies delivered aid and then 'forgot about it', producing no structured action reviews. However, with today's more complex disasters and more public scrutiny, aid has to be better organized. Therefore, agencies helping during disasters are subject to reviews by other agencies with which they have related. Most of our respondents noted their agencies do evaluation reviews after disaster actions. These reviews, inter alia, report on the relationships the agency had with other agencies, and decide on action plans going forward, potentially affecting future decisions to cooperate.

LIMITATIONS OF THE RESEARCH

Most of the research was undertaken with US-based agencies. Therefore, the results may be culturally specific. According to Castillo and Carter (2011), extreme shocks do not give rise to good cooperation, while intermediate shocks gave rise to a higher level of cooperation. Our quantitative instrument did not make this distinction, and the respondents did not mention it in interviews. Moreover, McFadden (2013) found players are more 'generous' in games when pumped with oxytocin. Thus, cooperation may be greater when aid workers experience uplifting events during disaster response, and this consideration also is lacking in our model.

Our quantitative research addressed one-on-one (pairwise) cooperation between two agencies. In reality, multiple agencies respond to disasters and may interact.

Because of the small sample, results were not broken out by agency type.

In developing the game, Phillips *et al.* (2014) anticipated further limitations, which still hold true:

- Agency 1 shows its hand and decides on the level of cooperation it will extend, before knowing how cooperative Agency 2 will be. In reality, the respective levels of cooperation may be decided simultaneously and blindly.
- The model treats the disaster victims as passive 'third players' in the game. In reality,

[4] For example, http://www.nytimes.com/2007/01/18/us/18cross.html?_r=0

[5] https://nonprofitquarterly.org/2014/10/31/as-scandal-breaks-red-cross-gives-2m-grant-to-sandy-survivors/

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victims can be active participants in disaster response and recovery.
- In the research model, we made no distinction between cooperation with an agency *per se* and cooperation with individuals within the agencies. In the real world, personal relationships reaching across agency boundaries can be a deciding factor in cooperation decisions.

In that regard, Østensvig (2006) emphasizes the importance of committed individuals in engendering cooperation among disaster management agencies, and Currao (2009) emphasizes the role of leaders. Bharosa *et al.* (2010) showed that information sharing within organizations was determined at the community, agency and individual levels. Mathbor (2007) showed that social capital aids in mitigating the consequences of natural disasters in coastal regions. These studies valuably go beyond the agency level. Future research should further incorporate the multiple perspective approach (Linstone, 1989), recognizing there are important effects taking place at the personal, organizational and political levels.

CONCLUSIONS AND RECOMMENDATIONS

Our quantitative research showed that likelihood of working with a disaster aid agency again is the primary driver of a decision to cooperate with that agency. It is generally more important than the agency's reputation. This answers—for the studied group of disaster managers—a high-profile question in the evolution of cooperation. Supporting qualitative research revealed the proviso that indirect reciprocity, that is, the agency's reputation, is most important when deciding to cooperate with another agency for the first time. Ranking third through fifth as drivers of the decision, although in no particular order, were learning, reviews, and directives. Evolutionary or double-loop learning was evident as a minority of respondents changed their budget allocations and played more rounds of simulated disasters.

Empirical examples of such learning exist and are encouraging. The US Federal Emergency Management Agency experienced a turnaround after its reorganization in 1992 and enjoyed an improved reputation thereafter (until Hurricane Katrina), encouraging the Department of Homeland Security to cooperate more fully with Federal Emergency Management Agency (Roberts, 2006). Wong (2013) reports improved disaster response following the 2013 Sichuan earthquake, attributing the improvement to the fact that disaster response is 'a crucial leadership test in China'.

Wei *et al.* (2012) further report that inter-organizational trust and information exchange enhance performance in the logistics functions that are so important for disaster relief. Bolstering Nowak's (2006) 'evolution of forgiveness' idea, Malhotra and Lumineau (2011) show how organizations can regain trust after a conflict between them. They find that when an agreement between agencies contains both control and coordination functions, 'control provisions increase competence-based trust, but reduce goodwill-based trust, resulting in a net decrease in the likelihood of continued collaboration. Coordination provisions increase competence-based trust, leading to an increased likelihood of continued collaboration'.

Our results plus the cited literature imply aid agencies would be well served to

- Construct network maps of agency interactions, for ready reference in disaster mode. The map can help estimate future interactions with other agencies, and identify sources of information about other agencies' reputations, both aiding the cooperation decision.
- Become more sophisticated about learning—across organizations, between organizations and across different levels of organizations—indeed becoming learning organizations. See, for example, White (2008).
- Write clearer and simpler directives, at the same time hiring aid workers who understand that saving life and limb is more important than strict adherence to the directive. Industry standards for directives would allow workers switching between agencies to quickly find the information they need.
- Build databases of the expertises of diverse agencies, again for ready reference in emergencies. Some agencies will be skilled at quickly

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constructing shelters in post-hurricane situations; others will excel at persuading reluctant populations to swallow needed medications. This will result in efficient division of labour.

Not all trust needs to be won in 'swift' mode. Between disasters, aid workers and officials interact at conferences and professional association meetings. Learnings from these meetings, like post-disaster learnings on the ground, can be written up as reviews. This task is asymmetrical, requiring more resources on the part of agencies with nationwide and global missions; they may well work with thousands of state, province, county and city-level agencies over the years. The latter agencies will interface with a smaller number of national and global aid agencies.

The qualitative component of the research revealed that the decision to cooperate has a different basis when interacting with another agency for the first time. The structure of the game may have led participants to view each of the scenarios as a 'first-time' interaction with the scenario's other agency, thus giving 'reputation' a higher weight than it would have received otherwise. We believe that if this effect had not been present, the differences in the chi-squared scores would have been even greater, strengthening the conclusion that 'probability of future interaction' is the more powerful motivator for post-disaster inter-agency cooperation.

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Appendix 1: Game mechanics

The game assumes an inverted u-shaped function of aid efficacy versus per cent of training budget spent on learning cooperation. Too little spent in this way means the agency cannot cooperate with others; too much means essential technical skills go wanting.

In the game, an agency head must make the budget decision and then participate in 12 hypothetical disasters. In each play (i.e. each disaster scenario), the Agency 1 head will interact with a different 'Agency 2'. The head of Agency 1 will know Agency 1's probability of interacting with Agency 2 in the future and will know the 'reputation' of Agency 2 for cooperation. She or he will then choose a level of cooperation to extend to the other agency. The cooperation level ranges from low to very high, although the stipulated budget may disallow one or more of the higher cooperation levels. The game responds by showing the level of cooperation the other agency offers. The payoff to victims will be visible—a table of these payoffs is shown at the lower left of Figure 2—as is the cumulative mean and standard deviation of payoffs in all completed plays. The rightmost two columns of Figure 2 are shown to the player only after she or he has chosen 'Level of Cooperation You Extend to this Agency'.

After 12 plays, the Agency 1 director is offered an opportunity either to stop or to modify the budget decision and proceed to another 12 plays.

The interaction probabilities and the reputation of each 'Agency 2' are random numbers, drawn from Excel's random number generator. A test is done to ensure that there is no accidentally high correlation between these two small-sample series. The 'Level of cooperation the other agency extends to you' (Figure 2; this is the cooperation level offered by Agency 2) has a random component plus a second component, which causes the probability of tit-for-tat (i.e. matching Agency 1's offer) to rise with the interaction probability.

The dominance of 'probability assessment' versus 'indirect reciprocity' as a driver of rapid post-disaster inter-agency cooperation can then be tested statistically. The ordinal dependent variable is the cooperation offered by Agency 1 (low, medium, high and very high). The uncorrelated independent variables are 'probability of interaction' and 'reputation of Agency 2'.

Insight on leadership and evolutionary behavior is drawn from players' tendency to adjust their budgets mid-game and by the extent of the adjustment.

The game—mechanism

At the current stage of the project, the game serves as a data collection questionnaire. A respondent is asked to set the per cent of his or her agency's budget that will be devoted to technical training. The balance (calculated automatically) is presumed to be available for training in cooperation and alliance maintenance. Also automatically calculated are the agency's morale level (assumed to increase monotonically with technical training level) and the maximum level of cooperation this agency can extend to others. (For the latter, the ratio-scale budget percentage is converted to an ordinal lo-mid-hi-very hi scale.) The cooperation training budget, the morale level and the maximum possible level of cooperation are displayed to remind the player/respondent that the budget decision implies trade-offs.

Likewise, the payoff matrix for the disaster victims is shown in the spreadsheet as a reminder for the respondent. It is also used as a lookup

table to calculate the payoffs as the respondent reacts to the game's disaster scenarios.

After entering the budget percentage, the respondent is given 12 disaster scenarios. Each of the scenarios requires that the respondent's agency cooperate with another agency, the 'cooperating agency'. For each scenario, the respondent enters only two items in the spreadsheet:

(1) A click in a checkbox to reveal the cooperating agency's reputation and the probability of interacting with the cooperating agency again in the future. (The latter two quantities are hidden prior to the play of each disaster scenario.)
(2) From a drop-down menu, the level of cooperation the respondent's agency will extend to the cooperating agency. If the respondent enters a cooperation level that exceeds his or her allowable maximum, an error message appears, and the respondent is asked to specify a lower cooperation level.

The level of cooperation with which the cooperating agency reciprocates (hidden heretofore) now appears. The benefit to the disaster victims appears in the rightmost column, and a running calculation of mean benefit and standard deviation is shown.

'Under the hood' of the spreadsheet, we have the following:

- The 'probability you will interact with this agency again' is a random number, uniformly distributed between 0 and 100 per cent, calculated by Excel's RAND function.
- The same is true for the cooperating agency's reputation, which ranges from 0 to 100. Reputation and interaction probability are thus uncorrelated (we will check for excessive 'accidental' correlation of the random vectors).
- The calculation of the 'level of cooperation other agency extends to you' is more complicated. It has a random component and a second component that makes matching the respondent's cooperation offer more likely if the two agencies have interacted frequently in the past. (Note that the 'probability you will interact with this agency again' can also be read as the 'probability you have interacted in the past'.)

What 'evolves', in this evolutionary game? First—if the player elects to take the second set of scenarios—the agencies' strategies for extending cooperation to other agencies. Second, the agencies' views of their own missions. As an example of the latter, a recent news item reported that Scottish fire departments now emphasize fire prevention skills over dousing skills. We can admire the courage and leadership needed to sublimate firefighters' desire for the heroic (putting out dangerous fires) into a commitment to the mundane (preventing such fires).

Appendix 2: Instructions for participants

The players were told:

When your agency responds to a disaster, it will usually be called upon to extend some cooperation to other aid agencies. Quick benefit to the disaster victims depends on aid agencies' ability to deliver in their areas of technical expertise (e.g. firefighting, food aid and medical relief) and also their ability to cooperate with other aid providers. This research looks into aid agencies' willingness and capacity to cooperate.

Thank you for agreeing to participate in the research. As the manager of a disaster aid agency, you are asked to help the researcher by playing a computer game. Following the game, we will ask you for general comments on the game's assumptions and level of realism.

The first task in this game is to make a budget decision for your agency. You will decide the balance of resources to be spent on your employees' technical training versus training in cooperation with other aid agencies. Your decision will have consequences for your agency's morale and public image (the game board will suggest these consequences to you) and for the maximum amount of cooperation your agency can extend to other involved agencies in any given disaster scenario.

Next, you will be presented with several disaster scenarios. In each scenario, you must deal with another agency (Agency X) that is also involved in the crisis response and recovery. This may be a different agency in each scenario. The

cooperation tendency of each Agency X will be presented, and then you can choose the level of cooperation you wish to extend to this agency. A table in the game shows the resulting benefit to the disaster victims.

It is important to save all your played scenarios and return the completed game file to the researcher.

Follow the simple steps given below.

(1) Set the percentage of your agency's budget for technical training. According to your budget, the game board will determine the cooperative capacity of your agency, on a scale from low to very high.
(2) Play a set of 12 scenarios, and review the overall payoff to victims. In each scenario, you will click a checkbox to reveal the past and future cooperation tendency (the reputation) of Agency X and your chances of working with Agency X again in the future. You will then select your level of cooperation towards Agency X.
(3) After finishing a set of 12 scenarios, you will see the overall benefit (to the disaster victims) of your cooperation decisions. You can stop playing if you are satisfied with the overall payoff result.
(4) If not satisfied, you may change your budget decision and play an additional set of 12 scenarios.
(5) Do not forget to SAVE the spreadsheet file. If you are playing on your own computer or a shared one, return the file with the completed game to the researcher on the provided USB key or by email to _____@_____.

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Appendix 3: Chi-squared results

Quantitative results—reputation

Case processing summary

	Cases					
	Valid		Missing		Total	
	N	Percent	*N*	Percent	*N*	Percent
reputation • cooperation	384	100.0	0	0.0	384	100.0

Cross-tabulation for reputation • cooperation

			cooperation				
			0.00	1.00	2.00	3.00	Total
reputation	0.00	Count	37	33	30	2	102
		Expected count	15.7	28.4	47.3	10.6	102.0
		% within cooperation	62.7	30.8	16.9	5.0	26.6
	1.00	Count	18	40	70	24	152
		Expected count	23.4	42.4	70.5	15.8	152.0
		% within cooperation	30.5	37.4	39.3	60.0	39.6
	2.00	Count	4	28	56	8	96
		Expected count	14.8	26.8	44.5	10.0	96.0
		% within cooperation	6.8	26.2	31.5	20.0	25.0
	3.00	Count	0	6	22	6	34
		Expected count	5.2	9.5	15.8	3.5	34.0
		% within cooperation	0.0	5.6	12.4	15.0	8.9
Total		Count	59	107	178	40	384
		Expected count	59.0	107.0	178.0	40.0	384.0
		% within cooperation	100.0	100.0	100.0	100.0	100.0

Chi-squared tests

	Value	df	A ymp 2-sided
Pearson chi-squared	70.594•	9	0.000
Likelihood ratio	74.366	9	0.000
Linear-by-linear association	45.943	9	0.000
N of valid cases	384		

a.1 cells (6.3%) have expected count less than 5. The minimum expected count is 3.54.

Quantitative results—interaction

Case processing summary

	Cases					
	Valid		Missing		Total	
	N	Percent	*N*	Percent	*N*	Percent
reputation • cooperation	384	100.0	0	0.0	384	100.0

Cross-tabulation for interaction • cooperation

			cooperation				
			0.00	1.00	2.00	3.00	Total
interaction	0.00	Count	17	10	7	0	34
		Expected count	5.2	9.5	15.8	3.5	34.0
		% within cooperation	28.8	9.3	3.9	0.0	8.9
	1.00	Count	29	39	29	3	100
		Expected count	15.4	27.9	46.4	10.4	100.0
		% within cooperation	49.2	36.4	16.3	7.5	26.0
	2.00	Count	3	30	54	7	94
		Expected count	14.4	26.2	43.6	9.8	94.0
		% within cooperation	5.1	28.0	30.3	17.5	24.5
	3.00	Count	10	28	88	30	156
		Expected count	24.0	43.5	72.3	16.3	156.0
		% within cooperation	16.9	26.2	49.4	75.0	40.6
Total		Count	59	107	178	40	384
		Expected count	59.0	107.0	178.0	40.0	384.0
		% within cooperation	100.0	100.0	100.0	100.0	100.0

Chi-squared tests

	Value	df	A ymp 2-sided
Pearson chi-squared	70.594•	9	0.000
Likelihood ratio	74.366	9	0.000
Linear-by-linear association	45.943	1	0.000
N of valid cases	384		

a.1 cells (6.3%) have expected count less than 5. The minimum expected count is 3.54.

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