

## Corruption drives the emergence of civil society

Sherief Abdallah, Rasha Sayed, Iyad Rahwan, Brad L. LeVeck, Manuel Cebrian, Alex Rutherford and James H. Fowler

*J. R. Soc. Interface* 2014 **11**, 20131044, published 29 January 2014

---

### Supplementary data

["Data Supplement"](#)

<http://rsif.royalsocietypublishing.org/content/suppl/2014/01/23/rsif.2013.1044.DC1.html>

### References

[This article cites 25 articles, 7 of which can be accessed free](#)

<http://rsif.royalsocietypublishing.org/content/11/93/20131044.full.html#ref-list-1>

### Subject collections

Articles on similar topics can be found in the following collections

[computational biology](#) (272 articles)

### Email alerting service

Receive free email alerts when new articles cite this article - sign up in the box at the top right-hand corner of the article or click [here](#)



## Report

**Cite this article:** Abdallah S, Sayed R, Rahwan I, LeVeck BL, Cebrian M, Rutherford A, Fowler JH. 2014 Corruption drives the emergence of civil society. *J. R. Soc. Interface* **11**: 20131044.  
<http://dx.doi.org/10.1098/rsif.2013.1044>

Received: 12 November 2013

Accepted: 6 January 2014

### Subject Areas:

computational biology

### Keywords:

social learning, evolutionary dynamics, politics

### Author for correspondence:

Sherief Abdallah  
e-mail: [shario@ieee.org](mailto:shario@ieee.org)

Electronic supplementary material is available at <http://dx.doi.org/10.1098/rsif.2013.1044> or via <http://rsif.royalsocietypublishing.org>.

# Corruption drives the emergence of civil society

Sherief Abdallah<sup>1,2,3</sup>, Rasha Sayed<sup>1</sup>, Iyad Rahwan<sup>4,2</sup>, Brad L. LeVeck<sup>5</sup>, Manuel Cebrian<sup>6,7</sup>, Alex Rutherford<sup>4,8</sup> and James H. Fowler<sup>5</sup>

<sup>1</sup>Informatics Department, The British University in Dubai, Dubai, United Arab Emirates

<sup>2</sup>School of Informatics, University of Edinburgh, Edinburgh, UK

<sup>3</sup>Faculty of Computers and Information, Cairo University, Cairo, Egypt

<sup>4</sup>Department of Electrical Engineering and Computer Science, Masdar Institute of Science and Technology, Abu Dhabi, United Arab Emirates

<sup>5</sup>Political Science Department, University of California, San Diego, CA, USA

<sup>6</sup>National Information and Communications Technology Australia, Melbourne, Victoria 3010, Australia

<sup>7</sup>Department of Computing and Information Systems, University of Melbourne, Melbourne, Victoria 3010, Australia

<sup>8</sup>United Nations Global Pulse

Centralized sanctioning institutions have been shown to emerge naturally through social learning, displace all other forms of punishment and lead to stable cooperation. However, this result provokes a number of questions. If centralized sanctioning is so successful, then why do many highly authoritarian states suffer from low levels of cooperation? Why do states with high levels of public good provision tend to rely more on citizen-driven peer punishment? Here, we consider how corruption influences the evolution of cooperation and punishment. Our model shows that the effectiveness of centralized punishment in promoting cooperation breaks down when some actors in the model are allowed to bribe centralized authorities. Counterintuitively, a weaker centralized authority is actually more effective because it allows peer punishment to restore cooperation in the presence of corruption. Our results provide an evolutionary rationale for why public goods provision rarely flourishes in polities that rely only on strong centralized institutions. Instead, cooperation requires both decentralized and centralized enforcement. These results help to explain why citizen participation is a fundamental necessity for policing the commons.

A centuries-old debate exists on how to best govern society and promote cooperation: is cooperation best maintained by a central authority [1,2] or is it better handled by more decentralized forms of governance [3,4]? The debate is still unresolved, and identifying mechanisms that promote cooperation remains one of the most difficult challenges facing society and policymakers today [4].

Decentralized, individual sanctioning of non-cooperators (also known as free-riders or defectors) is one of the main tools used by societies to promote and maintain cooperation [5]. Individuals can sanction free-riders implicitly via behavioural reciprocity (as in the case of the highly successful tit-for-tat strategy [6]) or explicitly via costly punishment [7]. Both of these forms of peer punishment have been widely studied using evolutionary models and behavioural experiments [8–10,6,11].

Recently, however, Sigmund *et al.* [12] showed that centralized institutions can have an evolutionary advantage over peer punishment because, unlike peer-punishers, these institutions may eliminate ‘second-order’ free-riding. Second-order free-riders cooperate with other players but they do not pay the cost of punishing defectors and this can allow defectors to re-emerge [13–15]. To address this problem, Sigmund *et al.* present a model of ‘pool’ punishment, where agents commit resources to a centralized authority that sanctions free-riders [12,16]. Pool punishment avoids the second-order free-rider problem because the centralized authority punishes *any* individual who does not

contribute to the punishment pool (including cooperators and peer-punishers). This allows pool-punishers to quickly take over a population, displacing both free-riders and peer-punishers [12]. These advantages help to explain why human societies frequently delegate punishment to centralized institutions [12,17,16]. They also help to explain why centralized institutions acquire an increasing monopoly over legitimate punishment over time by stigmatizing [18] and criminalizing [19, p. 371,372] various forms of peer punishment.

However, the dominance of pool punishment in the Sigmund *et al.* model [12] also creates three puzzles. First, the results imply that increasing the severity of centralized pool punishment always increases cooperation. Yet, many authoritarian states, which have the ability to severely punish citizens, suffer from low levels of participation and public goods provision [20]. Meanwhile, states with high levels of public goods, such as western democracies [20–22], typically limit the government's ability to punish individuals and tolerate more forms of peer punishment.

Second, centralized pool punishment quickly takes over a population and completely displaces peer punishment [12] in the Sigmund *et al.* model [12], but many (if not most) societies exhibit a mix of centralized and decentralized punishment strategies. Even in societies with centralized punishment, citizens engage in costly acts of protest against agents who harm the public good. As recent events—from the Occupy protests to the Arab Spring—illustrate, this occurs even when the government punishes protestors [23–25]. What unmodelled factors might allow peer punishment to evolve alongside centralized enforcement institutions—even when these institutions are actively hostile towards various forms of peer punishment?

Third, the Sigmund *et al.* model [12] assumes that the centralized authority punishes all forms of peer punishment. This is because peer-punishers in their model, by definition, do not contribute to the centralized authority. However, many societies with centralized enforcement also recognize certain forms of peer punishment as legitimate. For instance, civil litigation, jury duty, anti-incumbent voting and other forms of political participation are also instances of altruistic peer punishment [26–28]. In these and other cases, citizens engage in a *hybrid* peer-pool punishment strategy. These individuals pay taxes to a central authority but also engage in selective acts of peer punishment that are individually costly, but not punished by a central power. Given all the costs they bear, it is unclear how such hybrid strategies may evolve.

Here, we show that allowing for *corruption* in the model can help to explain both why societies want to limit the severity of centralized punishment, and why peer punishment frequently evolves alongside centralized punishment institutions. We investigate the effect of corrupt players who can bribe a central authority to avoid punishment. The results show that when pool-punishers dominate a system, the central authority becomes a single point of failure, which is highly vulnerable to corruption. This gives an opportunity for individuals playing a hybrid peer-pool strategy to evolve because peer punishment becomes relatively more effective under these circumstances by helping to increase the overall level of cooperation.

In summary, given the possibility of corruption, Leviathans can promote cooperation, but only if they also allow individuals to take action against actors who harm the public good. Our model therefore provides an evolutionary rationale for why public goods provision and cooperation

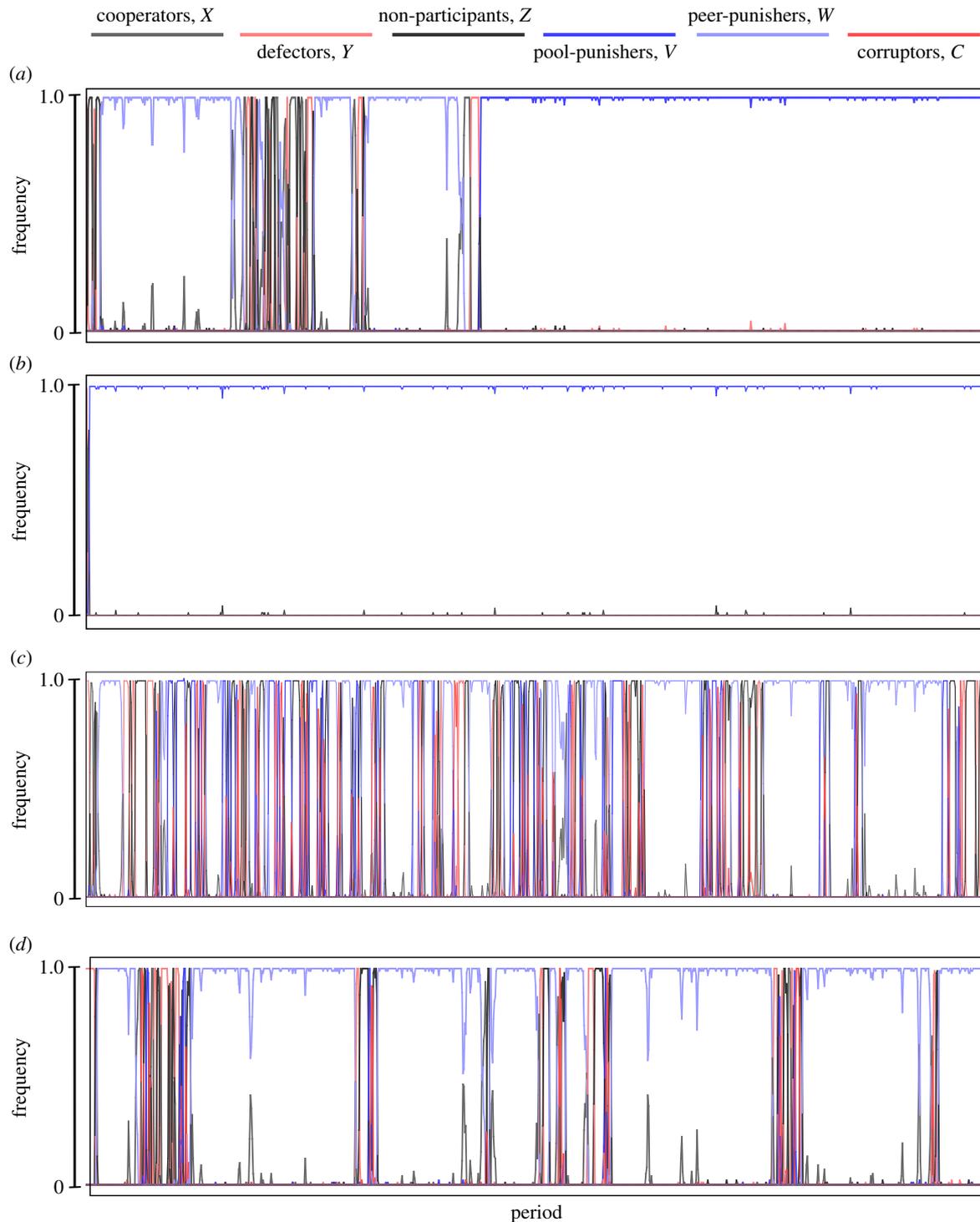
rarely flourish in polities with strong centralized punishment alone. Instead, cooperation rests on an authority that protects a fundamental aspect of civil society, citizen participation in policing the commons [29,30].

Our baseline model is a public good game (PGG) with both peer and pool punishments [12]. The PGG is a simple model for studying contributions to a project with non-excludable positive externalities, which may include everything from the provision of social insurance to the protection of the environment. Let  $M$  denote the population size and let  $N \leq M$  denote the number of individuals who are randomly chosen in a given round to play a PGG. In the game, each individual is faced with a choice: whether or not to contribute a fixed amount,  $c > 0$ , to the common pool. Once each individual chooses her action, each individual will obtain  $rc(N_c/N)$ , where  $r$  is a factor greater than 1,  $N_c$  is the number of contributors to the common pool and  $N$  is the total number of participants (whether they contributed or not). If all individuals contribute,  $N_c = N$ , then the social welfare is maximized and each individual obtains  $rc$ . However, each actor gains an equal share of  $rc(N_c/N)$ , whether or not they contribute, making it a dominant strategy for each individual to free-ride by contributing 0 (the pay-offs are written explicitly in the electronic supplementary material).

The population includes  $X$  cooperators, who contribute  $c$  and  $Y$  defectors (*free-riders*), who do not. Consistent with previous work, we also assume that the game is not compulsory and some players may choose not to participate in the PGG [12,31–34]. These *loners* earn a fixed small pay-off,  $\sigma$ . In addition,  $W$  peer-punishers cooperate by contributing  $c$  to the PGG but also impose a fine,  $\beta$ , on each free-rider at a cost  $\gamma$  [5]. In other words, each free-rider pays a total fine  $\beta N_w$ , where  $N_w$  is the number of peer-punishers in the group, and every peer-punisher incurs an extra cost  $\gamma N_f$ , where  $N_f$  is the number of free-riders in the group. Furthermore, peer-punishers inflict a penalty on cooperators proportional to the number of defectors (second-order punishment). We also have  $V$  pool-punishers who, instead of directly punishing free-riders, contribute a fixed amount,  $G$ , to a punishment pool before participating in the game and then contribute  $c$  to the PGG. Those who do not contribute to the pool (including free-riders, cooperators and peer-punishers) are then fined  $BN_v$  each, where  $N_v$  is the number of pool-punishers in the group. We also introduce  $C$  corruptors to the model. A corruptor pays the central authority a fixed fee  $KG$  to avoid being punished for not contributing to the PGG (this only makes sense if the fee is less than the total contributions paid by pool-punishers,  $KG < G + c$ ).

We study the equilibria of fully mixed populations of fixed size  $M$  and variable composition by computing the pay-offs obtained by players using these strategies, assuming that agents play in randomly sampled groups of size  $N$ . The difference in pay-offs, together with the parameter  $s \geq 0$ , determines the rate at which individuals with lower pay-offs are replaced by types with higher pay-offs. As in other evolutionary models, this process can be interpreted either as evolution or social learning. We also allow for random switching of strategies with a mutation rate  $\mu \geq 0$ . We derive equilibria as the long-run distribution of different strategies both analytically (in the limit of strong imitation) and using numerical simulation. For details, see the electronic supplementary material.

Figure 1 shows sample runs of a numerical simulation of the model. Without corruption, pool punishment eventually



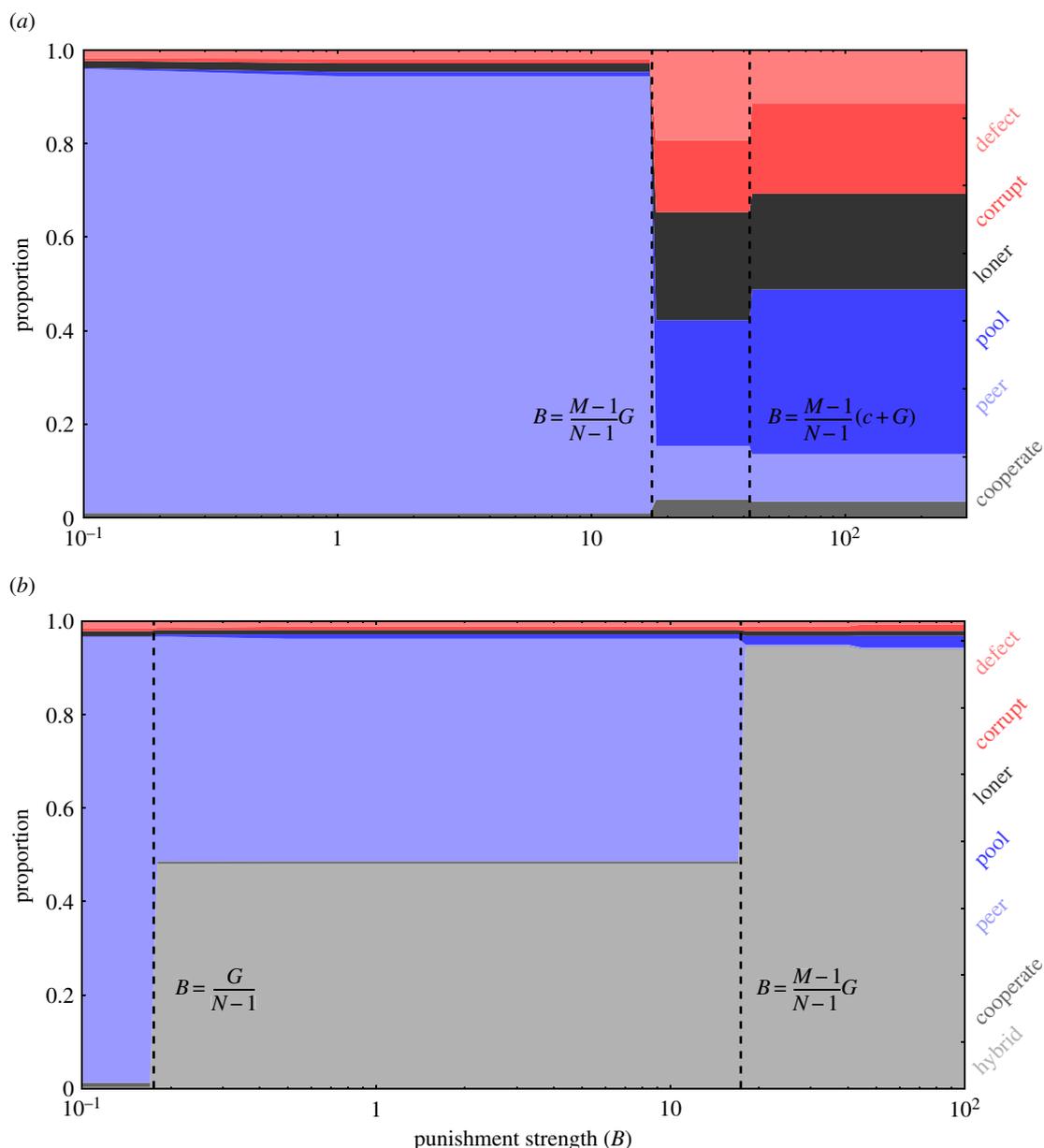
**Figure 1.** Sample simulation runs showing the effect of the corruptor strategy. For all the runs, the following parameter values were used (please refer to the electronic supplementary material for more details):  $S = 100\,000$ ,  $M = 100$ ,  $N = 5$ ,  $\mu = 0.001$ ,  $\sigma = 1.0$ ,  $c = 1.0$ ,  $r = 3.0$ ,  $\beta = 0.7$ ,  $\gamma = 0.7$ ,  $k = 0.5$  and  $G = 0.7$ . The severity of institutional punishment is controlled via parameter  $B$ , which is set to either 0.7 or 7. In (a), without the corruptor strategy, the results are consistent with the results reported in the previous work [12], where pool-punishers predominate. In (b), the predominance of the pool-punishers becomes decisive as the severity of the institutional punishment escalates. In (c), with the corruptor strategy added to the mix of available strategies, and with the severity of institutional punishment set to  $(B = 7)$ , the pool-punishers are no longer stable and cooperation deteriorates in general. Finally, in (d), as institutional punishment becomes more lenient, peer-punishers emerge and largely maintain cooperation ( $B = 0.7$ ), even in the presence of corruptors.

takes over the population [12], and does so even earlier when  $B$ , the severity of second-order pool punishment, is higher.

The situation changes dramatically when we introduce corruptors. Pool punishment is no longer a dominant strategy, as shown in a sample simulation run (figure 1c). Interestingly, figure 1d shows that weakening pool punishment (lowering the fine  $B$ ) allows peer-punishers to re-emerge as a

relatively stable strategy that restores cooperation in the presence of corruption.

We investigate this further in figure 2a, which shows the proportion of different strategies as a function of second-order punishment severity. For low values of  $B$ , peer-punishers dominate and prevent the corruptor strategies from gaining ground. As  $B$  increases, peer-punishers disappear and pool-punishers



**Figure 2.** Stationary distributions of strategies as a function of institutional punishment severity (parameter  $B$ ). In (a), the corruptor strategy is included in the set of available strategies and we observe the adverse effect of institutional punishment. The greater  $B$ , the greater the percentage of corruption. A clear phase transition happens when  $B > (M - 1/N - 1)G$ , when the expected punishment exerted by a single pool-punisher (in a sample of  $N$ ) exceeds the punishment cost for the pool-punisher,  $G$ . This allows a pool-punisher to severely suppress peer-punishers, which in turn allows corruptors, defectors and loners to grow in the population. In (b), both the corruptor and the hybrid strategies are included. As a result, increasing  $B$  no longer backfires, and the same level of cooperation is maintained. The hybrid strategy becomes dominant for  $B > (M - 1/N - 1)G$ , when the expected punishment exerted by a single peer-punisher (in a sample of  $N$ ) exceeds the punishment cost for the pool-punisher,  $G$ .

become more prevalent. However, with even higher values of  $B$ , the prevalence of corruptors also increases. This causes the total number of cooperative individuals to decline. We confirm these results by analytical computation of the long-run frequencies of strategies in the  $(X, Y, Z, V, W, C)$  subpopulation (for methods, see the electronic supplementary material). With low  $B$ , the frequencies, respectively, are  $1/(M+7)$  [1,2,2,1, $M$ ,1], confirming the clear dominance of peer-punishers (with a population of  $M=100$ , this is approx. [0.01, 0.02, 0.02, 0.01, 0.93, 0.01]). Strong central punishment, however, yields the distribution [0.034, 0.114, 0.204, 0.352, 0.102, 0.193], i.e. ineffective (corrupted) pool-punishers dominate, followed by loners and corruptors.

Strong centralized punishment allows corruptors to exploit pool-punishers in two ways: pool-punishers contribute to a public good, at the same time funding a flawed institution that corruptors use to their advantage. Weak centralized

punishment, on the other hand, provides an opportunity for peer-punishers to counteract both corruptors and defectors.

Lastly, we introduce  $H$  hybrid punishers. In addition to contributing  $c$  to the public good, individuals using this strategy pay both  $\gamma$  to punish defectors directly and  $G$  to the punishment pool, and as such they are not punished by the central authority. Hybrid individuals can be thought of as upstanding citizens that pay their taxes but also engage in forms of 'legitimate' peer sanctioning.

Figure 2b shows that, unlike peer punishment alone, this hybrid strategy dominates the population when centralized punishment is severe. This occurs even though the hybrid strategy pays a higher average cost compared with pool-punishers. Setting  $M=100$ , the long-run distribution of strategies in the  $(X, Y, Z, V, W, C, H)$  subpopulation is [0.001, 0.004, 0.008, 0.013, 0.004, 0.007, 0.96]

As a consequence, a high level of cooperation is maintained across all levels of centralized punishment. The dominance of the hybrid strategy is robust against different parameter values (including  $\beta$ ,  $\gamma$  and  $K$ , as we show in the electronic supplementary information).

Of course, one might wonder why individuals would create a second-order punishment institution in the first place, as figure 2*b* also shows that second-order punishment does not increase the overall level of cooperation; nor does it make cooperation significantly more stable than peer punishment alone. Our relatively simple model is unlikely to fully answer this very general question, as we have left out many features that could cause centralized institutions to remain advantageous. For example, these institutions might aggregate views on who should be punished; and this aggregation could cause perceptual errors (which are not in our model) to cancel out [35].

It is also possible that institutions may further evolve to deal with this remaining instability. Analytical results in the electronic supplementary information show that when second-order punishment is strong, hybrid punishers are only destabilized by neutral-drift towards pool-punishers (who then allow corruptors and defectors to emerge). Institutions may therefore want to screen and punish pure pool-punishers; and it is interesting that many justice

systems have evolved rules that fine people who merely pay their taxes but do not register for various forms of hybrid punishment, for example jury duty.

Importantly, however, we have shown that simply adding the risk of corruption can help to explain why centralized and decentralized forms of punishment frequently coexist. No additional appeal to civic norms or civic culture is needed. Which is not to say that these things do not exist or that they do not further promote citizen participation in policing the commons. Rather, our model shows that independent of other virtues, peer-punishment strategies can have a fitness advantage over pool punishment alone. In the face of corruption, peer and hybrid punishment strategies better promote cooperation because they are competitive. If one punisher fails to punish a corrupt individual, another might step in; and this result may help to explain why polities who want to control corruption and promote cooperation often become more tolerant to various forms of decentralized sanctioning [36].

**Funding statement.** S.A. is funded by the British University in Dubai. M.C. is funded by the Australian Government as represented by the Department of Broadband, Communications and the Digital Economy and the Australian Research Council through the ICT Centre of Excellence programme.

## References

- Hobbes T. 1960 *Leviathan: or the matter, forme and power of a commonwealth ecclesiasticall and civil*. New Haven, CT: Yale University Press.
- Hardin G. 1968 The tragedy of the commons. *Science* **162**, 1244–1248. (doi:10.1126/science.162.3859.1243)
- Kropotkin PA. 1907 *Mutual aid: a factor of evolution*. London, UK: W. Heinemann.
- Dietz T, Ostrom E, Stern PC. 2003 The struggle to govern the commons. *Science* **302**, 1907–1912. (doi:10.1126/science.1091015)
- Nowak MA. 2006 Five rules for the evolution of cooperation. *Science* **314**, 1560–1563. (doi:10.1126/science.1133755)
- Axelrod R. 2006 *The evolution of cooperation: revised edition*. New York, NY: Basic books.
- Fehr E, Gächter S. 2002 Altruistic punishment in humans. *Nature* **415**, 137–140. (doi:10.1038/415137a)
- Boyd R, Richerson PJ. 1992 Punishment allows the evolution of cooperation (or anything else) in sizable groups. *Ethol. Sociobiol.* **13**, 171–195. (doi:10.1016/0162-3095(92)90032-Y)
- Fehr E, Gächter S. 2000 Cooperation and punishment in public goods experiments. *Am. Econom. Rev.* **90**, 980–994.
- Egas M, Riedl A. 2008 The economics of altruistic punishment and the maintenance of cooperation. *Proc. R. Soc. B* **275**, 871–878. (doi:10.1098/rspb.2007.1558)
- Ohtsuki H, Hauert C, Lieberman E, Nowak MA. 2006 A simple rule for the evolution of cooperation on graphs and social networks. *Nature* **441**, 502–505. (doi:10.1038/nature04605)
- Sigmund K, De Silva H, Traulsen A, Hauert C. 2010 Social learning promotes institutions for governing the commons. *Nature* **466**, 861–863. (doi:10.1038/nature09203)
- Panchanathan K, Boyd R. 2004 Indirect reciprocity can stabilize cooperation without the second-order free rider problem. *Nature* **432**, 499–502. (doi:10.1038/nature02978)
- Fowler JH. 2005 Human cooperation: second-order free-riding problem solved? *Nature* **437**, E8. (doi:10.1038/nature04201)
- Dreber A, Rand D, Fudenberg D, Nowak M. 2008 Winners don't punish. *Nature* **452**, 348–351. (doi:10.1038/nature06723)
- Traulsen A, Röhl T, Milinski M. 2012 An economic experiment reveals that humans prefer pool punishment to maintain the commons. *Proc. R. Soc. B* **279**, 3716–3721. (doi:10.1098/rspb.2012.0937)
- Baldassarri D, Grossman G. 2011 Centralized sanctioning and legitimate authority promote cooperation in humans. *Proc. Natl Acad. Sci. USA* **108**, 11 023–11 027. (doi:10.1073/pnas.1105456108)
- Rosenbaum T. 2011 Justice? Vengeance? You need both. *The New York Times*. See <http://www.nytimes.com/2011/07/28/opinion/28rosenbaum.html>.
- Hallam H. 1853 *View of the state of Europe during the middle ages*. New York, NY: Harper & Brothers.
- Acemoglu D, Robinson J. 2012 *Why nations fail: the origins of power, prosperity, and poverty*. New York, NY: Crown Publishing Group.
- Deacon RT. 2009 Public good provision under dictatorship and democracy. *Public Choice* **139**, 241–262. (doi:10.1007/s11127-008-9391-x)
- Lake DA, Baum MA. 2001 The invisible hand of democracy political control and the provision of public services. *Comp. Political Stud.* **34**, 587–621. (doi:10.1177/0010414001034006001)
- Harcourt BE. 2011 Occupy Wall Street's 'political disobedience'. *New York Times*, 11 October 2011, p. 13.
- Morsi M. 2013 Egypt president issues stern warnings to opposition. *Ahram Online*. See <http://english.ahram.org.eg/NewsContent/1/64/67627/Egypt/Politics-/Egypt-president-warns-opposition-against-promoting.aspx>.
- Moghadam VM. 2012 *Globalization and social movements: Islamism, feminism, and the global justice movement*. Lanham, MD: Rowman and Littlefield Publishers.
- Fowler JH, Kam CD. 2007 Beyond the self: social identity, altruism, and political participation. *J. Polit.* **69**, 813–827. (doi:10.1111/j.1468-2508.2007.00577.x)
- Grechenig K, Nicklisch A, Thöni C. 2010 Punishment despite reasonable doubt—a public goods experiment with sanctions under uncertainty. *J. Empir. Legal Stud.* **7**, 847–867. (doi:10.1111/j.1740-1461.2010.01197.x)
- Smirnov O, Dawes CT, Fowler JH, Johnson T, McElreath R. 2010 The behavioral logic of collective action: partisans cooperate and punish more than nonpartisans. *Polit. Psychol.* **31**, 595–616. (doi:10.1111/j.1467-9221.2010.00768.x)

29. Putnam RD, Leonardi R, Nanetti RY. 1994 *Making democracy work: civic traditions in modern Italy*. Princeton, NJ: Princeton university press.
30. Verba S, Scholzman KL, Brady HE. 2005 *Voice and equality: civic voluntarism in American politics*. Cambridge, MA: Harvard University Press.
31. Fowler JH. 2005 Altruistic punishment and the origin of cooperation. *Proc. Natl Acad. Sci. USA* **102**, 7047–7049. (doi:10.1073/pnas.0500938102)
32. Hauert C, De Monte S, Hofbauer J, Sigmund K. 2002 Volunteering as Red Queen mechanism for cooperation in public goods games. *Science* **296**, 1129–1132. (doi:10.1126/science.1070582)
33. Hauert C, De Montewy S, Hofbauer J, Sigmund K. 2002 Replicator dynamics for optional public good games. *J. Theor. Biol.* **218**, 187–194. (doi:10.1006/jtbi.2002.3067)
34. Semmann D, Krambeck HJ, Milinski M. 2003 Volunteering leads to rock–paper–scissors dynamics in a public goods game. *Nature* **425**, 390–393. (doi:10.1038/nature01986)
35. McLennan A. 1998 Consequences of the Condorcet jury theorem for beneficial information aggregation by rational agents. *Am. Polit. Sci. Rev.* **92**, 413–418. (doi:10.2307/2585673)
36. Egorov G, Guriev S, Sonin K. 2009 Why resource-poor dictators allow freer media: a theory and evidence from panel data. *Am. Polit. Sci. Rev.* **103**, 645. (doi:10.1017/S0003055409990219)