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The Evolution of Political Intelligence: Simulation Results

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Several bodies of theory develop the idea that the intelligence of highly social animals – most interestingly, humans – is significantly organized around the adaptive problems posed by their sociality. By this 'political intelligence' hypothesis, sociality selects for, among other attributes, capacities for 'manipulating' information others can gather about one's own future behaviour, and for 'mindreading' such manipulations by others. Yet we have little theory about how diverse parameters of the games that social animals play select for political intelligence. We begin to address that with an evolutionary simulation in which agents choose between playing Prisoner's Dilemma and Hawk–Dove games on the basis of the information they can retrieve about each other given four broad information processing capacities. We show that political intelligence – operationally, the aggregate of those four capacities – evolves to its highest levels when co-operative games are generally more attractive than conflictual ones, but when conflictual games are at least sometimes also attractive.

'What does he *mean* by that?'
Prince Metternich, on hearing the news that Tallyrand had died.

Aristotle famously argued that humans are 'political animals' because we acquire moral standing by living socially – in the polis – but in recent years evolutionary psychology has developed the complementary idea that one consequence of our sociality has been evolution of a distinctively political *brain*. By this hypothesis, significant components of our cognitive or information-processing apparatus have evolved through natural selection for successfully negotiating the complex, highly interactive social space comprised by fellow group members. We are, by this hypothesis, 'political animals'

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because our brains have evolved, in part at least, for successfully playing political games.

This broad paradigm is often known as the 'Machiavellian' or 'social' intelligence hypothesis. We prefer 'political intelligence', and will use that term here. 'Machiavellian intelligence'[1] certainly does nicely capture the deceit, bluff, threat and self-interested manipulation that is often involved in social game playing, but it misses the benign mutualism and co-operation that is also a potential in social games. Conversely, the somewhat bland 'social intelligence' captures neither the conflictual nor the co-operative potential inherent in social games. But 'politics' – certainly as studied by political scientists – does involve both, and coining the term 'political intelligence' points not only to the potential usefulness of the theoretical tools developed by political scientists for those in other disciplines, but also to the importance for political scientists of the hypothesis itself. A discipline whose substance is, in large part, defined by the conflictual and co-operative games that people play should, we believe, be interested in a hypothesis proposing that the human brain has evolved through natural selection to play exactly such games.[2]

How could a 'political brain' have evolved? The selective gains available from sociality are clear. Living with others can provide protection against predation, more successful exploitation of the environment for food, and ready access to mates. We should expect adaptations designed to help capture such gains – and our remarkable capacity to work together in co-operative relationships has, indeed, been argued as evidence that they do exist.[3] But sociality also involves genetic competition *between* group members, and that means selection in favour of whatever attributes promote success in the various games that group members play. In the most general terms, these attributes are the capacity for:

1. 'Manipulation' – to convey information to other group members that, if believed, will lead those individuals to actions that rebound to the manipulator's own interest;[4] and for

[1] Introduced by Andrew Whiten and Richard W. Byrne, 'The Manipulation of Attention in Primate Tactical Deception', in Richard W. Byrne and Andrew Whiten, eds, *Machiavellian Intelligence: Social Expertise and the Evolution of Intellect in Monkeys, Apes, and Humans* (Oxford: Clarendon Press, 1988), pp. 211–23. See also Andrew Whiten and Richard W. Byrne, eds, *Machiavellian Intelligence II: Extensions and Evaluations* (Cambridge: Cambridge University Press, 1997).

[2] To our knowledge this particular evolutionary hypothesis has not been addressed in political science journal literature. For comment on the slight impact of evolutionary thinking on political science, see Albert Somit and Steven A. Peterson, 'Review Article: Biopolitics After Three Decades – A Balance Sheet', *British Journal of Political Science*, 28 (1998), 559–71.

[3] Linnda Caporael *et al.*, 'Selfishness Examined: Cooperation in the Absence of Egoistic Incentives', *Behavioral and Brain Science*, 12 (1989), 683–99.

[4] As Trivers observes: 'One of the most important things to realize about systems of animal communication is that they are not systems for the dissemination of the truth. An animal selected

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2. 'Mindreading' – to penetrate to the truth of signals that are emitted by other group members.[5]

Whether the games are broadly co-operative or competitive, both these capacities can work to the individual's advantage. In co-operative games, for example, my convincing you that I am likely to co-operate will help persuade you to enter play with me – making it possible for me to reap either the modestly profitable mutual co-operate payoff or the more profitable free rider's payoff (depending on my own co-operate vs. defect choice). But your penetrating to the truth of my intentions will allow you to avoid me if I do intend defection, and to enter play if I intend co-operation. In conflictual games, by the same token, my convincing you that I am *very* strong – stronger than is in fact the truth – might persuade you to back off and leave some valuable resource to my unchallenged use. By contrast, your recognizing the fact of my relatively low strength could lead you to offer (or accept) a fight that would be likely to turn out profitable for you.

At the heart of the 'political intelligence' hypothesis is the assumption that, throughout human evolution (or at least in the Pleistocene 'environment of evolutionary adaptation' or EEA), there was an arms race between such manipulative and mindreading capacities. Social living was indeed a necessary condition for our ancestors' survival, but social living also meant that any mutation-produced advantage in manipulation provided a basis for selection on mindreading and vice versa – producing an upwardly ratcheted arms race that continually increased both capacities.

This hypothesis has been particularly fertile for empirical studies of human cognition. Working from the assumption of modularity,[6] Cosmides[7] hypothesized and found strong evidence for reasoning capacities specialized to the domain of 'cheater detection' in social contract (or exchange) relationships.

(F'note continued)
to signal to another animal may be selected to convey correct information, misinformation, or both.' See Robert Trivers, *Social Evolution* (Menlo Park, Calif.: Benjamin/Cummings, 1985), p. 395.

[5] These terms were introduced by Dawkins and Krebs in their seminal work on animal signalling. See Richard Dawkins and John R. Krebs, 'Animal Signals: Information or Manipulation?' in J. R. Krebs and N. B. Davies, eds, *Behavioral Ecology: An Evolutionary Approach* (Oxford: Blackwell Scientific Publications, 1978), pp. 282–309; John R. Krebs and Richard Dawkins, 'Animal Signals: Mind-Reading and Manipulation', in J. R. Krebs and N. B. Davies, eds, *Behavioural Ecology: An Evolutionary Approach* (Oxford: Blackwell Science, 1984), pp. 380–402. O'Connell provides a recent overview: Sanjida O'Connell, *Mindreading: An Investigation into How We Learn to Love and Lie* (New York: Doubleday, 1998).

[6] Jerry Fodor, *The Modularity of Mind* (Cambridge, Mass.: MIT Press, 1983); Gerd Gigerenzer, 'The Modularity of Social Intelligence', in Whiten and Byrne, eds, *Machiavellian Intelligence II*, 264–88; Lawrence A. Hirschfeld and Susan A. Gelman, eds, *Mapping the Mind: Domain Specificity in Cognition and Culture* (Cambridge: Cambridge University Press, 1994); Dan Sperber, 'The Modularity of Thought and the Epidemiology of Representations', in Hirschfeld and Gelman, eds, *Mapping the Mind*, pp. 39–67.

[7] Leda Cosmides, 'The Logic of Social Exchange: Has Natural Selection Shaped How Humans Reason?' *Cognition*, 31 (1989), 169–93.

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Others have shown that cheater detection is responsive to role-taking[8] and status relationships,[9] and that it is involved with memory.[10] More generally, the idea that human intelligence evolved, in substantial part, in response to the exigencies of social game playing has proved an organizing principle for work in 'theory of mind',[11] comparative cognition,[12] the origins of language,[13] the relationship between dominance structures and democracy,[14] and in a variety of other areas.

What we do not know is the set of game parameters under which 'political intelligence' of the kind suggested by these studies is likely to have evolved. Co-operative and conflictual games undoubtedly did exist in the EEA and both undoubtedly contributed to the evolution of political intelligence. But natural and social ecologies can produce a wide variety of parameters for such games, and we simply do not know how variation in such parameters might influence the path of cognitive evolution.

In particular, ecological parameters might be such that there are strong group benefits to be captured from successful co-operative games (as, for example, when successful food gathering depends on many individuals acting in a joint manner) but also substantial costs for individuals who participate in such joint action (as, for example, when the food in question is large and dangerous). Then we would expect strong selective pressures on both the capacity to lie about co-operative intentions ('*Of course* I will co-operate!') and the capacity to penetrate to the truth underlying such lies. But a different set of ecological parameters might provide relatively modest incentives associated with collective action games and relatively substantial incentives associated with conflictual games. Food resources, for example, might be relatively accessible to solitary individuals, but desirable mates – from an evolutionary point of view, the ultimately scarce resource – might be relatively few, or perhaps capable of being monopolized by a single individual. When that is the case, we would

[8] Gerd Gigerenzer and Klaus Hug, 'Domain Specific Reasoning: Social Contracts, Cheating and Perspective Change', *Cognition*, 43 (1992), 127–71.

[9] Denise Dellarosa Cummins, 'Cheater Detection is Modified by Social Rank: The Impact of Dominance on the Evolution of Cognitive Functions', *Evolution and Social Behavior*, 20 (1999), 229–48.

[10] Linda Mealey, Christopher Daood and Michael Krage, 'Enhanced Memory for Faces of Cheaters', *Ethology and Sociobiology*, 17 (1996), 119–28.

[11] Simon Baron-Cohen, *Mindblindness: An Essay on Autism and Theory of Mind* (Cambridge, Mass.: MIT Press, 1995); Peter Carruthers and Peter K. Smith, *Theories of Theories of Mind* (Cambridge: Cambridge University Press, 1996).

[12] Whiten and Byrne eds., *Machiavellian Intelligence*; Reuven Dukas, ed., *Cognitive Ecology: The Evolutionary Ecology of Information Processing and Decision Making* (Chicago: University of Chicago Press, 1998); Alexander H. Harcourt and Frans B. de Waal, eds, *Coalitions and Alliances in Humans and Other Animals* (New York: Oxford University Press, 1992).

[13] Robin Dunbar, *Grooming, Gossip, and the Evolution of Language* (Cambridge, Mass: Harvard University Press, 1996); Robin I. M. Dunbar, 'The Social Brain Hypothesis', *Evolutionary Anthropology*, 6 (1998), 178–90.

[14] Albert Somit and Steven A. Peterson, *Darwinism, Dominance and Democracy* (Westport, Conn.: Praeger, 1997).

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expect strong selective pressures on the capacity to bluff about fighting strength, thus on the capacity to penetrate to the truth underlying such bluffs.

Of course, an ecology might also provide strong incentives to play *both* co-operative and conflictual games. Then we could expect strong selective pressures for manipulation and mindreading across both kinds of games. This would be the case, for example, if food or mates were both scarce and only able to be captured by competing groups of co-operating individuals – that is to say, as a result of 'wars' between 'alliances'. In general, we know little about how co-operative and competitive game parameters interact. Does selection on manipulative and mindreading capacities for co-operative games happen independently of selection on such capacities for competitive games? Or is selection on such capacities for one kind of game dependent on selection on such capacities for the other? And are there ecological circumstances in which selection on such political intelligence is maximized in general – that is, across co-operative and competitive games? Or is political intelligence for co-operative games maximized under one set of ecological parameters and that for competitive games maximized under a different set?

Cosmides's experiments supporting the existence of domain specific, special purpose 'cheater detection' capabilities in laboratory subjects[15] do suggest that 'social contract' games with a broadly prisoner's dilemma structure were adaptively important in humans' EEA. The strength and generality of her findings support the hypothesis that such capacities are adaptations, not just the product of drift or cultural learning. But such games are only one of many 'political' games that humans play, and evidence of special purpose cheater detection mechanisms adapted to such games says nothing about their importance in the EEA relative to other games that our ancestors played.

We can get some insights by extrapolating from what we know about the selective pressures confronting contemporary hunter-gatherers. Assuming that humans have the most developed political intelligence, then it is a fair bet that the circumstances of life that we observe for such contemporary groups are also those that maximize political intelligence – or, at least, that those circumstances promote that particular kind of intelligence more than the circumstances confronting other animals. There are a number of problems with this course, however, in particular that it does not tell us anything systematic of a comparative nature. Even if the extrapolation from modern hunter-gatherers to the EEA is defendable (and that is, of course, debatable), it tells us little or nothing about the evolution of political intelligence across the range of ecological conditions that might exist for different social species, now or in the remote past. It does not, in other words, tell us anything general about the evolutionary pressures supporting political intelligence.[16]

In this article we use computer simulation as an alternative route to answering

[15] Cosmides, 'The Logic of Social Exchange'.

[16] Our emphasis on political intelligence as an adaptive response to social game-playing in the ancestral environment does not, of course, preclude individuals' learning how to play such games in the course of their own development, or their figuring out how best to play such games by rational

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such general questions.[17] Of course, simulations do not provide data about any particular natural world; their only empirical referent is the simulated world itself. In the present context, this means that our analysis cannot demonstrate that political intelligence actually did evolve. It can only demonstrate the possibility of its having done so, and the circumstances under which it could have happened.

The results of simulations are also notoriously vulnerable to the specifics of parameter settings. But the advantage of simulations is that they allow the researcher to replay evolutionary sequences – whose natural world referents have been gone for perhaps hundreds of thousands of years – under a range of parameters, permitting inferences about the adaptive consequences of parametric differences. It is a commonplace that if evolution were 'rewound' and started again many times it would never produce the same result twice, but it is also true that any set of natural world parameters will embody distinctive evolutionary pressures that can, in principle, be identified. The capacity to run simulations many times makes them useful for identifying such selective pressures, and that is the spirit in which we employ the method here. In our case, the parameters of interest are those under which political intelligence is likely to have evolved to the highest levels and, as we will show, our simulation does make it possible to derive plausible inferences on that score.

Of course, the adaptive problems posed by natural world interpersonal relationships are much more complex than those posed by just pairs of individuals having to decide whether to enter a two-person fight or co-operative game. *N*-person games of both kinds are also possible, each requiring individuals to assess not only others' probable responses towards themselves, but third – and *n*th – parties' responses towards each other. In *n*-person Hawk – Dove (HD) games, for example, a crucial part of assessing the threat from a potentially hostile alliance is assessing how effectively the members of that alliance are likely to work together in using the strength that they do possess as an aggregate. In general, increasing numbers produce a combinatorial explosion[18] whose demands increase exponentially beyond the binary case.

(F'note continued)
calculation. Indeed, experience and rational calculation might well build on the kind of evolved capacities that concern us here. For a discussion of the relation between rationality based models and evolutionary psychology, see Leda Cosmides and John Tooby, 'Better than Rational: Evolutionary Psychology and the Invisible Hand', *American Economic Association Papers and Proceedings* (May 1994), 327–32.

[17] Thus the focus of this simulation is not on evolving game theoretic strategies, as is the focus of much well-known simulation work dealing with co-operative games – for example, Robert Axelrod, *The Complexity of Cooperation: Agent-Based Models of Competition and Cooperation* (Princeton, NJ: Princeton University Press, 1997); Robert Axelrod, *The Evolution of Cooperation* (New York: Basic Books, 1984). It is on evolving capacities for manipulating and accessing the information necessary to make adaptive choices between games modelled by game theorists.

[18] Leda Cosmides and John Tooby, 'The Psychological Foundations of Culture', in Jerome Barkow, Leda Cosmides and John Tooby, eds, *The Adapted Mind: Evolutionary Psychology and the Generation of Culture* (Oxford: Oxford University Press, 1992), pp. 19–136. The issue of group size is critical to Dunbar's important argument about the relation between social complexity and the neocortex ratio: Dunbar, *Grooming, Gossip, and the Evolution of Language*, pp. 54–69.

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There is also the 'levels of intentionality' problem[19] posed by each individual's knowing that each other individual is, simultaneously, engaged in his or her own efforts at mindreading and, possibly, manipulation in response to the results of that mindreading.

Some flavour of the complexity of cognitive structures for responding to social games that we might expect is reflected, for example, in Baron-Cohen's well-known modelling of the cognitive structures that he hypothesizes surround autism.[20] And, certainly, Dunbar's demonstration[21] of an increase of neocortex ratio (the percentage of total brain volume) with group size is substantially based on the potential for very complex *n*-person coalitions in larger groups. A fully developed simulation for studying how political intelligence evolves would require agents to make these far more complex evaluations.

Similarly, there is a distinction between the circumstances under which 'political brains' in general evolve and those under which humans' peculiar version of political intelligence has evolved. As Miller has pointed out recently,[22] the political intelligence hypothesis is by itself at best strained as an explanation of humans' creativity, wit, humour, moral sensibilities, and artistic and musical capacities; he proposes that, in our case, political intelligence was complemented by *sexual* selection for such attributes as 'costly signals' of mate quality. Our analysis addresses only the circumstances under which political intelligence is particularly likely to evolve, but does not address the important further question of how humans' distinctive variant on that form of intelligence might have evolved.

Nevertheless, an appropriately modest first step towards understanding political intelligence – the one we take here – is to trace the selective pressures posed by 'simple' societies with only binary encounters and with only two types of 'legal' games. Methodologically, it is far more productive to start with simple models and then to add complexities as those simple models are increasingly well understood than it is to try and incorporate all known complexities at the outset. This is, surely, particularly the case when the complexities in question involve humans' seemingly unending capacity to 'invent' political games of one kind or another.

A simulation must first be justified by internal validity, and in the next section we provide such a justification for our 'political intelligence simulation' that was designed to explore the evolution of such intelligence in 'simple' societies that provide agents with binary encounters and that permit only broadly co-operative

[19] Daniel Dennett, 'The Intentional Stance in Theory and Practice', in Whiten and Byrne, eds, *Machiavellian Intelligence*, pp. 180–202. Levels of intentionality are a particular problem in conflictual games when, for example, one individual might be willing to issue a challenge even when believing that it would lose a fight – if it also believed that the target of that challenge were *under*estimating its own relative strength, thus would be unlikely to take up such a challenge.

[20] Baron-Cohen, *Mindblindness*.

[21] Dunbar, *Grooming, Gossip, and the Evolution of Language*.

[22] Geoffrey F. Miller, *The Mating Mind: How Sexual Choice Shaped the Evolution of Human Nature* (New York: Doubleday, 2000).

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and conflictual games. We then report findings from a succession of runs of that simulation under diverse game (or ecological) parameters, asking: *How do game parameters influence the extent to which political intelligence evolves, and the process by which it does so?*

THE POLITICAL INTELLIGENCE SIMULATION

Our 'political intelligence simulation' is based on six broad assumptions about social interactions each of which is, we believe, innocuous in itself:

1. *The most important political or social games that people play can be broadly categorized as either 'conflictual' or 'co-operative'*. As several authors have recently emphasized, human evolution – and evolution more generally – is in very large part the story of individuals finding and exploiting opportunities for mutual gain.[23] That said, theorists since Darwin have recognized the inevitability of conflict of interest; Malthus's famous insight about the capacity of animals to reproduce beyond the carrying capacity of their environment ensures that. This assumption does no more than accept the commonplace that co-operation and conflict are the basic modalities of social life, whether that of humans or other group-living species.
2. *An encounter between any two people requires them to make choices between such co-operative and conflictual games – and also to consider the further option of playing no game at all*. In everyday life, of course, we often make standing decisions of this kind. I do not have to decide anew whether to co-operate or fight with my neighbour every time I meet her in the hall outside my office. But conflict and co-operation are at least options, and my standing decision is – no doubt – under constant (sub-conscious?) re-evaluation (perhaps as the winds of departmental politics change).
3. *Such choices are made by expected value (EV) criteria informed by whatever information people can retrieve about their protagonists' intentions and capacities.* Once again, in everyday life few people (even decision theorists) actually conduct EV analyses, let alone for the continuing 'decisions' they must make with respect to ongoing, iterated social encounters. It is only necessary that their decisions can be reconstructed *as if* they were doing so. Natural selection does not care whether an animal's behaviour follows the specifics of the EV algorithm when making decisions, but it is brutally efficient in selecting out those animals whose behaviour does not produce decisions that are consistent with that algorithm. Of greater interest is the information that agents use in conducting these EV 'analyses'. Since Simon's introduction of bounded rationality,[24] we have understood that full

[23] Alison Jolly, *Lucy's Legacy: Sex and Intelligence in Human Evolution* (Cambridge, Mass.: Harvard University Press, 1999); Robert Wright, *Non Zero; The Logic of Human Destiny* (New York: Random House, 2000).

[24] Herbert Simon, 'A Behavioral Model of Rational Choice', *Quarterly Journal of Economics*, 69 (1955), 99–118; Herbert Simon, 'Rational Choice and the Structure of the Environment', *Psychological Review*, 63 (1956), 129–38.

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information is neither cognitively possible nor (usually) rational as an aspiration, yet the political intelligence hypothesis elaborates on Simon's insight by suggesting that the information that people do retrieve for use in their social decision making is a function, simultaneously, of their own efforts at mindreading and of a protagonist's efforts at manipulation.

4. *People have variable capacities to manipulate information and to read other peoples' minds.* Expected value calculations require estimates about others' intentions and their capacities, but, as we have suggested, the information from which such estimates are made is subject to manipulation and its truth value is subject to mindreading. Minimally, therefore, people need capacities that support manipulation of the information they convey to others, and penetration to the truth of the information that they receive from others. Although such functions could in principle be performed by a general purpose structure, a functional analysis suggests modularity.[25] The information that must be cued for detecting cheating in social contracts is likely to be very different from the information that must be cued for seeing through bluffs with respect to fighting strength. Similarly, telling a lie about one's co-operative intentions requires the liar to mobilize significantly different information than when he or she is emitting a bluff about his or her fighting strength. From an evolutionary perspective, however, the critical fact is that people vary in these several capacities, and that such variation affects the accuracy of the EV estimates they make when deciding between entering vs. not entering political games with particular individuals.

   Importantly, while our model focuses on the functions of manipulation and mindreading for the respective games, in the natural world such functions are known to be performed by a wide variety of mechanisms. Notably, the mindreading function includes memory. Of course, memory – however minimal – about others' past behaviour underlies standard reciprocity-based explanations of co-operation,[26] and there is even recent laboratory evidence that memory for faces is particularly involved in cheater detection.[27] Similarly, memory about the outcome of past fights (perhaps involving oneself, but also between others) is surely an important contributor to mindreading with respect to fighting capacities. No less interesting, the manipulation function has been argued to include self-deception, capable of making a deceiving individual's lies more believable.[28] Many other natural

[25] Sperber, 'The Modularity of Thought and the Epidemiology of Representations'.

[26] Axelrod, *The Evolution of Cooperation*; Robert Trivers, 'The Evolution of Reciprocal Altruism', *Quarterly Review of Biology*, 46 (1971), 35–57.

[27] Mealey, Daood and Krage, 'Enhanced Memory for Faces of Cheaters'.

[28] Robert Trivers, 'The Evolution of Reciprocal Altruism', *The Elements of a Scientific Theory of Self-Deception* (New York: Academy of Sciences, 1999). But see also V. S. Ramachandran, 'The Evolutionary Biology of Self-Deception, Laughter, Dreaming and Depression: Some Clues from Anosognosia', *Medical Hypotheses*, 47 (1996), 347–62; and V. S. Ramachandran and S. Blakeslee, *Phantoms in the Brain: Probing the Mysteries of the Human Mind* (New York: William Morrow, 1998).

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processes might bear on individuals' capacities to manipulate and mindread, and understanding how these two functions are performed in natural circumstances is certainly an important research agenda. But for present purposes all we need is the assumption that such capacities do exist, and that individuals vary with respect to them.

5. *The wealth consequences of these conflictual and co-operative games bear on people's reproductive success*. Granted Darwin's basic argument about the 'struggle for life', not everyone can be equally successful in reproductive terms, but this assumption says simply that relative success in social games translates into relative reproductive success. In natural circumstances, the path between success in a particular game and having more offspring is likely to be a long and perhaps tortuous one, but we are agnostic about the specifics of that path, assuming simply that the outcome of any particular social game does have reproductive consequences.[29]
6. *Successful reproduction means that a person's manipulative and mindreading capacities are passed on to his or her offspring prior to death, subject to mutation*. Children inherit whatever capacities a parent might have for manipulation and mindreading, but subject to errors of transmission that are random with respect to the child's success in the various political games that now must be played in the course of his or her lifetime. Such errors of transmission ensure that all members of a given generation will not have identical capacities for manipulation and mindreading, thus that some are likely to be more successful game players than others – thus that population levels of manipulative and mindreading capacities can change throughout successive generations. It is such 'cognitive evolution' and the circumstances surrounding it that we are interested in understanding.

Our objective, then, was to design a simulation broadly isomorphic with these 'simple society' assumptions, and we proceeded as follows:[30]

Cooperative and competitive games. Since the Prisoner's Dilemma (PD) and the Hawk–Dove (HD) games are standard formulations of the problems involved in, respectively, co-operative and conflictual relationships, we work within their terms. PD games are modelled in the standard manner as offering a co-operate vs. defect choice, with the payments ordered $t > c > d > s$, and $2c > t + s > 2d$.[31] HD games are modelled in similarly standard terms as offering a hawk vs. dove choice, with the former being a willingness to fight

[29] In this article, 'wealth' is only available from social games, and the term means 'any arbitrarily bestowable resource, ability, or status that might enhance the reproductive success of its possessor' (John Hartung, 'On Natural Selection and the Inheritance of Wealth', *Current Anthropology*, 17 (1976), 607–22, p. 607).

[30] The program was written in Visual Basic. Code is available from the authors on request.

[31] Where t = temptation, the payoff for defecting when a protagonist co-operates; c = the payoff for mutual co-operation; d = the payoff for mutual defection; and s = the 'sucker's' payoff, for co-operating when a protagonist defects.

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and the latter being retreating from a fight. The payoff from playing hawk when the other plays dove is Value (v), and the payoff from playing dove when the other plays *either* hawk or dove is zero.[32] Should both play hawk, a fight ensues with the winner capturing v and the loser paying Cost (c). Each of these payoffs is a parameter that can be changed.

Encounters. The simulation establishes a set of agents who, on encountering each other, might enter a PD game, a HD game, or play no game at all. More specifically, one cycle of the simulation involves selection of a first (Alpha) and a second (Beta) agent, with the former's having the initiative, assessing the EV of 'offering' a PD game, of 'challenging' with hawk, or of doing neither – that is, of simply 'walking on by'. Should Alpha offer a PD, Beta then must calculate the EV of accepting the offer and playing such a game vs. the no play option of 'walking on by'. If Beta chooses the latter, no game of any kind is consummated and neither gains or loses anything. However, should Alpha issue a hawk challenge, Beta must calculate the EV of accepting that challenge vs. playing dove – walking away and leaving Alpha in undisputed possession of v. Importantly, therefore, while Alpha cannot impose a PD on Beta, it can impose a HD game on Beta (although, because Beta can respond with dove, it cannot impose a fight *per se*).[33]

Calculating EV: information. Each agent is equipped with 'strength' which is defined by an integer above zero; the larger that number, the greater is the agent's fighting ability in any hawk–hawk fight that is joined. And each is also equipped with a 'base rate of co-operation' (BRC) which defines the probability of an agent's co-operating on any PD game that is consummated. For any particular encounter, an agent's decision between co-operation and defection is defined by a sample of one from a probability distribution defined by its BRC.[34] Each agent knows its own strength and its own particular decision between co-operation and defection, as well as the various payoffs for the respective games. The information that an agent still needs in order to compute an EV for those games thus concerns the strength and the BRC of the other agent it has encountered.

Making those estimates depends on the flow of information between the two agents, thus on the capacity of the target to manipulate information and the simultaneous capacity of the judge to mindread to the truth underlying such manipulations. Agents are equipped with two manipulative capacities, one

[32] In some Hawk–Dove formulations, the Dove–Dove outcome gives each an equal chance at capturing v or, alternatively, a 0.5 share of v. Our modification implies that, should neither want to fight, neither captures the resource – both go away empty handed. This outcome is, therefore, equivalent to the 'no play' outcome in PD games.

[33] Note that the 'non-social' outcome can happen by Alpha's choosing no play (as it would if its EV for both games were negative) or by Beta's choosing to reject an offer from Alpha to play a PD game. Beta's playing dove in response to Alpha's hawk does classify as a 'social' outcome – albeit one characterized by domination of Beta by Alpha.

[34] Thus even an individual with a 0.99 BRC might defect on rare occasions, just as one with a BRC of 0.01 might co-operate on similarly rare occasions.

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specialized to each game – 'persuasion^{HD}' and 'persuasion^{PD}'. Persuasion is, in general, an agent's capacity to issue a *credible* manipulation and is defined operationally as an integer above zero. For Hawk–Dove games, therefore, an agent sends a message about its fighting strength that consists of the truth plus a bluff of some magnitude, and its persuasion^{HD} value defines its capacity to make the bluff part of that message credible. For Prisoner's Dilemma games, we assume that agents will always send the message: 'My BRC is 1.0 – I will always co-operate'; it makes no strategic sense for an agent to assert, for example, 'I will co-operate 0.75 of the time.' For PD games, therefore, the bluff is the difference between the agent's true BRC and 1.0; and its persuasion^{PD} is its capacity to make the bluff part of the 'I will always co-operate' message believable.[35]

To mindread, agents are equipped with 'perception^{HD}' and 'perception^{PD}' – respectively, the capacity to penetrate any bluff that is issued about fighting strength, and to penetrate any bluff that is contained within the message 'I will always co-operate'. Once again, these capacities for a given individual are defined as integers above zero, with a larger number indicating a greater capacity.[36] Similarly, the size of the bluff that an agent emits in a HD encounter is specified as some integer above zero. In general, an agent's estimate of the truth about another is a function of that other's capacity to manipulate information in conjunction with its own capacity to mindread. When Perception^{self} is an agent's own perception, and Persuasion^{other} is the encountered individual's capacity to make its bluff stick, the proportion of that bluff that the agent penetrates is

$$\text{Perception}^{self}/(\text{Perception}^{self} + \text{Persuasion}^{other});$$

the magnitude of the 'accepted bluff' is that proportion multiplied by the magnitude of the bluff; and the actual estimate that the agent uses in its EV calculation is the accepted bluff added to the encountered individual's true value – namely, its 'estimated strength' in the HD case and its 'estimated BRC' in the PD case.[37] The stimulation has Alpha make its two EV calculations first and then

[35] Suppose, for example, that an agent's true BRC is 0.25, thus that it will co-operate in only a quarter of the PD games it consummates. Its 'message' remains that it will co-operate with a probability of 1.0, but the bluff component of this message is 0.75, the difference between the true 0.25 and the claimed 1.0. The agent's persuasion^{PD} is an attribute of this bluff – which might be very persuasive, very unpersuasive, or something in between.

[36] This simulation only addresses the problem of penetrating the truth of a message that is false. We acknowledge that the problem of accepting the truth of a message that is true is also a mindreading issue, and are developing a simulation that addresses both.

[37] In PD games when the sampled choice is to co-operate, the EV calculation is other$^{estBRC}(c)$ + $(1 - \text{other}^{estBRC})(s)$; and for one whose sampled choice is to defect, it is other$^{estBRC}(t)$ + $(1 - \text{other}^{estBRC})(d)$. In HD games, an agent must first estimate the probability of winning (p^{win}) as follows: own^{Str}/(own^{Str} + other's^{estStr}, where Str = strength. The EV of a fight is then: $p^{win}(v) + (1 - p^{win})c$. Alpha, who has the initiative, will offer a PD game when its EV of such a game is higher than the EV of issuing a hawk challenge and also the zero payoff for not playing at all; Beta, who must respond, will accept when its EV of a PD game is greater than zero. Conversely, Alpha will issue a hawk

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offer the game with the highest EV to Beta, who must then make its own calculations with respect to the offered game – accepting or rejecting play if that offer is for a PD, and playing hawk (joining a fight) or playing dove (abandoning *v* without a fight) if the 'offer' is for a HD. A joined game is then played out with the payoffs being added to or subtracted from the respective agents' wealth.[38]

Survival and reproduction. The simulation is played through a succession of 'generations' each of which consists of some number of encounters among agents. At the end of each generation, any agent whose wealth is below zero dies without the chance of reproducing. The survivors are ranked by wealth after which: (1) those whose wealth is below the median die without reproducing at all; (2) those whose wealth is between the median and below twice the median have one offspring; (3) those whose wealth is between twice the median and below three times the median have two offspring, etc. If the population at the outset of the next generation is above the ecology's carrying capacity, a lottery is conducted among offspring for slots in the ecology. The losers are excluded, thus 'die at birth'.

Cognitive evolution through successive generations. Offspring inherit their parents' various attributes – perception^{PD}, perception^{HD}, persuasion^{PD}, persuasion^{HD}, BRC, bluffing magnitude and strength[39] – subject to the chance of mutations, which involve a random positive or negative change on the value of a parental attribute as it is being transmitted to an offspring. Mutations are, of course, the source of the variation from which evolution builds. Mutation is governed by *frequency*, the probability with which an attribute, on being transferred to an offspring, will mutate in the process; and by *magnitude*, the size of the change on an attribute selected for mutation. Operationally, the latter defines a range above and below the parental value on the attribute in question. The mutation itself is decided by a sample from that range, and the offspring's value on that mutated variable is then the original parental value plus or minus that mutated value.[40]

(F'note continued)
challenge when its EV of doing so is greater than its EV of a PD game and of the zero no play payoff; and Beta will accept when its EV of doing so is greater than zero.

[38] Payoffs from a PD game are allocated according to the respective players' co-operate vs. defect choices in conjunction with the payoff matrix. Payoffs from a hawk–hawk fight are determined probabilistically by their respective *true* strengths. Thus, Alpha's true probability of winning is $Alpha^{Str}$ / ($Alpha^{Str}$ + $Beta^{Str}$) and Beta's is 1 minus that amount. The outcome of a fight is then produced by a sample of 1 from that probability distribution, with Alpha winning if the sample is within its range and Beta winning if it is outside that.

[39] All agents begin life with the same starting wealth.

[40] When agent attributes are defined as a string of zeros and ones, as is often the case in evolutionary simulations, the normal procedure for introducing mutations is to 'flip', zeros to ones and vice versa with some probability. This becomes awkward when, as in the present case, variables are integers. The approach adopted here is discussed as an alternative in simulations employing integer variables that are subject to mutation in Nigel Gilbert and Klaus G. Troizsch, *Simulation for the Social Scientist* (Buckingham: Open University Press, 1999), p. 233. Notice that this method would not work in a parallel manner on BRC, which is defined as a probability, and on the other

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Thus designed, the simulation is a tool for systematic experimentation, allowing us to manipulate HD and PD payoff parameters, and to study the consequences of such manipulations for evolutionary change in the attributes of the agents who comprise successive generations, as well as the processes by which such change comes about.

EXPERIMENTAL DESIGN

Two considerations govern the experimental approach that we adopt. First, because of the many stochastic components of the simulation, any two runs using exactly the same starting parameters will almost inevitably produce at least *somewhat* different results. As we observed earlier, this stochastic component certainly operates in natural evolution.

Secondly, payoff parameters for the HD and PD games will affect agents' expected value calculations – thus the frequency with which the respective games are played, thus the selective pressures that bear on manipulative and mindreading capacities. Reporting the evolutionary changes over many generations for a wide range of game parameters would be prohibitively cumbersome. Accordingly, our strategy has been to run many simulations under systematically varying game parameters, but to report only the mean population attributes for the final 1,000 generations of runs with particular parameters. We are, in other words, less interested in the specifics of the path that natural selection takes in particular cases than we are in its end product after an extended number of generations across diverse game parameters. In general, therefore, the graphics to follow show, for varying game parameters, population attributes at the end of 30,000 generations of selection.

Inevitably, the simulation's stochastic components will mean that a given set of game parameters will produce some variation in 'end values' across different runs, but (1) our experience suggests that this variation is not great – findings for given parameters are generally stable; and (2) the relatively small variation in the '29,000 to 30,000 generation mean end values' that does happen under given game parameters does not prevent us from observing clear patterns across incremental parameter changes. Simulations are sometimes criticized because their results are characteristically sensitive to parametric assumptions; mathematical results are argued to offer greater generality.[41] Our theoretical concern

(F'note continued)
attributes, which are defined as integers. Our solution was to define two integers above zero, BR^c and BR^d, using the algorithm $BR^c / (BR^c + BR^d)$ to define the probability term BRC. Mutation then acted on these two 'component elements' of BRC in the same manner as on other integer variables. Conceptually, of course, it makes no sense for a numerically defined capacity to mutate below zero, meaning that mutations were truncated at zero. This does introduce an upward bias in mutations for cases in which parental values are low relative to mutation magnitude but this bias does not change our findings.

[41] Robert Hoffmann, 'Twenty Years On: The Evolution of Cooperation Revisited', *Journal of Artificial Societies and Social Simulation*, http://www.soc.surrey.ac.uk/JASSS/3/2/forum/1.html (2000).

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is precisely with the consequences of variation in game parameters, and the method we adopt allows us to trace the consequences of such variation as an experimental intervention.

While we might have varied game parameters in many ways, we have chosen to hold constant PD payoffs (at respectively: $t = 20$; $c = 10$; $d = -10$; $s = -20$) and also the HD c payoff (at -20) but to vary the HD v payoff – specifically, in increments of 1 between zero and 80. This approach allows us observe selection on individual attributes across the complete range of relative attractiveness between HD and PD games. Otherwise, for all the runs reported here: (1) carrying capacity of the ecology is set at fifty agents with that ecology being fully populated at the outset of each run; (2) one generation is defined by each agent in the population having encountered each other agent once in both the Alpha and the Beta roles; (3) the mutation rate is set at 0.04 and mutation magnitude is set at 5; (4) at the outset of each run, all agents are in effect clones of each other, with the two mindreading and two manipulation capacities, strength and wealth all set at 50, and BRC set at 0.5.[42]

FINDINGS

We report results in response to two questions: (1) To what extent do changes in game parameters influence selection on the four capacities that, in our model, together comprise the elements of political intelligence? (2) What is the relation between selection on these four capacities and the choices that agents make both between and within Prisoner's Dilemma and Hawk–Dove games?

First, however, we address the incidence of joined PD and HD games – the two types of 'relationships' that can result from an encounter in this ecology – across game parameters. Figure 1 reports the percentage of all encounters that produced each of these as, with PD parameters and cost constant, the value of the stake (v) increases between 1 and 80. Not surprisingly, when what is to be won from a successful hawk–hawk fight is less than what is to be lost from an unsuccessful one (here 20 in all cases), HD games are seldom if ever played. An Alpha would have to be *very* confident of winning for a hawk challenge to be rational under those parameters. Neither is it surprising that, as what is to be won from fighting becomes greater, fights themselves become more frequent and PD games become relatively less so. Why should agents engage in

[42] Tests have confirmed that, although the specifics naturally vary somewhat, the broad pattern of results to be reported below is maintained by alternative ways of varying the relative attractiveness of the two games, starting population size, starting levels of individual attributes, and mutation rate and magnitude. With respect to game parameters, the important consideration is the relative attractiveness of the two games, and varying v while holding other values constant serves that purpose as well as any other approach. Similarly, the specifics of mutation rate and magnitude only influence the speed with which selection operates – a higher rate and magnitude, for example, makes it operate faster – not the pattern of findings. It would be possible, of course, to seed the population with diverse 'types' of agents, but mutation is a fully sufficient source of variation. Distinctive 'types' rapidly vanish through successive generations as their offspring are subject to selection on mutation.

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problematic co-operative games when the payoff from a successful fight makes the expected value of issuing or accepting a challenge *so* attractive – even for those who are relatively weak?

More interesting is the fact that, when HD games are effectively ruled out by $v < |c|$, populations seldom last longer than a few hundred generations before all their members die out. Not only are there no HD games, but PD games – potentially, at least, still a source of wealth – become vanishingly few, certainly not enough to sustain the population. By contrast, within the range where v relative to $|c|$ makes HD games sometimes attractive but not overwhelmingly so (here between $v = 21$ and $v = 39$), whole populations survive for the full 30,000 generations, reaching carrying capacity and (basically) staying there. Remembering that PD game parameters are constant across the full range of v, it appears that having HD games a *modestly* viable option for agents makes possible both a high incidence of joined PD games and – more important – survival of the population itself.

We will return to the possible importance of conflict for the survival of the population itself, but our primary interest is in the evolution of the four cognitive capacities that, in our simulation, together comprise political intelligence across variation in game parameters for HD games relative to those for PD games.

The Evolution of Political Intelligence

On the face of it, we might expect that manipulation and mindreading specialized to the respective games will evolve most rapidly when the game in question is most attractive, thus is played most frequently. The more frequently a game is played, the more adaptively important would appear to be whatever cognitive attributes facilitate that game's being played *well* – and, in our model, manipulation and mindreading specialized to the respective games are such attributes. From the incidence of the respective games reported in Figure 1, therefore, we might expect that political intelligence (the aggregate of perception^{PD}, persuasion^{PD}, perception^{HD} and persuasion^{HD}) will evolve to more or less constant values across the full v range, but that it will be composed of substantially different capacities depending on the relative attractiveness of the two games. Specifically, it would seem that when PD games are most frequent (roughly within the v range between 21 and 39), political intelligence will be substantially comprised of perception^{PD} and persuasion^{PD}, while it will be substantially comprised of perception^{HD} and persuasion^{HD} when HD games are most frequent (in the v range beyond about 41). Only when the two games are played with roughly the same frequency (from Figure 1, with v around 40) would we expect political intelligence to be constructed about equally of the capacities for dealing with the two types of games.

This is not what we observe, however. First, Figure 2 shows that the aggregate of the four capacities peaks at around 2,300 when PD games dominate the ecology and there are only very few HD games (within the v range between about 22 and 30), and that it declines thereafter as HD games become more frequent

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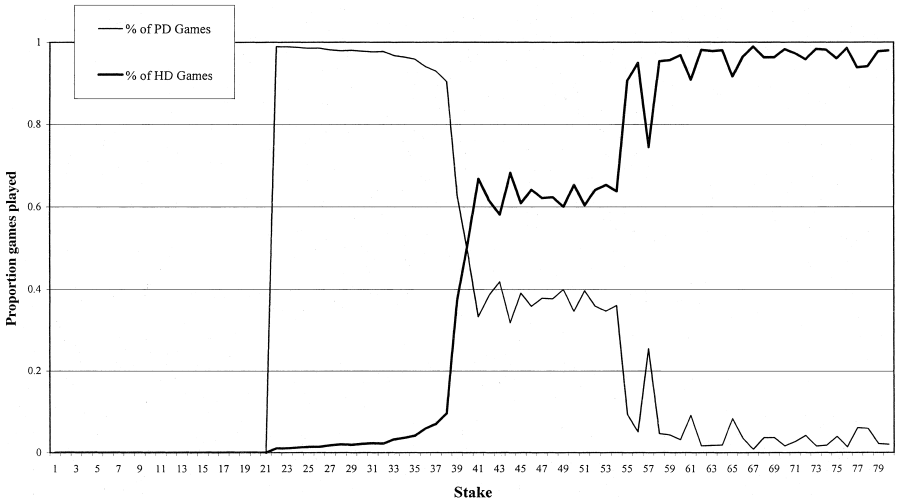


Fig. 1. Average proportion of PD and HD games played through 30,000 generations, by game parameters

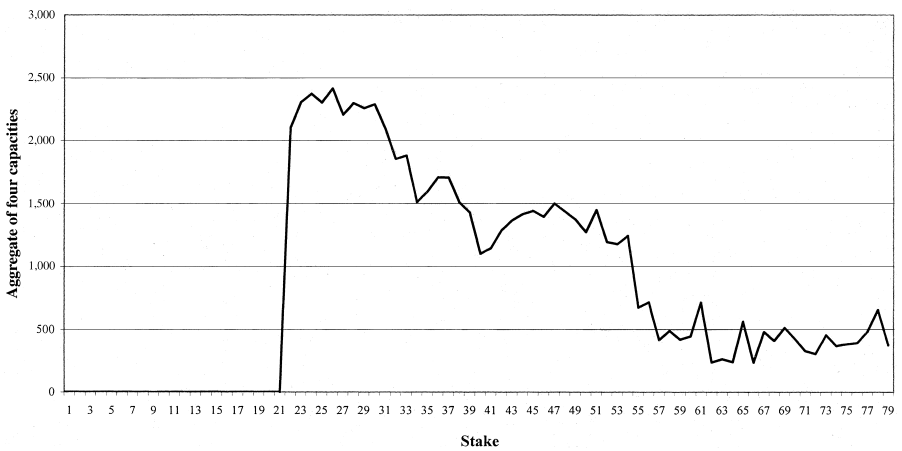


Fig. 2. Four PD and HD capacities aggregated at end of 30,000 generations, by game parameters

– to the point where it appears to equilibrate around 400 when HD games are the almost sole way by which agents interact. Remembering that the first generation in the sequence had the four capacities each set at 50, thus with their aggregate at 200, selection across even 30,000 generations does not produce much growth of political intelligence when HD games dominate the ecology, but the same number of generations produces far more such growth when PD games dominate the ecology.

Some insight into this broad pattern is provided by breaking political

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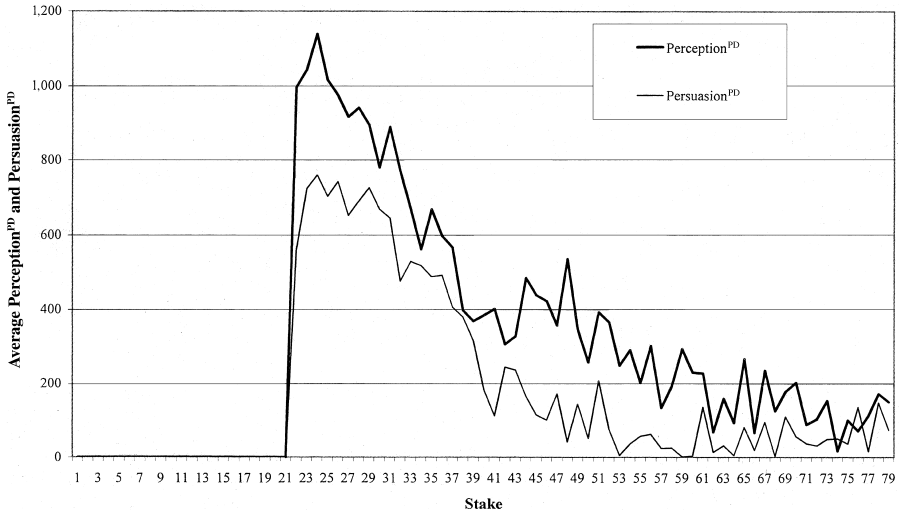


Fig. 3. Average Perception^{PD} and Persuasion^{PD} at end of 30,000 generations, by game parameters

intelligence into its four component parts. This is accomplished in Figures 3 and 4 which show, respectively, the evolution of perception^{PD} and persuasion^{PD}, and the evolution of perception^{HD} and persuasion^{HD} through 30,000 generations (or, at least, until the population dies out, as it does only within the range where $v < |c|$). From Figure 3, it is clear that the two capacities for playing Prisoner's Dilemma games do follow the prediction of decline as those games become a progressively less important feature of the social ecology. The pattern of their

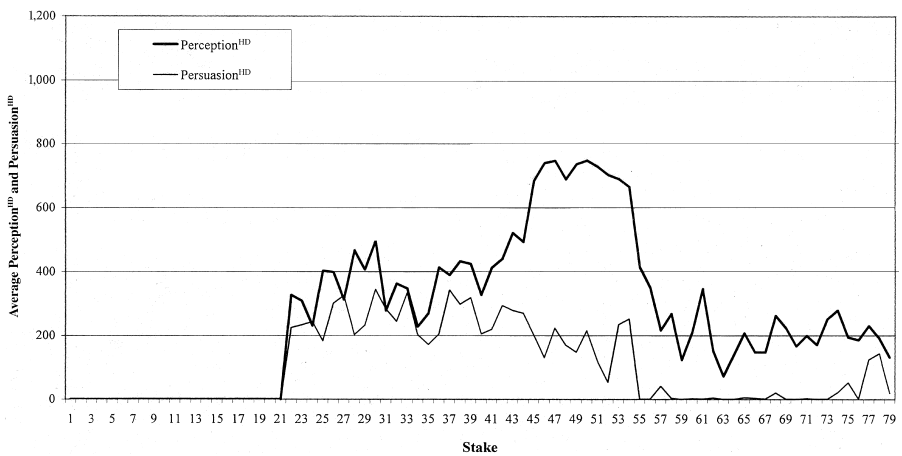


Fig. 4. Average Perception^{HD} and Persuasion^{HD} at end of 30,000 generations, by game parameters

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decline with increases in v does not follow the pattern of decline in the incidence of PD games exactly, but that pattern is broadly consistent with the prediction.

From Figure 4, however, there is no such equivalence between the incidence of HD games and selection on perception^{HD} and persuasion^{HD}. While these values are only a relatively minor component of political intelligence when PD games are most frequent, if anything they decline as HD games come to dominate the ecology. The peak of perception^{HD} roughly within the range $v = 45$ and $v = 55$ requires explanation and we will return to that, but our conclusion is that the decline of aggregate political intelligence as v increases relative to $|c|$ is a consequence of (1) capacities for playing PD games not being strongly selected when such games are only infrequent, as predicted; coupled with (2) capacities for playing HD games *not* being strongly selected when such games are overwhelmingly frequent – contrary to predictions. When v is very high relative to $|c|$, there is little selection on either capacities for playing PD games or on capacities for playing HD games.

With hindsight – always 20/20 – the failure of the two Hawk–Dove capacities to evolve upward with the increasing frequency of 'their' games is not too surprising. Increases in v relative to $|c|$ produce a corresponding increase in the incentives for considering HD games, but as those games become more attractive there is a corresponding *decrease* in the adaptive value of either perceptiveness^{HD} or persuasiveness^{HD}. The point is perhaps best made intuitively: if the prize for winning a fight against Mike Tyson were high enough relative to the cost of losing, even very poor boxers would rationally get in the ring with him (a lucky punch *could* happen), meaning that even the most accurate information about a low probability of winning would be redundant to the rationality of their decision.[43] When v is high enough, neither the capacity to bluff nor the capacity to penetrate bluffs will be of any adaptive significance, thus mutations supporting those capacities will not be selected.

It remains to explore the circumstances under which aggregate political intelligence *is* most strongly selected, and that means asking, in particular, about the adaptive value of perception^{PD} and persuasion^{PD} when v is somewhat higher than $|c|$ but not sufficiently high to make fighting the obvious choice.

The Behaviourial Value of Political Intelligence

Obviously, perception^{PD} is valuable in so far as it increases the likelihood of an agent's recognizing a protagonist's true probability of co-operating and, thus, contributes to the probability of a better, more adaptive decision about whether or not to play a PD with that particular protagonist. Similarly, persuasion^{PD} is

[43] Notice the important difference between HD and PD games in this respect. While game payoffs *per se* can make entering a PD game a more or less attractive proposition, the advantage of playing with a co-operator as opposed to a defector (part of the definition of the PD) means that protagonists can always benefit in making the 'enter vs. don't enter' decision from accurate information about each other's true intentions – whatever their own co-operate vs. defect intentions. As shown here, that is not necessarily the case for HD games.

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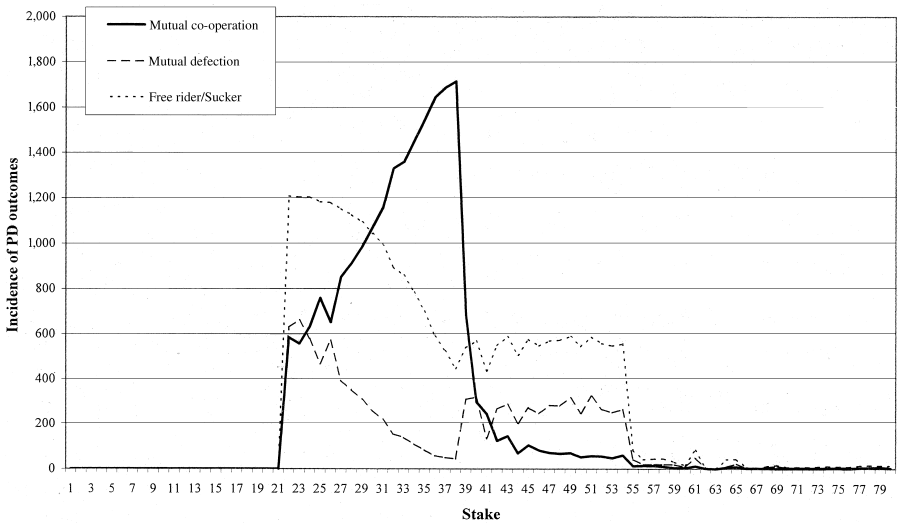


Fig. 5. Frequency of three PD outcomes at end of 30,000 generations by game parameters

valuable in so far as it helps persuade others of one's own co-operative intentions, thus increases one's own options for entering vs. not entering PD games with particular individuals. The question is how the presence of HD games that are at least sometimes viable as alternatives to PD games alters the importance of these two Prisoner's Dilemma-based capacities.

A clue is provided by Figure 5 which shows the incidence of the three possible outcomes to joined Prisoner's Dilemma games by increases in v relative to $|c|$ – mutual co-operation, mutual defection, and exploitation of a 'sucker' by a 'free rider'. The range of v between 21 and about 39, within which we know that PD games are generally the most attractive game but in which HD games are at least sometimes a viable option, is of particular interest. Within this range, mutual co-operation starts being the least frequent outcome but increases rapidly with increases in v until it becomes substantially the most frequent one; correspondingly, the two outcomes involving defection decrease in their frequency as v increases. Clearly, the increasing attractiveness of HD relative to PD games within this range is promoting co-operation-based outcomes to whatever PD games are joined, while it is also decreasing the incidence of defection-based outcomes.

In brief, this is happening because agents are freed from the necessity of choosing between a PD game that might offer only a low expected value and playing no game at all. If an HD game offers a higher expected value than a PD game, they can take that superior alternative and, quite possibly, win. Thus, as HD games become increasingly attractive throughout this range, agents can become increasingly 'choosy' about those with whom they enter PD games, insisting increasingly on their having a higher assessed probability of

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co-operating before they do enter. Importantly, the increasing viability of the HD option will work disproportionately to advantage those intending co-operation – for whom the payoff from a PD game is, by definition, lower than for those intending defection. With expectations of a protagonist's co-operation constant, those intending co-operation will have a lower expected value from a joined PD game than will those intending defection, meaning that the former will be disproportionately 'protected' from having to enter PD games with unpromising partners by the alternative of playing a HD game.

Within this range at least, therefore, co-operative dispositions are preserved by the viability of the HD alternative, and are increasingly preserved as that alternative becomes increasingly viable. This bears on the extensive literature seeking an explanation for the evolution of co-operation modelled in Prisoner's Dilemma terms, suggesting – perhaps paradoxically – that co-operation's evolution is facilitated by agents' having the option of fighting among themselves, in addition to the classic choice posed (for 'prisoners') between just co-operation and defection.[44]

To the point of the present concern with political intelligence, however, the usefulness of the Hawk–Dove alternative depends critically on agents – both co-operators and defectors – having the capacity to make reasonably accurate assessments of protagonists. If they cannot make good assessments of protagonists' intentions between co-operation and defection, they will not know when to abandon PD play in favour of the HD alternative. And if they cannot make good assessments of protagonists' fighting strength, they will not know when it is worth taking that alternative to PD play.

Of course, the capacity to deceive will be valuable within this range as well. Defectors will gain from persuasion^{PD} to the extent that it helps co-operators believe (wrongly) that they have benign, co-operative intentions, thus to be persuaded to enter exploitative PD play. And defectors will also gain from persuasion^{HD} to the extent that it helps persuade co-operators that the HD alternative is a futile one, and that they are better off with an only modestly promising PD game. In general, the presence of a viable – but not too viable – HD alternative makes all four components of political intelligence particularly valuable, and thus increases selective pressure on all four. But, as can be seen from Figures 3 and 4, within this range selective pressures are stronger on perception (of both kinds) than on persuasion (of both kinds). When PD games are generally most attractive but HD games are attractive enough to be seen sometimes as a better alternative, perceptiveness about another's intentions and fighting abilities is more valuable than is persuasiveness about one's own.[45]

[44] The preceding argument is more fully developed in James Hanley, John Orbell and Tomonori Morikawa, 'Conflict, Interpersonal Assessment, and the Evolution of Cooperation: Simulation Results', in Elinor Ostrom and James Walker, eds, *Trust, Reciprocity, and Gains from Association: Interdisciplinary Lessons from Experimental Research* (New York: Russell Sage Foundation, 2001).

[45] The general advantage of perception^{PD} over persuasion^{PD} may be, in part, a consequence of the fact that the former is unambiguously helpful while the latter is something of a mixed blessing. A unit increase of perception in the context of a PD game will always contribute towards a more accurate

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In summary, therefore, the pattern of political intelligence observed in Figure 2 is a consequence of (1) none of the four capacities being of particular adaptive value when HD games are overwhelmingly more attractive than PD games; and (2) perception^{PD} and persuasion^{PD} being of particular adaptive value when – with PD games more attractive but HD games still *sometimes* a viable option – there is much at stake from making an accurate assessment of which game is best to enter.

Three questions raised by the data remain to be addressed: From Figure 1, what accounts for the failure of populations to survive beyond a few dozen generations when $v < |c|$? From Figure 5, what accounts for the greater incidence of defection-based outcomes to PD games when in the range of v between about 39 and 55? And from Figure 4, what accounts for the 'spike' of perception^{HD} in the v range between about 40 and 55?

The Failure of Populations to Survive when $v \leq 20$

If perception^{PD} were higher among those with strong co-operative dispositions, and if persuasion^{PD} were not particularly strong among those with defecting dispositions, the former would often discover each other and, rejecting the latter as partners, could thrive – and with their wealth-producing co-operative relationships, make it possible for the population as a whole to survive. But there is no basis for expecting this correlation between the two Prisoner's Dilemma information processing attributes and BRC, and no evidence of it in the data. In its absence, intending defectors are just as likely to be successful in their efforts to penetrate protagonists' intentions as are intending co-operators, meaning that the latter are just as likely to play with the former as with others with their own co-operative intentions – and that co-operation will decline as a consequence.[46]

Of course, this logic would also apply to the set of parameters where we have observed strong selection on political intelligence (in the v range between about 22 and 30) if there were no viable HD alternative there, but the presence – or absence – of that alternative makes all the difference. Without it, and without co-operators having an advantage in recognizing others' intentions, co-operators necessarily confront a lower expected value from entering PD games than do defectors (by definition in the Prisoner's Dilemma), making for negative selective pressures on BRC, a consequent increasing probability of players (both

(F'note continued)
assessment of the expected value of entering such a game, while a unit increase of persuasion in the same context could attract the interest of an intending defector, as well as of an intending co-operator.

[46] This does not preclude the existence, in natural situations, of heuristics that do leave intending co-operators more likely to join games with each other than with intending defectors (John Orbell and Robyn Dawes, 'Social Welfare, Cooperators' Advantage and the Option of Not Playing the Game', *American Sociological Review*, 58 (1993), 787–800). The present analysis, however, concerns the possibility of differential success in actually penetrating others' intentions, an issue that is distinct from the possibility of such co-operation-helping rules of thumb.

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co-operators and defectors) entering costly games with defectors – and, through successive generations, the erosion of all individual wealth and, eventually, collapse of the population.[47]

Defection-Based Outcomes to PD Games Between v = 40 and v = 55

As argued earlier, co-operation-based outcomes to PD games become more frequent within the range between $v = 22$ and $v = 39$ because, with a progressively more attractive HD alternative, co-operators can be progressively more 'choosy' about their partners for PD games as v increases, entering only those games that offer an EV higher than the (increasingly high) EV of entering a HD game. Joined PD games require both parties to agree to play, increasing the likelihood that those PD games that are, in fact, joined will be joined among co-operators. But why does the situation suddenly reverse as v moves above 39 and HD games become still *more* attractive?

The answer involves a mirror logic to that by which co-operators are advantaged by their ability to be 'choosy' as v increases through the lower range. Once again, it is a consequence of the defectors' payoff being higher, by definition, in the Prisoner's Dilemma. In brief, when HD game parameters make those games generally more attractive than PD games but when the latter are still *sometimes* a viable alternative, agents will only reject the HD alternative when a PD game appears to offer a better payoff, and that will happen more often for intending defectors – with their higher expectation in PD games – than for intending co-operators. The result of such 'selecting in' of intending defectors is a high incidence of defection-based outcomes, in particular, of mutual defection.

The 'Spike' of Perception^{HD} in the v range between 40 and 55

The explanation for the 'spike' of perception in this higher range of v – thus for the corresponding 'bump' in the aggregate of the four cognitive capacities reported in Figure 2 – is now clear from the logic just presented. When HD game parameters make HD games generally more attractive than PD games but when the latter are still *sometimes* a viable alternative, an increment of perception^{HD} will improve an agent's ability (notably, a defecting agent's ability) to make a value maximizing choice between a HD and a PD game, and thus will be positively selected. Notice that these selective pressures bear most strongly on perception^{HD} because of the frequency with which HD games are played within this range, but that there is some sign of a corresponding 'spike' of perception^{PD} within the same parameter range (Figure 3). Notice also that, as v continues to

[47] This outcome is robust even when starting parameters include a very high BRC, high starting wealth, and high levels of perception^{PD} coupled with low levels of persuasion^{PD}. For a more extensive development of this theme, see James Hanley, 'The Evolution of Cooperation in an Ecology of Diverse Social Games' (doctoral dissertation, University of Oregon, 2000).

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increase these selective pressures on perception^{PD} fairly rapidly fall away. When HD games become such an attractive alternative that PD games are no longer a serious alternative, there is no longer any selective advantage to be had from a cognitive capacity that facilitates choice between the two types of social games.

SUMMARY AND CONCLUSIONS

Simulation is not, of course, a substitute for the direct observation of natural processes which is, and should be, the bottom line of scientific inquiry. But when those processes extend over a few hundred thousand years and leave only very fragmentary objects to observe, and when the complexity of those processes resists formal analysis, simulation can be a useful complement. Simulations also have the great advantage of allowing for systematic experimentation; they can be run many times under varying parameters, allowing the investigator to make informed statements about the consequences of such parametric variation. Such an exercise can provide informed hypotheses about the parameters and processes that underlie outcomes that have been observed in the natural world.

We know from a rapidly developing body of empirical studies that human intelligence is, in substantial part at least, organized around our long-standing hyper-sociality, but even the most sophisticated efforts to derive from the fossil record the social parameters under which our 'political' intelligence evolved[48] run up against the brute fact that social parameters, along with brains themselves, do not fossilize. Granted that we can draw useful inferences from observing the few remaining hunter-gatherer societies as well as social patterns among other highly social primates, the social parameters under which political intelligence evolves remain substantially unspecified. Since specifying them is certainly a problem complex enough to resist formal analysis, it is also a problem appropriately addressed by simulation, and we have taken some initial steps in that direction.

Political intelligence is, doubtless, far more complex and subtle in its cognitive architecture than implied by the four simple information processing 'capacities' we have modelled. Most social animals play a wide range of social games beyond the two, simple co-operative and conflictual games captured by the Prisoner's Dilemma and Hawk–Dove games, and a full model of the social circumstances under which political intelligence evolved would include many other games. Similarly, the need to track relations among multiple other individuals, not to mention the need to take account of multiple levels of intentionality among those individuals, suggests the existence of hugely complex structures for tracking 'political' relations in natural brains.

Nevertheless, studying simple binary encounters in the context of broadly 'co-operative' and 'conflictual' games seems a reasonable place to start, and that

[48] Notably Steven Mithen, *The Prehistory of the Mind: The Cognitive Origins of Art, Religion and Science* (London: Thames & Hudson, 1996).

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is where we have started in this article. Our interest has been in the extent to which, and the manner *by* which, the mechanisms supporting the information demands for such games evolve through many 'generations' in response to systematically varied game parameters. Methodologically, we offered agents the same simple set of social options – play a PD game, play a HD game, or play no game at all – in many different runs of the simulation, while systematically varying the game parameters surrounding those options. This allowed us to observe how selection on four different 'capacities' relevant to agents' making good (namely, adaptive) decisions was influenced by such parametric variation after, potentially, 30,000 generations. While we could have varied such game parameters in several essentially equivalent ways, we chose to hold Prisoner's Dilemma game parameters constant while progressively increasing the value of the Hawk–Dove stake (v) relative to the cost of losing a joined fight ($|c|$). Operationally, therefore, we asked: (1) *To what extent does the aggregate of those four 'capacities' (namely 'political intelligence') evolve under diverse game parameters?* (2) *By what selective process does it evolve under such diverse game parameters?*

After 30,000 generations, 'political intelligence' evolves to its highest levels when game parameters make Prisoner's Dilemma games frequently – but not invariably – more attractive than Hawk–Dove games. Beyond that, as increases in v relative to other game parameters make fighting increasingly attractive (thus more frequently chosen), political intelligence generally declines until, with PD games only rarely more attractive, it has evolved upward only modestly beyond the low values with which the starting population was seeded. By contrast, when v is lower than $|c|$ and the HD alternative is so unattractive that it is seldom if ever chosen, populations die out within a few dozen generations, meaning that any questions about political intelligence's evolution are moot.

Our analysis identifies two reasons for this pattern in the evolution of political intelligence as operationally defined. First, when v is sufficiently high to make HD games substantially the more attractive alternative, there will be few if any selective pressures favouring such intelligence. With PD games vanishingly few, selective pressures on capacities for playing those games well will be weak or non-existent – they will be, that is to say, *irrelevant*. And under those same parameters, mutations favouring capacities for playing HD games well will make no difference to the rationality (namely, adaptiveness) of a 'hawk' choice – they will be, that is to say, *redundant*.

Secondly, when v is low enough to make PD games substantially the more attractive alternative but not so low as to make HD games *always* unattractive, there will be strong, positive selective pressures on capacities that contribute to playing PD games well. Playing with a defector is always costly and playing with a co-operator is always rewarding, making increments in perception^{PD} always adaptive. Similarly, persuading a co-operator to enter a PD game with oneself is always rewarding, making increments in persuasion^{PD} also adaptive – although not *always* so since, without appropriate levels of perception^{PD} sufficient to spot defectors, persuasion^{PD} can get oneself into costly trouble. The

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difference here is that game parameters strongly favouring PD games do not make attributes contributing to good decision making in those games either irrelevant or redundant, as was the case for attributes contributing to good decision making in HD games when game parameters strongly favoured those games. Perceptiveness and persuasiveness are always useful in PD decision making, and when PD games are very frequent, as they are for this range of game parameters, selective pressures on the relevant attributes will be strong enough to push political intelligence to the high levels that we have reported above.

This granted, the question is why such selective pressures are not strong enough to operate when levels of v are sufficiently low to make HD games seldom if ever an attractive alternative. The answer draws attention to the necessity of agents' having a viable alternative to PD games for 'making a living' – such as is provided by HD games in our simulation. When there is no such alternative, defection-inclined agents are just as likely to develop perceptiveness as are co-operation-inclined agents; the capacity to distinguish co-operators from defectors is useful regardless of one's own co-operate vs. defect dispositions. Because defection pays more than co-operation (by definition), this 'equality of perceptiveness' means selection against co-operation – and, eventually, death of the whole population. When there is such a viable alternative, however, perceptive co-operators are more likely than similarly perceptive defectors to abandon unpromising PD games in favour of that alternative, making it possible for co-operation to evolve and for the society itself to survive. In short, positive selection on perception^{PD} is not sufficient to keep a population alive when there is no viable alternative to PD games, but it is sufficient to do so when such an alternative exists – and in our simulation, HD games can, with appropriate parameters, be such a viable alternative.

Are the results of the simulation consistent with what we know about the evolutionary pressures governing political intelligence in other species beyond ourselves? Circumstantial evidence, at least, may be found in the 'restless stability'[49] characteristic of groups of animals that are generally understood to be high in such intelligence. Fighting certainly does happen, and there are numerous, ongoing minor skirmishes. Nevertheless, actual fighting is rare – even in the confined circumstances of captivity where escape is difficult – with most confrontations ending bloodlessly and being followed by strenuous efforts at reconciliation.[50] Such confrontations are, in fact, readily understandable as 'probes' designed to provide individuals with information about others' fighting strength or willingness to fight, consistent with our model. For the most part, relationships among chimpanzees are both peaceable and co-operative –

[49] Frans de Waal, *Chimpanzee Politics: Power and Sex among Apes* (Baltimore, Md: Johns Hopkins University Press, 1982).

[50] F. de Waal, *Peacemaking Among Primates* (Cambridge, Mass.: Harvard University Press, 1989).

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granted there are many well-documented instances of cheating within *potentially* co-operative relationships.[51]

The same can be said of other primate societies, including humans. While our analysis has focused on the adaptive pressures in the ancient social environment, the politics of everyday life that we currently experience in modern, complex, organizationally-based societies is, perhaps, not so different from the environment that, from our simulation-based analysis, appears to have selected them for political intelligence. We do occasionally fight – happily now only seldom with 'tooth and claw' – but for the most part we seem to co-operate quite effectively with each other. That pattern is, we propose, both a consequence of our evolved political intelligence and a modern expression of the same social environment that selected for such political intelligence in the first place.

We know (or believe we do) that among primates humans have unusually high political intelligence, but simulations can only suggest where empirical investigations to understand the origins of that intelligence should be directed. Ours suggests that efforts to understand humans' political intelligence should be directed to understanding the circumstances that, in our environment of evolutionary adaptation, made incentives for co-operative games substantially stronger than those provided for conflictual games, but in which the latter were *sometimes* strong enough to bring group members to blows.

[51] F. B. M. de Waal, 'Deception in the Natural Communication of Chimpanzees', in N. W. Mitchell and N. S. Thomson, eds, *Deception: Perspectives on Human and Nonhuman Deceit* (New York: SUNY Press, 1986), pp. 129–46; Sue Savage-Rumbaugh and Kelly McDonald, 'Deception and Social Manipulation in Symbol-Using Apes', in Byrne and Whiten, eds, *Machiavellian Intelligence*, pp. 224–37; Whiten and Byrne, 'The Manipulation of Attention in Primate Tactical Deception'. We need to remember, however, that an important type of co-operative behaviour among chimpanzees – and, no doubt, among members of other primate societies – involves co-operation whose objective is to successfully compete with some other individual or group of individuals. Such 'alliances' have the form of PD games internally, but of HD games externally.

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