Notes on coordination, game theory and the evolutionary basis of language

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Abstract

It is widely appreciated that establishment and maintenance of coordination are among the key evolutionary promoters and stabilizers of human language. In consequence, it is also generally recognized that game theory is an important tool for studying these phenomena. However, the best known game theoretic applications to date tend to assimilate linguistic communication with signaling. The individualistic philosophical bias in Western social ontology makes signaling seem more challenging than it really is, and thus focuses attention on theoretical problems – for example, coordination on lexical meaning – that actual evolution did not need to solve by improving humans' strategic or social intelligence relative to the endowments of other primates. At the same time, issues of genuine evolutionary significance related to language, especially those around the tensions between individual and collective agency, and around intergenerational accumulation of knowledge, are obscured. This in turn leads to underestimation of the potential contribution that game theory can make to enlightening models of the evolution of human language.

JEL classification

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Introduction

It is regularly said, indeed often taken as a truism, that human language evolved to help solve the coordination problems that arise for an intensely social, highly intelligent species. Acknowledgment of an evolutionary association amongst sociality, intelligence and language allows for a multiplicity of sometimes complementary and sometimes competing hypotheses as to which of these factors were preconditions for selection pressures that favored the others. For example, did unusually intense and complex social pressures, relative to those that affect primates generally, come first in hominid evolution, giving rise to complex coordination problems that higher intelligence and language then evolved to solve? Or, in light of the importance of social norms and conventions for selecting focal points in coordination games, did intelligence generate coordination problems to

which increasingly complex social structures, co-evolving with unusually elaborate capacities for information exchange, are adaptations?

It is not the purpose of this note to attempt to shed new light on these controversies. Its modest objective is instead to add structure and clarity to the idea of 'coordination' as it figures in considerations of the origins and development of language. The modeling technology used to formally study coordination is game theory. This will be understood here – as I urge that it always should be – as a branch of mathematics that can be applied to many empirical phenomena, rather than as a body of substantive empirical hypotheses about agents' behavior. I will distinguish three ways in which the formal theory of games can be used to model functions of language that are relevant to its evolution. This of course does not exclude the possibility of other kinds of applications. The three classes of phenomena I will discuss are (i) signaling and messaging, (ii) team construction and (iii) intergenerational knowledge transmission. All involve more than coordination and cannot be completely modeled by game theory; but game theory models their coordinative aspects.

The note incorporates a philosophical argument to the effect that the most important conceptions of coordination for purposes of framing enlightening hypotheses about language evolution are those that do not incorporate the atomistic and individualistic biases that have characterized mainstream traditions in Western social ontology.

Signaling and messaging

A major preoccupation of the game theory literature in general is *signaling*. This is motivated by the fact that many strategic interactions among agents involve asymmetries of information, that is, possession by some players of knowledge that other players lack. In some of the most extensively explored sets of games, the knowledge in question is of the players' own beliefs and/or preferences. This is important because estimation by players of equilibria depend on their estimation of all other players' utility functions, perceived strategy sets (roughly, the options that players consider), and recursive beliefs (that is, beliefs about what other players believe about other players' beliefs, to indefinite levels of recursive embedding). In many games it is in a player's strategic interest to reveal her private information to others, but this very fact creates credibility problems. For example, if I know I am a competent and suitable candidate for a particular kind of job, I want potential employers to know this; but since employers know that I would want them to believe this about me even if it were false, they will discount my communication of the information unless I can find a way of conveying it that an incompetent candidate could not afford to do. For example, I might *signal* it by taking and passing a difficult course of study, perhaps one that is unrelated to the job task except with respect to the intelligence and diligence it demands. Potential receivers of signals typically have an interest in helping to create conditions for successful transmission, so strategic choices interact – which is why game theory is the necessary technology for modeling signaling. Where successful signaling depends on strategic actions by

two or more players, it involves coordination on the relevant equilibrium vector of strategies. In addition, successful signaling typically facilitates second-order coordination on other choice vectors; for example, you decide to offer me a salary commensurate with my estimated value to your firm, and I decide to accept your offer. Some games lack equilibria in which signals can be successfully sent. The best known example is Akerlof's (1970) 'market for lemons', in which potential buyers of used cars shouldn't believe assurances by sellers that their cars are reliable, so sellers of good cars, knowing that buyers won't be willing to pay for their real value, withhold them from the market.

One standard technology for signaling among human game players is language. Because most linguistic production is inexpensive for most people, however, it is often ineffective in the signaling models that interest game theorists. Indeed, signals that receivers should not believe are standardly referred to as 'cheap talk'. However, this does not exhaust the interest of linguistic signaling to game theorists. The meanings of linguistic signals are 'non-natural', in the sense that the word 'cat' does not resemble cats more than it resembles dogs (or anything else). Thus in cases where the incentives of potential signalers and receivers are closely aligned – for example, you are looking for your lost cat and I would like to help you find it – a coordination game arises with respect to the establishment of common lexical meanings. Suppose we live in a simple world in which there are two kinds of objects, cats and dogs, and we can form two possible sounds to denote them, /k/ /a/ /t/ and /d/ /o/ /g/. Each of us could thus use 'cat' to refer to felines and 'dog' to refer to canines, or vice-versa. We will be able to send successful signals to one another, and thus improve our payoffs in the interaction (you find your cat, and I am glad of it) just in case we both employ the same convention. The game has two equilibria in pure strategies: 'cat' refers to cats and 'dog' refers to dogs for both of us, and 'cat' refers to dogs and 'dog' refers to cats for both of us. It also has a so-called 'babbling equilibrium' (Crawford and Sobel 1982) in which we can't use our little language fragment to send signals: if we each use our two words randomly, neither of us can improve our payoff by switching to non-random denotation. This satisfies the definition of a Nash equilibrium. Choice by independent agents among arbitrary lexical reference codes thus has the character of what game theorists regard as the classic form of a coordination game. If neither of us has external information about word-object links that favors one referential convention over the other, then we each maximize our utility by flipping coins between them. Then we will have a 50% chance of managing to talk successfully about cats and dogs.

Coordination games around lexical reference have been extensively studied by philosophers, economists and ethologists, for different respective reasons. Philosophers, following Lewis (1969), are concerned with the epistemology and metaphysics of reference in its own right. The best known more recent philosophical studies are Skyrms (1996) and Skyrms (2010). Economists (Rubinstein 2000; Austen-Smith & Banks 2000; Dewatripont & Tirole 2005; Kartik 2007) have investigated lexical reference coordinated under different signal cost

conditions as a test-bed for understanding signaling dynamics more generally.[1] Ethologists are motivated by the fact that evolution actually produces stable signaling conventions in groups of related animals; the fountainhead of this vein of investigation was Cheney & Seyfarth's (1990) discovery that vervet monkeys in Kenya coordinate on three conventional alarm calls for their three main kinds of predators, leopards, eagles and pythons. Signaling succeeds in that vervets hearing each type of call generally take the evasive actions appropriate to the kind of predator indicated. A general survey of the animal signaling literature is provided by Maynard Smith and Harper (2004).

All of this work might best be understood, in the present context, as modeling reference coordination among agents who *lack* language. For communities that already share languages, after all, coordinating on new lexical reference relations is smoothly achieved on a continuous basis, since anyone who adopts a deviant convention can readily be corrected. (Exceptions occur with words, such as names of animals, over which specialist communities claim expertise that might be incompletely respected by speakers; scientists sometimes re-name animals to reflect new discoveries about genetic relationships, but the general public often fails to follow as directed.) Such models may be relevant to the evolution of language for an obvious reason, namely that at some point in the past the ancestors of language-using humans did not have language, but almost certainly had signaling systems of the same general kind as used by the vervets. On the other hand, few linguists think that the explanatory problems posed by the evolution of language are helpfully addressed by attention to the much easier problem of explaining the origin of signaling systems (Deacon 1997).

The evolution of coordinated reference is 'easy', by comparison with the problem of explaining the evolution of language, in two respects. First, coordinated reference is observed only in animal groups in which most members have close relatives, and in instances of inter-specific mutualism. In both types of case, inclusive fitness maximization will often straightforwardly imply selective advantages to individuals that participate, as both senders and receivers, in referential conventions. To be sure, non-zero levels of free riding, where some individuals benefit from receiving costly signals but do not send them, may also be indicated; but biologically plausible parameters under which free riding does not drive out truthful signaling are typically not elusive. Second, mechanisms by which groups of neurons in mammal brains can converge on Nash equilibria by estimation of statistical likelihoods based

[1] An innovative but less prominent body of work by Parikh (2001, 2009) seeks to model the pragmatics of linguistic behavior, and thus to cast light on details of language use by speakers, using game theory. I pass over these models here because they do not touch upon the evolutionary origins or development of language, though it is possible that they may at some point be extended to do so, and also because this remains an extremely specialized project that has yet to be rigorously examined by scholars from the discipline that must constitute its primary site of evaluation, linguistics.

on conditioned learning have been identified in theory (Wang 2001, 2002; Schweighofer & Doya 2003) and confirmed in experiments with monkeys (Glimcher 2003; Lee & Wang 2009). Such learning requires no high-level cognitive governance long-range anticipation, or situation-specific modeling; equilibria are tracked by incremental adjustment to local target states through drift diffusion. Thus there is no general reason to believe that coordinated lexical reference depends on high intelligence.

By contrast, and as best emphasized by Deacon (1997), the evolution of language is very difficult to model or even to fathom, since it required some animals to unlearn manifest relationships between representational tokens and specific objects and events, and instead recognize and regulate behavior by reference to abstract relationships among representations themselves. Though we cannot rule out the possibility that elephants, or some species of whales, learn in this symbolic style (as Deacon calls it), what seems more likely is that natural selection brought about this evolutionary transition only once, under circumstances that do not fall naturally out of any well understood model of more general evolutionary dynamics.

The reader may wonder why, if actual animals that lack language can non-mysteriously solve the standard coordination problems underlying shared signal meanings, philosophers and economists have devoted so much effort to identifying solution conditions in the context of sparse models in which the learners are hobbled in biologically unnatural ways. Specifically, agents in such models typically maximize individual rather than inclusive fitness, and no mechanisms are included that, like actual neuronal groups, automatically exploit statistical regularities in large data sets. The answer, already suggested, is that neither the philosophers nor the economists are mainly concerned with actual evolutionary history. The philosophers are interested in discovering necessary and sufficient conditions for unambiguous reference, and the economists are preoccupied by general structural conditions governing the relative stability of signaling equilibria. Nature solves specific material problems, not generalized formal ones.

That said, I suggest that the popularity of very abstract models of the origination and maintenance of reference conventions and signaling equilibria may have had unintended consequences for prevailing ideas, in wider quarters, about what needs to be understand in thinking about language evolution and development as a process serving social coordination. In game theoretic models of reference coordination, players are constructed as having definite information content they aim to signal, and then as having to overcome the problem of making this content socially available. This comports naturally with a classic Western social ontology of preformed fully individual atoms that struggle, only partly successfully, to coalesce socially. It also resonates with the idea, promoted in the philosophies that have been associated with Chomskyan linguistics, that language ontologically proceeds and is merely one of several technologies *used for* communication. Standard game theoretic models encourage interpretation consistent with this logic. Though nothing strictly incorporated into the mathematics entails such interpretations, in

applications players of games are typically taken to be whole individual people. These people are then represented as having relatively stable and relatively coherent preferences, consistent with their beliefs, which are in the first place independent of social contexts. Beliefs are expected to adapt through game play, but against a stable background of preferences. Both preferences and beliefs are understood as internal states about which their holders have private information. This sets up the conditions under which signaling challenges are confronted as coordination problems.

Of course individual people *do* regularly encounter other people in strategic interactions, and sometimes their beliefs and preferences *are* known only to themselves. Indeed, in modern market societies an adult's material and social flourishing requires that she be a competent player of such games. However, Ross (2005, 2011) argues that this is not the basic or paradigm economic problem setting that the standard pedagogy of economics implies[2]; it is a derivative, rather than the foundational, agent ontology of economic analysis. Alternatives to this ontology will be indicated in the next sections of the current note. For the moment, I stress only that two similar ideas are equally empirically implausible: an individual with a language that did not develop under selection pressure for communicative success; and an individual with preferences and beliefs that did not develop under selection pressure for social success. As emphasized by Dennett (1987), so-called intentional attitudes such as beliefs are rationalizations applied by people to their own and to one another's behavior in order to make sense of it within rubrics of socially constructed norms. As emphasized by Deacon (1997), the human brain adapted to the demands of language processing, which in turn allowed for steady growth in linguistic complexity, because among our *H. habilis, H. erectus* and early *H. sapiens* ancestors, being at a comparative communicative disadvantage implied lower Darwinian fitness.

In summary, the study of coordination in the strict sense of identifying stability of signaling equilibria is relevant to the evolution of language only because signaling is a necessary etiological precondition for language. However, neither the neural nor the evolutionary learning involved in signaling are hard problems compared with learning symbolic representation, and game theory should not be expected to contribute to our understanding of the second problem simply by adding structural complexity to models of the first problem.

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[2] This pedagogy is readily defensible in light of the main problems economists are expected to tackle; it causes trouble only when they try to integrate their modeling framework with those of neighboring disciplines. I should add that in my opinion the dominant ontology for pedagogy in psychology fares even worse when transported away from its home base, and is harder to unlearn because it is much less explicit.

Team construction

A second sense of coordination that economists and game theorists study, also connected with the evolution of language, is the recruitment by agents of coalitions to accomplish joint projects. This was the basic original subject matter of modern economics as launched by Adam Smith. In application to the evolutionary trajectory of hominids from *H. habilis* through to modern *H. sapiens* it has recently and insightfully been explored by the economist Haim Ofek (2001). Ofek persuasively argues, based on paleontological evidence and analysis of opportunity costs associated with alternative hunting and gathering strategies, that market exchanges between keepers of fires and those who hunted game crucially co-evolved with the great hominid encephalization, which in turn necessarily co-evolved with language. Ofek's economic analysis thus adds another element to the coevolutionary vector that promoted language evolution. Coordination, in a more generic sense than that discussed above, was at the heart of these processes. Fire keepers could only set up new stations conditional on expectation that enough hunter-gatherers would work a territory to establish sustainable economies of scale, and hunter-gathers could in turn cultivate new foraging grounds only if they could relax two constraints: the need to range within carrying distance of dry kindling, and the unacceptably high risk of being unable to start nightly fires without reliable ignition technology. The relationship between access to fire and the evolution of large brains in hunter-gatherers was not incidental: the resources needed to meet the metabolic demands of encephalization could be recruited only through shrinkage of the complex gut required for digestion of raw food (Wrangam *et al* 1999; Wrangam 2009).

Language may or may not have been essential to these relatively simple market exchange equilibria, revolutionary though they were against the backdrop of primate ecology and social relationships. However, thanks to game-theoretic insights we can identify a stronger sense in which the evolution of markets both depended on language evolution and created conditions that increased selection pressure for its development. Markets are incompatible with generalized warfare and require the establishment and maintenance of temporary, complex coalitions that extend outside groups of close relatives. As argued by Bacharach (2006), modern people stabilize such coalitions by identifying their interests, sometimes permanently but more typically episodically, with corporate entities – bands, teams, ethnicities, religions, firms, countries etc.. This is facilitated by people's disposition to partially frame their agency in collective terms. Team reasoning – assessing alternative outcomes by reference to what is best for 'us', by contrast with what is best for 'me' – can have the effect of turning games with no efficient equilibria, such as Prisoner's Dilemmas, into games with less socially wasteful alternatives (so called Assurance games and, by a second possible transformation, into Hi-lo games with easily reached unique socially optimal solutions). By such transformations of agent identities that in turn change games, players eliminate the conflicts among individual interests that give rise to wasteful social dilemmas.

Such agency and game re-framing appears implausible at best, and downright magical at worst, to economists or game theorists who begin from the atomistic social ontology discussed in the preceding section, since it appears to require people to forget that they can detach their interests from those of their teams whenever an available free-rider's bonus could be taken without attracting detection and retaliatory punishment from the rest of the group. It is a basic methodological principle of economics, and an altogether sound one, that agents do not arbitrarily ignore available information or strategic possibilities that could improve their welfare or that others could exploit against them. However, welfare is defined relative to preferences. The skeptical bias against team reasoning in principle – which is a different thing from caution about accepting a hypothesis that team reasoning is the empirically correct characterization of some specific situation[3] – rests on reversal of evolutionary and developmental figure and ground. Individual preferences are not brought pre-formed into strategic encounters with others; they are instead cultivated and stabilized under social pressure. The processes by which this happens essentially involve language.

As discussed extensively by Ross (2005, 2011), in modern human societies it is obligatory for a person to be able to offer a specific biographical narrative that partly justifies and partly explains her distinctive preferences, beliefs and aptitudes. The normative social insistance on such narratives is both collectively and individually rational, since in their absence no one has any basis for the stable expectations about future comparative advantage, and more specific behavioral choices, that are necessary to support coordinated division of labor. But why and how do narrative biographies about people's *pasts* constitute more than cheap talk with respect to *future* behavior?

The key to understanding this is precisely that the fully-fledged 'individual', constructed by a narrative that draws richly on institutionalized cultural reference points and templates for its internal logic, is a symbolic construct, not a direct product of genetic properties or dispositions that proceed socialization. The complex human brain, decoupled from the direct discipline by environmental reward contingencies that makes other animals into naturally consistent economic agents, will not produce behavior that accords with norms governing consistency of character unless other people support the ongoing effort. They do this in three main

[3] Team reasoning tends to be undermined by many market institutions, precisely those with which economists are most familiar and are most often professionally concerned. It is therefore natural that development of team reasoning models has low priority on the disciplinary agenda. But the evolution of early markets occurred, perhaps necessarily, in the absence of institutions that encourage people to differentiate their own interests from those of their relatives. Markets come to require such institutions once capital formation, over and above mere specialization of labour, is necessary for their expansion; markets tend to grow slowly in traditional societies because social norms oblige successful entrepreneurs to share profits across extended families.

ways: first, they directly sanction, through low-cost social disapproval, actions and declarations that are too difficult to rationalize as emanating from a stable set of standing preferences; second, they allow slack by simply ignoring many out-of-character episodes that don't have serious consequences, which in turn encourages self-narrators to forget the episodes or confabulate away the dissonance they would otherwise generate (Dorris 2002); third, they participate in rituals celebrating approved biographical turning-points, such as graduation, marriage and parenthood, that authorize substantial but communally scripted character change. As Dennett (1991) puts the point, people are principal authors of their self-narratives, but they depend on many readers who are simultaneously co-authors. The resulting mutual dependence commits people, barring exceptional levels of environmental or psychopathological stress, to continuously adapting their preferences for the sake of unified symbolic coherence.

The Western myth of pre-social atomic individuals, based on failure to appreciate the symbolic nature and social governance of biographical narratives, does *not* entail denial of the obvious fact that people have adaptive social identities. However, it tends to accommodate these facts through metaphors of concealment, pretense or acting (Goffman 1959). This framing encourages some game theorists to take successful *detection* of such concealment as the principal problem of social coordination (Frank 1988). Social equilibria can be recognized as less fragile, and (ironically) as closer to the normal bargaining equilibria game theorists routinely identify for corporate agents who are constrained by strong legal and marketplace institutions, once it is acknowledged that symbolic, socially supported, narratively regulated preferences are the basic *real* preferences of people. Of course, all people sometimes engage in duplicity, and some people do so much of the time; but, outside of pathological cases and narrowly episodic deliberate fraud, the duplicity in question involves *fragmenting* inconsistent narratives for different audiences, not hiding a pre-narrated 'true' self behind 'mere' stories.

This capacity for symbolic self-construction is at the heart of the coevolution of language and the brain as related by Deacon (1997). The pressure for such elaborate, dynamic coordination on people's basic identities, he argues, emanated from the peculiar reproductive ecology of the first hunter-gatherers, which in turn required symbolic ritualization of marriages between individuals that implicated whole communities in institutions of promising. According to Donald (1991), the evolution of linguistic narrative found a pre-linguistic platform in mimetic re-enactment of notable events in communal life. However, this must be counted as only proto-narrative by comparison with the symbolic social construction of human selfhood, because without language and full symbolic representation it is not possible to regulate consistency of character by reference to non-existent ideals. As Deacon points out, traces of this ancient history are observed in many modern marriage ceremonies, in which couples pledge to help one another live up to codified standards of virtue and faithfulness, and the witnesses implicitly promise to support the enterprise (not least by refraining from attempts at cuckoldry). Of course, the scope of such symbolic role-assumption and aspiration to personify

social norms extends far beyond marriage rites in modern societies, to take in the entire range of non-trivial human activities, along with no small proportion of the relatively unimportant ones.

As implied above, game theorists are only beginning to develop resources for modeling these kinds of coordination dynamics. Since they are intensely strategic, the potential value of game theorists' contributions is considerable. It is sometimes suggested that the primary barrier to such modeling is the definitional association in the economic theory of choice between agent identity and preferences: the first cannot be allowed to endogenously adapt without unlocking the other. However, this is equally true of narrative self-construction, or so I have contended. I will return the question of how game theory can be used to represent team construction after discussing the third form of coordination that bears on the evolution of language, since, I will suggest, the same formal possibilities arise for both.

Intergenerational knowledge transmission

As Deacon (1997) describes in detail, the coevolution of language and the massive prefrontal cortex that supports it was a ratchet process. Relatively elementary capacity for symbolic communication favored individuals with larger forebrains, which increased symbolic capacities, which increased selection pressure for yet further neural adaptation and yet more extensive symbolic facility. This runaway process gave rise to a second-order coevolutionary dynamic, because as humans manipulated more and more aspects of their world symbolically – that is, by learning to control abstract relationships in addition to, and often instead of, more local and concrete contingencies – they constructed the environment to better fit their own unique niche of comparative advantage. This was a disaster for competing predators, and ultimately for species of hominids others than *H. sapiens*, and it ensured that language would go to fixation in our species, since no human lacking it can cope at all successfully in the new world dominated by ideas rather than by 'material' particulars.

Until very recently, of course, no one generation, or even medium-length sequence of generations, transformed the environment more than incrementally. Humans may be individually cleverer than other animals, but the overwhelming source of their ecological dominance is the fact that their discoveries of new levers of environmental control are not forgotten across generations. Language, allowing one person to pass a new generalization along to another person, was the key to the conservation and consolidation of the species' niche-construction. By this device, language guaranteed its own establishment as the indispensible and universal natural technology of the apex planetary species, at least for long as humans continue to occupy that role.

Since pioneering work by Allais (1947) and Samuelson (1958), economists have modeled cross-generational investment and intergenerational accumulation of wealth as a kind of coordination problem. The original motivation for this was to solve technical problems in representing the function of money, and to relax

implausible assumptions of previous models that made the capital stock in an economy a deterministic function of investment. In older 'overlapping generations' (OLG) models, a central planner typically selected from amongst available equilibria by allocational fiat. In later models that incorporate game theory, equilibria arise endogenously through coordination amongst agents who produce, invest and consume at different times. Along with their centrality in models of growth, OLG models are standard instruments of choice in environmental economics, in which current generations face coordination problems with future ones. To illustrate the logic simply, the incentive of people in generation *x* to avoid depleting non-renewable resources depends partly on how prudent they expect people in each of generations *x*+1, …, *x*+*n* to be.

Economic growth models are replete with assumptions about intergenerational equilibria in knowledge transfer. Mokyr (2004) surveys historical evidence from the period of written records but does not pursue development of a general model. Foray (2006) offers the beginnings of a general account of the spread of knowledge, but his concern is primarily with the effects of incentives on *intra*generational transfer. Thus there is not, at present, a formal account that could be applied to interesting and important questions about how our early human ancestors might have responded to innovations in technology and culture, possibilities for relocation, and linguistic change itself, in light not only of their own opportunities but prospects for their offspring. Economists have the relevant tools for such modeling; what waits upon future research is their co-assembly. The point of such modeling should not be confused with cognitive modeling of the *representation* by individual people of their incentives and alternatives; the distinctive kind of value that economists could bring to the table is generalization of aggregate effects of changes in circumstances on responses at the population level. Thus I am *not* here echoing a familiar call for economics to be furnished with 'cognitive foundations' (Turner 2003). Rather, I forecast and look forward to theoretical development in the opposite direction, which will help us to understand how social pressures in general, and market pressures in particular, constrain and shape the evolution of cognitive dispositions and models.

A particularly important variable on which it would be helpful to gain purchase is information *losses* and *waste* under different evolutionary conditions. As emphasized by Donald (1991) and other theorists of early human evolution, a crucial factor in our ancestors' niche transformation is our unique disposition to copy one another by reference to abstract, symbolic relationships. By mimicking *styles* of behaviour rather than literal routines, scope is created for much more rapid discovery of novel processes and techniques, that does not depend on individual genius or detailed strategic foresight. At the same time, a recent vein of microeconomic experimental literature (Bannerjee 1992; Anderson & Holt 1997; Hung & Plott 2001; Sgroi 2003; Chamley 2004) has explored differences in conditions under which copying produces loss of information at the population level because people find it rational to ignore their private information due to uncertainly about whether others have *superior* such information. Suppose I am considering a

set of possible investments, infer that you evaluated a similar set, and observe that you are flourishing. I may be unable to determine whether your (ex post) wise choice reflected your own copying of someone else, or private information you found. In such circumstances, conditions exist under which my best ex ante response is to ignore contradictory private information that I happen to have and copy you. In that case my information will be lost to the market, and we may all be trapped, at least for awhile, in an inefficient equilibrium. Such so-called information cascades are not merely of abstract interest; in their dynamics we find the origins of asset bubbles and market panics. Much potential value lies in trying to model the drag effects of cascades against the benefits of symbolic mimicry in intergenerational niche construction in early human evolution.

OLG models have the further potential to be used to formally represent the dynamics by which social, symbolic norms recruit relatively more episodically motivated interests into coordinated teams, as discussed in the previous section. An agent encouraged to adapt his or her preferences to suit evolving preferences for certain narratives by others can be usefully thought of as a cultural ancestor to the new agent, with new preferences, who will come to inherit his or her physical and other assets and liabilities (including genes) following adoption of new styles of reasoning and self-representation. Agents can plausibly be presumed to care differentially about such descendents – who are, after all, literally transformations of themselves. Models that represent intrapersonal bargaining dynamics as coordination games among successive stages of a person are becoming increasingly familiar in economic literature on such phenomena as savings behavior and addiction (Ross 2010). For application to human evolution, this idea would need to be transferred to the population scale. OLG modeling is an obvious setting for such technology transference.

Conclusion

It is relatively widely appreciated that establishment and maintenance of coordination are among the key evolutionary promoters and stabilizers of human language. In consequence, it is also widely recognized that game theory is an important tool for studying these phenomena. However, the best known game theoretic applications to date tend to assimilate linguistic communication with signaling. The individualistic philosophical bias in Western social ontology makes signaling seem more challenging than it really is, and thus focuses attention on theoretical problems – for example, coordination on lexical meaning – that actual evolution did not need to solve by improving humans' strategic or social intelligence relative to the endowments of other primates. At the same time, issues of genuine evolutionary significance related to language, especially those around the tensions between individual and collective agency, and around intergenerational accumulation of knowledge, are obscured. This in turn leads to underestimation of the potential contribution that game theory can make enlightening models of the evolution of human language.

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