Convention and the Origins of Ownership

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We examine contemporary game-theoretic accounts of ownership as a convention. New results from dynamic networks complicate matters, suggesting that if ownership is conventional, it should not be as prevalent as it seems to be. In fact, such models reveal a tendency toward antiownership norms. The value of resources may be crucial: low stakes lead to conventional ownership, but ownership norms rarely evolve; high stakes lead to a predominance of ownership at the cost of its conventionality. We argue that conventional ownership norms can originate in nonconventional ways and discuss some philosophical implications.

1. Introduction. A key question we can ask about norms or practices—involving anything from morality and metaphysics to money and manners—is whether, or to what extent, they are conventional. Here we want to focus on ownership and investigate some recent game-theoretic arguments that ownership norms are conventional. Perhaps the most appropriate starting point is Hume's claim about the nature of ownership:

> I observe, that it will be for my interest to leave another in the possession of his goods, provided he will act in the same manner with regard to me. He is sensible of a like interest in the regulation of his conduct. When this common sense of interest is mutually express'd, and is known to both, it produces a suitable resolution and behaviour. And this may properly enough be call'd a convention or agreement betwixt us. . . . Nor is the rule concerning the stability of possession the less deriv'd from human conventions,

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> that it arises gradually, and acquires force by a slow progression, and by our repeated experience of the inconveniences of transgressing it. On the contrary, this experience assures us still more, that the sense of interest has become common to all our fellows, and gives us a confidence of the future regularity of their conduct. (Hume, *Treatise*, 3.2.2.10)

Here Hume articulates a hypothesis about both the origins of ownership norms and their stability. Hume's view has been enormously influential and a guiding idea for game-theoretic analyses of convention. Yet new formal work that investigates games on dynamic networks upends the Humean conventional origins hypothesis. After introducing the game-theoretic approach to convention, we will take a closer look at one particular hypothesis about ownership framed in games of conflict (i.e., hawk-dove, snowdrift, and chicken). The results from dynamic networks show that antiownership behavior emerges more readily than ownership in most cases. This casts the problem of ownership in a new light and prompts a reevaluation of the implicit commitments behind Hume's claims.

We argue that ownership may be ubiquitous simply because resources are valuable and that this jeopardizes the view that ownership is a convention. When resources are less valuable, ownership is conventional, but antiownership norms may be more prevalent than previously thought. We conclude by exploring a model of changing games in which ownership conventions arise in nonconventional ways, which poses challenges for existing game-theoretic definitions of convention.

2. On the Nature of Convention. Lewis (1969) pioneered the use of game theory to analyze conventions. He proposed that conventions are coordination equilibria (a subset of Nash equilibria) of coordination games. In the space of 2×2 symmetric games, coordination games are the subset of games that involve a kind of common interest. We both want to play the same strategy but, in the simplest case, do not care which specific strategy we play. For instance, in the driving game, both (right, right) and (left, left) are equally efficient equilibrium solutions. Players prefer to coordinate on one equilibrium but have no preference between the two. While Lewis provided a groundbreaking approach to convention, game theory offers an array of tools that may be useful for analyzing conventions. We may want to extend the analysis to include other 2×2 games, such as conflict or repeated prisoner's dilemmas. We may want to generalize the equilibrium concept deployed, using correlated equilibria or stochastic stability. Alternatively, we may find game theory too limiting a framework to analyze the rich concept of convention, as some philosophers have argued. These grand concerns are beyond the scope of this article, yet we want to make a conjecture about convention based on the game-theoretic discussions: *conventionality* comes in degrees that vary along at least two dimensions: *stability* and *arbitrariness*.[1]

First, consider stability. The reference to common interest and repeated experience in Hume's proposal can be interpreted using equilibrium concepts from game theory. These involve a commitment to some notion of stability for the equilibria to count as solutions to the game. Deviating from the equilibrium, say playing left when the rest of the population plays right in the driving game, is not rational, nor would an evolutionary or learning dynamic facilitate a departure from the equilibrium. Any deviation would be costly. While Lewis uses coordination equilibria, there are a range of concepts that can work in this role, including correlated equilibria (Aumann 1974; Vanderschraaf 1995), evolutionarily stable strategy (ESS; Maynard Smith 1982), or stochastic stability (Young 1993). Stochastic stability provides an updated version of the Humean idea of common interest: "A convention is a pattern of behavior that is customary, expected, and self-enforcing. Everyone conforms, everyone expects others to conform, and everyone wants to conform given that everyone else conforms" (Young 1993, 57). These different equilibrium concepts have different stability properties for various dynamics. They can, but need not, coincide for some points in particular games.

A second feature that contemporary accounts of convention take to be important involves arbitrariness. A convention should not be the unique solution to some problem. Solutions to games with a dominant strategy or a globally stable attractor should not count as conventional. Playing defect in the one-shot prisoner's dilemma is not a convention. In contrast, both efficient solutions to the driving game work equally well, and which solution a group adopts is largely a matter of historical contingency. Millikan puts this point well: "to be conventional a pattern of behavior need only be handed down from person to person and be such that, should it have a function, it is not the only pattern that might have served that function about as well" (2017, 27–28). With respect to game theory, the degree of arbitrariness is best associated with the severity of the equilibrium selection problem and the comparative efficiency of the equilibria. Solutions to games with many equilibria, say the Nash bargaining game or repeated games, may look more conventional. When games have multiple equilibria that are equally efficient, say driving left versus right or the different signaling systems in Lewis's sender-receiver games (Lewis 1969; Skyrms 2010), they provide the exemplar for game-theoretic conventions. That said, considerable philosophical work will need

1. In the context of linguistic conventions, Simons and Zollman (2019) distinguish three dimensions of conventions that admit of degrees: stability, quality, and availability. Our proposal here is in broad agreement with their approach.

to be done to pin down a more precise account of arbitrariness (Planer and Kalkman 2019; Simons and Zollman 2019).

While it may look like there is a strict trade-off between stability and arbitrariness, the two properties come apart in more complicated games, especially repeated games. Consider two examples. In the repeated prisoner's dilemma there are complicated strategies that can evolve and are stable but not efficient, involving one player engaging in a kind of extortion (Press and Dyson 2012). In the Nash bargaining game, while there may be a large number of Nash equilibria, fair division tends to evolve and be stable, although polymorphic traps with unequal division are still possible and occasionally evolve (Skyrms 1996). Finally, dynamical approaches to games generally reveal important behavior related to stability that can be hard to classify (Huttegger and Zollman 2012).

O'Connor (2019) proposes a measure of conventionality that is based on the basins of attraction for the relevant equilibria in standard evolutionary models. This is a promising idea that combines both our dimensions, but it has some potential problems when extended beyond games of pure coordination. First, in situations with an infinite number of equilibria, such as indefinitely repeated games or games with Lyapunov stable sets of equilibria (e.g., the partial pooling equilibria in signaling games), it is not clear how this measure would apply. Second, in many cases the mean payoff of an equilibrium relates directly to its basin of attraction, but there are some cases when it does not (e.g., some versions of the stag hunt). These concerns suggest that how likely a norm is to evolve is distinct from its arbitrariness (or, as Millikan puts it, whether it functions about as well as alternatives). This distinction will become important when we examine the possibility of conventions with nonconventional origins.

Beyond a commitment to the importance of both stability and arbitrariness, we want to remain flexible about the exact nature of conventions and whether game theory is the right analytical tool. There is a case to be made that a suitable philosophical account of human conventions may outstrip the resources of game theory (Gilbert 1989; Amadae 2011). This may be, but game theory provides a way to make precise certain claims about convention, and we will use it here. However, because of the idealizations inherent in game theory, how the framework gets applied to particular problems will dictate which equilibrium concepts or dynamics are appropriate for analyzing whether some solution counts as conventional. With respect to ownership, we will follow the consensus in the field and focus on games of conflict, evolutionary dynamics, and correlated equilibria.

3. The Skyrms–Maynard Smith Hypothesis. Desirable resources, especially resources that cannot be divided, create the potential for conflict. Conflict tends to be costly, and one crucial role for effective social contracts is to

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TABLE 1. Normal Game of Conflict

	Hawk	Dove
Hawk	f	w
Dove	l	t

Note.—Fight = f; lose = l; tie = t; win = w; $w > t > l > f$. Hawk-dove, snowdrift, and chicken are common instantiations of a game of conflict.

help us avoid conflict. Hume's hypothesis, in part, is that ownership is a convention for settling disputes and avoiding conflicts. We follow the convention because it is in our best interest given everyone conforms to the same rule. Transgressing the rule involves "inconveniences." The classic hawk-dove game of conflict provides a way to model Hume's hypothesis. The hawk-dove game can also be used to model conflict in animal behavior, and thus it provides a way to investigate whether conventions to avoid conflict can emerge in animal populations more generally (Stephens and Heinen 2018). Hawk-dove is a 2×2 game in which each player simultaneous plays either an aggressive hawk or deferential dove strategy when engaged in a conflict over some resource or territory. The normal form is given in table 1.

There is one ESS for a game of conflict: a mixed Nash equilibrium strategy that randomizes between hawk and dove. Let x be the probability of playing hawk (or, the proportion of hawks in the population) and the outcomes be utilities or fitness payoffs that respect the strict ordering for games of conflict. The equilibrium is then:

$$x = \frac{w - t}{w - t + l - f}, \qquad (1)$$

where f is fight, l is lose, t is tie, and w is win. Evolutionary dynamics generally push populations toward the mixed Nash.[2] The concern about the Nash solution is that conflict still occurs with appreciable frequency; interactions end in a fight with probability x^2 in random mixing cases. A correlated equilibrium (CE)—achieved by both players correlating their strategies on an external cue such as a coin toss—can do significantly better. Vanderschraaf (1995) argues that these are essential to the concept of convention.

When considering the case of animal conflict, specifically territoriality, Maynard Smith (1982) showed that a strategy that plays hawk at home and dove away can invade a population at the mixed Nash equilibrium. By correlating on the role—visitor or owner—animals could resolve conflicts without risking a fight by effectively taking turns claiming the resource or holding

2. Note that there are different ways for populations to instantiate the Nash, and these can have dynamical consequences (Bergstrom and Godfrey-Smith 1998). For simplicity we will set this issue aside.

the territory. This bourgeois strategy comprises a CE and is an ESS. There is another correlated strategy in this case. The paradoxical strategy represents the antiownership behavior of playing hawk when visitor and dove when owner. The existence of this alternative strategy makes the bourgeois solution conventional. The paradoxical strategy is just as effective as the bourgeois strategy. Given the symmetry the key question then becomes: Why is ownership (territoriality) so prevalent in nature and antiownership so rare? This relates to a general tension with explaining the origins of conventions. Since conventions are understood to be arbitrary in some way, we must explain why the alternatives did not come about. Simply because there are equally efficient alternatives does not mean each is equally likely to arise.

Maynard Smith argued that territory holders have an advantage in fights and that this advantage is responsible for the prevalence of bourgeois over paradoxical behavior. It may also be the case that it is worse to lose fights in your own territory than elsewhere. To represent this, we can introduce a resource-holder advantage a that corresponds to a benefit to the holder in fights and a cost to the holder in lost contests (see table 2). Note that if $2a > l - f$ then hawk becomes a dominant strategy for the current territory holder, the paradoxical strategy is no longer viable, and the bourgeois solution becomes the unique ESS. However, if this is why ownership is so prevalent, it also means that ownership is not conventional: ownership evolves because holding territory is sufficiently valuable.

Skyrms refines and generalizes the Maynard Smith argument: ownership is indeed conventional, but its predominance is generated by relatively small advantages breaking the symmetry between the two conventional solutions: "If the correlated equilibrium arises from a random fluctuation in mutation or learning breaking symmetry of the uncorrelated mixed equilibrium in hawk-dove, then a small increment in the value of the resource or fighting ability of the owner will make a very large difference in favor of the population going to the bourgeois equilibrium rather than the paradoxical one" (Skyrms 1996, 79). This view is plausible but difficult to assess without more detailed models, and there are many ways these could be developed. We suspect that

TABLE 2. Modified Game of Conflict

	Hawk	Dove
Hawk	$f + a, f$	w, l
Dove	$l - a, w$	t, t

Note.—The row-player is the holder of the resource or territory, and the column-player is the visitor. Fight = f; lose = l; tie = t; win = w; $w > t > l > f$; a represents the added stake for the current holder of the territory, yielding an advantage in fights and an extra cost if losing contests.

Skyrms's suggestion is true in some models but not in others. Below we focus on two: (i) a model of learners in dynamic networks and (ii) a model of evolution in a changing game. In both cases we find that the conventionality of ownership is, in some ways, at odds with its seeming predominance.

4. Games of Conflict in Dynamic Networks. Foley et al. (2018) model the evolution of convention in the form of correlated equilibria on dynamic networks. This model was designed to explore Skyrms's suggestion that relatively small differences in efficiency of conventions may cause learners to converge on the bourgeois solution. In this model there were a finite number of agents playing the hawk-dove game against one another for many rounds. In each round, agents first chose whom to visit and then chose a strategy based on their role (host or visitor). Learning occurred by Roth-Erev reinforcement (Roth and Erev 1995), which was applied to choice of both whom to visit and what strategy to play in each role. To ensure that any ownership norms would be purely conventional, losses in contests were limited to lower payoffs in the game and nothing else. In particular, losses were not catastrophic—they did not result in eviction from a territory, death, or some other negative consequence not represented in the game payoffs.

If individuals cannot learn whom to visit, the paradoxical and bourgeois strategies emerge with equal proportions. If the payoffs are biased, the convention favored tends to emerge more frequently but roughly in proportion to the degree of bias. However, including dynamic network learning has a dramatic effect on the evolution of conventions: learners reliably converge on the paradoxical strategy. This result was robust with respect to small and moderate differences in the payoff structure, different population sizes, error rates, discount rates, and initial conditions. The paradoxical strategy was far more prevalent than the bourgeois strategy in the vast majority of cases considered.[3]

The reason learners tend to find the paradoxical equilibrium is that individuals who tend to play dove when hosting will attract more visitors. Those visitors then tend to learn to play hawk when visiting. And, since most visitors learn to play hawk, hosts tend to learn to play dove. This effect persists even when payoffs are biased in favor of the bourgeois solution. The bourgeois strategy does not become the expected outcome of evolution until significant biases in payoffs or in initial conditions are introduced.

In light of these modeling results, we advance two arguments. First, that paradoxical behavior is not as uncommon or paradoxical as it seems—that there are cases in which it is and ought to be expected. Second, that even if the prevalence of the bourgeois strategy is an effect of a previous exceedingly

3. For an interactive presentation of the full simulation results, see http://www.ccs.neu.edu/home/criedl/conflict-convention/.

high value of holding territory (i.e., an extreme payoff bias) this does not preclude the possibility that it is currently conventional.

5. On the Paradoxical Strategy. Territoriality and ownership-like behavior are very common in nature, yet there are some cases of antiownership. Burgess describes the paradoxical behavior of *Oecobius civitas*:

> The spiders' behavior features a curious combination of tolerance and avoidance. On the underside of the rock that shelters the spiders each individual weaves a small open-ended tube of silk that is its hiding place; around this retreat the spider constructs a thin, encircling alarm-system net close to the surface of the rock. The pair of structures makes up the spider's web, which is generally found in a hollow or a crevice of the rock. If a spider is disturbed and driven out of its retreat, it darts across the rock and, in the absence of a vacant crevice to hide in, may seek refuge in the hiding place of another spider of the same species. If the other spider is in residence when the intruder enters, it does not attack but darts out and seeks a new refuge of its own. Thus once the first spider is disturbed the process of sequential displacement from web to web may continue for several seconds, often causing a majority of the spiders in the aggregation to shift from their home refuge to an alien one. (1976, 105)

Note that in this case, the loss of a spider's web is not exceedingly costly, nor is there an obvious advantage to the web owner in conflicts. Webs are also relatively easy to replace, making this a low-stakes scenario.

The cyclical pattern brought about by the paradoxical strategy occurs in humans as well, obviously much more adept learners, but with higher stakes. Weatherford (2005) describes how Mongolian herding groups (before the Mongolian Empire) typically responded to incoming raiders: "at first sign of attack, the targeted victims usually fled, leaving behind most of their animals, the material goods of their homes and whatever else the attackers might want. Since the object of the attack was to secure goods, the attackers usually looted the gers and rounded up the animals rather than pursuing the fleeing people. Because the raiders wanted goods, casualties in this type of struggle remained low. . . . The men of fighting age usually fled first" (16). Weatherford goes on to describe how these groups would then reorganize and start making plans for a counterattack, saying that "for the Mongols, fighting functioned as more of a cyclical system of raiding" (17). It seems that the norm of abandoning one's possessions to raiders and then planning a raid in response was well established in Mongol culture.

The Mongol and spider cases are striking but by no means the most familiar example of so-called paradoxical behavior. Hospitality norms in many cultures establish that hosts ought to be generous and deferential toward their guests. "Make yourself at home" and "What's mine is yours" are well known phrases expressing such antiownership norms. Parents go to great lengths to teach their children to share their toys with visiting friends, working against the consternation it can cause. If there is a difference of opinion about something, or both the host and the guest want the last cupcake, it is the host who is expected to defer. For most of us this behavior is normal and expected; seeing the opposite would strike us as strange or unusual. It seems that when resources are plentiful and "losing" conflicts is low stakes, "paradoxical" behavior is not so paradoxical.

6. Ownership in a Changing World. Even if we are correct that paradoxical behavior may be more common than supposed in humans, the model from Foley et al. (2018) has some important limitations with respect to understanding the origins of ownership. It assumes agents are capable of reinforcement learning in several ways, which may not respect the idea that ownership behavior probably has deep biological roots given the ubiquity of territoriality in nature. It also assumes a stable strategic game, which is a significant idealization. Both of these limitations can be addressed by considering a model with a clear biological interpretation that also allows for a changing environment. Such a model shows that ownership norms may predominate because they originate in nonconventional ways.

Suppose we have an infinite population of randomly mixing individuals who are paired to play the hawk-dove game with positional (host vs. visitor) awareness. There are four possible strategies that may be employed: hawk no matter the position, dove no matter the position, the bourgeois strategy, and the paradoxical strategy.[4] In this situation, evolution in the replicator dynamics will invariably lead to either the paradoxical or the bourgeois solution with equal probability. This is also the case if we include mutation in the dynamics.

If we consider the modified game in table 2, we see that the paradoxical strategy occasionally evolves provided $2a < l - f$. In general, the proportion of bourgeois outcomes increases as a increases over time. Increasing a increases the efficiency of the bourgeois solution and thereby increases the size of the basin of attraction and makes it a less contingent outcome of evolution, although arguably at the cost of its conventionality. Interestingly, if we initialize the population at the mixed-strategy Nash equilibrium point (condition 1), and mutation introduces equal proportions of bourgeois and paradoxical strategies, then any value of $a > 0$ invariably leads to the bourgeois solution, exactly as Skyrms (1996) suggested. However, this result is

4. Beyond mixed populations, we do not explicitly consider individuals with mixed strategies in this model since previous work has shown that mixed strategies are easily outperformed by correlated strategies (Skyrms 1996; Foley et al. 2018).

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not robust if the correlated strategies are introduced at different rates or as a result of a stochastic perturbation of the population.

To further develop the model, suppose individuals play multiple games. Sometimes they face a game with a significant a-value and other times not. Let p represent the probability that individuals are faced with the symmetric game ($a = 0$), and $1 - p$ represent the probability that individuals play an asymmetric game biased toward hosts ($a > 0$). The results are as one would expect: high p generates results more in line with the symmetric case, and low p increases the effect of any asymmetry generated by including a (see fig. 1).

Whether the bourgeois solution counts as conventional depends on whether the paradoxical solution is a viable equilibrium. This occurs when

$$l - f \geq (1 - p)2a. \tag{2}$$

We can elaborate the model further. In more realistic evolutionary scenarios, the game itself may change over time (Smead 2014). As the environment changes, resources can be more or less important. Holding territory may be crucial in harsh environments but unnecessary in lush environments. To

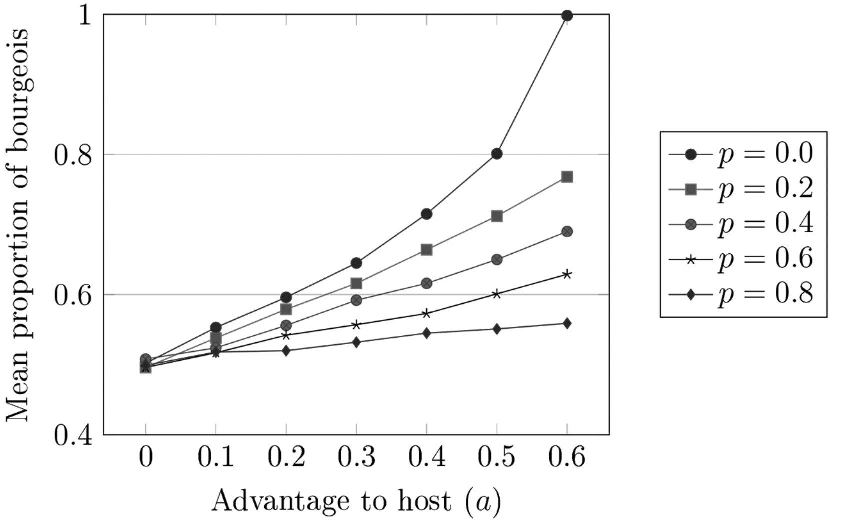

Figure 1. Mean proportion of bourgeois in each simulated population as a function of asymmetric advantage to aggressive host behavior (a) and probability of playing a the symmetric hawk-dove game (p), with 10,000 runs for each data point, random initial conditions from a uniform distribution, and 100,000 gens max. Parameter values: $f = 0, l = 1, w = 5, t = 2, \mu = 0.0001$. Simulations written in C using the discrete-time replicator dynamics with mutation (Weibull 1995). Mutation is weighted equally among strategies. Color version available as an online enhancement.

represent possible changes in this regard, we can imagine that p changes from generation to generation. We will use the following rule: draw a random variable r from a uniform distribution in $[-0.005, +0.005]$, and set $p^{t+1} = p^t + r$ provided it is in [0, 1] and to the nearest value in [0, 1] otherwise. This allows the game to gradually change via a random walk over time. In this case, every one of 1,000 simulations resulted with the predominance of the bourgeois strategy within 1 million generations. This is despite the fact that, in 83.1% of these simulations, the bourgeois solution had some degree of conventionality given the value of p at the end of the simulation. If we look at the average game (mean Bayesian game over time), the bourgeois solution is also conventional. In other words, ownership was conventional in most cases even though the alternative convention never evolved.

The size of the change increments could be altered without substantially affecting the qualitative results. Further, the game need not change randomly but could change in a periodic pattern (e.g., seasonal change) or be dependent on the proportion of strategies being played by individuals. For our purposes, as long as the game will occasionally go through periods where condition 2 is not satisfied, then the bourgeois solution will invariably evolve even if the game then changes to a state in which it is not the only solution. This shows that it is possible for certain conventions to have nonconventional origins. If this is the case with respect to ownership and territoriality, it would explain both their seemingly conventional nature as well as their ubiquity.

So, when ownership evolves in this model, is it conventional? This depends on what we take the underlying game to be. Should we only consider the current game being played? Perhaps it is the game in which the behavior originated? Or perhaps it is the mean game in some time frame? Given the dynamic nature of the world, these are crucial questions for any account of convention. Existing game-theoretic accounts, which focus only on stable strategic scenarios, are largely silent on the matter.[5]

7. Conclusion. By deploying correlated equilibria in the hawk-dove game, Maynard Smith and Skyrms identified a puzzle: Given the symmetry between bourgeois and paradoxical equilibria, why is the paradoxical strategy so rare in nature? Their analysis revealed multiple, equally efficient equilibria, the supposed hallmark of a strategic scenario with conventional solutions. Yet it seemed that one of the conventions rarely, if ever, evolved. Their proposed solution involved a bias toward playing hawk at home that would break the symmetry in favor of bourgeois. Yet the dynamic network model shows that a small bias will not lead to ownership when individuals can decide whom to visit, a natural dynamic for representing territory disputes. Instead,

5. Note that Lewis (1969) seems to adopt a here-and-now standard for the relevant game (44), which implies that a given norm may be conventional one day and not the next.

we see mostly the paradoxical host-guest convention evolving, even in cases when there is a bias toward playing hawk at home.

We observe a preponderance of ownership behavior in animal systems and in many human cases. This may be because most cases start within the basin of attraction of the bourgeois solution (as Skyrms suggested). However, there is an alternative explanation. In many cases resources are valuable, and holding onto them matters for success (reproductive or otherwise). When resources are sufficiently valuable, ownership norms should not have conventional origins—otherwise there would be no advantages to theft over honest toil. We may stabilize ownership norms, and avoid conflict over owned resources, by adopting conventions to resolve conflicts in favor of owners or conventionally extending ownership norms to cover new scenarios. In contrast, when resources are not sufficiently valuable, both ownership and host-guest conventions can emerge and be stable. On this view, it is unsurprising that we see both patterns of behavior in humans: guests are welcome to help themselves to your last piece of cake but not to your credit card.

Furthermore, our changing-game model of the origins of ownership reveals that it is possible for ownership to emerge invariably when it is nonconventional and then later become conventional. This possibility raises questions about how we identify the relevant game being played for classifying something as conventional. How does the current game relate to earlier (different) interactions that are responsible for establishing the relevant behavior? Does the origin of a norm matter for determining its "conventionality" or only the current state of the world? Addressing these questions will be necessary for a complete account of convention.

What of Hume? We suspect Hume was half right. The stability of ownership may be due to conventions, and ownership may be used as the cue to reach a CE in games of conflict, but the ownership norms themselves probably do not have conventional origins. Rather, hospitality norms have a much better claim to conventional origins.

REFERENCES

Amadae, S. M. 2011. "Normativity and Instrumentalism in David Lewis." *History of European Ideas* 37:325–35.

Aumann, R. 1974. "Subjectivity and Correlation in Randomized Strategies." *Journal of Mathematical Economics* 1:67–96.

Bergstrom, C. T., and P. Godfrey-Smith. 1998. "On the Evolution of Behavioral Heterogeneity in Individuals and Populations." *Biology and Philosophy* 13:205–31.

Burgess, J. W. 1976. "Social Spiders." *Scientific American* 234:99–106.

Foley, M., P. Forber, R. Smead, and C. Reidl. 2018. "Conflict and Convention in Dynamic Networks." *Royal Society Interface* 15:20170835.

Gilbert, M. 1989. *On Social Facts*. London: Routledge.

Huttegger, S. M., and K. J. S. Zollman. 2012. "The Limits of ESS Methodology." In *Evolution and Rationality: Decisions, Cooperation and Strategic Behavior*, ed. S. Okasha and K. Binmore. Cambridge: Cambridge University Press.

Lewis, D. 1969. *Convention*. Cambridge, MA: Harvard University Press.
Maynard Smith, J. 1982. *Evolution and the Theory of Games*. Cambridge: Cambridge University Press.
Millikan, R. 2017. *Beyond Concepts: Unicepts, Language, and Natural Information*. Oxford: Oxford University Press.
O'Connor, C. 2019. *The Origins of Unfairness: Social Categories and Cultural Evolution*. Oxford: Oxford University Press.
Planer, R. J., and D. Kalkman. 2019. "Arbitrary Signals and Cognitive Complexity." *British Journal for the Philosophy of Science* 19:1–26.
Press, W. H., and F. J. Dyson. 2012. "Iterated Prisoner's Dilemma Contains Strategies That Dominate Any Evolutionary Opponent." *Proceedings of the National Academy of Sciences* 109 (26): 10409–13.
Roth, A., and I. Erev. 1995. "Learning in Extensive Form Games: Experimental Data and Simple Dynamical Models in the Intermediate Term." *Games and Economic Behavior* 8:164–212.
Simons, M., and K. J. S. Zollman. 2019. "Natural Conventions and Indirect Speech Acts." *Philosophers' Imprint* 19:1–26.
Skyrms, B. 1996. *Evolution of the Social Contract*. Cambridge: Cambridge University Press.
———. 2010. *Signals: Evolution, Learning, and the Flow of Information*. Oxford: Oxford University Press.
Smead, R. 2014. "Evolving Games and the Social Contract." In *Complexity and the Human Experience: Modeling Complexity in the Humanities and Social Sciences*, ed. P. A. Youngman and M. Hadzikadic, 61–80. Boca Raton, FL: CRC.
Stephens, D. W., and V. K. Heinen. 2018. "Modeling Nonhuman Conventions: The Behavioral Ecology of Arbitrary Action." *Behavioral Ecology* 29:598–608.
Vanderschraaf, P. 1995. "Convention as Correlated Equilibrium." *Erkenntnis* 42:65–87.
Weatherford, J. 2005. *Genghis Khan and the Making of the Modern World*. New York: Broadway.
Weibull, J. W. 1995. *Evolutionary Game Theory*. Cambridge, MA: MIT Press.
Young, H. P. 1993. "The Evolution of Convention." *Econometrica* 61:57–81.