4

The Evolution of Gender

In almost every society men are responsible for hunting big game (as mentioned in Chapter 2). In almost every society, women provide the majority of the infant care. And when it comes to rope-making, while labor is usually divided by gender, there is no strong pattern determining which gender will do the job.

This chapter will do two things. The first is to use the evolutionary framework we have developed to explain this particular feature of the gendered division of labor—that some aspects of it seem conventional, and others less so. In Chapter 1, I argued that conventionality comes in shades of gray. Along these lines, we will see here that cultural evolutionary processes are more or less variable. Some coordination outcomes are almost guaranteed to emerge, while others are more truly conventional in the sense that they really could have been otherwise. Gendered division of labor is a case where we see the full range of conventionality—some jobs are almost guaranteed to end up performed by one gender or the other, and for others their assignment is better explained by appeal to chance. This discussion contributes to debates on the innateness of gender roles by showing that even when patterns of division of labor seem enduring and fixed, and even when these patterns show cross-cultural regularity, we should understand them as nonetheless conventional, at least to some degree.

The second thing I will do in this chapter is, again, address an explanandum for social science via evolutionary modeling. Chimpanzees do not have genders, so somewhere between our most recent common ancestor and now this categorical distinction emerged in human groups.[1]

[1] To be clear, chimpanzees have some sex differences in behavior, but they do not have culturally learned behaviors and roles for males and females.

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Not only that, it has emerged in every human group. The question is—why? What is it about gender that makes its cultural emergence completely dependable? The answer can't simply be that gender is innate, again, because of massive cross-cultural variability. Some social scientists have argued not just that gender facilitates division of labor, but that gender itself *exists* in order to divide labor (Lorber, 1994). Could the efficiencies associated with using social categories to solve coordination problems themselves lead categories to evolve? We will look at a model that provides a how-possibly story for this sort of evolution.

I will start the chapter by describing a measure intended to capture conventionality. In particular, I'll illustrate how for any evolutionary model we can generate a number that represents how conventional the outcomes of that model are. This will give us a way to grasp the difference between coordination problems where one outcome is highly likely, and those where things are more uncertain, and, in doing so, develop a representation of what is happening in different cases of gendered division of labor. We'll then move on to the second part of the chapter and look at how the efficiencies of dividing labor might lead to something like gender itself evolving. As we'll see, this process again occurs dependably under relatively bare preconditions. For any group faced with a complementary coordination problem, and where there is some underlying visible tag to attach a category to, categories can emerge spontaneously.

4.1 Conventionality and Basins of Attraction

A basin of attraction for an evolutionary model, remember, is the set of population states that end up at some particular equilibrium. In the last chapter, we saw that for a group with two types playing the dancing game, there were two basins of attraction—one for the equilibrium where women stepped forward, and the other for the equilibrium where men stepped forward—and these were of equal size.

Now, let's use this concept to return to a topic raised in Chapter 1—how to measure which sorts of coordination problems have a more conventional character. According to Skyrms (2004), "A convention is typically an equilibrium in an interaction which admits many different equilibria. That is what makes conventions conventional. An alternative equilibrium might have done as well" (51). As discussed, this is a typical requirement for conventionality—things could have been otherwise. But there are many games where it is the case that there exist multiple equilibria, and any of them might do, but some of these will do *better* than the others. Conventions do not come in black and white, but in shades of gray between those that are more arbitrary and those that are less arbitrary (or more and less conventional). In recent work focusing on linguistic conventions, Simons and Zollman (2018) make a similar point. They use game theoretic models to show that some conventions will be less arbitrary in that they provide better payoffs, are harder to disrupt, or are more likely to emerge in the first place.

I will here use the sizes of basins of attraction for a model to create a measure for conventionality based on this last idea. In some games, as mentioned, basins of attraction for different outcomes will be of more or less identical size, meaning that in evolutionary settings, with no information about a population starting place, it is equally likely that either outcome arises. In such a case, it seems appropriate to think of the outcomes as highly conventional. There aren't reasons, besides differences in initial conditions, or vagaries of chance, for one outcome versus the other to arise. For this reason, a successful explanation of the emergence of such a solution will often draw on chance occurrences. We always listen to Bach instead of Stravinsky because that is what was playing when we first met. Or my mother gave me Settlers of Catan for Christmas ten years back, and that is why we always play Settlers on Sundays.

In other models, the basin of attraction for one outcome will be significantly larger than that for the other(s). In such a case, outcomes of the evolutionary process often seem more functional in the sense that one can typically give a functional explanation for their emergence based on the underlying scenario. Jim does the cooking and Cailin does the cleaning because Jim never "remembers" to clean anything and Cailin mostly cooks root vegetables.

One might further wish to say that in cases where there are many possible outcomes for an evolutionary process, the outcomes of the model are more conventional than for one with just a few outcomes. (Though it is perhaps stranger to say that the outcomes in a model with fewer equilibria are more "functional".)[2] Millikan (2005), for example,

[2] Thanks to Mike Schneider and Hannah Rubin for this point.

describes conventions as patterns of behavior that would be unlikely to emerge a second time. In cases with many equilibria, the preponderance of possibilities may mean that the outcome is less predictable and depends more on chance differences or initial conditions. To illustrate this, compare the coordination problem of which side of the road to drive on with the problem of what word to use to refer to a fork. These are both classic examples of conventional solutions to coordination problems. In the first case, though, there are only two possible solutions, while in the second the number of solutions is extremely large.

One possible way to measure conventionality versus functionality, capturing both the differences between games with many and fewer equilibria, and the differences between games with basins of attraction of different sizes, is to use the Shannon entropy measure (Shannon, 2001). This formula calculates, for a channel transmitting information and a receiver, the expected value of information contained in a message. The equation for Shannon entropy is:

$$H(x) = \sum_i P(x_i)I(x_i) \tag{1}$$

$H(x)$ is entropy. It is equal to the sum, over all possible messages, i, that might arrive via a channel, of the probabilities of each message ($P(x_i)$) multiplied by the information contained in the message ($I(x_i)$). $I(x_i)$ is calculated as $-log_2 P(x_i)$ meaning that information from an observed message is very high if the probability of the message is low, and reaches 0 as the probability of the message reaches 1. We can think of the amount of information in a message as corresponding to how surprised one would be to receive it. Holding other aspects fixed, this measure will be larger if there are more possible messages and if they are closer to equiprobable.

This may seem like a strange measure to use in our case, but here conventionality can be thought of as measuring the level of how unsure one is about what the outcome of an evolutionary process will be (absent other information), and so the amount of information one expects to receive upon learning what the outcome is. Conventional problems are ones where there is more uncertainty about what will happen—where things might really be otherwise. To be clear, the entries to the entropy formula indexed by i are now basins of attraction for a model and $P(x_i)$ refers to the size of the basin of attraction (how likely this outcome is).[3] Holding other aspects fixed, coordination problems with more possible outcomes will be more conventional on this scale, as will problems where the basins of attraction are more equal in size. Of course, this measure can be applied to any evolutionary model where there are multiple basins of attraction. Perhaps for some of these it might be strange to call them conventional at all. I do not claim that any possible application of this measure will make sense, but rather that for coordination games it is a good way to capture the level of conventionality.

One might point out that even in conventional type models, there will be situations where we know quite a lot about the initial conditions of a situation. In explaining outcomes, then, one will appeal not to chance, but to pre-existing features of a population—it contains a lot of bigots, or people here mostly drove on the left side of the road before, or this population evolved from one that already had this feature.

For a good example, consider the emergence of coordination behavior in a small company that employs both men and women, where interactions are well modeled by hawk–dove. We expect that the group evolves to a convention so that when men and women meet, either women get more, or men get more. We also know that the members of this company come from a larger population where, say, 80 percent of people adhere to a general convention where women get more. As a result, we expect that this group of people is likely to come to adhere to this norm as well. But, of course, there is some probability that each of them does not and so we aren't sure how they will establish their own conventions. In calculating the conventionality of solutions to this problem, one might want to use chances of the initial starting place of the population's being in each basin of attraction as inputs to the measure described above, rather than the objective sizes of the basins of attraction. If you think there is a 90% chance that the population is in one basin and 10% that it is in the other, the measure yields a value of .469, in contrast to a value of 1 for two basins

[3] There are some strange features of this measurement. Consider a model where the basins of attraction measure 99% and 1% of the state space. Now imagine breaking the 1% area into ever smaller divisions. This process will make the conventionality of a model arbitrarily high, though it is still very likely that the 99% equilibrium will emerge. Thanks to Nikhil Addleman for pointing out this case. Justin Bruner suggests that in a stag hunt with many stag options there could be a high level of conventionality despite a large basin of attraction for the arguably unconventional hare hunting outcome. And thanks to Agnes Bolinska for inspiring this entire discussion.

of attraction of size .5. In general, we can add a probability distribution over potential population starting points to tackle cases like these.

In the next section, we will put this measure to work for the case of gendered division of labor.

4.2 Asymmetry and Division of Labor

Part of the story that our evolutionary models tell us is that division of labor by gender is conventional. This means that a good answer to the question, "why do men, but not women, weave nets in this society?", may not involve anything about innate differences between men and women, or about special ecological circumstances. Instead the story may have to appeal to chance. Remember, though, that data on the division of labor by gender reveals a range of patterns from what looks like complete conventionality (cross-culturally men and women are equally likely to perform a particular job) to complete functionality (men almost always perform a particular job cross-culturally, or else women do).

As I will argue, we can appeal to the understanding of conventionality just elaborated to better understand these patterns. For some jobs, there is little functional advantage in having either men or women perform them (though there is still advantage to be gained from dividing the job). For some jobs, there is great functional advantage for one gender because of sexual dimorphism. For many other jobs, there is a moderate advantage for one gender to perform them. In evolutionary models, these cases range from strongly to less strongly conventional. In other words, our explanations for patterns of division of labor can incorporate facts about innate sex differences without losing conventionality. Although there are sometimes reasons for particular gendered divisions of labor, this does not mean that they could not have been otherwise.

Consider the game in Figure 4.1. This is a version of the MFEO (made for each other) game introduced in Chapter 1. It is identical to the dancing

		Player 2	
		A	B
Player 1	A	0, 0	1, 1
	B	$1+\alpha$, $1+\beta$	0, 0

Figure 4.1 Payoff table for an MFEO game where α and β determine the benefits to the two actors for reaching the preferable equilibrium

game except that both actors get an extra benefit (α for player 1 and β for player 2) for one combination of roles but not the other. The idea is that one of the coordination equilibria is better, in some way, than the other.

This is an asymmetric game whenever either α or β is not equal to 0, because the two players have inherently different roles. In our evolutionary models of symmetric complementary coordination games, it is always equally likely that either type takes either role. In this game that is no longer the case. To illustrate this, let's turn to computer simulations. In particular, imagine a population with two types given random strategies, so that the group starts at some random point in the phase diagram. Let them play the MFEO game over and over in the course of a simulation. At each stage they update what they are doing according to the replicator dynamics, and we see which equilibrium (A vs. B or B vs. A) they end up at. Figure 4.2 shows outcomes for 10,000 runs of simulation where actors played this MFEO game with $\alpha = \beta$ for a range of values. The x-axis tracks different values of α and β and the y-axis shows how often the less desirable equilibrium is reached.

As $\alpha = \beta$ increases, the basin of attraction for the less preferable A vs. B equilibrium gets smaller and smaller. This should be no great

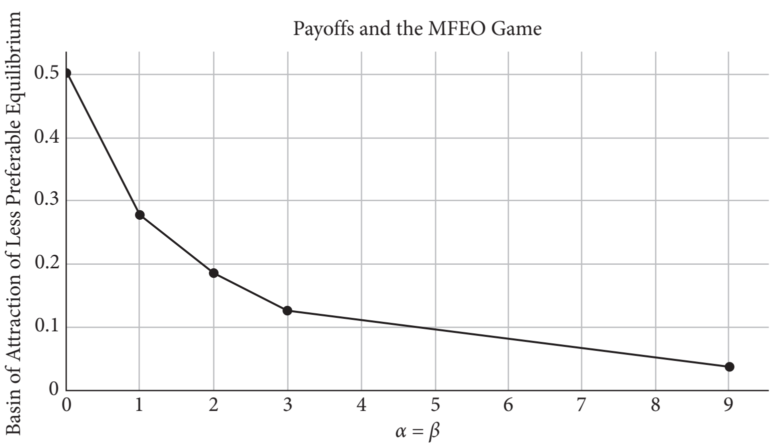
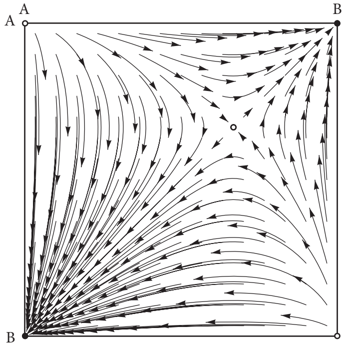


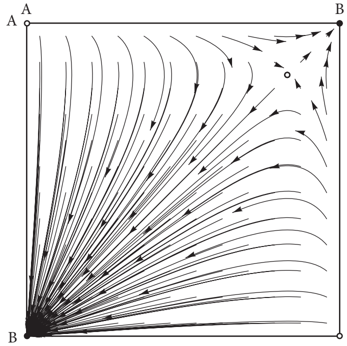
Figure 4.2 Proportions of simulations that go to the jointly less preferable equilibrium for a perfectly divided population playing the MFEO game where $\alpha = \beta$

surprise. Cultural evolution is selecting the better equilibrium with higher probability the more attractive it is. We can get a better sense of what is going on by looking at the phase diagrams of this model in Figure 4.3 where $\alpha = \beta = 1$ and where $\alpha = \beta = 4$. These phase diagrams look similar to that for a dancing game, but now the central rest point (white dot) is shifted to one side, increasing the size of the basin of attraction for the better equilibrium (at the bottom left corner). In (b), where the payoff at the better equilibrium is higher than in (a), the dot is shifted further, making the sizes of the basins of attraction more disparate.

Exactly what is causing this shift? Under the replicator dynamics, strategies that do better than average expand. When one coordination strategy yields a significantly higher payoff, it will expand under the replicator dynamics as a result, even if it leads to lower levels of coordination initially. For example, suppose that for the game in Figure 4.1 women act as player 1 and men act as player 2. If 80% of men are playing B, women coordinate more often on average if they choose A. However, if $\alpha = 9$ the expected payoff of choosing A is $1 * .8 = .8$ and the expected payoff of choosing B is $10 * .1 = 1$. In other words, the Bs in the female population do better and proliferate even though they coordinate much less often. This drives a much larger percentage of populations toward the mutually preferable equilibrium. In cases where $\alpha \neq \beta$, note, we can see similar outcomes when even one of these payoffs gets larger. This change for one



(a) $\alpha = \beta = 1$



(b) $\alpha = \beta = 4$

Figure 4.3 Phase diagrams for perfectly divided populations playing MFEO games where $\alpha = \beta$ varies. As $\alpha = \beta$ increases, the size of the basin of attraction for the better equilibrium also increases side will also increase the size of the basin of attraction for the better outcome.

Notice that in this model, we see a range of conventionality. When $\alpha = \beta = 0$, the two equilibria will have equal basins of attraction. Using our Shannon entropy measure, this yields a conventionality level of 1. If $\alpha = 9$, meaning that the preferable outcome arises more than 96% of the time, the conventionality of the model will be .24. We could increase $\alpha = \beta$ indefinitely, making the size of the basin of attraction for the worse equilibrium smaller and smaller. As we did, we would become increasingly certain that cultural evolution would select the better equilibrium, driving the measure closer and closer to 0.

We can use this particular set of models as a rough representation of what is going on when we see either strongly conventional, or very functional patterns for division of labor. Suppose that pair-bonded individuals producing children both have strong preferences for their family unit (or a larger extended family unit) to remain healthy, well-fed, and safe. In other words, the preferences of the parents strongly align toward measurable, visible positive outcomes for their loved ones. In such a case, the MFEO game can tell us why net-making is conventional cross-culturally, house-building tends to be performed by men, and big-game hunting almost always is. Consider our game above and for each type of labor suppose that actors engage in a strategic interaction where *A* is "do job X" and *B* is "do not do job X, spend your time contributing elsewhere". For each of these types of labor, all the benefits of division by gender hold. But for net-making, α and β are low, meaning that in each culture either gender is likely to evolve to adopt that role. For house-building, α and β take a moderate value, so there is some likelihood that women become the house-builders, and some greater likelihood that men do. For big-game hunting, α and β are so high that it is almost guaranteed that cultural patterns will evolve where men play this role, and women evolve to play it only rarely.[4] Remember that there are multiple ways to interpret cultural evolutionary models. One is to take payoffs to correspond to objectively

[4] Of course, we do not need evolutionary models to guess that when everyone benefits from a particular division of labor, people will tend to follow it. As Murdock and Provost (1973) point out, without the help of mathematical models, "The probability that any activity will be assigned to males is increased to the extent that it has features which give males a definite advantage and/or females a definite disadvantage, in its performance, regardless of whether the distinction is innate or socio-cultural" (211).

successful outcomes—obtaining food, raising healthy children, etc.—and to assume that preferences track these. The explanation I provide here uses this sort of interpretation.

Of course, this is all overly simplistic. Particular ecological facts, and other facts about a culture, will influence all these processes. If it is the case that house-building materials near a group tend to be lighter and require less upper-body strength to deal with, the payoffs for women and men performing that job will be very different from those for a group where houses must be built with chopped lumber. For agriculture, as we have seen, the details of how crop production happens determine the likelihood that planting is done by men and women. In other words, there will be no set values for α and β that hold for every human group, but there will be general patterns for these values, which means that overall certain outcomes are more likely than others cross-culturally. It is also the case that once certain jobs are adopted by one gender, this can change the conventionality of another, related coordination problem. It has been widely pointed out that child care and big-game hunting are largely incompatible, so that if child care has been adopted by women, the basin of attraction for women hunting big game is decreased and this becomes a more functional problem.

Another simplification is the assumption that we will have complete common interest between genders when it comes to the emergence of division of labor. Varying interests between genders can arise in situations where there are differences in what outcomes are desired by either side, such as cases where one job provides better control over desired resources and so is preferable to each gender. We can make small variations to the models to better track these cases.

Consider games where one equilibrium is preferable to one player, and the other to the other, but one equilibrium still provides a greater joint payoff. The simplest case of this sort is shown in Figure 4.4. This is like the leader–follower game but where one outcome is relatively more preferable for one of the players.

		Player 2	
		A	B
Player 1	A	0, 0	1, $1+\beta$
	B	$1+\alpha$, 1	0, 0

Figure 4.4 An asymmetric leader–follower game

In this case, if $\alpha > \beta$, the B vs. A equilibrium will have a larger basin of attraction and if $\beta > \alpha$ the opposite will be true. In other words, the type that derives the greater benefit from their preferred strategy will be more likely to evolve to it. For example, if $\alpha = 1$ and $\beta = 9$, the preferable outcome for player B is reached about 75% of the time, making this problem less conventional than if $\beta = 0$. So in cases with conflict of interest between genders as to which sort of division of labor is preferable, we can still see a range of conventionality. This might occur in a case, for example, where a particular job is dangerous, and so is not preferred, but facts of pregnancy and breastfeeding make it especially dangerous for women.

As I suggested in the last chapter, evolutionary models do a better job than rational choice models, in some ways, of explaining the gendered division of labor. In this last section, we saw a new reason to care about the evolutionary perspective—rational choice models of the marriage market analyze which population outcomes are equilibria, but this does not give us fine-grained predictions about which of these equilibria are more or less likely to emerge in an evolutionary process. As such, they tell us less about why there is a range of conventionality when it comes to gendered division of labor.

4.2.1 Convention and justification

Innate sex differences in humans are often taken to justify inflexible gender roles and gender status divisions (Lorber, 1994; Okruhlik, 1994). In particular, such arguments often take on a functional flair. Women are naturally better at nurturing, and men are naturally poor at it. Or else, women are less aggressive and so fail in competitive interactions, while men are more aggressive and so excel at competition. We see in these narratives an appeal to the innate skills of men and women to not just explain, but also justify, the role divisions that emerge. Even Becker (1981), whose early models of household division of labor do not depend on any innate differences between men and women, suggests that traditional divisions of labor result because "normal" boys and girls are oriented toward market and household work, respectively, while only "deviant" ones show the opposite preference. Part of the goal of feminist gender theorists has been to simultaneously explain the pervasiveness and seeming naturalness of gender roles and gender differences while still maintaining that inegalitarian gender roles cannot be justified by appeal to biological sex.

The analysis here suggests that justifying gender roles and status divisions by appeal to function will not always work. Many divisions of labor, even ones that are distinct and enduring in a society, are nonetheless highly conventional. In these cases, there is no actual function to appeal to in justifying gender roles, and any attempt to do so is simply ad hoc. For divisions of labor that are less conventional, a functional explanation can often be provided for the cultural pattern that appeals to sex differences in ability, as described. However, it is a further question whether this sort of explanation can also justify gender roles. Our analysis suggests that the appeal to abilities can be used in some cases to partially justify gender roles along the following lines: "Women have feature X, which men lack, therefore there are benefits to various parties from women taking job Y." However, our analysis tells us that such justifications *cannot* appeal to anything like the inevitability or innateness of gender roles, even in cases where there is strong cross-cultural regularity. Such roles still "could be otherwise" in a stable society. To some degree, at least, they are arbitrary. Furthermore, in modern societies, where many jobs tend to be intellectual rather than physical, the functionality of many such roles disappears.

Some theorists focus especially on supposedly innate differences in the preferences, rather than abilities, of men and women for different sorts of work in justifying gender roles. In particular, a debate has broken out between evolutionary psychologists and sociologists over this topic. The evolutionary psychologists involved claim that psychological sex differences in humans can be attributed to different evolutionary environments for human males and females (Buss and Schmitt, 2011). These different environments led to significantly different preferences for different sorts of labor. Social structure theory, on the other hand, posits that gender roles largely create sex differences in psychology (Eagly and Wood, 1999; Wood and Eagly, 2012). Gender roles emerge first on cultural evolutionary time scales, and then actors come to behave in ways that fit the roles they take, including preference differences. One accusation against this latter theory is that it claims that gender roles emerge arbitrarily. In other words, the worry is that social structure theory fails to provide an explanation of why we have particular gender roles at all, and so does not actually provide an alternative to accounts from evolutionary psychology. Wood and Eagly (2012), in response, point to the role of ecological conditions in determining which gender will take what roles.

The analysis here gives them, arguably, a much better response. In fact, arbitrariness *is* a part of the emergence of gender roles, and is a perfectly appropriate part of a cultural evolutionary explanation. When there are not significant functional differences between roles for genders, division of labor is still expected, and it is expected to be highly conventional. Even where there are significant functional differences, we should expect evolution to sometimes choose the less efficient outcome. (Wood and Eagly (2012) give examples of cultures where women have assumed traditional warrior roles, for example. Alternatively among the Aka tribe, men literally suckle infants (Hewlett and Lamb, 2005).) Far from being a worry for social structural theory, the arbitrariness of gender roles is just what we would expect when they emerge via cultural evolution to solve coordination problems (rather than being determined by innate psychological differences).[5] In such an appeal, social structural theorists can present a detailed, dynamical analysis of the emergence of gendered division of labor to counter a speculative, just-so story about sexual selection.

4.3 The Evolution of Types

Why do humans have genders at all? Many theorists have argued that gender and gender differences are not innate, but are culturally constructed. But, if so, why should it be the case that every human culture has developed such a construction? Why don't we see some cultures where this particular feature failed to emerge? The universality of gender contributes to the perception described in Chapter 1 of gender as innate

[5] One thing to note is that whether or not it is fallacious to employ psychology/biology to justify gender role divisions, people simply do it. And, in particular, in recent studies, it has been observed that men who believe that there are significant biological differences between men and women are more discriminatory and more sexist (Keller, 2005; Morton et al., 2009). This fact means that those working on innate gender differences, or on the evolution of gender roles, face *inductive risk*, as described by philosophers of science, or the risk that they could be wrong and, furthermore, cause social ill by being wrong (Hempel, 1965; Douglas, 2000, 2009; Elliott, 2011). When it comes to work on gender differences, researchers should arguably be taking this inductive risk into account, especially when promoting evolutionary narratives to explain supposed psychological sex differences. This is especially true because work in evolutionary psychology is often built on relatively thin evidence, and is often highly speculative. While there is room for speculative evolutionary narratives in science, in cases where these narratives have the capacity to create social ills, their proponents should arguably be held to higher standards.

and unchanging. It is not impossible that a universal cultural feature could be nonetheless constructed. In order to tell a coherent story along these lines, though, one must provide a good reason for why the cultural feature is so robust. This section presents a toy model that tells such a story about gender.

We have seen how gender can act as a type that human actors take advantage of to solve complementary coordination problems. One further possibility, though, is that gender does not just provide an opportunity for such solutions, but that it arises for the very purpose of doing so. Ridgeway (2011), for example, argues that gender inequality persists in modern, post agricultural, US society *because* of the key role it plays in allowing actors to organize their social relations and thus achieve coordination.

Consider the following model. There is a homogenous group playing a complementary coordination game. Cultural evolution should take this group to a polymorphism, where they manage to coordinate sometimes, but not always.

Suppose that two individuals in this group change strategies. In particular, suppose that these individuals decide to start conditioning their behavior based on some underlying marker that distinguishes them. Now the rest of the group is doing about as well as they were before, but when these two individuals meet each other, they always manage to coordinate, and so do a bit better than average. On cultural evolutionary assumptions, we should expect others to start imitating the behavior of these coordinators, by recognizing the same underlying marker and using it to condition behavior and so coordinate. Once more individuals start to recognize the marker, everyone using it to coordinate will do better than before, because they have more partners who know how to break symmetry. This process will carry the population to a state where now there are types, and everyone uses these to coordinate. In other words, from a completely homogenous group we can see the endogenous emergence of social categories.[6]

Why do we see gender and gender roles in every society? This analysis indicates that the emergence of types is selected for given a need to facilitate coordination and the ability to make use of underlying differences

[6] This process is similar to the invasion of actors using correlated strategies discussed by Skyrms (2014, 70).

to do so. Of course, the analysis does not entirely explain why gender in particular has emerged universally, rather than some other sort of type. There are a few observations that can help explain this universality. From a game theoretic standpoint, when it comes to gender, we see almost the best possible conditions for the use of types to solve complementary coordination problems. There are two types that are equally prevalent. (In two-type mixing models, remember, 50–50 between types is the division that allows for the greatest coordination. This is because it maximizes the chances of the different types meeting, and so being able to use their categories to coordinate.) Furthermore, we see actors in many societies grouping into households with one member from each type, or perfectly dividing, leading to the best possible payoffs from a coordination standpoint. Lastly, as Ridgeway (2011) points out, sex differences are already salient for coordinating reproductive roles, leading to a natural salience as an easily observable physical difference upon which to build gender.

Of course, gender categories are probably not the only ones that have emerged to facilitate coordination. There are at least some other cases—class differences and castes, perhaps—where we see types that seem to have emerged for complementary coordination. As mentioned earlier, though, details mean that for every such case careful work will have to be done to fill in and assess the applicability of models such as those presented. In the case of caste, for example, social structures are very different from those associated with gender—the population proportions are not 50–50, there are more than two types, and individuals tend to be raised in environments with only in-group members, rather than the mixed environments we see for gender. (Of course, one might likewise point out that genders vary greatly from culture to culture, and the analysis here surely will be a better or worse fit in different cases. This is absolutely right, but for reasons of space, I will not elaborate further.)

Some sorts of types certainly did not emerge for the purpose of solving complementary coordination games, though some of these may have emerged to solve correlative coordination problems. In particular, consider cultural, racial, or religious groups that constitute types. Richerson et al. (2003) compellingly argue that these sorts of divisions may develop, and persist, in order to facilitate the use of separate correlative coordination conventions in separate groups. In such a case, types allow actors to recognize individuals using similar coordination strategies and interact with them more often. In still other cases, of course, types might play no functional role in coordination, but emerge as a result of innate out-group biases.

4.3.1 Learning inequity?

One feature of the toy models just presented is that actors themselves learn to adopt types that, as we have seen, can facilitate the emergence of inequity. Is it realistic to suppose that individuals will themselves be willing to adopt types when this is a consequence?

Remember from Chapter 2 that for many coordination situations, everyone does better to adopt categories, meaning that moving toward an unequal outcome may nonetheless be attractive. In some strategic scenarios, though, one type does less well than they would do in a homogenous group by adopting categories. This happens, remember, whenever actors play hawk–dove, introduced in Figure 1.5. The payoff details mean that doves would rather meet other doves than meet hawks at equilibrium. In a case like this, the evolutionary process just described cannot get off the ground. Note, though, that gender typically solves many coordination problems and not just one. We might imagine a situation where the evolving group encounters a portfolio of coordination problems—some best represented by hawk–dove, others by the leader–follower game, and others by the dancing game or the MFEO game. In such a case the benefits reaped by both sides may be enough for cultural evolutionary processes to promote typing, even if some interactions are straightforwardly worse for one type as a result.

To give a simple example of what I mean, consider a situation where actors interact in two sorts of complementary coordination problems—one that is well represented by hawk–dove and one that is well represented by the dancing game. Furthermore, suppose that the dancing-type interaction is very important to the actors so that they achieve payoffs of 5 when they coordinate and 0 otherwise. Suppose that actors play each of these games 50% of the time when they randomly interact with a group member. Lastly imagine that if actors do choose to condition on types, they do so for both games, not just one. In other words, once they recognize something like gender, they use it for role division in multiple cases.[7]

[7] This possibility is somewhat related to explorations of the possibility that humans generalize learning across many games, and that this could influence evolutionary outcomes (Bednar and Page, 2007; Skyrms and Zollman, 2010; Bednar et al., 2012; Mengel, 2012).

In this situation is there cultural evolutionary pressure to adopt types? In a homogenous group, actors will get an average payoff of 2 across the two games. (Half the time they expect to get 1.5 on average from playing hawk–dove, and the other half get 2.5 on average from playing the dancing game.) If two individuals adopt types, and use these for coordination, their payoff improves slightly since on average when they interact in both hawk–dove and the dancing game they will get a payoff of 3 for the type that plays dove and 4 for the type that plays hawk. In other words, when gender is facilitating multiple coordination interactions, the overall benefit from this can swamp any detriment to one type from some of the interactions.

There is an interesting connection, here, to philosophical work on the rationality of women's choices to engage in inequitable social roles. Cudd (1994, 2006) addresses arguments claiming that because women often choose domestic labor over market labor, they cannot be oppressed by the resulting inequitable arrangement. Cudd's response is to highlight the sense in which women's choices along these lines are restricted by social structure, drawing on the work of Okin (1989). So though they may be acting rationally in their own best interest, they may still be oppressed. In the models I have developed in this first half of the book, we see a situation arise where all members of society are restricted in their choices of social roles in the sense that anyone who makes a non-conventional choice will significantly damage their own material well-being. Furthermore, these arrangements are inequitable. And yet, any individual should be rationally willing to enter this social situation (starting from a state of nature), because doing so leads to payoff benefits.[8]

4.3.2 Bundling

When it comes to sex and gender, factors that need not necessarily go together *bundle* in individuals. For example, biological sex usually bundles with gender identity (as a man or woman).[9] This bundles with reported sexual preference.[10] These factors, of course, strongly bundle

[8] A further requirement Cudd gives for "oppression" is that one group is harmed to another's advantage, and I am unsure whether the social arrangements I have been modeling meet this crtierion.

[9] In a recent survey, only 0.3% of Americans self-identified as transgender. Of course, social stigma against transgender people means that this is probably an underestimate.

[10] About 3.5% of Americans self-identified as lesbian, gay, or bisexual (Gates, 2011).

with how households are formed. Especially in recent Western history, the vast majority of households involved one man and one woman. And all these factors bundle with behavioral regularities regarding division of labor. Women are people with female biological sex, who adopt the gender of woman, signal their membership in this group, sexually prefer men, form households with men, and take the household and workplace roles that are appropriate for women. In learning these behaviors, of course, they use other women as their models for social learning. And men can be defined in a similar way.

It is not just biological sex, or just gender roles, or just learning the appropriate divisions of labor that allow gender to facilitate coordination, but the entire bundle. When these factors are always present in the same types of people, the same social patterns will successfully solve complementary coordination problems. The arguments in the last section suggest that these bundles may even evolve for the purposes of coordination.[11]

Henrich and Boyd (2008) pursue this idea further. They consider cultural group selection in situations where some groups, but not others, have adopted conventions that use types and type-conditioning to divide labor. Cultural group selection, here, refers to situations where the success of competing social groups (as opposed to the success of competing individuals) can act as the mechanism by which cultural variants spread. As they show, in cases where actors play complementary coordination games, this sort of process should select for groups where actors interact more with those of the other type, where they learn only from their own type, where they adopt complementary roles, and where they focus on success-based cultural learning (i.e., adopt learning processes that are well-modeled by the replicator dynamics). In other words, the bundles themselves evolve.

If we consider the resistance of gender-based norms to social change, these bundles for coordination tell part of the story. If they are simply unraveled, a social function is not being performed. While much of the resistance to social change is driven by psychological biases, it is important to also recognize that dynamical factors related to successful

[11] Cudd (2006) actually defines social groups via the sorts of constraints these groups face. The fact that this is a plausible move makes salient how tight these bundles tend to be.

social coordination are at play. We must introduce factors to take the place of this complex if we want to change gender roles effectively.

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Why do men make ropes in a certain culture? As we've seen in this chapter, the answer need not appeal to anything special about men, or even about the environment in which this behavior develops. We should expect division of labor by gender to be conventional to at least some degree, and so well explained by appeal to coordination, but not necessarily by other functional features. When it comes to the inequities that emerge because of gendered division of labor, this holds as well. These inequities might well have been otherwise, and appeals to innate differences in preference or abilities won't do the job to justify them.

We also saw in this chapter that from a homogenous group with entirely symmetric roles, categories can emerge spontaneously to solve complementary coordination problems. In the last few chapters, I have described social categorization as a precondition for social inequity. Now we see that this precondition itself can emerge, as well as the bundle of features necessary to get coordination (and resulting inequity) off the ground. This reduces by one the set of preconditions required to generate this sort of inequity via cultural evolution. We see that in a situation where we have 1) a complementary coordination problem, and 2) individuals who learn to do what benefits them, we can end up with social categories that divide people into different groups who get more or less based on their otherwise irrelevant differences.

We'll now move on to Part II of the book.