Evolutionary game theory pdf

The application of game theory to developing populations in evolutionary game theory (EGT) is the application of game theory to developing populations in biology. It defines the framework of competitions, strategies and analytics in which Darwinian competition can be modeled. It originated in 1973 with John Maynard Smith and George R. Price in formalizing contests analyzed as strategies and mathematical criteria that can be used to predict the results of competing strategies. The theory of evolutionary games differs from the classical theory of games in that it focuses more on the dynamics of the change of strategy. This is influenced by the frequency of competing strategies in the population. The theory of evolutionary games helped explain the basics of altruistic behavior in Darwinian evolution. This, in turn, interested economists, sociologists, anthropologists and philosophers. History Classic Game Theory Home article: The Theory of The Game Classical Theory of Non-Cooperative Games was conceived by John von Neumann to determine the best strategies in competitions between opponents. The competition includes players, all of whom have a choice of moves. Games can be one round or repetitive. The approach a player takes when making his moves is his strategy. Rules govern the outcome for moves made by players, and results give wins to players; rules and related payouts can be expressed as tree-making or in the winning matrix. Classical theory requires that players make rational choices. Each player should consider a strategic analysis of what his opponents are doing to make their own choice of moves. The problem of ritual behavior by Mathematical biologist John Maynard Smith is modeled by evolutionary games. The theory of evolutionary play began with a problem of how to explain the ritual behavior of animals in a conflict situation; Why are animals so gentlemanly or lady in resource contests? Leading etiologists Nico Tinbergen and Konrad Lorenz have suggested that this behavior exists for the benefit of the species. John Maynard Smith believed that it was incompatible with Darwinian thought, where selection takes place at an individual level, so vested interests are rewarded in the search for the common good. Adapting the game theory to evolutionary games, Maynard Smith realized that the evolutionary version of game theory does not require players to act rationally - only that they have a strategy. The results of the game show how good this strategy was, just as evolution tests alternative strategies for the ability to survive and reproduce. In biology, strategies are genetically inherited traits that control human action, similar to computer programs. the success of a strategy is determined by how good the strategy is in the presence of competing strategies (including itself) and the frequency with which these strategies are used. Maynard Smith described his work in his book Evolution and Game Theory. Participants tend to produce as many copies of themselves as possible, and gain in fitness units (relative value in being able to reproduce). It is always a multiplayer game with many competitors. The rules include replicator dynamics, in other words, how fitter players will generate more replicas of themselves in the population and how less fit will be selected, in the replicator equation. The dynamics of the replicator simulates pro-talk, but not mutation, and involves asexual reproduction for the sake of simplicity. The games are repeated without any termination conditions. The results include population dynamics, success strategies, and any equilibrium states have achieved. Unlike classical game theory, players do not choose their strategy and cannot change it: they are born with a strategy, and their offspring inherit the same strategy. Evolutionary Games Models of Evolutionary Game Theory analyze Darwinian mechanisms with a system model with three main components - Population, Game and Replicator Dynamics. The system process has four phases: 1) The model (as evolution itself) deals with the population (Pn). The population will show variation among the competing faces. 2) The game checks people's strategies according to the rules of the game. These rules produce a variety of gains - in units of Fitness (the speed of production of offspring). Controversial people meet in pairs competitions with others, usually in a very mixed distribution of the population. The combination of strategies in the population affects the results of winning, changing the chances that anyone can meet in contests with different strategies. Individuals leave the game match pairwise with the resulting fitness of the match determined outcome, presented in the winning matrix. 3) Based on this resulting fitness each member of the population then undergoes replication or culling determined by the exact math process of the replicator dynamics. This common process then produces a new generation of P (n-1). Each survivor now has a new fitness level determined by the result of the game. 4) The new generation then takes the place of the previous and the cycle repeats. The mixture of the population can converge with an evolutionarily stable state that cannot be captured by any mutant strategy. Evolutionary theory of the game includes Darwinian evolution, including competition (game), natural selection (replicator dynamics) and its embroidery. Evolutionary game theory contributed to the group's understanding sexual selection, altruism, parenting, joint development and environmental dynamics. Many counterintuitive situations in these areas have been put on a solid mathematical basis through these models. The common way to study evolutionary dynamics in games is the replicator equations. They show the rate of increase in the proportion of organisms using a particular strategy, and this figure is equal to the difference between the average payment for this strategy and the average payout of the population as a whole. Continuous replicator equations involve infinite populations, continuous time, complete confusion and what strategies generate truth. The attachments (stable fixed points) of equations are equivalent to evolutionarily stable states. A strategy that can survive all mutant strategies is considered to be evolutionarily stable. In the context of animal behavior, this usually means that such strategies are programmed and highly dependent on genetics, making the strategy of any player or organism determined by these biological factors. Evolutionary games are mathematical objects with different rules, wins, and mathematical behavior. Each game presents different challenges that organisms must deal with, and strategies they can adopt to survive and reproduce. Evolutionary games are often given colorful titles and covers, describing the general situation of a particular game. Representative games include a pigeon hawk, one war of attrition, 15 deer hunting, a producer-scrounger, a common heritage tragedy, and a prisoner's dilemma. Strategies for these games include Hawk, Dove, Bourgeois, Prober, Defector, Appraiser, and Retribution. Different strategies compete according to the rules of a particular game, and mathematics is used to determine results and behavior. Hawk Dove solution from Hawk Dove for V'2, C-10 and B-4 fitness base. The Hawk's suitability for different demographic mixes is built like a black line that dove in red. ESS (stationary point) will exist when Hawk and Dove fitness are equal: Hawks 20% of the population and pigeons 80% of the population. Main article: Chicken (game) The first game analyzed by Maynard Smith is a classic Hawk Dove game. It was conceived to analyze the problems of Lorenz and Tinbergen, a competition for a shared resource. Contestants can be either Hawk or Dove. These are two subtypes or morphing of the same species with different strategies. The hawk first shows aggression, and then develops into a fight until he wins or is injured (loses). The pigeon initially shows aggression, but if faced with a major escalation works for security. If you do not face such escalation, the pigeon tries to share the resource. The winning matrix for Hawk Dove Game meets With Hawk if Hawk V/2 q C/2 V, if Dove 0 V/2 Given that the resource is given a V value, from the loss of loss The fight is given a cost of C: 1 If a hawk meets a pigeon he gets a full V resource for himself, if the hawk meets the hawk - half the time he wins, half the time he loses... so its average result, then V/2 minus C/2 If the pigeon meets a hawk it will retreat and get nothing - 0 If the pigeon meets the pigeon as a share resource and get a V/2 actual win, however, depends on the probability of meeting Hawk or Dove, which in turn is the representation of the percentage of hawks and pigeons in the population when a particular contest takes place. This, in turn, is determined by the results of all previous contests. If the cost of losing C is more than the cost of winning v (normal situation in the natural world) the math ends with an evolutionarily stable strategy (ESS), a combination of two strategies where the population of Hawks V/C. Population regresses to this point of equilibrium if any new hawks or pigeons make temporary public outrage. The Decision of Hawk Dove explains why most animal contests only involve ritual combat behavior in contests, not live fights. The result does not depend on the good behavior of the species, as Lorenz suggests, but solely on the consequences of the actions of so-called selfish genes. War of Attrition Home article: War of Attrition (game) The game's Hawk Dove resource is a total that gives wins to both pigeons meeting in a pair of contests. Where the resource is unavailable for use, but the alternative resource may be available by retreating and trying elsewhere, clean Hawk or Dove strategies are less effective. If an inseparable resource is combined with the high cost of losing a contest (injury or possible death), Hawk and Dove payouts are further reduced. A safer strategy for a lower cost display, bluff and expectation to win, then viable - Bluffer Strategy. The game then becomes one of the accumulation costs, either the cost of displaying or the cost of long-term unresolved interactions. It's actually an auction; the winner is a participant who swallows a lot of value, while the loser gets the same cost as the winner, but without resources. The resulting evolutionary theory of the game mathematics leads to the optimal strategy of timing bluffing. A war of attrition for the various values of the resource. Note the time it takes to accumulate 50% of participants to come out against the cost (V) of a contested resource. This is because in a war of attrition any strategy that is unwavering and predictable is unstable because it will eventually be superseded by a mutant strategy that relies on the fact that it can better the existing predictable strategy by investing an additional small delta of waiting resources to ensure so he can win. Thus, only an accidental unpredictable strategy can sustain itself in the Bluffers population. Contestants are essentially acceptable costs that will be incurred in connection with the cost of an idle resource, effectively making a random bet as part of a mixed strategy (a strategy in which the participant has several or even many possible actions in his strategy). This implements the distribution of bets on a resource of a certain value V, where the bet on any particular contest is chosen randomly from that distribution. Distribution (ESS) can be calculated using the Bishop-Cannings theorem, which is true for any mixed ESS strategy. The distribution function in these contests was determined by Parker and Thompson to be: p (x) e q x/v V . (display p(x) frak e-x/V'V'. The result is that the cumulative population of quitters for any particular cost m in this mixed strategy solution: p (m) 1 y y/m/v, displaystyle p(m) 1-e'm/V, as shown in the adjacent graph. Where the timing of disconnection in contests, as predicted by evolutionary theory of mathematics. Asymmetry, which allows new strategies Dung Fly (Scatophaga stercoraria) - War of depletion playerThe mantis shrimp guard their home with a bourgeois strategyAnimial strategy Examples: by studying behavior, then determining both the costs and the cost of resources achieved in the competition, the strategy of the organism can be tested in the war of exhaustion. that signals the size of the bet to the opponent, otherwise the enemy can use the signal in an effective counter-strategy. There is, however, a mutant strategy that can better Bluffer in the war of attrition games if a suitable asymmetry exists, a bourgeois strategy. Bourgeois uses some kind of asymmetry to break the deadlock. In nature, one of these asymmetries is the possession of a resource. The strategy is to play the hawk if in possession of the resource, but to display then retreat, if not in possession. This requires more cognitive abilities than Hawk, but Bourgeois is common in many animal contests, such as in contests among mantis shrimp and among spotted tree butterflies. Social Behavior Alternatives for Game theorists of social interaction games like Hawk Dove and War of Attrition represent pure competition between people and have no concomitant social elements. Where social influences are applied, competitors have four possible alternatives to strategic engagement. This is displayed on a nearby figure, where the plus sign is an advantage and the minus sign represents value. In a cooperative or reciprocal relationship as a donor and recipient is almost indistinguishable, how to benefit in the game, i.e. the couple is in a game-wise situation where both can get by performing a certain strategy, or both must act in concert because of some covering restrictions that effectively puts them in the same boat. In an altruistic relationship, the donor, at a cost to himself, benefits the recipient. In general, the recipient will have a relationship with the donor and the donation is one way. Behavior in which benefits are sacrificed alternatively (in both directions) at cost is often referred to as altruistic, but in analysis such altruism can be seen to emerge from spite's optimized selfish strategies is essentially the reverse form of altruism, where an ally is helped by harming a rival ally (s). The general case is that the ally is related to relatives, and the benefit is an easier competitive environment for an ally. Note: George Price, one of the first mathematical fashion designers of both altruism and malice, found that this equivalence is particularly disturbing on an emotional level. Selfishness is the basic criterion of all strategic choice in terms of game theory - strategies that are not aimed at survival and self-reproduction are not long for any game. However, this situation is critically affected by the fact that competition takes place at several levels, i.e. at the genetic, individual and group levels. Competitions of selfish genes gophers of belding females risk their lives by making loud alarm calls, protecting closely related female members of the colony; men are less closely connected and do not call. At first glance, it may seem that the participants in evolutionary games are persons present in each generation who are directly involved in the game. But people only live through one game cycle, and instead it's strategies that really challenge each other during these many generations of games. So ultimately, the genes that play full competition are the selfish gene strategies. Controversial genes are present in humans and to a certain extent in all human genes. Sometimes this can have a profound impact on which strategies survive, especially with regard to cooperation and desertion. William Hamilton, known for his theory of choosing relatives, has investigated many of these cases using theoretical models of games. Related attitudes to gaming helps to explain many aspects of the behavior of social insects, altruistic behavior in the interaction of parents and descendants, behavior of mutual protection and cooperative care of offspring. For such games, Hamilton identified an extended form of fitness - inclusive fitness, which includes human offspring, as well as any hereditary equivalents found in relatives. Mathematics Keen Choice Concept Keen Choice is that: an inclusive fitness-owning contribution to fitness and the contribution of all relatives. Measured in relation to the average population; for example, fitness 1 means a rise in Rate for the population, fitness zlt; 1 means a decrease in the proportion of the population (extinction), fitness zgt;1 means an increase in the proportion of the population (take over). Inclusive fitness of individual Wi - the sum of its specific suitability itself ai plus the specific suitability of each relative, weighted by the degree of kinship, which equates to the summation of all rj'bj....... where rj is the kinship of a particular relative and BJ is that fitness of a particular relative - production: w I and I ∑ j r j j j . w_ a_ yo-r_ b_ display. Now, if individual Ai donates his own average equivalent of a fitness 1, taking the fitness cost of C and then getting that loss back, Wi should still be 1 (or more than 1)... and if we use the RCB to represent the summation we get: 1 zlt; (1-C) .... or permutation. . . . > . . . . Eusociality and the choice of relatives Ant Meat Workers (always women) are associated with the parent at 0.5, with the sister at 0.75, with the child at 0.5 and with the brother at 0.25. Therefore, it is much more profitable to help in the production of a sister (0.75) than to have a child (0.5). Main article: Eusociality Eusocial insect workers lose reproductive rights to their queen. It has been suggested that Kin Selection, based on the genetic makeup of these workers, may predispose them to altruistic behavior. Most of the insect's eusocial societies have a gatlodiploid sexual resolve, which means that workers are extremely closely related. This explanation of the insect's eusociality, however, has been challenged by several highly regarded evolutionary game theorists (Novak and Wilson) who have published a controversial alternative theoretic explanation for the game based on the consistent development and group selection of effects proposed for these insect species. The Prisoner's Dilemma Main article: The Prisoner's Dilemma Difficulty of Evolution Theory, recognized by Darwin himself, was a problem of altruism. If the basis of selection is at the individual level, altruism makes no sense at all. But universal selection at the group level (for the benefit of the species, not the individual) does not pass the test on the mathematics of game theory and, of course, is not a common case in nature. However, in many social animals there is altruistic behavior. A solution to this paradox can be found in applying the evolutionary theory of the game to the dilemma of the prisoner game - a game that benefits from cooperation or in flight from cooperation. This is by far the most studied game in all game theory. Analyzing a prisoner's dilemma is a recurring game. This gives competitors the opportunity to retribution for desertion in the rounds of play. Many strategies have been tried; the best competitive strategies are general cooperation with reserved responses if necessary. The most famous and one of the most successful of them is eye for an eye with a simple algorithm. def tit_for_tat (last_move_by_opponent): if the defect last_move_by_opponent: defect () is different: to cooperate () Payment for any round of the game is determined by the payout matrix for one round of the game (shown in bar chart 1 below). In multi-game games, different options - cooperation or defect - can be made in any particular round, leading to a certain round win. It is, however, a possible accumulated payout over several rounds that are factored into the formation of total payouts for various multi-city round strategies such as Tit-for-Tat. Payouts in two varieties of the dilemma of the prisoner's game. Prisoner's dilemma: cooperation or defect? Winning (Temptation in Defect vs. Collaboration) (Winning (Mutual Collaboration) (Winnings) (Joint Defection) (Sucker Cooperatives, but Opponent Defects) Example 1: Simple One Round Of Prisoner Dilemma Game. The dilemma of playing classic prisoner winnings gives the player the most out of the game if he has a defect and his partner cooperates (this choice is known as temptation). If, however, the player cooperates and his partner defects, he gets the worst possible result (suckers winning). In these conditions, the best choice (Nash's equilibrium) is a defect. Example 2: The prisoner's dilemma has been played repeatedly. Tit-for-Tat strategy is used, which changes behavior based on the actions taken by the partner in the previous round, i.e. rewards cooperation and punishes desertion. The effect of this strategy in the accumulated winnings over many rounds is to produce a higher gain for both players co-operation and a lower winning for desertion. This eliminates the Temptation to the defect. The sucker winnings are also getting smaller, although the invasion of pure desertion strategy is not completely eliminated. Routes of altruism altruism occurs when one person, at a price of C to himself, implements a strategy that provides a B advantage to another person. Cost may consist of loss of opportunities or resources that help in the struggle for survival and reproduction, or an additional risk to one's own survival. Altruism strategies can arise through: Type applied to: Situation Mathematical Effect Kin Selection - (inclusive fitness related contestants) Keen - genetically related individuals Evolutionary game participants genes strategy. The best win for a person is not necessarily the best win for the gene. In any generation, the player's gene is not only in one person, it is in Kin-Group. Highest fitness win for Kin Group natural selection. Thus, strategies that include self-sacrifice on the part of the Game winners are an evolutionarily stable strategy. During the game, the animals must live in a related group for this altruistic victim to ever take place. Games should take into account inclusive fitness. The fitness function is a combined fitness group of related contestants - each weighted by a degree of kinship - relative to the general genetic population. Mathematical analysis of this gene-oriented view of the game leads to Hamilton's rule that the kinship of an altruistic donor must exceed the cost-benefit ratio of the altruistic act itself: A couple of people exchange favors in a multi-round game. Individuals are recognisable to each other as partners. The term direct applies because the benefit return is specifically returned only by a couple of partners. The characteristics of the multi-series game pose a risk of desertion and potentially less benefits of cooperation in each round, but any such defection can lead to punishment in the next round - creating the game as a re-prisoner dilemma. Therefore, on the first day to come out a family of strategies eye for an eye. Indirect reciprocity Related or not related to the contestants trade benefits, but without partnerships. Return of favor is implied, but without a specific identified source that should give it. This behavior is akin to scratching your back, you scratch someone else's back, someone else will scratch mine (probably). The benefit return is not derived from any particular established partner. The potential for indirect reciprocity exists for a particular organism if it lives in a cluster of people that can interact over a long period of time. It is argued that human behaviour in the creation of a moral system, as well as the expenditure of significant energies in human society to track individual reputation, is a direct consequence of society's dependence on indirect reciprocity strategies. The game is very susceptible to desertion, as direct retribution is impossible. Thus, indirect reciprocity will not work without the preservation of a social account, a measure of past cooperative behavior. Mathematics leads to a modified version of the Hamilton Rule, where: q'gt;c/b, where q (probability of knowledge of social score) should be more than cost-benefit ratio, and organisms that use social score are called Discriminators and require a higher level of cognition than strategies of simple direct reciprocity. As evolutionary biologist David Haig put it: You need a face to reciprocity; for indirect reciprocity, you need a name. Evolutionarily stable Winning Matrix strategy for Hawks A game with the addition of an appraiser's strategy. This studies his opponent, behaving like a hawk, when in a match with an opponent he judges weaker as a pigeon, when the opponent seems bigger and stronger. The ESS evaluator, as it can invade both the Hawk and Dove populations, and can withstand the invasion of either Hawk or Dove mutants. The main article: An evolutionarily stable strategy of an evolutionarily stable strategy (ESS) is akin to Nash's balance in classical game theory, but with mathematically advanced criteria. Nash Equilibrium is a game equilibrium in which it is irrational for any player to deviate from their current strategy, provided that others adhere to their strategies. ESS is a state of game dynamics in which, with a very large population of competitors, another mutant strategy cannot successfully enter the population to disrupt existing dynamics (which in itself depends on the population combination). Thus, a successful strategy (with ESS) should be effective both against competitors when it is rare - to enter the previous competing population, and successful when later in the high proportion of the population - to protect themselves. This, in turn, means that the strategy must be successful when it fights others just like herself. ESS is not: the optimal strategy: it will maximize fitness, and many ess states well below the maximum fitness achievable in the fitness landscape. (see Hawk Dove chart above as an example of this) Special solution: often multiple ESS conditions can exist in a competitive situation. A specific contest can stabilize in any of these opportunities, but later major outrages in the conditions can move the solution to one of the alternative states of ESS. Always present: you can avoid ESS. The evolutionary game without ESS is Rock Scissors-Paper, as found in species such as side-spotted lizards (Uta stansburiana). Unsurpassed strategy: ESS is just an inseparable strategy. Female funnel spiders (Agelenopsis aperta) compete with each other for possession of their desert web using the evaluator's strategy. The state of ESS can be decided by studying either the dynamics of population change to determine ESS, or by solving equations for stable stationary point conditions that define ESS. For example, in Hawk Dove Game, we can see if there is a static state of a population mix in which pigeon fitness is exactly the same as that of hawks (so both have an equivalent growth rate - a static point). Let the chance to meet Hawk'p so the probability of meeting dove (1-p) Let WHawk equal win for Hawk ..... WHawk-Payoff in chance to meet Dove and win in the chance to meet hawk taking the results of PAYOFF MATRIX and connecting them in the above level: WHawk Related: Same for pigeon: WDove' V/2 (1-r) (p) so.... VDova B/2 (1-r) Equating two fitness, Hawk and Dove V (1-p) (V/2-C/2) (1-r)... and the solution for PV/C so for this static point where the population percentage of ESS decides to be ESS (percentage Hawk) v/C Similarly, using inequality, you can show that an additional Hawk or Dove mutant entering this state of ESS eventually leads to less fitness for some sort - like true Nash and ESS equilibrium. This example shows that when the risk of injury or death of a competition (cost C) far exceeds the potential reward (beneficial value V), a stable population will mix between aggressors and pigeons, and the share of pigeons will exceed the share of aggressors. This explains the behavior observed in nature. Unstable Games, Cyclical Patterns Rock Paper Scissors Rock Paper Scissors Mutant Invasion for Rock Paper Scissors Payment Matrix - Endless Cycle Home Article: Rock Paper Scissors Computer Simulation Rock Scissors Paper Game. The RPS Game Payoff Matrix is displayed. Starting with an arbitrary population, the percentage of three morphs is built in a continuously cycling model. Stone paper scissors included in the evolutionary game are used to simulate natural processes in the study of ecology. Using experimental economics techniques, the scientists used the RPS game to test the socio-evolutionary dynamic behavior of humans in the laboratory. Social cyclical behavior predicted by the evolutionary theory of games has been observed in various laboratory experiments. The lizard plays RPS and other cyclical games... The first example of RPS in nature was seen in the behavior and throat color of a small lizard in western North America. The side lizard (Uta stansburiana) is polymorphic with three throat-colored morphs that each pursues a different mating strategy of the side-spotted lizard effectively using the rock-paper-scissors mating strategy. 1) Orange Throat is very aggressive and acts in large territory - tries to mate with numerous females in this larger area 2) The non-aggressive yellow throat mimics the markings and behavior of female lizards, and sneaky slips into the orange throat territory to mate with the females there (thus taking the population), and 3) blue mates and carefully protects one woman - making it impossible for sneakers to succeed and therefore overtaking them. However, blue throats cannot overcome more aggressive orange throats. Later, the work showed that blue males are altruistic to other blue males, with three key features: 1) they signal with blue, 2) they recognize and settle next to other (unrelated) blue males, and 3) they will even protect their partner from orange to make them This is a hallmark of another collaboration game that includes the green beard effect. Females in the same population have the same throat colors, and this affects the amount of offspring they produce and the size of the offspring that generates cycles in density, another game - the game r-K. Here r is the Maltese parameter that regulates exponential growth, and K is the carrying capacity of the population. Orange females have larger clutches and smaller offspring and are good at low density. Yellow females (and blue) have smaller clutches and larger offspring and are better when the population exceeds capacity and the population drops to low density. Orange then takes over and it generates eternal cycles of orange and yellow tightly tied to population density. The idea of cycles because of the density of regulation of the two strategies originated with Dennis Chitty, who worked on rodents, ergo of this kind of games lead to Chitty Cycles. There are games in games built into natural populations. These drive RPS cycles in men with periods of 4 years and r-K cycles in women with a frequency of 2 years. The overall situation corresponds to Rock, Scissors, Paper Games, creating a four-year population cycle. The RPS game in the male side spotted lizards doesn't have an ESS, but it has Nash Equilibrium (NE) with endless orbits around the NE draw. Since then, many other three polymorphism strategies have been discovered in lizards, and some have the dynamics of RPS fusion of male play and density regulation of the game in one sex (male). More recently, mammals have been shown to harbor the same RPS game in men and r-K play in women, with coat color polymorphisms and behaviors that drive cycles. This game is also associated with the evolution of male care in rodents, and monogamy, and drives speciation stakes. Dennis Chitty was right, there are r-K strategy games related to rodent population cycles (and lizard cycles). When he read that these lizards were essentially involved in a game with a rock-paper-scissor structure, John Maynard Smith is said to have exclaimed: They read my book! The alarm, sexual selection and principle of the Peacock Tail Handicap can be an example of the handicap principle in action. The main article: Signaling Theory Aside from the difficulty of explaining how altruism exists in many developed organisms, Darwin was also concerned about the second mystery - why do a significant number of species have phenotypic attributes that are clearly unprofitable for them in regards to their survival - and should the process of natural division be chosen against - for example, a massive uncomfortable feather structure found in a peacock's tail? As for this question Darwin wrote to a colleague of the Kind of Pen's tail peacock, when I at him, makes me sick. This is the mathematics of evolutionary game theory, which not only explained the existence of altruism, but also explains the completely illogical existence of the tail of a peacock and other similar biological formations. According to the analysis, the problems of biological life as opposed to the problems that define the economy - nutrition (akin to the acquisition of resources and management), survival (competitive strategy) and reproduction (investment, risk and profitability). Game theory was originally conceived as a mathematical analysis of economic processes, which is why it has proved so useful in explaining so many biological behaviors. One of the important additional refinements of the evolutionary model of game theory, which has an economic overtones, depends on cost analysis. A simple cost model assumes that all competitors suffer from the same fine imposed on the game, but this is not the case. More successful players will be endowed with or will have a higher margin of wealth or accessibility than less successful players. This wealth effect in evolutionary game theory is represented by mathematically resource-holding potential (RHP) and shows that the effective cost to a competitor with a higher RHP is not as great as for a competitor with a lower RHP. As a taller RHP person is a more desirable mate in producing potentially successful offspring, it is only logical that having a sexual selection RHP had to evolve to be signaled in some way by competing rivals, and for that to work this alarm must be done honestly. Amotz Sahawi has developed this mindset in the so-famous principle of handicap, where superior competitors signal their superiority with an expensive display. As a superior RHP a person can properly afford such an expensive display this alarm is inherently honest, and can be taken as such a signal receiver. Nowhere in nature is this better illustrated than in the magnificent and expensive plumage of a peacock. The mathematical proof of handicap principle was developed by Alan Grafen using an evolutionary game modeling theorist. The main article coevolution: Coevolution Two types of dynamics have been discussed so far in this article: Evolutionary Games, which lead to a stable situation or point of stagnation for competing strategies that lead to an evolutionarily stable strategy of evolutionary games that demonstrate cyclical behavior (as in the RPS game), where the proportions of competing strategies continuously cycle over time into the overall population of competitive kovolution - the rough-skinned newt (Tarricha granaulos) is highly toxic , due to the evolutionary arms race with the predator, the common garter snake (Thamnophis sirtalis), which in turn is highly tolerant of poison. They're locked in an arms race. Queen. Mutual kovlution - Darwin orchid (Angraecum) and Morgan's sphinx moths (Xanthopan morgani) have a reciprocal relationship where the mole gets pollen and the flower is pollinated. The third, the paper, dynamic combines intra-specific and interconferent competition. Examples include predator-mining competition and host parasites of joint evolution as well as reciprocity. Evolutionary game models were created for paired and many types of coervolutionary systems. The overall dynamics differ between competitive systems and reciprocal systems. In a competitive (non-non-neutral) inter-revolutionary system, species participate in an arms race, where adaptations are generally maintained that compete better with other species. Both game wins and replication dynamics reflect this. This leads to the dynamics of the Red queen, where the main characters have to run as fast as they can to just stay in one place. A number of evolutionary models of game theory covering the core-volutation situations have been created. The key factor applicable in these core-revolutionary systems is the continuous adaptation of the strategy in such an arms race. Therefore, joint evolutionary modeling often includes genetic algorithms that reflect mutational effects, while computers simulate the dynamics of the general corvolutionary game. The resulting dynamics are studied when different parameters change. Because there are several variables at the same time, solutions become a multi-name optimization province. Mathematical criteria for determining stable points are Pareto's effectiveness and Pareto's dominance, a measure of the optimality of tackling peaks in multivariate systems. Carl Bergstrom and Michael Lachmann apply the theory of evolutionary games to the separation of benefits in mutual interactions between organisms. Darwinian fitness assumptions are modeled using replicator dynamics to show that the body develops at a slower rate in a reciprocal relationship, receiving a disproportionate share of benefits or gains. The expansion of the Mathematical Model A, which analyzes the behavior of the system, should be as simple as possible at the initial stage to help develop a basic understanding of the basics, or first-order effects pertaining to the study. With this understanding in place, it is appropriate to look if other, more subtle, parameters (second-order effects) further impact of primary behavior or form of additional behavior in the system. After Maynard Smith's seminal work in evolutionary game theory, this topic had a number of very significant extensions that shed more light on understanding evolutionary dynamics, especially in the field of altruistic behavior. Some of these key extensions of evolutionary game theory are: Spatial playIn spatial evolutionary game contestants meet in fixed-position contests and interact only with immediate immediate It shows the dynamics of the Hawk Dove competition, showing Hawk and Dove participants, as well as the changes in strategy occurring in different cells of spatial games Geographic factors in evolution include the flow of genes and horizontal gene transmission. Spatial game models represent geometry, dropping the contestants with a lattice of cells: contests are held only with the nearest neighbors. Victory strategies take over these immediate areas and then interact with neighbouring areas. This model is useful, showing how the pockets of co-operators can invade and introduce altruism in the game Prisoners' Dilemma, where Tit for Tat (TFT) is Nash Balance, but not also ESS. The spatial structure is sometimes abstracted into the overall network of interactions. This is the basis of the evolutionary theory of graphs. The effects of information availability In evolutionary game theory, as in conventional game theory, the effect of signaling (acquisition of information) is crucial, as in indirect reciprocity in the prisoner dilemma (where contests between SAME paired persons are not repeated). This simulates the reality of most normal social interactions that are not related to relatives. Until a measure of the likelihood of reputation is achieved in the Prisoners' Dilemma, only direct reciprocity can be achieved. Indirect reciprocity is also maintained with this information. In addition, agents may have access to an arbitrary signal that is not originally related to the strategy but is correlated due to evolutionary dynamics. This is the effect of a green beard (see lateral lizards, above) or the evolution of ethnocentrism in humans. Depending on the game, this may allow for the evolution of cooperation or irrational hostility. From molecular to multicellular level, the signal model of the game with information asymmetry between the sender and receiver might be co-verse, such as in the attraction of the mat or the development of translation machines from RNA strings. End populations Many evolutionary games have been modeled in end populations to see the effect this may have, for example, in the success of mixed strategies. See also Adaptive Dynamics Behavioral Ecology Dynamic Dynamics Evolutionary Dynamics Gen Center for Evolution Memetics Notes - Maynard Smith chose the name Hawk Dove from a description of the political views present during the Vietnam War. Links to b c d e Maynard-Smith, J.; Price, G. R. (1973). The logic of animal conflict. Nature. 246 (5427): 15–18. Bibkod:1973Natur.246... 15S. doi:10.1038/246015a0. S2CID 4224989. Newton, Jonathan (2018). Evolutionary Game Theory: Renaissance (PDF). Games. 9 (2): 31. doi:10.3390/g9020031. Easley, David; John Kleinberg (2010). 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