Competition . . . or Cooperation

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Version 12/23/15

> "Social cognition refers to the processes involved in understanding and interacting with conspecifics. Its evolution arose out of a complex and dynamic interplay between two opposing factors: on the one hand, cooperation among individuals to form groups can provide enhanced security against predators, better mate choice, and more reliable food resources; on the other hand, competition between group members provides individuals with selective advantages in terms of mate selection and food procurement. An evolutionary approach to social cognition therefore predicts mechanisms for cooperation, altruism, and other aspects of prosocial behavior, as well as mechanisms for coercion, deception, and manipulation of conspecifics. Classical evolutionary theory emphasized competitive interactions based on the struggle for life and the survival of the fittest, but cooperation is also common between members of the same species and is indeed advantageous for the individuals because it increases their survival fitness."[1]

1 Introduction

The words "competition" and "cooperation" have a range of meanings. We will say that two entities (individuals, genes, organizations, nations, . . .) behave competitively with respect to each other if their respective actions are ones that further their **individual interests**. We will say that two entities behave cooperatively with respect to each other if their respective actions are ones that further their **mutual interest**.

Economics is very largely based on the assumption that people behave competitively and not cooperatively in the above sense. To the extent that observed behavior appears cooperative — think, for example, of mutual cooperation in setting of a repeated game — this is explained as resulting from extended individual interest. But the **evolutionary sciences** teach us differently. The leading primatologist Frans de Waal talks about a "propensity to cooperate"[2] that can be traced back to our primate ancestors.

2 Evolutionary Basis of Cooperation

De Waal[2] summarizes findings from studies of primate cooperation:

- Kinship relationships do not limit the extent of cooperation. This has been observed in both chimpanzees and bonobos.

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- Reciprocity supports cooperation. This basis of cooperation is, perhaps, the closest to the economic mechanism of extended self-interest.

- Empathy motivates cooperation. Identification with the emotions of others prompts helping behavior, and the underlying neural and hormonal processes may be adapted from maternal caring behavior. Empathy develops early in human infants (in the first year of life), and studies also indicate that it emerges as a stable and, to some extent, genetically determined disposition in individuals.[3]

De Waal suggests that humans may have taken cooperation further than other primates in being able to create **hierarchical command structures** that enable cooperation on an especially large scale. But we should not conclude that humans are purely cooperative. We are both competitive and cooperative:

> "Students of law, economics, and politics lack the tools to look at their own society with any objectivity. What are they going to compare it with? They rarely, if ever, consult the vast knowledge of human behavior accumulated in anthropology, psychology, biology, or neuroscience. The short answer derived from the latter disciplines is that we are group animals: highly cooperative, sensitive to injustice, sometimes warmongering, but mostly peace loving. A society that ignores these tendencies can't be optimal. True, we are also incentive-driven animals, focused on status, territory, and food security, so that any society that ignores those tendencies can't be optimal, either. There is both a social and a selfish side to our species."[4]

Exercises:

- Find an example where a real-world situation has been described as competitive (or cooperative), and you agree with the description.

- Find an example where a real-world situation has been described as competitive (or cooperative), and you disagree with the description.

3 Game Theory of Cooperation

If game theory is a language for describing and analyzing interactions among players, and if cooperation is a (not the!) fundamental aspect of human behavior, then we should expect cooperative behavior to be a basic building block of the theory.

The parts of game theory with which most people are familiar, namely game matrices and game trees, are usually employed to describe and analyze individual behavior. But if we go back to the beginning of game theory, in particular to the founding 1928 paper by the famous mathematician John von Neumann,[5] we find there the notion of joint action for joint benefit. This work marked the beginning of the branch of game theory called **cooperative game theory**, while the branch that studies individual action in matrices or trees is called **non-cooperative game theory**. These are the conventional terms used to distinguish the two branches of the field, but they can be misleading. As we have already said, cooperative effects can emerge in the non-cooperative setting, when players act in their extended self-interests. Equally, as we will see below, competitive effects can arise in the cooperative setting.

Since cooperative game theory is less well known, we now give a very brief introduction to some of its elements. A cooperative game consists of a **set of players**, which we can write as

$N = \{1, 2, \ldots, n\}$ if there are n players, and a function which gives to each subset of players a number, which is interpreted as the value of what the players in that subset can achieve through joint action. Write $\mathcal{P}(N)$ for the set consisting of all the different possible subsets of the set N of players. (This is conventional notation.) Question: If there are n players in total, how many different subsets of players are there? In mathematical language, we can then say that there is a function $v : \mathcal{P}(N) \to \textit{Real Numbers}$, so that, for each subset S of players, the number $v(S)$ is the value that the players in S can jointly create. The function v is called the **characteristic function** of the game.

Cooperative game theory is strikingly different from non-cooperative game theory. It is game theory without moves! Rather than committing to a specific model of all the possible moves and countermoves in a game, as non-cooperative theory does, cooperative theory does not talk about moves at all. Joint action is assumed — perhaps, even better is to say that it is presumed — and the focus is on how different combinations of players yield different (joint) outcomes.

As we have described it so far, cooperative game theory is a very broad language, but it is also quite abstract. Often, it is useful to specialize the theory to settings with some particular structure. A common setting is what in business strategy is called the **value chain**, that is, a game consisting of firms, customers, and suppliers. Value is created by subsets S of players containing appropriate combinations of suppliers (providing resources to firms), firms (transforming resources into products), and customers (acquiring products from firms). The amount of value created by a particular subset S will differ according to which suppliers, firms, and customers 'come together' in that subset. Notice that in this picture, the fundamental business activity is the cooperative one of the creation of value that occurs when players along the value chain come together.

4 Competition in the Presence of Cooperation

The natural next question to ask is: Now that we have described the value that different subsets of players can create, what can we say about how much value each individual player receives? This is where competition enters the cooperative branch of game theory, since this is a question about individual rather than mutual interest. The idea we want to capture is that each player goes about tentatively entering into agreements to create value with various groups of other players, and the player seeks the best such agreement for itself. The key concept for capturing this idea in cooperative theory is that of a player's **added value**.[6] This is defined as the total value created in the game minus the total value that would be created if the player in question was not present in the game. Algebraically, we can write player i's added value AV_i as:

$$\text{AV}_i = v(N) - v(N \backslash \{i\})$$

where the notation $N\backslash\{i\}$ means the set $\{1, 2, \ldots, i-1, i+1, \ldots, n\}$ of all players except player i.

A basic method of analysis in cooperative game theory, called the Core,[7] includes the requirement that the total value in the game, $v(N)$, is divided among the players in such a way that no player i receives more value than that player's added value AV_i. Sometimes, this method of analysis will yield a unique division of value among the players in a game. Other times, it will delimit but not uniquely specify the division of value. In either case, this method of analysis is how the notion of competition is captured within cooperative game theory.

Notes

[1]Decety, J., P. Jackson, J. Sommerville, T. Chaminade, and A. Meltzoff, "The Neural Bases of Cooperation and Competition: An fMRI Investigation," *NeuroImage*, 23, 2004, 744-751. References within this excerpt are not included.

[2]de Waal, F., "One for All: Our Ability to Cooperate Has Deep Evolutionary Roots in the Animal Kingdom," *Scientific American*, September 2014, 69-71.

[3]Knafo, A., C. Van Hulle, C. Zahn-Waxler, J. Robinson, and S. Rhee, "The Developmental Origins of a Disposition Toward Empathy: Genetic and Environmental Contributions," *Emotion*, 8, 2008, 737-752; Knafo, A., "Are People Naturally Inclined to Cooperate or Be Selfish?" *Scientific American*, August 14, 2014.

[4]de Waal, F., *The Age of Empathy: Nature's Lessons for a Kinder Society*, Harmony Books, 2009, 4-5.

[5]von Neumann, J., "Zur Theorie der Gesellschaftsspiele," *Mathematische Annalen*, 100, 1928, 295-320. English translation by Bargman, S., "On the Theory of Games of Strategy," In Tucker, A., and R.D. Luce (eds.), *Contributions to the Theory of Games*, Volume IV, Princeton University Press, 1955, 13-42.

[6]The usual term in cooperative game theory is "marginal contribution." The term "added value" comes from Brandenburger, A., and H. Stuart, "Value-Based Business Strategy," *Journal of Economics & Management Strategy*, 5, 1996, 5-24, where it was proposed to accord with colloquial meaning.

[7]For the full definition, see Owen. G., *Game Theory*, 4th edition, Emerald Group, 2013.