Backward Induction in Indian Animal Tales

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The tragedy that follows a wrong plan,
The triumph that results from the right plan,
To the rules of Polity both are linked;
so the wise can point them out,
as if displayed in advance.

(*Pañcatantra* 1.23; Olivelle 2006: 77)

Introduction

The famous Indologist Heinrich Zimmer observes that Indian political thought was characterized by "cold-blooded cynical realism and sophistication" (1969: 89). He also finds that "ancient Hindu political wisdom" brings about "the cold precision of a kind of political algebra, certain fundamental natural laws that govern political life, no matter where" (90).[1]

Meanwhile, economists and mathematicians under the heading of "game theory" have developed Zimmer's political algebra. The interested reader can consult one of the many textbooks on game theory; for example, Parts 1 and 2 in Robert Gibbons (1992) or Chapter 3 in Avinash Dixit and Susan Skeath (1999). The aim of this paper is to show that the reasoning employed by human and animal actors in some Indian fables can be analyzed by a powerful method developed by game theorists, namely, backward induction. Sometimes these actors employ backward

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induction, and sometimes, very much to their disadvantage, they fail to do so. In the stories presented below, the didactic purpose of teaching forward-looking behavior seems very obvious. Thus, we may credit Indian political thought with the early invention and application of backward induction.

It is not easy to say whether or not the Indians share this achievement with other ancient cultures. For example, when Steven J. Brams (2003) analyzes stories from the Hebrew Bible, he also uses backward induction. To our mind, this does not necessarily mean that the Bible authors also apply backward induction. In contrast to the Indian fable-tellers, their focus is not on strategic thinking, but rather on telling the history of the Israelis and on the relationship between God and His people. (Of course, the fact that Brams [2003, 2011] applies the Theory of Moves developed by that author to biblical stories, does not imply that biblical story-tellers had any idea about this recent branch of game theory.)

Apart from biblical stories, Brams (2011) shows how non-cooperative game theory can be used to analyze, *inter alia*, jury selection, Aritophanes' play *Lysistrata*, Shakespeare's *Macbeth*, or the Cuban Missile Crisis. Similarly, in an as yet unpublished manuscript, Michael Suk-Young Chwe (2010) argues that "folk game theory" can "take the perspective of outsiders" such as slaves or Jews. To the best of our knowledge, this paper is the first to provide a game-theoretic analysis of some Indian fables. However, it is not the first one to point out early advances of Indian scholarship in the fields of economics and game theory. In particular, Balbir S. Sihag (2007) claims that Kauṭilya's *Arthaśāstra* already "knew" about game-theoretic niceties, such as time inconsistency and asymmetric information.

We will explain the political algebra of game theory by way of three animal tales: (*i*) the tiger and the traveler, (*ii*) the lion, the mouse and the cat, and (*iii*) the cat and the mouse. Zimmer himself cites the second and third fables. While the Indian fable-tellers did not have the formal method of backward induction at their disposal, the stories and the morals of the stories clearly show that they understood backward induction very well. This is obvious from all three stories, although only the last one has the players act according to backward induction. In the first two examples, backward induction is violated, and it is this very violation that the fable-tellers want to point out to their readers.

Non-cooperative Game Theory and Backward Induction

In this section, we present as much game theory as is necessary for the purposes of this paper. Instead of formal definitions, we try to put across the basic reasoning by way of a simple example. Consider the game between the players 1 and 2 depicted in Figure 1. You can see that some nodes are indexed by the player names (1 or 2). At these nodes players 1 and 2 have to make a choice. Player 1 moves first, at the initial node (the leftmost node). He chooses up or down. Next, it is player 2's turn to choose between left and right. When both players have chosen their actions, they obtain the appropriate payoffs or "utilities." The payoff information is noted near the terminal nodes (the rightmost nodes). The first number indicates the payoff for player 1, and the second number is the payoff for player 2. For example, if player 1 chooses up and player 2 chooses right, player 1 obtains the payoff of 0 and player 2 the payoff of 3.

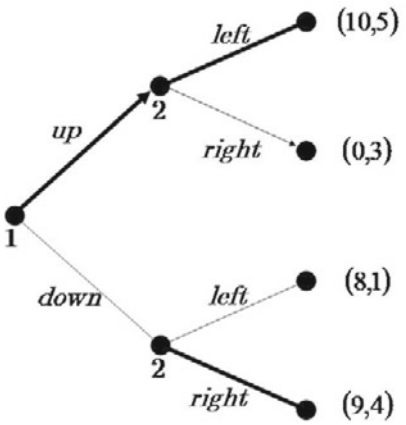

Figure 1: A Game Tree

Backward induction means "looking ahead" by "proceeding backwards." Before player 1 can decide on his move, he needs to know how player 2

will react to up or down, chosen by player 1. Thus, backward induction starts with the players who move last. Consider the node where player 2 has to make a decision after player 1 chose up. Comparing the payoffs 5 and 3, player 2 chooses left. The corresponding edge has been reinforced. In contrast, player 2 will choose right if he learns that player 1 has chosen down (this follows from 4>1).

Now, knowing the choices of player 2, we can look at player 1's decision. If he chooses up, player 2 will choose left so that player 1 obtains a payoff of 10. If, however, player 1 chooses down, player 2 will choose right so that player 1 obtains 9. Comparing 10 and 9, it is obvious that player 1 should choose up.

Thus, player 1 choosing up and player 2 choosing left is the predicted outcome. However, this may not be the observed outcome. For example, the arrows indicate player 1 choosing up and player 2 choosing right. In that sequence of events, player 2 would have made a mistake. By 5>3 he could have done better.

The Tiger and the Traveler

The first example is the tale of the tiger and the traveler known from the *Hitopadeśa* collection of fable-based advice (see, for example, Kale 1998: 7–9) or the comic book by Kamala Chandrakant and Jeffrey Fowler (1975: 14–18).

This is the story: A tiger on one side of a lake sees a traveler passing by on the opposite side. With the offer of a golden bracelet, the tiger attempts to lure the traveler across so that he can eat him. When the traveler expresses suspicions about the tiger's intentions, the tiger argues that he would not (he claims to have reformed his former wicked ways) and could not (he claims to be old and weak) do any harm to the traveler. Finally, the traveler is convinced and enters the murky waters where he gets stuck. Immediately, the tiger takes advantage of the traveler's misfortune and kills him as planned.

Consider the payoffs in Figure 2. The first number at the final nodes refers to the tiger (ti), the second one to the traveler (tr). The tiger's payoffs are -2 for giving away the bracelet and not eating the traveler, 10 for keeping the bracelet and enjoying a good meal, and 0 for the status quo of keeping the bracelet but staying hungry. The corresponding traveler's

payoffs are 5, -100, and 0.

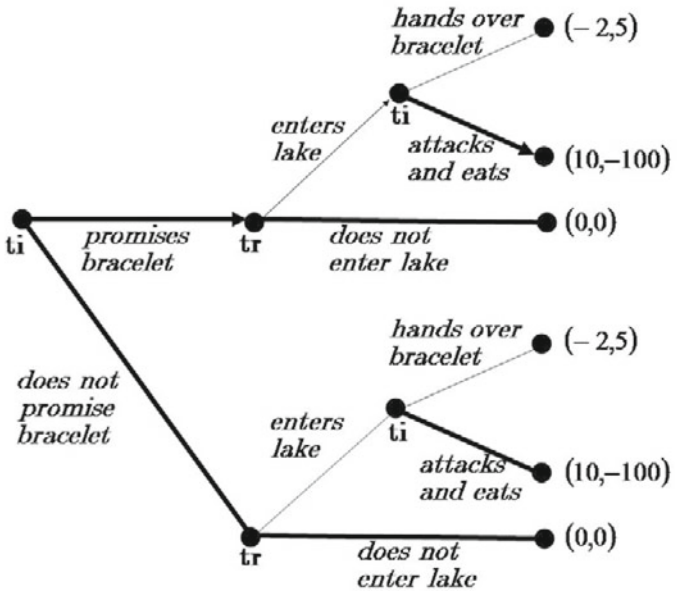

Figure 2: The Tiger and the Traveler

The arrows indicate the tragic sequence of events sketched above. The tiger moves first by promising the bracelet (upper branch). The traveler enters the lake (upper branch), and then the tiger kills the traveler (lower branch).

The game tree of this story has three stages. First, the tiger offers the bracelet and talks about his *guru* who has convinced him to lead a more virtuous life, or the tiger refrains from offering the bracelet and/or from talking persuasively. Then, the traveler needs to decide whether or not to accept the tiger's invitation to join him by crossing the lake. Finally, the tiger keeps his promise or reneges on it.

One may of course speculate about the traveler's "stupidity." Did "greed cloud the mind," or did he act on some probability assessment about the tiger telling the truth? Indeed, the tiger claims to have studied the Vedas to lend credibility to his good intentions. However, it seems obvious that the fable writer does not consider this example under the

heading of "better safe than sorry." Instead he argues that the tiger's predilections being as they are, the traveler should have known what fate held in store. Before being killed, the traveler has time to share some wise insights with the readers:

> That he reads the texts of religious law or studies the Vedas, is no reason why confidence should be reposed in a villain: it is the nature that predominate [*sic*] in such a case: just as by nature the milk of cows is sweet (Kale 1998: 8)

Knowledge of backward induction would also have led the traveler to avoid the lake. By 10>-2, he should have foreseen that he would be eaten after entering the lake so that keeping clear of the lake is best by 0>-100.

Interestingly, the traveler should refrain from entering the lake independent of whether or not the tiger talks about the *guru* who advised him to pursue a more virtuous life. In game-theory parlance, the tiger's arguments, the first step in our game tree, are just "cheap talk." Both a mischievous and a benevolent tiger could claim their benevolence without any cost. Therefore this claim is not credible.

The appearance of piety is also used by the cat in an animal tale from the *Pañcatantra* (see, for example, Olivelle 2006: 393–99). The cat is chosen to judge in a dispute between a partridge and a hare. Although wary of the danger, the two contestants finally approach the cat who kills them without much ado.

The Lion, the Mouse, and the Cat

The second animal tale is also taken from the *Hitopadeśa* (see Kale 1998: 51). A lion that lives in a cave is infuriated by a mouse that also lives there. The mouse regularly gnaws at the lion's mane while he is sleeping. Since the lion does not succeed in catching the mouse, he invites a hungry and desperate cat to come and live with him in the cave and share his food.

The arrangement between the lion and the cat works out well. The mouse does not dare to show itself while the cat is present. Therefore, the lion is happy to share his food with the cat as he promised to do, although he does not particularly enjoy the cat's company. One day, the cat detects

the mouse, catches and kills it. The lion does not see any reason to extend his hospitality and makes the cat leave his cave. Soon, the cat returns to its former miserable state.

The moral to be drawn from this fable is obvious: Do your work but see to it that you are also needed in the future.

The reader is invited to take a look at Figure 3. The first number at the final nodes refers to the lion, the second to the cat. Both players obtain a payoff of 0 if the lion does not invite the cat to stay, so that the lion's mouse problem is not solved and the cat cannot eat the food provided by the lion. The lion's payoff is 5 if the mouse does not annoy him, and increases up to 7 if, in addition, the cat does not stay in the cave. The cat in the cave has a payoff of 3 if it can stay in the cave and an increased payoff of 4 for eating the mouse and staying in the cave.

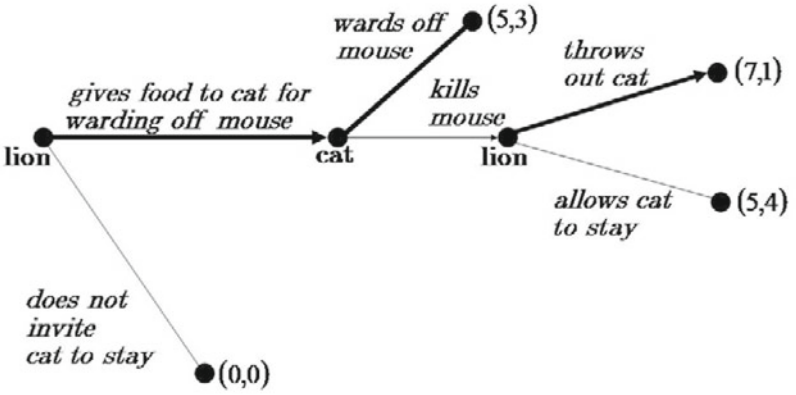

Figure 3: The Lion, the Mouse, and the Cat

The arrows indicate the story as told in the *Hitopadeśa*. This is not the backward-induction result, which, again, is indicated by the thickened lines. The wise cat would foresee that it is in the lion's best interests to get rid of it after the mouse is killed (7>5). Therefore, the cat should have continued to intimidate the mouse (payoff 3), rather than killing it and

being thrown out of the convenient cave (payoff 1). Working backwards one final step, we see that the lion was right to invite the cat into his cave (5>0). Indeed, because of the cat's mistake, the lion is even better off obtaining 7 rather than 5.

Again, one may ask whether there are defensible reasons for the violation of backward induction. Did the cat think that another mouse would soon show up so that the lion would need the cat's services again? It seems that the fable's author did not think along these lines, but had the more straightforward didactic aim of teaching the forward-looking behavior the cat did not master.

A second possibility comes to mind: The cat may have entertained the hope that the lion would be grateful to it for permanently getting rid of the mouse. However, in line with the cynical realism observed by Zimmer, we would rather not follow this line of thought, but insist on the lesson that friendship has no worth and that the behaviors of humans or animals are dictated by future gains and losses rather than by past friendly acts.

The Cat and the Mouse

In the previous animal tale, the lion profited from the opponent's mistake. Sometimes, however, players hope that opponents react rationally. To show this, we finally present a fable from Book 12 of the grand epic *Mahābhārata* (see Fitzgerald 2004: 513–18). A tomcat is caught in a net laid by a trapper. The mouse is happy to see her enemy in this difficult situation when she realizes that an owl is about to attack from above and a mongoose is sneaking up on her. She offers to destroy the net if the cat will give her shelter. The mouse realizes that her plan requires a good deal of rationality and foresight on the cat's part: "So I will make use of my enemy, the cat. I shall contribute to his welfare.…And now may this enemy of mine happen to be smart" (514).

Fortunately, the cat agrees to the bargain. Upon seeing that the mouse is under the cat's protection, the owl and mongoose go in search of other prey. The cat is dismayed to find that the mouse is in no hurry to keep her promise. Indeed, the mouse realizes that freeing the cat immediately will put her in danger from the cat. In a long dialogue, the logic of the situation is explicitly spelled out. As the mouse remarks:

> No one is really an ally to anyone, no one is really a friend to anyone.… When a job has been finished, no one pays any attention to the one who did it; so one should make sure to leave all his tasks with something still to be done. At just the right time, sir, you will be filled with fear of the [trapper] and intent on getting away, and you won't be able to capture me (517).

Thus, the mouse waits until the trapper approaches. At the very last moment, the mouse liberates the cat which now has better things to do than hunt mice. Both manage to find a safe place to hide, but certainly not the same one.

Figure 4 shows the game tree of this animal tale. The first payoff accrues to the mouse (m), the second one to the cat. The mouse obtains 0 for escaping unharmed and suffers the payoff of -100 for being killed by owl, mongoose, or cat. The cat's payoff is 0 for escaping unharmed, 2 for escaping and eating the mouse, -50 for being killed by the trapper, and -48 for being killed by the trapper after eating the mouse.

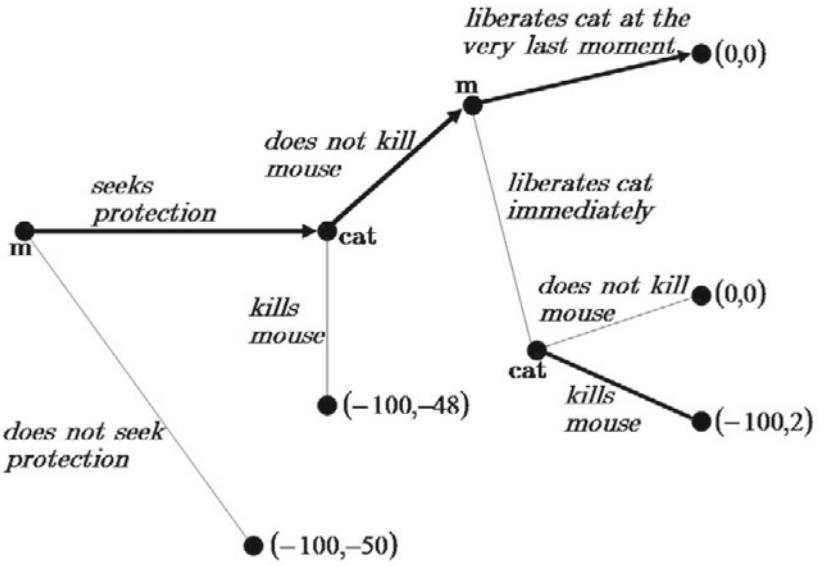

Figure 4: The Cat and the Mouse

Foreseeing that the cat will kill it if liberated well in advance of the trapper's arrival (2>0), the mouse prefers to wait until the trapper approaches (0>-100). The cat is clever enough not to kill the mouse before he is liberated (0>-48). Thus, indeed, the mouse made a clever move in seeking the cat's protection (0>-100).

Unlike the first two stories, in this tale the sequence of events is the one predicted by backward induction. Neither the mouse nor the cat makes a mistake.

Conclusions

As noted in the introduction, Indian political thought was cold-blooded and cynical. From the point of view of virtue ethics (see, for example, McCloskey 2006: 63), one may say that Indian fables and also a good deal of economics stress the virtue of prudence at the expense of other virtues, such as justice, hope, love, faith and so on. Indeed, Indian animal tales often have a clear didactic purpose—to teach future kings how to exercise prudence by paying heed to basic tricks in strategic thinking.

Ulrich Schwalbe and Paul Walker (2001) trace the "early (*sic*) history of game theory" and note (on page 126) that "The first time a proof by backward induction is used seems to be in [John] von Neumann and [Oskar] Morgenstern (1953)." We do not mean to contradict these authors when we say that the application (rather than the use for a proof) is definitely much older, going back to at least some hundred years BCE, in India and maybe also in other ancient cultures.

Notes

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