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# IBM Research Report

## Towards a Formal Analysis of Emotions in Games

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# Towards A Formal Analysis of Emotions in Games

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## 1 Introduction

**Rational choices depend on emotions.** It is often said that human players tend in many situations to act irrationally (see, for example [3]). What is meant by the phrase "the player acted irrationally" is that at the time of the decision the player was aware of another possible choice, which he preferred over the one he actually chose. Implicit in the latter is an assumption that the player has a preference order over the set possible choices that he is aware of. Of course, the meaning of preference is immediately contradicted by the "irrational" choice. Thus, definitions of rationality tend to be circular. We prefer here to view all players as rational and assume that what may seem to an observer to be an irrational choice may be in the final account the most preferred choice from the decision maker's viewpoint. The factors that affect the choice include various emotions associated with different actions and state, and lack of information or inability to adequately analyze the decision problem. In this paper we focus on such emotional aspects. The decision maker chooses actions depending on his own emotional state and what he believes the emotional states might be in the future, depending on the choices he might make. Thus, when a player has to form his preferences or to understand the emotions of other players in the game, he needs to understand the emotions that may arise in various situations in the game. In nontechnical speech, emotional decisions may seem to be the antithesis of rational ones. However, in the analysis of games, what matters are the preferences of players, regardless of whether or not they are formed based on a quantitative analysis or on spontaneous emotions. To understand the preferences, we have to understand the emotions that affect them. In [4] we argued that in many situations strategic analysis and formation of preferences are intertwined.

**The importance of modeling emotions.** One challenge for game theory is to assist designers of software systems in situations where it is desired to develop software agents that interact with human agents as well as with other software agents. Such interactions inherently involve cooperation and conflict, which are the main issues of interest in game theory. In other words, a software agent is expected to act like a player, which means that it has to analyze game situations and pick strategies. The games may not be given in the form assumed by standard game theory, and thus the agent may have to analyze games strategically and *form preferences* at the same time. In particular, a software agent may have to take into account the emotions of human players that participate in the same game. Such emotions inherently affect the preferences of human players and thus affect their strategic choices, which are essential for the software agent to consider while it is analyzing the game. Furthermore, although the software agent is not human and thus may not have emotions, the designer of the agent is accountable to some other humans, for example, the directors and investors in a company, who may later judge the designer by the performance of the agent, and the emotions of such humans have to be taken into account. For instance, such individual may evaluate the outcomes from a minimum-regret point of view rather than profit maximization.

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One difference between real-life interactions among human players, and interactions through computers among any kinds of players, is the possibility to observe emotions of other players, which is the case in real life. The preferences of a human player may change during the play of the game if he observes certain emotions in other players. A software agent can only be trained to infer emotions from the description of the game.

In view of the above discussion, there is a need to formalize some of the emotions that may arise in such a way that a software agent may be able to process them. In particular, playing some very simple game trees can be shown to evoke various emotions. In principle, the space of all game trees can be partitioned into subregions corresponding to emotions. For example, the plane of possible monetary payoffs to two players in a game can be partitioned into regions from the emotional point of view of one of the players, using labels like joy, sorrow, envy, pity, etc.

Here we attempt to start building a library of game trees with various emotions that may be evoked at various states of the game.

# 2 Emotions and feelings

There does not seem to exist a consensus with regard to the differences between emotions and feelings. Some limit the definition of feelings to certain states of mind and body, for example, feeling cold, being hungry, feeling sick, feeling tired, feeling pain, etc., while they are defining emotions as interpretations of situations, for example, disappointment, fear, anger, etc. Aristotle offered the following list of emotions: anger, mildness, love, enmity (hatred), fear, confidence, shame, shamelessness, benevolence, pity, indignation, envy, emulation, and contempt.

In each state of a game, where games include simple decision problems and random experiments, players and observers of the game may experience various feelings. Different feelings may be caused by various kinds of uncertainty, for example, lack of information about past and future moves (by players or by Nature) and lack of information about the preferences and beliefs of players. When some uncertainty is resolved, different feelings may arise, depending on the outcome and the prior probabilities of possible outcomes. However, some feelings may also be caused only by actions without any element of uncertainty.

## 2.1 Emotions related to probabilistic uncertainty

We start with scenarios that involve only decisions by Nature, i.e., randomized choices.[1] However, we assume that there is at least one "player" who has preferences over outcomes of the random process, and we are interested in the feelings of such a player at any state of the process. There is obviously happiness with a "good" outcome and unhappiness with a "bad" one, but there is also the element of surprise or shock related to the a priori probabilities. Below are several examples.

**Fear.** When a person awaits a choice of Nature, if there is a significant chance of a bad outcome, then the person may be *afraid.* Figure 1 depicts such a situation.

**Happiness.** A "good" outcome following an uncertain situation, which could end in a much worse can invoke *happiness.* See Figure 1. Similarly, a "bad" outcome can cause *unhappiness,* as depicted in 1.

[1] We use the standard notation where Player 0 is Nature who makes randomized choices.

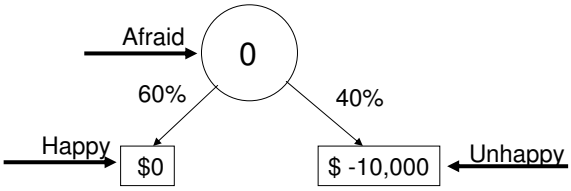


Figure 1: Fear

**Confidence.** If the probability of a "bad" outcome is very small, the person may feel *confident* that nothing bad will happen. The situation depicted in Figure 2 is that the outcomes are not very different from each other. Confidence can also be experienced when the probability of a "bad" outcome is very small.

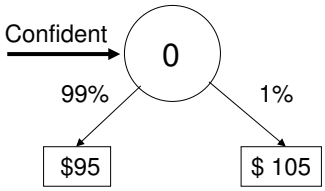


Figure 2: Confidense

**Suspense.** If there are significant probabilities of both very good and very bad results, then an emotion of *suspense* may ensue. Such a situation is depicted in Figure 3.

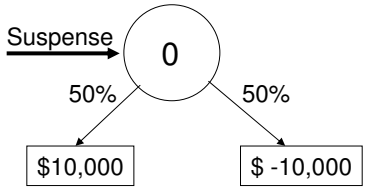


Figure 3: Suspense

**Joy of hope** If the amount at risk is small and there is a sizeable prize, then there can be an emotion of *joy* from the gambling. See Figure 4. The joy may simply be attributed to the *hope* of winning a prize. Even when the probability of winning a prize is small, people are willing to pay for the hope because it gives a good feeling.

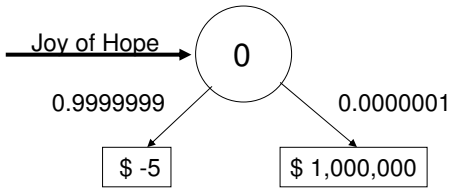


Figure 4: Joy of Hope

**Joy of high risk** If the value at risk is substantial and the probability is significant, the player may still enjoy the risk if it is more likely that the outcome will be "good." See Figure 5. The joy may be simply attributed to the hope of winning.

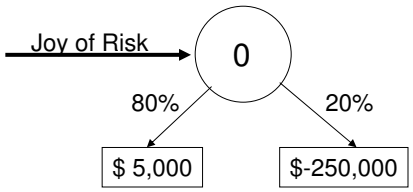


Figure 5: Joy of Risk

**Elation.** *Elation* is a feeling or state of great joy or *pride.* Elation can be experienced when uncertainty is resolved in a way that is highly beneficial to the decision maker, while it was not at all certain that the result would be like this. In the situation depicted in Figure 6, the player is initially involved in a significant risk, and feels great joy when the risk is removed and a prize is won. If the player actually chose to take this risk and the gamble succeeds, then his elation may include pride.

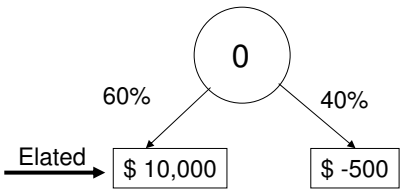


Figure 6: Elation

**Relief.** A player may feel *relief* when some risk is lifted. It is similar to Elation but the difference is that the reward of the successful bet is not large, whereas a failure is very costly but unlikely. See Figure 7

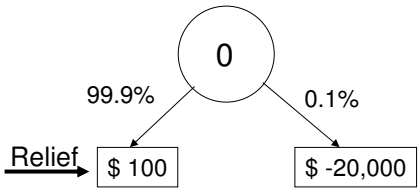


Figure 7: Relief

**Disappointment.** In the situation depicted in Figure 8, the player is involved in a bet of one dollar on winning $100 with probability 90%. He is *disappointed* if he loses the dollar, which was expected to happen only with probability 10%. The probability of losing is not very small, yet the player felt quite confident

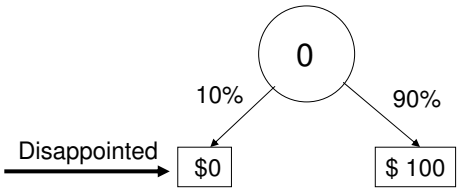


Figure 8: Disappointment

that he would win, hence the disappointment.

**Shock.** In the situation depicted in Figure 9, if the player is involved in a risk of 1% of losing $1,000, in order to win $100 with probability 99%. He is almost sure he is going to win, so when he loses he is shocked.

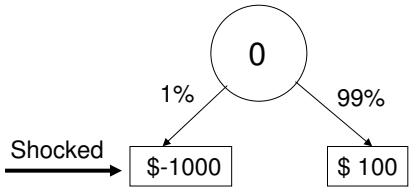


Figure 9: Shock

**Devastation.** An extreme case of shock, which we call devastation, is depicted in Figure 10. The player suffers a catastrophic loss, because an event that was supposed to occur with a minuscule probably of 0.00001, indeed happened.

The terms used here can also be generalized into continuous parameters depending on the payoffs and probabilities so that, for example, we could talk about the intensity of the shock.

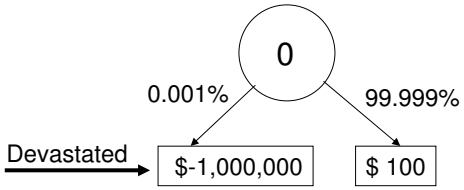


Figure 10: Devastation

## 2.2 One decision maker

Note in the all the examples discussed above, the only decisions were made by Player 0, i.e., Nature. We now consider feelings and emotions that may be invoked when a non-Nature player makes some decision. Some of the feelings are due to re-evaluation of one's decision when subsequently some information is revealed. Other feelings arise at the point of decision when the future is not known. Each example of Section 2.1 can be expanded into a decision problem, where the decision maker has to decide whether or not to play the respective game, and then various emotions arise at each node of the tree. When the outcome is "good" the player may derive additional satisfaction from the fact that he *chose* to play the game, and when the outcome is "bad" the player may experience additional unhappiness from the fact that he chose to play the game.

**Stress.** In the decision problem depicted in Figure 11, the decision maker, Player 1, has to choose between losing \$1000, e.g., by buying an insurance policy or by paying some tax, and taking a chance of 1% of losing \$50,000, e.g., by suffering damages without insurance coverage, or by getting caught evading taxes. At the decision point the decision may experience *stress.*

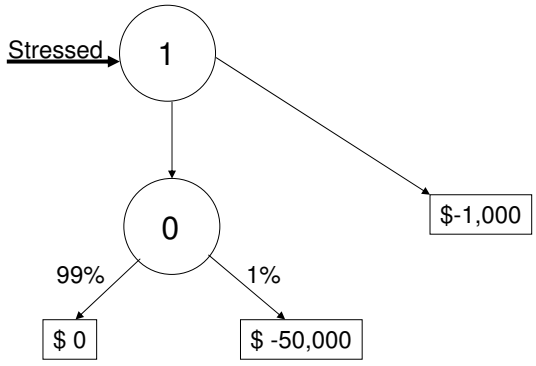


Figure 11: Stress

**Self-blame** Figure 12 depicts a situation where, with probability 1/2 the decision maker has the option to play safe and avoid a major loss, and probability 1/2 he has no choice. It seems that if the player chooses not to play safe, then the remaining subgame is equivalent to the subgame where he has no such choice. However, there is a difference in feelings because in one sub-game the player can *blame himself* whereas in the other one he cannot. There is a slight distinction between self-blame and regret. The term regret sometimes

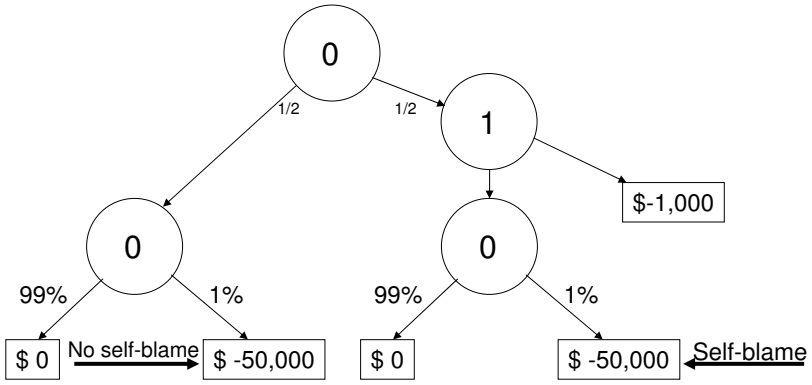


Figure 12: Self blame

includes comparisons to what outcomes could have been realized, not necessarily requiring the involvement of the decision maker.

**Satisfaction.** A decision maker feels *satisfied* if the result of his actions is good and anticipated. See, for example, the decision problem depicted in Figure 13.[2] The decision maker is satisfied because it is not just

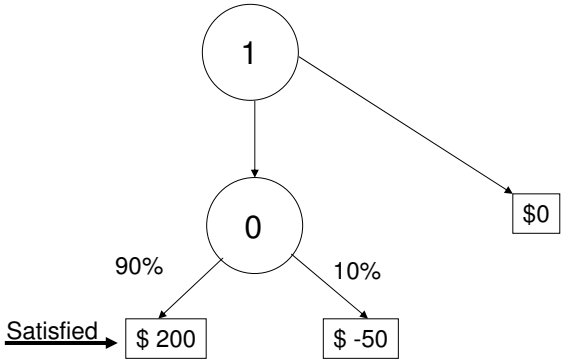


Figure 13: Satisfaction

luck that brought him the good result.

**Regret and contentment** A feeling of *regret* is experienced when a decision maker learns that by acting differently from what he actually did, he could have gained more. An example is depicted in Figure 14. In this example, the decision maker can choose to invest or not to invest without knowing the direction of the market. If he does not invest, then he may experience different feelings of regret or *contentment,* depending on the market movement, respectively, even though the monetary payoff is zero in both circumstances.

[2]Note that the information set depicted in this figure means that Player 1 decides to invest or not to invest without knowing whether Nature picked Up or Down.

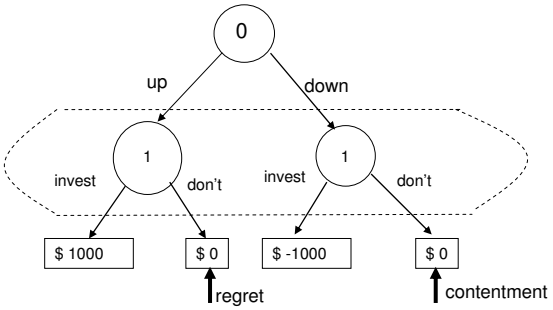


Figure 14: Regret

**Reduced satisfaction.** A decision maker who is initially satisfied with his decision, may later receive information that potentially can cause him to feel *less satisfied.* An example in depicted in Figure 15. The decision maker chooses $A$ and receives \$1,000, which is better than $B$ under either circumstance. The

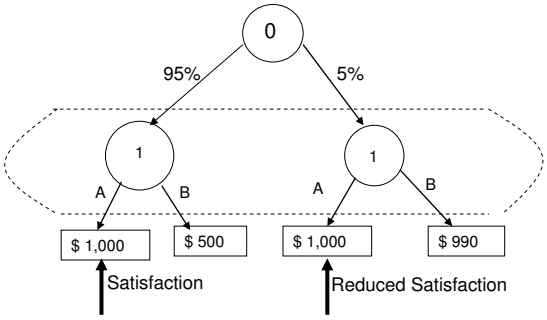


Figure 15: Reduced Satisfaction

decision maker expects with probability 95% that his choice would be better than $B$ by \$500.[3] So, before he receives the information he may be quite content that his decision has an advantage value of about \$500. However, if he learns later that a choice of $B$ would have been almost as good as the choice of $A$, giving \$990, his satisfaction may be reduced because the advantage of his decision in such a case is worth only \$10. Note that \$1,000 is the maximum payoff in this decision problem but the decision maker's utility is not the same in both terminal nodes that yield \$1,000.

**Guilt.** The feeling of *guilt* can exist in a single-decision situation, but it is probably related to how other entities are affected by the actions of the decision maker. In Figure 16 a situation is depicted where Player 1 has the option to steal \$10 from Player 2, and if he does he may feel guilty about it.[4]

[3] We assume that eventually the players learns the exact outcome.
[4] The upper payoff in the boxes refers to Player 1 and the bottom one to Player 2.

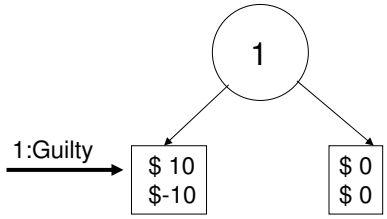


Figure 16: Guilt

## 2.3 Two-person games

**Embarrassment.** The emotion of *embarrassment* can exist only when there is more than one player. Essentially, it may arise when a player realizes that another player has learned about an action taken by the first player or about some private information, which had not been expected to be revealed to the other player. Figure 17 depicts such a situation. Initially, there is a probability of only 1% that Player 2 would learn about Player 1's choice, so Player 1 can take the risk and make a choice that could embarrass him with a small probability.

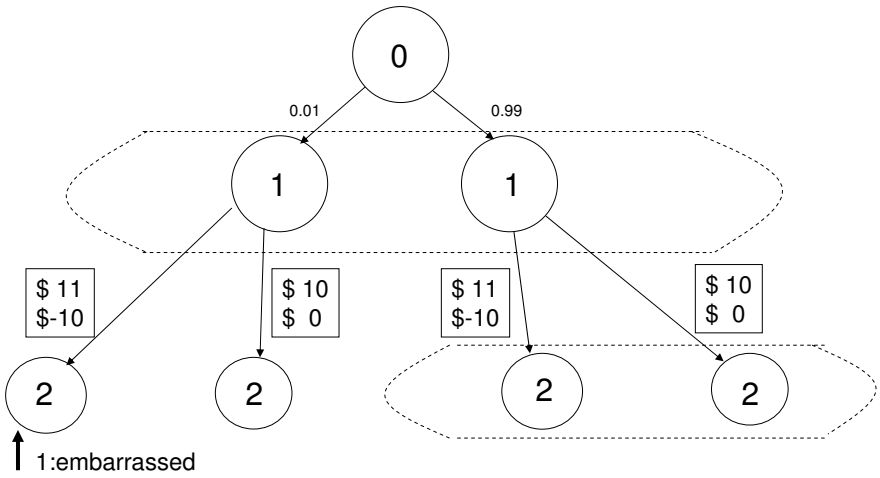


Figure 17: Embarrassment

**Mercy.** In the game depicted in Figure 18, if Player 2 is called upon to play, then it is only after Player 1 has decided to steal from Player 2 the amount \$1,000, while he had the option not to do it, and Nature picked with probability of 1% the event in which Player 1 is caught and forced to return the \$1,000; Player 2 then has the option to punish Player with a fine of \$20,000. If Player 2 chooses not to punish, then this move can be interpreted as an act of mercy on his behalf . Thus, being merciful, Player 2 prefers the net outcome $(\$0, \$0)$ over the net outcome $(\$ - 20,000, \$0)$.

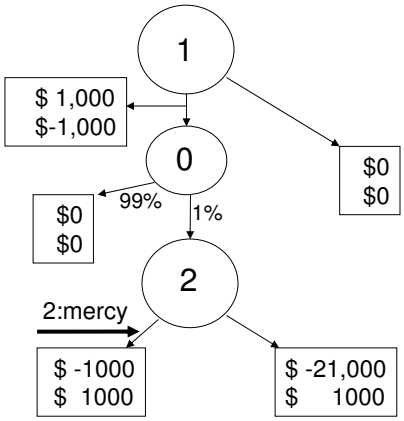


Figure 18: Mercy

## 2.4 Three-person games

When there are more than two players in the game, the feelings of one player can be affected by the way a second player treats a third one.

**Jealousy.** Jealousy may be experienced by person 3 when he realizes that person 1 prefers person 2 over him (i.e., person 3). In the game depicted in Figure 19 if player is called upon to play, then it happens after

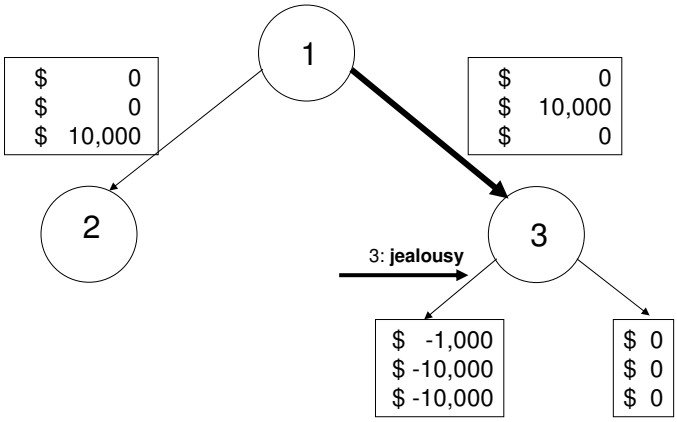


Figure 19: Jealousy

Player has decided to give Player 2 $10,000, when he could have given the same to player 3. If player 3 chooses the left branch, he damages everybody, and this act is a manifestation of jealousy.

**Vengefulness** In the game depicted in Figure 20, Player 2 observes Player 1 acting in a certain way against Player 3, namely, Player 1 decides to get for himself an additional one dollar, thereby reducing the payment to player 3 by $100. Player has the option to do the same to Player 1. When he does it he may act out of

the emotion of vengefulness. Note that Player 2 has the same option under any choice of Player 1, but the

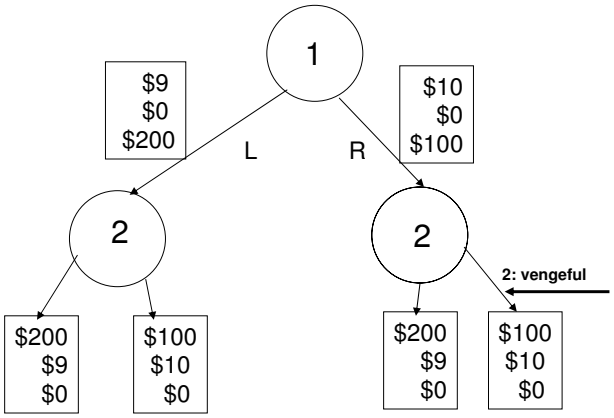


Figure 20: Vengefulness

emotions of Player 2 that arise are quite different, depending on the choice of Player 1.

**Anger, Indebtedness, Pride, Regret** We close with a relatively small example where yet several different emotions may arise. See Figure 21. Imagine a situation where both Player 2 and Player 3 would like

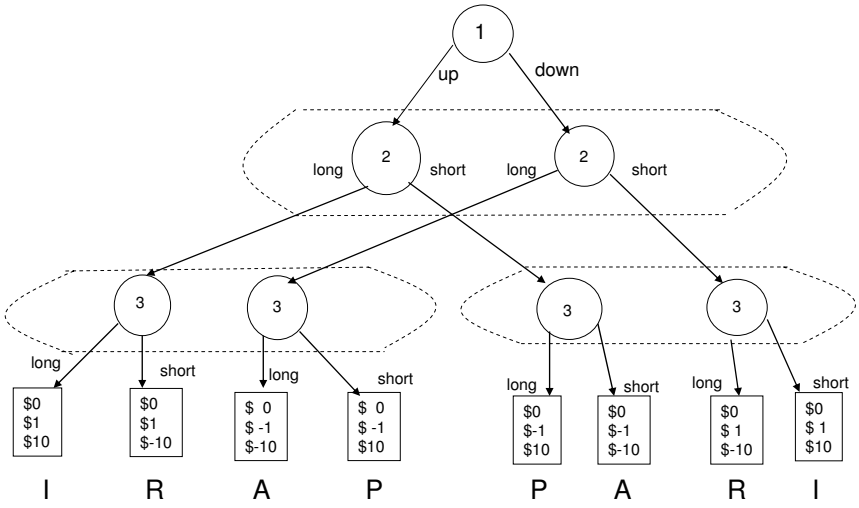


Figure 21: Anger, Indebtedness, Pride, Regret

to guess what Player 1 has chosen, and Player 3 is informed of Player 2s bet before he makes his choice. If Player 3 copies Player 2 and loses, he may develop some anger at 2 and blame him for the loss. (A) If both win, then 3 may become indebted to 2. (I) If Player 3 bets the opposite of Player 2, he may develop some pride if he wins (P) or regret if he loses. (R)

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[1] "What is the difference between feelings and emotion?"
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[2] J. Anderoni and J. H. Miller, "Rational cooperation in the finitely repeated Prisoner's Dilemma: Experimental evidence," *The Economic Journal* **103** (1993) 570-585.

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