DOMINANCE AND COMPETITION

Aldo Rustichini

Department of Economics, University of Minnesota
Faculty of Economics, University of Cambridge

Abstract
We propose and test two possible explanations of envy and its opposite, gloating. One explanation views them as a learning process, just as regret and rejoice are in the private domain: envy is the social correspondent of regret. The other explanation traces envy back to the natural tendency of individuals to seek higher positions in the social ranking, that is a dominant position, a tendency with very strong evolutionary motives. We show experimentally that these two functional reasons for envy coexist. Competition is the product of the desire for dominance, rather than the artificial output of a social arrangements.

1 Two balancing emotions

Neuroeconomics is also a dialogue with the classics, allowing us to study with scientific method what they could only glimpse with the power of their intuition ([9]). In a fashionable politically correct view Adam Smith is in *The Theory of Moral Sentiments* (TMS) the prophet of sympathy, seen as the source of benevolent and cooperative behavior in social and economic life. The simple fact that the word sympathy is not mentioned once in *The Wealth of Nations* has been a problem for this view since the 19^{th} century, and has been dubbed [8] *The Adam Smith Problem*: are the two major works of Smith, TMS and the *The Wealth of Nations* contradictory? The answer is no, as Smith himself stated in the *Advertisement* of the final edition of TMS, written in the year of his death. But if not, why the feeling of contrast?

As introduction to our main topic we offer a solution of the puzzle: some readers of TMS prefer not to see one of two emotions. To see this, let us start with a peculiar property of sympathy, that Smith points out from the start:

> The word sympathy, in its most proper and primitive signification, denotes our fellow-feeling with the sufferings, not with the enjoyments, of others. [TMS,I.III.1]

Sympathy, in other words, is *asymmetric*: our fellow-feeling is mostly inspired by the suffering, not to the joys of the others. What produces this asymmetry? Smith has a clear answer:

> a sentiment of envy commonly prevents us from heartily sympathizing with his joy [TMS, I.II.32]

Having identified two emotions, sympathy and envy, which play a fundamental role in shaping human social behavior, he notes a fundamental property of the way in which these two emotions interact: They cancel each other when what we observe is the success of others, they strengthen their effect when we observe their misfortune.

> There is, however, this difference between grief and joy, that we are generally most disposed to sympathize with small joys and great sorrows. The man who, by some sudden revolution of fortune, is lifted up all at once into a condition of life, greatly above what he had formerly lived in, may be assured that the congratulations of his best friends are not all of them perfectly sincere. [TMS, 1.II.32]

We may sympathize with our neighbor when he loses his job, or when his stray cat returns home. We may find a harder task sympathizing with him if he wins a large sum at the lottery. Smith had now traveled through the same path that Hume had followed a few years earlier: section VII of his *Treatise of Human Nature* (THN), *Of Compassion*, immediately followed by section VIII, *Of Malice and Envy.*

This is very speculative, and more than two centuries later we can bring to the analysis of these emotional processes a much more sophisticated set of tools than those available to Smith. We have an insight on the way sympathy works from the recent research on mirror neurons. We will try to build the same understanding for the other emotion.

2 Why are we envious?

We will explore in the rest of this paper two potential explanations for the existence of envy among the human emotions.

Regret and Envy: two ways to learn. The first explanation is that envy is the equivalent for an individual who is in a society of what regret is for the same individual when he is in isolation. Regret is the painful realization, *ex post*, that the outcome of a choice we made, A, is worse than the outcome of the choice we could have made but did not, say B. Similarly, envy is the painful realization that the outcome of the choice A we made is inferior to the outcome of the choice B that we could have made but someone else made. Upon meeting a former school mate that chose a different career than we did, but we could have chosen, and finding that he is more successful than we are, we feel envy. That the choice is one that someone else did and that we could have also made is important and explains one of the widely accepted regularities of envy: this feeling is stronger when the person we envy is closer to us. The reason why this is the case is clear: the experience of someone who is far from us (for example, someone who has completely different talents, or different personal history) is less useful and directly relevant, hence the impact on us is weaker. As Hume noted:

> 'tis not the great disproportion betwixt ourselves and another, which produces [envy], but on the contrary our proximity. A poet in not apt to envy a philosopher [THN, II.2.7]

In both cases, the motivation is provided by a counter-factual thought: I would have done better if I had chosen the option B, instead of the option A as I did. From this standpoint, the only difference between the two emotions is that in regret the choice of B is something that *we* could have done, but did not, while in envy is something that *someone else* did, and we did not.

Both emotions are useful to learn how to choose under uncertainty. Several models of adaptive learning are based on the idea that we learn by associating a negative affective reaction to an inferior outcome. Both regret and envy have potentially this functional explanation. The idea that learning is implemented by these two emotions is supported by recent literature in learning that regret can lead to choices that maximizes expected utility.

3 Envy as Social Regret: a Test

A simple experimental test of the hypothesis that envy is just the social correspondent of regret is provided in [1]. The experimental design emphasizes the similarity between envy and regret, using two conditions: a one-player condition (tailored for regret) and a two-players condition (for envy). In both conditions the subject has to choose between two lotteries displayed on the screen. The probability of each outcome is described as a sector on a circle. Every point on the circle has equal probability.

In the one-player condition, after the subject has made his choice, a square surrounds the lottery he chose. The other lottery is kept on the screen. Then a spinner spins on both circles, and stops randomly at some point on the circle, indicating the outcome. Since this happens on both lotteries, the subject knows the outcome of both lotteries. He is then asked to rate how he feels about the outcome, on a fixed scale from -50 to 50. Regret is the event in which the outcome for the chosen lottery is smaller than the outcome on the other lottery, and relief the event in which the opposite happens.

The two-players condition is very similar: but after his choice, the subject observes the choice that a subject like him has made out of the same two options available. If the two subjects choose the same lottery and have the same outcome, then they will experience what we can call common regret or common relief. If they choose a different lottery, then they might experience envy (if their outcome is lower than the outcome of the other) or gloating (if the opposite occurs). In the experiment, subjects were facing choices made by a computer program.

The Result of the Test. If the hypothesis that learning is just social regret is correct, then there should be no substantial difference in ratings in the two conditions for any given pair of outcomes of the chosen and unchosen lottery. We measured the Skin Conductance Response (SCR) of the subjects. Also for this measurement we should not expect any difference at the moment in which the outcome of the two lotteries is displayed.

Table 1 shows in the first column the average value of the evaluations in the different events. The second column reports the value of the SCR. Two results are clear: Envy does behave like regret, and gloating like relief. But the two player emotions have a higher rating, in absolute value, than the single player ones. Non-parametric tests show that the differences are significant. For positive emotions, envy is stronger than regret (z =2.754 , p=0.0059) and regret is stronger than shared regret (z = 4.120, p= 0.00001). For positive emotions, gloating is stronger than relief (z =4.032 , p= 0.0001) and relief is stronger than shared relief (z =4.620 , p=0.00001). In summary, the two player emotions are stronger than the single player ones. In particular, gloating, or the joy of winning, is stronger than relief: These subjects like inequality, as long as they are at the top of the scale. The magnitude of the SCR response is increasing in the absolute value of the rating, showing that verbal statements have a parallel in sympathetic activity and

Table 1: **Subjective Ratings and SCR value for different events.** The value of the SCR is reported for the moment in which the outcome is displayed.

Emotion	Ratings	SCR response
Gloating	33.04	0.1055
Relief	25.62	0.0886
Shared Relief	19.91	0.0589
Shared Regret	-18.49	0.0375
Regret	-25.27	0.0559
Envy	-29.19	0.0799

emotional arousal measured by the SCR.

How Choices change. The findings on emotional evaluations and SCR suggest an important difference between the private and social dimension. To describe it we rely on an axiomatic analysis of social decision theory [6]. Under appropriate axioms, the value to the decision maker of the act f to him and g for another individual is

$$V(f,g) = \int_S u(f(s))dP(s) + \int_S \gamma(u(f(s) - u(g(s))dP(s) \qquad (1)$$

where S is the state set, P the subjective probability on it, and u is the utility function. The gloating function γ represents the effect of the difference between the utility of the outcomes: when $u(f(s)) > u(g(s))$ we can say there is a social gain, otherwise a loss. We can now measure, as in prospect theory [5] the relative weight of gains and losses. Loss aversion in *private* choices can be formally described as the condition that $-\gamma(-x) > \gamma(x)$, losses looming larger than gains. Our results on verbal statements and SCR suggest that for *social* gains and losses the inequality is reversed.

This is of crucial importance in the analysis of equilibria of games and economies where individuals evaluate choice according to a value function V as in 1. If losses loom larger than gains (envy dominates gloating) equilibria are symmetric, and the society is conformist: agents have similar incomes. Instead, if gains loom larger than losses, (gloating dominates envy), the equilibria may be asymmetric, with people accepting at equilibrium differences in income and consumption. Here is the reason for the difference: when envy dominates, the externality adds a concave term, so if agents are *ex-ante* equal the economy is a representative agent economy with concave utilities, so equilibria are symmetric. Instead, when gloating dominates, the externality adds a convex term that can induce asymmetric equilibria in economies (and games) with agents that are *ex ante* identical. Details are in [6].

These results predict that with our subjects pool, where gloating seems to dominate, equilibria may be asymmetric. This is what we observe when we analyze the choices of subjects, who could be in one of two groups: in one, the computer chose lotteries to maximize expected value (risk neutral environment); in the other it chose to minimize variance (risk averse environment). The difference in the policy produced very different average payoffs of the opponent for our subjects: an average of 4.125 dollars for the risk neutral environment against one of 1.875 for the risk averse. The nature of the opponent affected the choices of subjects. In a simple model where the utility depends on mean and variance of the lottery one finds that the coefficient on the variance is affected by the past experiences of envy and gloating. The overall effect on behavior is in agreement with the prediction of asymmetric equilibrium when gloating dominates: subjects in the risk neutral environment became more risk averse, and the opposite happened to subjects in the risk averse environment.

4 Learning and Dominance: the Neural Basis

A brain imaging experiment based on the behavioral experiment just described is reported in [3]. One subject in the scanner and two more outside chose from the same set of lotteries. When subjects chose the same lottery, the outcome was drawn independently for the two subjects: hence in the two players condition we can test the difference between the case in which outcome is due to personal responsibility of the subject (because he chose a different lottery) or chance (when they chose the same lottery, and the outcome is different just because of chance). This gives a two by two design, one-player and two player interacted with personal and chance responsibility.

The experiment is a test of the model summarized by the equation 1. The predictions of our theory are that the function γ is different from zero, increasing, and its slope is larger in the two-players than in the one-player condition and in the personal rather than chance responsibility. These predictions translate into corresponding statements for the observable variables: the behavioral measure given by the emotional evaluation and the brain activation (measured by the BOLD signal) in the areas processing rewards (for example the ventral striatum). The results conform these hypotheses.

Comparing, in the two-players condition, events in which the payoff to the subject is larger than than the other subject's with those in which the payoff is smaller reveals a large cluster of activation in the ventral striatum, (globus pallidus and caudate) devoted to processing rewards. Similarly mood is significantly and positively affected by the difference, so the effect of the difference in payoff has a positive effect on both behavioral and brain variables.

The slope of the function can be estimated if we use the difference in the payoff as an independent variable in the regression of the brain activation. If we estimate separately for each subject the coefficient of the difference on the activation in the ventral striatum, the coefficient is significantly larger in the two-player than in the one-player condition. Similar results hold for the comparison between personal and chance responsibility.

The difference in brain processing goes beyond the quantitative difference in the effect of reward. Brain areas related to the processing of the thoughts of others (*Theory of Mind*) are more active in the two-players than in the one-player condition. This happens both at the moment in which the decision is taken and at the moment in which the outcome is evaluated. Clearly subjects take their decision, and process the information on relative payoff, realizing that the other subjects are doing the same.

5 Envy and dominance

The previous test has shown that although regret and envy move in the same direction, the two-players emotions are stronger than the one-player ones. An additional element must be playing a role. It is likely that this factor is not limited to humans. A possible reason for the strength of envy is that dominance is a crucial element in animal life. Dominance hierarchies are an ubiquitous feature of their relationships. They have been documented in insects, birds, fishes, and mammals, particularly primates. They are an important feature of relationships among men ([11], [7], [10]).

There are strong reasons among animals for wanting to be at the top of the scale, and disliking bitterly being at the bottom. In all the species in which dominance is clear, the individuals in the dominant position use their status to secure privileged access to resources, which include for example two fundamental elements: food and mates.

For food, being at higher positions in the ranking insures a larger quantity of food. For example the mean daily food intake of the high ranking females in a group of free ranging olive baboons was 30 % higher than that of the three lowest ranking females. Similar results hold for capuchin monkeys and female Japanese macaques.

For mates consider for example the research on the reproductive habits of the black-capped chickadees. These are socially monogamous birds who pursue a mixed reproductive strategy. About one third of the broods typically include young that are un-related to the current partner of the female. It is known that social interactions among the individuals are organized according to linear dominance. This affects the choice of partner: females who were paired with a low-rank male in one season are more likely to engage in mixed reproductive strategy then those paired with high ranking males.

Human who participate in a contest with others have strong preferences on relative outcomes of the contests, and are ready to translate these preferences into costly choices. More importantly, these preferences depend on what the outcome itself says about the underlying factors of the ranking. That is, human subject care about not the ranking of the *outcome* in itself, but for what it says on their position in the social scale, now and in the future. To understand the structure of dominance relationships in humans we may consider more closely what is known about those structures in animal societies.

Winner and loser effect. Take two randomly chosen individuals A and B, and set up a contest between them. A contest is any procedure that ends with one of the two declared a winner and the other a loser. The probability *ex ante* of A winning the contest is 50%. Suppose that A wins the contest with B. Pick now randomly a third individual C and match C in a contest with A. The observed conditional probability that A wins against C is higher than it was in the first encounter. This is the winner's effect; the loser's effect occurs if that probability is lower when A lost with B.

Winner and loser's effect are robust experimental regularities. One reason for the effect is clear: Animals have a mind, and they use it to process information before they make choices. So if A and C are animals and they are set up in a contest, they will keep into account the outcomes of the contests they have just witnessed. For example, if C watches A win a contest knows thanks to Bayes' rule that he is facing a stronger opponent than would be one drawn randomly from the population, and keeps this into consideration.

Eavesdropping, hiding and showing-off. If the outcome of past contests is so important in changing what other animals think of one's strengths, then animals must have developed an acute sense of what and when to show their strength, when to hide their weaknesses, and when to watch carefully when strangers are fighting it off, since a stranger today may be a rival tomorrow.

The behavior of black-capped chickadees illustrates why this is a reasonable expectation. In these birds, male singing is considered a signal of the quality of the singer. Mennill and colleagues [4] simulated an intruder singing next to the territory of a male-female pair, where the male could be high-rank or low-rank. The intruder challenged the male with counter-singing, and could be of two types: aggressive or submissive. Later the researchers checked with DNA analysis techniques the paternity of the nests in the birds that were unknowingly part of this experiment.

The percentage of nests containing extra-pair young was significantly affected by the outcome of the singing contest. If a high-rank male lost the contest with the intruder this percentage increased from 10% to 50 %, while there was no effect when the intruder was singing submissively. In the case of low-rank males, the loss *or win* in the contest with the aggressive intruder did not change the percentage of extra-pair activity of the female. It is hard to get back at the top of the scale once reputation is lost.

Eavesdropping, *hiding* and and *showing off* are natural consequences of the awareness that outcomes send signals to others and affect the social rank. Eavesdropping is the gathering of information on the rank of others collected by bystanders and occurs widely among animals. Females of the siamese fighting fish (*Betta Splendens*) pick among the male competitors on the basis of the information they gather from eavesdropping the fights among them. Anticipating this policy, male losers are more likely to court naive females (that is, females that have not witnessed their loss) than females who have seen their embarrassing moments. The opposite effect is showing off. In the male siamese fighting fish, males regulate their display depending on who is watching. If the audience is female, males increase the intensity of the display. Audience effects are also found in human subjects [2].

6 Envy and Social rank

We will now see how this behavior is present in human subjects. An important prediction of this view of dominance is that a signal is more important when it provides information on the ability of the individual rather than simply describing the outcome of a contest.

The experiment we use [12] to test this hypothesis is based on the comparison between two conditions: a game of skill and a game of luck. In both games the subjects in the experiment will observe a ranking of the outcomes of all participants, and will know exactly their position in the ranking. If individuals only care about monetary outcomes, theirs and also of the others, the nature of the two games should make no difference.

In the game of luck, subjects have to choose a number in a set, and the computer will also choose a number in that set with uniform probability. When the distance between the number chosen by the subject and the one chosen by the computer is smaller than a set distance, the subjects wins; otherwise, he loses. Clearly, the outcome in the game of luck tells very little on the subject. In the game of skill, subjects play a game against the computer. The game is a combinatorial game, in which the two players move sequentially. Although the game has a value and an optimal strategy, the optimal policy is complex: so the understanding of the strategy, or even the partial understanding of some components of it, is a measure of intellectual skill.

Experimental test with skill and luck. Subjects subtract money from the others. The fraction subtracted ranges from 20% to 50%, a range close to the average tax rate. The subjects that are chosen as targets of the subtraction are those with the larger amount won: their ranking is, on a unitary scale, between 2/3 to 3/4.

The decision to subtract and the amount subtracted are influenced by the nature of the game. Let us consider only the observations for the first of the two-games sequence, to abstract from the effects of the past history of subtraction from others.

For the decision to subtract or not, the marginal effect of the dummy variable *skill* is 0.34 (p=0.006, with a mean probability 0.64), so subtraction is more likely in the skill game. Also the interaction with the ranking of the subject is negative: the marginal effect is -0.77 (p=0.002), so an inferior position in the ranking increases the probability more in the skill game. Similarly the fraction subtracted from the other (amount subtracted over the total amount won) depends on the nature of the game. The interaction term between ranking of the subject and the dummy *skill* has a coefficient -0.16 ($p = 0.001$)).

The difference in the perception of ranking in luck and skill games is confirmed by analysis of brain activation at the moment in which subjects see the ranking. If we loos at the activation in the orbito-frontal cortex in the comparison between events in which the subject is the top scorer with those in which he is not, the difference is significantly stronger in the skill game than in the luck game. Also, a stronger activation at the outcome is a good predictor of the decision to subtract, an act that follows a few seconds later.

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