1 Introduction

Ever since Darwin's theory of evolution was proposed, cooperative traits in animals and humans were challenging to explain. In order to do so, Darwin's theory incorporates two novel kinds of extensions: the genetically kinship theory that Hamilton grounded mathematically (Hamilton,1964) and the reciprocal altruism theory (Trivers, 1971). Both appended theories are capable to explain social altruism behavior through natural selection. In evolutionary biology, reciprocal altruism is a behavior whereby an organism performs a costly act that benefits another organism with the expectation that the recipient will act similarly later time or even in the next generation.

The kinship theory that after landed on kin Selection and Maynar Smith use in first time (Smith,64), talk about, on knowledge of the genetic relationships of the organism involved, how altruistic behavior between closely related individuals can be selected though natural selection. This theory does not considers the altruistic act among distantly related organisms whereas Triver's theroy does. The term “reciprocal altruism” was first used by Trivers to refer to this type of behavior and therefore explain how selection favors altruistic behaviors in the long run when there is reciprocity in the population . Some of the most relevant and reliable examples about this type of cooperation are the Wilkinson studies in reciprocal food sharing behavior in vampires bats (*Desmodus rotundus)*, (Wilkinson, 1984). In these experiments, animals share a part of the harvested food only to a partner that previously shared with them. Other examples, ....

Different conditions must be fulfilled to ensure that reciprocally altruistic behaviors will be selected. Wilkinson makes a clear summary of these conditions : (1) the behavior must reduce a donor’s fitness relative to the selfish alternative, (2) the fitness of the recipient must be elevated relative to a non-recipient, (3) performance of the behavior must not depend on receipt of an immediate benefit, (4) a mechanism for detecting individuals who receive benefits but never pay altruistic costs has to exist, and (5) a large but indefinite number of opportunities to exchange aid must exist within each individual’s lifetime (Wilkinson, 1987).

Research on cooperative behaviors between non-related organisms has gained a new impulse since Trivers connected reciprocal altruism behaviors with the famous mathematical Prisoner's Dilemma (PD) (originally developped by Merrill Flood and Melvin Dresher 1950). The PD game is one class of 2x2 game that involves two players who must choose between two options, generally called cooperation and defection. The size of the reward delivered is established according both player's choice. If both chose the cooperation option both get payed a certain amount R (reward), and if both chose defection they bothget payed a smaller reward P (punishment) than R. However if one cooperates and the second player defects, the first one gets payed S (sucker) and other receives the best amount T (temptation) where the pay-off matrix maintains the inequality T>R>P>S.

Both the iterated Prisoner's Dilemma (iPD) and the Evolutionary Stable Strategies (ESS)(von Neumann and Morgenstern, 1944; Nash, 1949) predict, or suggest, what behavior (strategy) is likely to occur if a ESS is adopt by the population, in such a way, no minority using a another strategy can invade (Smith, 1974). When the 2x2 PD is played only for one time the best ESS is Defeat strategy. Nevertheless, when the pay-off matrix employed meets 2R>T+P and the game is played an indefinite numbers of times, the best strategy is mutual cooperation. e.i. if one stop reciprocity behavior the best option change to defeat. Axelrod and Hamilton (1981) showed that some organism's symbiosis can be understood through the reciprocal altruism's model and if organisms can remember the outcome of at least one previous interaction and they are able to recognize different partners, then the strategies situation includes a much richer set of possibilities. They present a ESS for iPD that combines robustness and stability with initial viability, called TIT FOR TAT. This strategy arised as the winner strategy, submitted by Anatol Rapoport, in the Robert Axelrod's computer tournament, because it can survive invations from other strategies. The highly simple strategy consists in cooperating on the first move and then doing whatever the opponent did on the preceding move.

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Thus, many experimenters have tried to understand different aspects of reciprocal altruism behavior in animals and whether non-human animals with less cognitive abilities can solve iPD. Green, Price and Hamburger (1995) assessed the iPD game on pigeons and observed that birds are very impulsive and prefer small immediate rewards rather than big, long-term, delayed rewards. Stevens and Stephens (2003) trained blue jays (Cyanocitta cristata) using four different pay-off matrices, where one of them was the iPD matrix, with a special dual operant box. This study found little cooperation in PD treatment and this findings suggest that blue jays don't cooperate when immediate benefit is available (defect only), even if a long-term benefit may exist. Then Steven and colleages (2002 and 2005) inspired by the low levels of cooperation observed (Gardner *et al.,* 1984; Clements and Stephens, 1995; Flood *et al.,* 1983; Green *et al.,* 1995) proposed assess over iPD frame to the effect of a pay-off accumulation and temporal clumping treatment to iPD game using blue jays in an apparatus that consisted of side by side V-shaped compartments. They found that combining both accumulation and clumping treatment birds showed a level of cooperation that scarcely surpassed chance choice. However, Danchin and colleages (2006) criticized the Steven's experiment arguing that each accumulation block the iPD payoff matrix becomes stag hung matrix (whereby the temptation outcome, T, leave to be the best reward, R>T≥P>S) because the bird quantify the effective amount after four trials. Adams and Mesterton-Gibbons pointed out that in a different study by Stevens And colleages (2002) birds care less about the immediacy of reward if seeds accumulation in a transparent food tray for some time before being delivered.

Moreover, Mendres and Waal(2000) and Waal(2000), used a pulling task in capuchin monkeys (*Cebus apella*) and a chamber divided with mesh to test cooperation. As a result, monkeys could adjust pulling task behavior according to their partner's presence and in turn the food shared behavior depended of quality of own and partner foods. Similarly, using a pulling task to give food to a partner and receive from a altruistic partner Hause and colleagues(2003) evaluated altruistic food giving behavior where sharing food through the mesh was not allowed over genetically unrelated cotton-top tamarin mokeys(*Saguinus oedipus*) and showed that monkeys give more or less foods to their partners taking into account whom was altruistic and whom not.

Knowing that primates have high psychological capabilities (cita) we can expect that these animals can learn reciprocal altruism despite of not performing this behavior in the wild. It's interesting then to investigatee whether animals with less cognitive habilities can learn reciprocal altruism. Using silimar protocols than the ones used for primates, Rutte and Taborsky (2007) assessed generalized reciprocity in female rats (*Rattus norvegicus*) by means of a alternating pulling task in a Wall and Menders chamber adapted for rats. In this protocol, the focal rats adopt a role of either “helper” in which they give food to a partner or “receiver” where thay take food from a partner. Generalized reciprocity is kind of reciprocal altruism between unrelated individuals where individual make altruistic behaviors by previous social experience irrespective of partner identity. The Taborsky's experiment was carried out with two phases: in the first, pre-training, phase the experimenter taught focal rats to perform alternating reciprocal task and in the second phase that after receive help or not for several days from differents partners were paired with a new partner in role of potential helper. They observe that the rats pull more frequently when they previously received interaction with a food-givers partner. From an operant conditioning perspective, we believe they have actually assessed extinction rate of pulling behavior after focal rats have or not received food for several days rather than rising the frequency of behavior by interaction between players. Then, Rutte and Taborsky (2008) evaluate direct versus generalized reciprocity using the same experimental set up. Direct reciprocity is a kind of reciprocate interaction in which a subject A cooperates with B on account of B previously cooperated with A. They observe that the pull rate is higher and its delay to pull is lower on direct reciprocity than generalized. This means that a know opponent is a more powerfull stimulus than unknown. Taborsky and colleagues(2012) have shown that rats reduced the pulling rate with increasing resistance to pull and Dolivo and Taborsky (2015) evidennce that rats take into account the quality of the food received from the opponent in future cooperation (pulling).

-creo que este párrafo no va----In our search for altruistic behavior in non-humans and non-primate animals we maybe demur that rats behavior in Taborsky's experiment didn't meet all of the conditions for reciprocal altruistic behavior. Because rats don't receive punishment for either punishment or temptation outcomes they rather assessed a different type of reciprocity-----

Reciprocal altruism has been widely tested by iPD, where the individual's decision rules can be described by a transition vector t, r, p, s that reflects the probability of cooperation when the previous trials resulted in outcomes of R, T, S or P, respectively (Stevens and Stephens,2004). If every component of this vector is 0.5, the agent's decision rule is random irrespective of the last outcome. Part of the experiments sets developed by Wood and colleagues (2016) were aimed to measure reciprocal altruism in Long Evans male and female rats using iPD. They used an operant chamber divided in halves by a removable mesh and equipped with retractable levers and stimulus light. As aresult, they show a 60% of altruistic behavior on male rats, barely surpassing chance choice.

To test whether rats have the ability to solve the iPD game when faced to altruist opponent, is necessary to force TIT FOR TAT behavior on the opponent (Stevens and Stephens, 2002; St-Pierre *et al.*, 2009; Viana *et al.*, 2010). In Moita's study (Viana *et al.*, 2010) mimicking a tit-for-tat strategy on the opponent in a double T-maze chamber was not enough to reach high levels of cooperation. We further analysed their Markov chain diagram and observed that the strategy performed by rats was more selfish than cooperative because it adopted an alternating decision's rule among sucker and temptation outcomes.

The rats often develop on social groups and studies have demonstrated that they prefer social reward rather that along or have a tendency to performe pro-social acts over the chance (Moita, 2015;Kalenscher, 2015).

Why all iPD-based studies haven't found high levels of reciprocity? In the aforementioned previous studies, rats don't learn iPD probably due to the fact that the test box and stimulus contingency are inadequate for its natural expectation, i.e. the rat maybe has the ability to achieve a approximated optimal solution but for example the length of time used to make the contingency is longer than what rats can keep in mind or maybe they don't realized the real difference within outcomes in the pay-off matrix.

Given these consideration, the present study was conduct to assess reciprocal altruism behaviors using a particular structure that combine iPD matrix pay-off and delay's punishment and a tit for tat opponent's strategy. We found that this combination achieve high level of reciprocal altruism behavior in rats.

2 Material and methods

All experimental procedures were approved by the ethics committee of the IByME-CONICET and were conducted according to the NIH Guide for Care and Use of Laboratory Animals.

2.1 Subjects and Housing

Two groups of male LongEvans rats (300–330 g) of two months of age were provided by the IBYME-CONICET. Twelves males were subjects and six (Nstooge=6) identical rats were opponents. At weaning time all subjects were housed in groups of two rats per cage to allow social interaction, whereas each stooge was housed in single individual cages. We had 12 stainless-steel cages altogether with sawdust as bedding and metal lids. All rats were food restricted to maintain animals at between 90-95% or 80-85% of free feeding body weight for subjects and stooges respectively. All animals were kept in a well-ventilated, temperature-controlled room (22 ± 2 °C) with a 12/12 h light/dark cycle (lights on at 8 am). Tap water was available *ad libitum*

2.2 Experimental Setup

All behavioral procedures were performed during the light phase of the light/dark cycle, using a standard operant chambers (MED associates Inc., USA) with Med PC IV software suit (Product SOF-735) and PCI Operating Package for up to Eight Chambers (Product MED-SYST-8) equipped with control of multiple devices SmartCtrl (Product DIG-716B) and pedestal mount pellet dispenser for rat, 45mg (Product ENV-203-45) and standard operant chambers (Product ENV 008). .We placed two chambers facing each other in such manner that each rat could make olfactory and eye contact through metal windows (FIGURA 1 CAJAS). Each standard chamber was equipped with two levers at the sides and two stimulus light over each lever and a feeder in the center. The boxes were faced by the wall that has levers and stimulus light. To allow the contact among rats we placed a aluminum rectangular windows below each levers. The window's height were such that the lever's height was 80% of maximum height of the forepaws while rearing (F. Cabrera et al., 2013). The subject's feeder was in same wall and the opponent's feeder in back wall. Each feeders were equipped with a stimulus light that turn on when foods is coming.

2.3 Experimental Design

2.3.1 General Task Design

2.3.2 Typical Trial Structure

2.4 Analysis

3 Results

4 Discussion

5 Reference