Dear Editor,

We are submitting a paper entitled “High mutual cooperation rates in rats learning reciprocal altruism: the role of payoff matrix”. Please consider it as a candidate for publication in PLOS ONE, as we believe this work will contribute a new sight in the learning of reciprocal altruism in non-related rats.

Reciprocity and reciprocal altruism were well

documented in several species. Although cooperation is needed in order to success in both reciprocity and reciprocal altruism, the latter add the possibility of getting reward by defecting an opponent. Some works had taught reciprocal altruism behavior by means of iPD paradigm in differents ways, but the experiments results were either low levels of cooperation (Wood *et al.*,2016) or depended on a treatment that enhance the cooperation preference (*mutualism matrix*) (stephens *et al.*,2002; Kefi *et al.*, 2007; St-Pierre & Dubois, 2009). Direct reciprocity, which is established between two individuals, has been observed in monkeys (De Waal, 2000, Mendres & De Waal, 2000; Hauser, 2003) and in rats (Taborsky *et al.*, 2007, 2008,2012,2015). There, while food quality seemed to impact on the cooperative behaviour, a key factor to obtain reliable cooperation levels was the opponent behaviour. In this sense, individuals tended to be more cooperative with opponents that had cooperated in the past. However, when reciprocal altruism is studied, differences between species come to light. Thus, while reciprocal altruism has been shown in monkeys, birds and rats failed to reach high levels of cooperation, even for complex combinations of rewards and punishments in the payoff matrix and treatments to induce preference (Green & Hamburger, 1995; Wood *et al*.,2016; St-Pierre & Dubois, 2009; Stephens & Anderson, 2001; Viana *et al*., 2010).

In order to train this behavior, we have studied the role of size and contrast among reinforcements in the rats´ learning, using iterated prisoner's dilemma (iPD) game with positive and negative reinforcement. Through this procedure, we have showed for the first time that rats learn reciprocal altruism reaching high mutual cooperation rates without any pre-training to enhance cooperation preference.

Finally, we found out that when the size of positive reward was modified by increasing cheat's rewards or by increasing mutual cooperation rewards, cooperation rates decreased. In this way, we show that beyond the theoretical relationship among iPD reinforcement necessary to learn reciprocal altruism, it is also the high contrast and the small size in positive rewards what enhance mutual cooperation. This finding allows to infer that of reciprocal altruism has early appeared in evolution.

We hope this finding is of interest to PLOS ONE readers.

*This paper is our original unpublished work and it has been submitted to PLOS Biology. In the decision letter they suggest to submitting our manuscript to PLOS ONE. The letter is attach.*

Type of article: **research article**.

Editors suggested:

**Ludek Bartos**, Thomas Boraud, Tommy Pattij, Peter G. Roma, Dante R. Chialvo.

Sincerely,



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