

## EMERGENCE OF REVENGE AND FORGIVENESS IN COMMITMENTS

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Commitments are widespread at all the levels of human societies, playing a key role in social interactions and being an evolutionarily viable strategy in one-shot social dilemmas [1]. Agreements are most often established to ensure favorable long-term interactions, implying repeated encounters with potentially repeated benefits. We analyze mathematically the conditions for apology, forgiveness, and revenge to evolve and deal with mistakes within ongoing agreements in the context of the Iterated Prisoners Dilemma [2]. We show that, when the agreement fails, participants prefer to take revenge by denying the benefit of the interaction to the opponent. Since mistakes in these relationships are practically inevitable, individuals may have acquired sophisticated strategies to deal with them. In this way, when we include costly apology and forgiveness, we see that there is a minimal apology cost that needs to be paid for which mistakes will not lead to the destruction of the agreement, inducing even higher levels of cooperation. Then forgiveness is evolutionarily viable when apology is sincere enough, playing an important role in inducing cooperation in repeated dilemmas.

[1] The Anh Han, Luis Moniz Pereira, Francisco C Santos and Tom Lenaerts; *Scientific Reports* **3**, 2695 (2013).

[2] Luis A. Martinez-Vaquero, The Anh Han, Lus Moniz Pereira and Tom Lenaerts; *Scientific Reports*, in press (2015).