Supplementary Material

To model learning by experience and to test if experience-based learning affects which neural correlates are activated when players are playing a repeated sequential prisoner's dilemma game, the experiment made use of the experience weighted attraction model (EWA) developed by Camerer and Hua Ho (1999).

This model computes an attraction for each strategy possible in the game. In a prisoner's dilemma, the two possible strategies are to cooperate (C) or to defect (D). In each subsequent trial, the attractions towards these strategies are updated.

The full equation for the attraction, A_C, towards the cooperative strategy, s_C, in trial t is given by:

eq. 1
$$A_C(t) = \frac{\varphi N(t-1)A_C(t-1) + [\delta + (1-\delta) * I(s_C, s(t))] * \pi(s_C, z(t))}{\rho N(t-1) + 1}$$

The first term in the numerator captures what the participant learned from experience in past encounters:

eq. 2
$$\varphi N(t-1)A_C(t-1)$$

where N(t-1) is the number of "observation-equivalents" referring to past encounters, and A_C(t-1) is the attraction towards the cooperative strategy in round t-1. The factor φ is a discount factor that weights prior experience in earlier trials less than the experience in the most recent trials. This term captures how strongly participants update their preference towards cooperation, based on built–up experience with this strategy, and therefore captures the learning process of the participants.

The second term describes the influence of the pay-off on the attraction in the current trial t:

eq. 3
$$[\delta + (1-\delta) * I(s_C, s(t))] * \pi(s_C, z(t))$$

The term $\pi(s_C, z(t))$ is the pay-off received when the participant chooses the cooperative strategy, given the response z(t) by the opponent (which can be cooperate or defect). The term $I(s_C, s(t))$ is equal to 1 if the participant chooses to cooperate, and 0 otherwise. Thus, if the participant cooperates, the pay-off term is equal to the actual pay-off and weighted by 1. If the participant defects, attraction to cooperate is affected by the pay-off that was forgone by not cooperating, weighted by δ.

The sum of these two terms is then normalized by dividing the number of previous encounters (the "observation-equivalents", N(t-1)), discounted by the factor ρ.

The probability of cooperation in trial t+1 is defined by the attraction to cooperation vis-à-vis the alternative strategy of defect, A_D:

eq. 4

$$P_C(t+1) = \frac{e^{\lambda A_C(t)}}{e^{\lambda A_C(t)} + e^{\lambda A_D(t)}}$$

in which λ is a scaling factor. To determine the values of the free parameters, we fitted equation 4 to the data using matlab code by den Ouden *et al.* (2005).

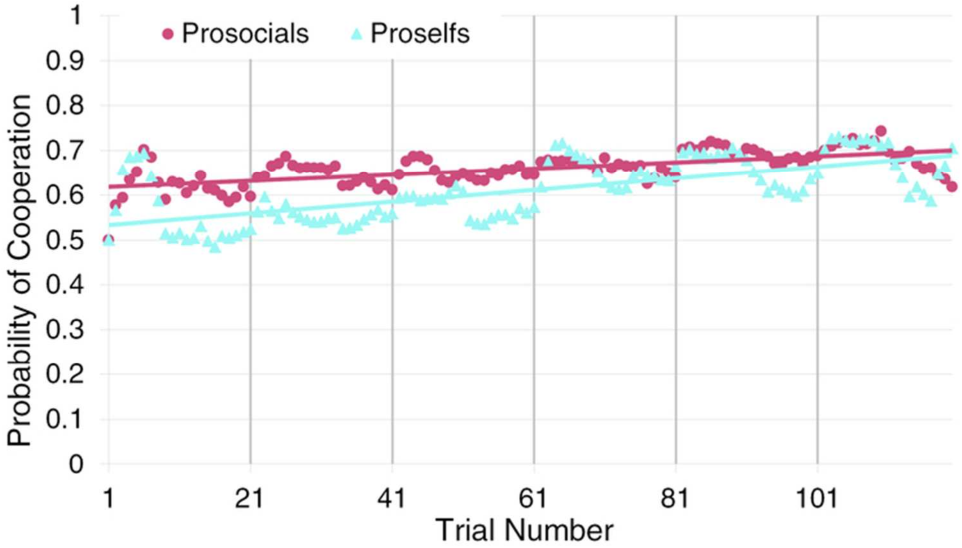
A linear regression model with random effects to account for the differences among participants was estimated, with the estimated probability of cooperation as dependent variable, and trial numbers and SVO as independent variables. This revealed that there is a significant effect of trial number (B = 0.010, 95% CI [0.008 0.011], $p < 0.000$, Wald $\chi^2 = 253.63$) but not of SVO. Similar to the results reported in the paper, the interaction between trial number and SVO is also significant (B = 0.0006, 95% CI [0.003 0.008], $p = 0.005$, Wald $\chi^2 = 275.00$).

Camerer, C. & Hua Ho, T. (1999) Experience-weighted attraction learning in normal form games. Econometrica, 67(4), 827-874.

den Ouden, H. E. M., Frith, U., Frith, C. & Blakemore, S. J. (2005) Thinking about intentions. Neuroimage, 28(4), 787-796.

Fig. S1.

Estimated probability of cooperative decisions made by proselfs or prosocials for each of the 120 trials. Best fit lines, based on least squares, are shown.



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