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Fast deliberation is related to unconditional behaviour in iterated Prisoners' Dilemma experiments

Keywords: Prisoner's Dilemma, cognitive process, intuition, Drift Diffusion Model, cooperation

Abstract

People's individual differences in allocating resources can be estimated from differences in their deliberation process. In this paper, we use the Drift Diffusion Model to analyze the participants' reaction times in three different experiments of the Iterated Prisoner's Dilemma. We find that individuals who allocate resources equally are correlated with more deliberation, while highly cooperative or highly defective participants accumulate evidence more quickly to reach a decision. The evidence collection is faster in fixed neighbour settings than in shuffled ones. The study suggests that fast decisions do not distinguish cooperators from defectors, but separate those who are more reactive to the behavior of others from those who act categorically.

Background

This text discusses Montero-Porras et al.'s work [2] on individual heterogeneity in cooperation and its relationship with cognitive processes in decision-making. The study analyzed response time (RT) in the Prisoner's Dilemma game to understand the relationship between cognitive processes and RT.

Progress has been made by linking neurosciences and behavioural economics, [1]. One of the models that has tried to explain the relationship between the cognitive process of discrete-choice tasks and RT is called Drift Diffusion Model (DDM) [3], without making any assumptions about how fast the participants responded.

We analyzed data from three treatments with different network structures and payoff matrices to study the impact of increasing interaction complexity on participants' reaction time (RT) in playing the iterated prisoner's dilemma game (IPD). The experiments included pairwise play (PIPD), multiple opponents in a Moore's neighborhood (mNIPD), and a Von Neumann neighborhood (vnNIPD). We then used DDM to infer participants' cautiousness and speed in making binary choices and associated their individual behavioral heterogeneity with their deliberation processes during game-play. See Figure 1 for more detail about the data used.

We propose Relative Allocation (RA°) to measure the desired allocation towards self and others given opponents' behavior in the IPD. We investigate whether RA° can provide insights into participants' cognitive processes by correlating it with DDM model parameters. To measure RA°, we use the subjects' planned allocation for themselves (a_{self}), and for others (a_{other}), given the context c of the decision, which is defined here as the number of co-players that cooperated in the last round. RA° assigns each individual an angle ranging from mostly cooperative ($RA^\circ \approx 90^\circ$), conditional behaviour ($RA^\circ \approx 45^\circ$) to mostly defective ($RA^\circ \approx 0^\circ$).

Results

Decision threshold: more individualistic participants consider the game more difficult

As seen in Figure 1 in panels A, B and C; we found that there is a significant negative relationship between the average decision threshold and the subjects' RA° (tested with Spearman's correlation measure, $p < 0.005$). The decision threshold a shows how wide the decision boundaries between two options are from each other, this can be interpreted as the perceived difficulty of the decision. It can be seen a significant negative correlation between the RA° score and their decision threshold, meaning that participants with low RA° scores found the settings more difficult. Note that in Panel A no significant correlation was observed in the fixed partners IPD ($PIPD_f$) (Spearman's $\rho = -0.15$, p-value $= 0.29$), which is why no orange line is drawn.

Drift speed: Fast evidence recollection is related to unconditional behaviour

In panels D, E and F of Figure 1, we also found a positive relationship between average drift speed and their RA° in all treatments ($p < 0.001$). The drift speed measures how fast the subjects accumulate evidence towards one of the two options, formatted as negative to defection and positive towards cooperation. The horizontal dotted line represents $v = 0$, or a point of no drift. It can be seen how subjects at both extremes of the RA° distribution accumulated speed faster towards their preferred option, while subjects near 45° were the slowest (equality-seeking), i.e. near zero drift speed v. This means that the evidence recollection speed for participants closer to the equality marker is slower than those who mostly defect or mostly cooperate. Moreover, having a fixed partner or network resulted in faster evidence collection compared with having a random co-player or network of co-players (KS statistic $D = 0.43$, p-value <0.001 for the PIPD and KS statistic $D = 0.31$, p-value <0.001 for the mNIPD, no significant different was found in vnNIPD.)

Discussion

Analysing individual heterogeneity in cooperation and cognitive processes can enhance our understanding of the mechanisms that influence human behaviour in social settings. We can now further study the relationship between our individual preferences and the way we collect evidence, and how difficult we perceive tasks. By modelling the cognitive processes of individuals through the lens of DDM, researchers can gain insights into the presence of social norms, institutions, and networks of contacts that shape human behaviour. This approach can provide valuable insights for policy and decision-making.

References

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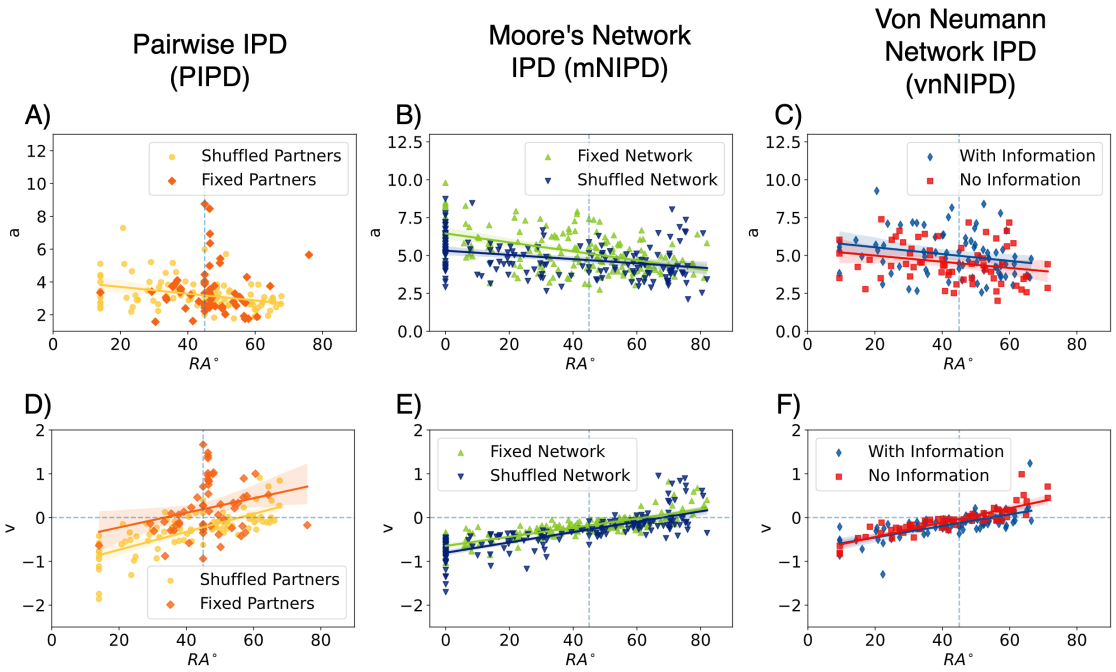

Figure 1: Relationship between the Relative Allocation RA° measure and the parameters of the Drift Diffusion Model (DDM). Top row: In the y-axis the a parameter describes the perceived difficulty of the task by the subject, the higher, the more difficult the task is perceived. Bottom row: the v parameter approximates the speed of evidence collection by the subject, values above zero are speed towards cooperation and below zero towards defection. Datasets of the first column: fixed partners ($PIPD_f, n = 56$), shuffled partners ($PIPD_s, n = 96$). Second column: Moore's Neighbors IPD, shuffled network $mNIPD_s$ and fixed network $mNIPD_f$, both $n = 169$. Third column: Von Neumann neighbourhood, with information of opponent's payoffs $vnNIPD_i, n = 50$ and no information $vnNIPD_o, n = 56$. The diagonal lines represent the linear regression and the shadows the 95% confidence interval. The vertical dotted line represents $RA^{\circ} = 45^{\circ}$.