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Defend or criticize:

Axelrod's account of the evolution of cooperation as the emergence of a Tit-for-Tat strategy turns on the fine-tuning of three variables. Since there is no reason to suppose that actual strategic interactions realize the values his account requires, the account lacks any explanatory bearing on the emergence or persistence of cooperative behaviour.

Axelrod's argument for Tit for Tat (TFT) being the optimal strategy in his mathematical simulation requires the precise tuning of three different variables—discount rate (*d*), payoff (*p*), and reunion probability (*w*). However, no justification is given for the *cardinal* payoff amounts (*T, R, P, S*), tournament design, or the precise values of these variables. Thus his trust in TFT's explanatory power is not only unfounded but also fails as a proof-of-concept for the emergence of cooperation in the natural and human world.

A quantitative misnomer in Axelrod's essay is confidence in the design of the tournament. Axelrod proves TFT's prowess under the condition that the *mean score* determines rank, the competition is a *single-stage round-robin* of *pure* strategies, and the three parameters are tuned to a "sufficiently great" *d*[1], "probability of two players meeting again is $w = .9$."[2] and specific cardinal payoff values.[3]

One can intuit the sensitivity of the results to a slight modification of any of the above conditions. The single-stage round-robin is a deliberately chosen tournament system—a subtle change, for example, into a two-stage round-robin as shown by Rapoport *et. al.,* dramatically changes the rankings, with TFT winning only 11% of the tournaments. [4]The weighted arithmetic mean is also a crude method of ranking the payoff maximization performance. The discount parameter alters payoffs with the weakly-founded assumption that "players tend to value payoffs less," and that "there is always some chance that the players will not meet again."[5] In reality, the weights have no reason to diminish; real-life payoffs are often concentrated on low-prevalence high-stakes interactions (performances such as job interviews, or interaction with important individuals), or increase through time (as one's responsibilities increase). Any of these

[1] Axelrod, The Evolution of Cooperation, 93.
[2] Axelrod, The Evolution of Cooperation, 63.
[3] Axelrod, The Evolution of Cooperation, 8.
[4] Rapoport, et. al., Is Tit-for-Tat the Answer? On the Conclusions Drawn from Axelrod's Tournaments, 2015.
[5] Axelrod, The Evolution of Cooperation, 12.

explanations are as reasonable as Axelrod's argument, as all are valid, yet imperfect descriptions of human nature and social interaction.

Additionally, the importance of the cardinal values of each payoff is overlooked. This is evident with more detailed computer simulations as done by Kretz, who suggest "different strategies emerge as winners for different payoff matrices,"[6] as well as Rapoport and Chammah, whose more mathematical models include stateful strategies or learning models, where the "cooperative response index," changes based on payoff magnitudes or the visibility of payoffs, even throughout a single iterated pair.[7] Axelrod's disregard for mixed strategies that vary the levels of *trust* within a single iterated PD—which better models reality—is also fatal to his argument, as not only can we intuit the importance of trust within a single iterated PD game, but can also be mathematically shown, when Rapoport's subjects "first [...] learn not to trust each other; then they learn to trust."[8]

A more far-reaching, qualitative error in Axelrod's simulation is that it has little concern with modelling reality. Axelrod is strictly reductionist and fiercely speculative: his suboptimal Nash-equilibrium game is a PD, from a total of 78 types of 2-by-2 ordinal payoff structures[9], and much more when agents are given more choices or more agents interact simultaneously; his agents' strategies are astonishingly simple and easily explained through vague concepts of *niceness*, *forgiveness*, and *vengefulness*, conflicting with modern computer models of, for example, Goodfellow et. al., whose general adversarial networks (GAN)—learning agents which compete to improve their strategies—require billions of parameters, and are realistically applicable and field-tested.[10]

Axelrod's models may explain a small subset of cooperative behaviour by early multicellular organisms, or cellular automata with simple strategies—with any more complexity, the argument falls apart. His conclusion that "cooperation can emerge in a world of egoists [...] starting with a cluster of individuals who rely on reciprocity,"[11] is a *reductio ad absurdum* and an overgeneralization of a limited conclusion. Indeed cooperation has in reality emerged; however, as its justification, Axelrod presents a contrived model, fine-tuned to *produce* cooperation—not by constructing a realistic environment from which cooperation *naturally* emerges.

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[6] Kretz, A Round-Robin Tournament of the Iterated Prisoner's Dilemma with Complete Memory-Size—Three Strategies, 2011.
[7] Rapoport and Chammah, Prisoner's Dilemma, 2009.
[8] Rapoport and Chammah, Prisoner's Dilemma, 2009.
[9] Brams, Theory of Moves, 1994.
[10] Goodfellow et. al, Generative Adversarial Networks, 2014.
[11] Axelrod, The Evolution of Cooperation, 69.

Ultimately Axelrod's lacklustre justification of the design of his models, and the faulty approach of fine-tuning parameters to support a predetermined conclusion, cast considerable doubt on his arguments. It is not difficult to imagine a more wide-ranging, mathematically-informed, technologically modern simulation with all variables varied and its analysis statistically sound; to devise a more nuanced and precise model for the emergence of cooperation—fortunately, has been conducted after Axelrod's initial essay. Thus we may find value in Axelrod's original model as a foothold for the new avenue of research in mathematical game theory; the argument itself, however, adds little in hindsight.

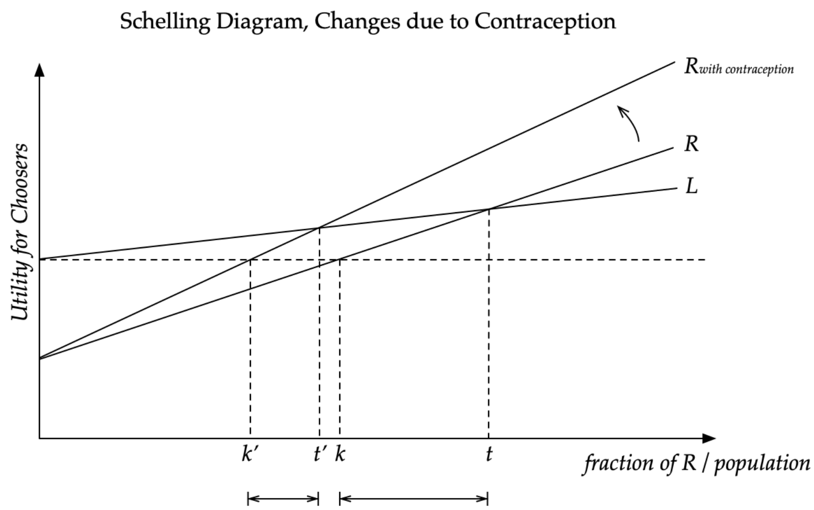
(736 words)

Mackie introduces the "Schelling diagram" to explain the sudden disappearance of the practice of foot binding at the beginning of the 20th century. Employing the features of his diagram (L, R, t and k), identify strategies that stand a chance of unravelling FGM in for example Ethiopia or Somalia over the next decade.

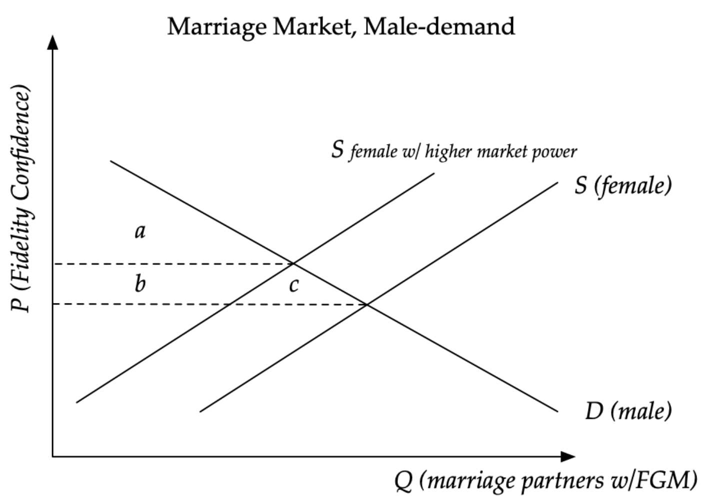
Mackie's prescription of escaping the suboptimal equilibrium is two-fold: to form an initial pledge group of *k*-members of *R* (preferring partners who did not undergo FGM), internally incentivized to recruit more members from *L* (preferring partners who underwent FGM), continuing until the tipping point *t*; while concurrently increasing and decreasing utility for *R* and *L* respectively, to minimize *k*. However the complication compared to footbinding is that FGM is a *necessity* in the marriage market—lifting *L* and shifting down *R*—and that it is *invisible*—reducing the recruitment incentive, and obfuscating one's position on the Schelling diagram. I present that the former can be tackled through contraception and the promotion of gender-equitable resource distribution, and the latter by providing faithful statistics on FGM to the populous.

Contraception is effective in battling FGM as it increases the utility of *R*. It encourages family planning and reduces unwanted births, concentrating resource provision to fewer children. The mother has higher confidence in resource provision to her offspring and thus is disincentivized for infidelity; the male is aware of this and has higher confidence in her fidelity, ultimately disincentivizing FGM for prospective women. The expectation of contraception in society further rebases the issue of fidelity in trust, not FGM, and eventually redefines the measure of paternity confidence not as intercourse but as *conception* and eventually *resource provision*. If the male is confident in the female's pre-marital use of contraception he has higher paternity confidence; if the female is confident of the male's use of pre-marital contraception she is more confident of resource provision to her own offspring.

Ultimately both pathways *increase* the utility for *R* at every point—due to increased paternity confidence—and *steepen* the curve—since *R* likely correlates with contraceptive use (as those without FGM pursue intercourse with contraception to avoid pregnancy), and thus with higher paternity confidence, leading to the new *R*'s dramatically left-shifted *k* and *t*. Contraception also incentivizes the pledge group's promotion of contraception, as widespread use will assist the growth of the pledge group—a reduction in the distance between *k* and *t*.



Gender-equitable resource distribution, on the other hand, disincentives polygamy, increasing female market power in marriage, and thus reduces utility for *L*. Once a female relies less on male resources she requires less promotion of appeal for marriage, including FGM, further reducing the number of available women in the FGM-demanding male-centric marriage market, and thus shifting left the supply of female marriage partners who underwent FGM. Surplus—i.e. the utility—of males decreases, resulting in a downwards shift of *L* on the Schelling diagram, and a following reduction in *t* and *k*. A concern, however, with this approach is that while contraception is *relatively* easy to implement, gender-equitable resource distribution requires a time-consuming rework of the overall society.



☞ Previous surplus is *a+b+c;* new surplus is *a.*

Initiatives will also benefit in making publically available *data* regarding the reality of FGM within a community. FGM distinguishes itself from footbinding in its opacity, making pledge group recruitment harder (as male choosers cannot distinguish between choice sets) and society being unaware of the current utility difference between *R* and *L*. Societies may also continue the practice even past *t* without such clear information.

Thus statistics comparing local FGM practices in various other populations will greatly aid choice, making other unravelling strategies more effective. A trusted organization, for example, may provide data on the surrounding villages' or one's ethnic/religious groups' reduction in FGM, which disincentives the practice for women within the community. While this approach does not directly tackle the issue, it does facilitate and amplify the above strategies (such as contraception or equitable resource distribution), since Mackie's assumption of perfect information—that all agents are aware of their current payoffs; i.e. the position on the Schilling diagram—does not reflect reality, especially with the opacity of FGM.

Mackie's application of the Schelling diagram to model the sustenance and the rapid withdrawal of footbinding is effective also in modelling the practice of FGM; however, the shortcomings of his prescription when applied to FGM, outlined in his conclusion, are sparingly addressed. This paper attempted to build on his model, externally manipulating the four variables through widespread contraception, gender-equitable resource distribution, and remedying imperfect information, that may assist in unravelling FGM in societies stuck in suboptimal equilibria. Considering the cost of FGM for females is high—arguably more so than in footbinding—it may be that an effectively organized strategy may show quicker results than in China.

(740 words)