# Literature Review

## Control effects on cooperation in embedded interactions

Thom Volker (5868777)

Supervisors: Vincent Buskens & Werner Raub

*Sociology and Social Research Master's programme*

*Utrecht University*

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# 1 Introduction

Social dilemmas are at the core of everyday life. Students may anticipate a good grade for group work with minimal effort by free-riding on the work of their peers, researchers could obtain another publication by letting their collaborators do the lion's share of the required work (Corten, Buskens, & Rosenkranz, 2020) and a car dealer may hide several vehicle defects when selling a second-hand car to a relatively uninformed customer (Buskens & Weesie, 2000). In these situations, for all individuals involved it would be rational to behave opportunistically. However, the rational decision to behave opportunistically would yield lower collective returns than what could have been achieved under mutual cooperation, and hence the term "social dilemma" (Kollock, 1998; Ostrom, 1998). Under the assumption of "social isolation", that is, the interacting actors can be considered perfect strangers that do not anticipate any future interactions, actors can maximize their individual returns by behaving uncooperatively.

Theoretically, it is well established that in isolated social dilemmas, it is generally hard to initiate a cooperative relationship (e.g., see Luce & Raiffa, 1989 for the Prisoner's Dilemma; and Buskens & Raub, 2002 for the Trust Game). Consider for example the standard one-shot Prisoner's dilemma. Regardless of the choice of one's partner, an individual actor obtains the highest payoff by acting opportunistically. Defecting when the other player cooperates leads to a higher payoff, relative to cooperating, similarly to defecting when the other player defects as well. Hence, the Nash equilibrium is mutual defection, even though both players would be better off with mutual cooperation. Contrary to these ominous theoretical findings, in practice researchers generally find non-negligible rates of cooperation in one-shot games (e.g., see Hayashi, Ostrom, Walker, & Yamagishi, 1999; Cooper, DeJong, Forsythe, & Ross, 1996; Snijders & Keren, 2001), although these cooperation rates tend to decline when participants gain experience with these games (Dal Bó, 2005).

Multiple scholars, however, noted that most real-life interactions do not take place in social isolation, but are actually embedded (Axelrod, 1984; Granovetter, 1985). Embeddedness refers to the fact that the actors involved share a common environment that could foster cooperation (e.g., Buskens & Raub, 2002; Yamagishi & Yamagishi, 1994). These actors may have interacted in the past, and/or speculate on interacting again in the future, which is referred to as *dyadic embeddedness* (Buskens & Raub, 2002), or, in an evolutionary biological context, as *direct reciprocity* (Nowak, 2012). Additionally, the actors may be connected indirectly, through third parties that have interacted with any of the two in the past, or speculate on doing so in the future, which is referred to as *network embeddedness* (Buskens & Raub, 2002), or *indirect reciprocity* (Nowak, 2012; Sigmund, 2012). Obviously, actors can be embedded both dyadically and in a network at the same time.

## 2 Theory

In the game-theoretic literature, there are two mechanisms through which embeddedness is considered to affect cooperation between actors: *control* and *learning* (e.g., Buskens & Raub, 2013; Yamagishi & Yamagishi, 1994). Control, which will be the focus of this review, denotes the opportunity to sanction opportunistic behaviour by exerting control over one's partner's long-term returns. Under dyadic embeddedness, one can punish the defection of one's interaction partner in a previous interaction by refraining from cooperation in current and future interactions. Additionally, one might inform future transaction partners of a defecting actor, who can in turn refuse to cooperate with this actor. Hence, the short-term benefits of acting opportunistically come with the prospect of future retaliation, hanging over the head of opportunistic actors as the sword of Damocles. Notably, what Buskens & Raub (2013) termed "control" differs from what is called "the illusion of control" in the social psychological literature (e.g., Morris, Sim, & Girotto, 1998; Hayashi et al., 1999). Where "control" in the sense of Buskens & Raub (2013) refers to actual sanctioning opportunities, "the illusion of control" concerns the finding that people act as if they can control their partner's behaviour in one-shot games, if this person's decision is made prior to the decision of the partner, even though no information is transferred between the players (Morris et al., 1998).

Learning, on the contrary, refers to the situation where the actors involved have interacted in the past, when they are embedded dyadically, and hereby gained information about each others' past behaviour (Buskens & Raub, 2013). If this behaviour is cooperative, the actors may infer that they deal with a partner that will behave cooperatively again in the future. When the actors are embedded in a common network, the actors may learn from others how their transaction partners behaved in interactions with third parties. If one's current partner behaved cooperatively during past interactions with oneself and/or with third parties, one might infer that the transaction partner will behave cooperatively in the current transaction as well. Obviously, when an actor's partner has abused cooperative behaviour of this actor, or of a third party, the actor may not be willing to take the risk of getting exploited, and defect in the current interaction as well.

A second distinction that can be made relates to the nature of the embeddedness of a transaction.

Namely, rather often, researchers decide who will interact with whom in an experiment, a situation that is commonly referred to as *exogenous embeddedness*. However, in real life, people often choose with whom they wish to interact, at least to a certain extent (Chaudhuri, 2009; Yamagishi et al., 1994). Some researchers tried to incorporate this characteristic of real-life encounters in their research by letting participants choose their transaction partners, which is referred to as *endogenous embeddedness*. Overall, it appeared that endogenously formed relations tend to have a larger effect on cooperation rates than exogenously formed relationships (e.g., Chaudhuri, 2011; Frey, Buskens, & Corten, 2019; Gürerk, Irlenbusch, & Rockenbach, 2014; Schneider & Weber, 2013; Wang, Suri, & Watts, 2012).

Substantively, the remainder of this paper will be concentrated around the question to what extent control affects cooperation. Hence, the effect of learning, as well as alternative explanations for the emergence of cooperation outside the game-theoretic paradigm such as inequity aversion or altruism (e.g., Fehr & Schmidt, 1999; Carpenter, Connolly, & Myers, 2008; Dreber, Fudenberg, & Rand, 2014) fall beyond the scope of this review. A distinction will be made between control in dyadically embedded interactions and in network embedded interactions, as well as between exogenously and endogenously formed relationships. This question will be answered via a literature review, with a focus on experimental research that employed 2-person Prisoner's Dilemma games or Trust games. That is, in general, experiments will be considered in which the behaviour of an actor only affects oneself, as well as the single actor toward whom this behaviour is directed. When occasionally another type of game or an $N$-person game (i.e., a game where the behaviour of an actor is directed toward more than one others) is discussed, this will be explicitly mentioned.

Notably, game-theoretic assumptions yield that actors maximize their utilities. Yet, in research settings, it is often complicated to infer the utilities of the participants at hand, as it is unclear how they value potential payoffs as specified in the study at hand. To partially overcome this problem, all participants of the experiments incorporated in this review faced economic incentives in the form of points that were translated into money at the end of the experiment. The amount of points an actor earns is dependent both on the behaviour of this actor, as well as on the behaviour of this actor's partner. Although these monetary payoffs do not diminish the possibility that subjects may strive for non-materialistic goals, it is assumed throughout that incentivizing the payoffs allows to interpret the payoffs as the actors' utilities.

Also note that a great deal of the work published in this area has not distinguished between learning and control explicitly, but merely addresses the question how different forms of embeddedness in general affect cooperation. Nevertheless, it is often possible to assess the effect of control, either explicitly or implicitly. In general, there are two ways to disentangle learning and control. The first possibility is to study solely behaviour of participants in the first round of a given game, because then no learning could have taken place. The second way, that is often used to analyse behaviour in finitely repeated games, is to assess the effect of the number of rounds left after controlling for any learning that could have taken place. Specifically, previous actions by an actor's transaction partner are taken into account when analysing the behaviour of an actor in any given round and assessing the effect of the number of rounds to play.

## 3 Control effects in dyadic relations

Control effects in dyadic relations can be studied in both finitely and infinitely repeated interactions. In finitely repeated interactions, however, it follows from backward induction that, under the assumption of game-theoretic rationality, no cooperation is possible (e.g., Luce & Raiffa, 1989; Selten, 1978). Namely, in the last round of the game, non-cooperative behaviour cannot be punished in any subsequent round, and hence, defecting always yields a higher payoff than cooperation. As actors decided to defect in the final round, actions in the penultimate round do not affect behaviour in the last round, and again defection is the payoff maximizing strategy. This pattern repeats itself to the first round of the game, and hence, under the assumption of rationality, no cooperation is possible in any round of the game. A wide variety of experiments however showed that subjects act cooperatively in initial rounds, leading Rapoport (1997, p. 122) to conclude that in practice, subjects do not rely on, or are not capable of backward induction.

Kreps, Milgrom, Roberts, & Wilson (1982) proved that even populations of rational actors could maintain high levels of cooperation, under the assumption that these rational actors belief with high enough probability that their transaction partners have no incentive to defect, until their partners are defected on themselves. If the rational actors believe that the probability to meet such a conditional cooperator is high enough, the benefits of mutual cooperation outweigh the gains of exploiting a conditional cooperator once and being punished with defection thereafter. The prospect of mutual cooperation directly allows for the introduction of control (Buskens & Raub, 2013). Namely, after an actor defects, it is immediately known to the other player that the defecting actor is not a conditional cooperator, and the finitely repeated game would be one of mutual defection hereafter if the players are rational. Yet, as long as both players cooperate, it is not known whether any of the two players is a conditional cooperator. The actors can thus control one another, because future payoffs depend on one's behaviour in the current round. In the final rounds of the finitely repeated game however, the long term benefits of mutual cooperation do no longer outweigh the short-term costs of maintaining one's reputation (i.e., the opportunities to control future behaviour of one another diminish), and hence rational actors will try to exploit their partners in these rounds.

In infinitely, or indefinitely, repeated games, there is no end-game effect, as there is no predetermined final round. Namely, a game will be played for another round with a certain continuation probability $\delta$, which Axelrod (1984) aptly termed the "shadow of the future", and end with probability $(1-\delta)$. In these games, cooperation can supported in equilibrium if the continuation probability is large enough (see e.g. Buskens & Raub, 2013 for the technical details). Comparing cooperation rates in the first round of an infinitely repeated game to cooperation rates in a one-shot game or in games with a different continuation probability allows to assess the effect of control. Namely, in a one-shot game, there is no possibility to sanction opportunistic behaviour, and thus there is no control, while in repeated games with different continuation probabilities, the control opportunities differ as well. Although the analysis of first round behaviour is merely a practical issue, that is, due to the continuation probability $\delta$ there is no guarantee that a second round will be played, it is beneficial to disentangle learning and control. Namely, in the first round of a finitely repeated game, no learning can have occurred yet.

### 3.1 Control in exogenously dyadically embedded interactions (repeated games)

In exogenously formed finitely repeated games, one can generally observe a pattern of high cooperation in the initial rounds of a finitely repeated game, with a sharp decrease in cooperation toward the end of the game (e.g., Buskens, Raub, & Van der Veer, 2010; Embrey, Fréchette, & Yuksel, 2018; Mao, Dworkin, Suri, & Watts, 2017; Van Miltenburg, Buskens, & Raub, 2012). However, this decline in cooperation cannot entirely be ascribed to the lack of control opportunities in the final rounds of the game. Participants may namely refrain from cooperation for three different reasons. First, defection could be a response to defection of one's partner in an earlier rounds. Second, an actor may have learned in previous games that in the final rounds of the repeated game, hardly any cooperation is possible, and hence defecting serves as a protection against being exploited. Third, an actor may realize that the short-term benefits of defecting outweigh the possible returns of another round of mutual cooperation.

Buskens et al. (2010) explicitly study the presence of control effects in a Trust Game, which slightly changes the nature of the game relative to a Prisoner's Dilemma. Rather than mutually risking possible exploitation, in the Trust Game only the trustor, who decides whether or not to trust the trustee, risks being exploited. The trustee on the other hand, has to decide whether whether to honor or abuse trust, if trust is placed, but cannot choose between these options if no trust is placed. Hence, the possible actions of the trustee depend on the initial choice of the trustor. Under dyadic embeddedness, Buskens et al. (2010) find that after controlling for learning effects, there is a positive effect of the number of rounds still to be played (i.e., control opportunities) on cooperation, for both the trustor and the trustee. Additionally, these authors study the effect of dyadic embeddedness when the dyadic relation is embedded in a small network, where two trustors are in a relationship with a single trustee (i.e., a triad). In this network, information can be exchanged between the first trustor and the second trustor, and hence, the trustors can learn about the trustee not only from their own game with the trustee, but also from the game of the other trustor in the triad with the same trustee. Also in this condition, the number of rounds that has to be played between a trustor and a trustee is positively related to cooperation for both trustor, and trustee, after controlling for learning effects in terms of past moves of the trustee in the game with the trustor at hand, as well as in terms of past moves of the trustee in the game with the other trustor.

Other studies corroborate the finding that the number of rounds that are to be played affect cooperation rates. Embrey et al. (2018) performs a meta-study with data from multiple previously held experiments on finitely repeated Prisoner's Dilemma games by Andreoni & Miller (1993), Dal Bó (2005), Cooper et al. (1996), Bereby-Meyer & Roth (2006) and Friedman & Oprea (2012). The combined evidence from these studies and a newly designed experiment, show that first round cooperation rates, where no learning could have occurred, increases with the length of the game. Additionally, Van Miltenburg et al. (2012) shows that dyadically embedded actors learn to play cooperatively in initial rounds of a finitely repeated Trust Game of fifteen rounds, with near perfect cooperation in the first round of later played games that remains above 80% until the twelfth round, but decreases to negligible levels shortly hereafter. However, no explicit distinction between learning and control effects is made in the analyses. Mao et al. (2017) also make the same observation that people learn to play cooperatively in early rounds of a finitely repeated Prisoner's Dilemma game, with near perfect cooperation in the first round that remains above 80% but decreases to negligible levels in the final two rounds, although again no explicit distinction between control and learning effects is made. Remarkably, this experiment is repeated on twenty consecutive days, with twenty 10-round games per day, and shows that this pattern keeps repeating itself, regardless of the actors experiencing that in final rounds cooperation seldom prevails.

Research into cooperation in infinitely repeated games was initiated by Roth & Murnighan (1978) and Murnighan & Roth (1983), who found on average somewhat higher cooperation rates under a high continuation probability relative to under low continuation probabilities. However, this increase was generally small, leading the authors to conclude that the introduction of infinitely repeated interactions hardly fosters cooperation. However, these authors let the participants play against the experimenters, rather than against each other. Additionally, Dal Bó (2005) remarks that these studies did not translate the amount of points participants earned during the experiment linearly to a monetary reward. Dal Bó (2005) subsequently builds upon this initial work in infinitely repeated Prisoner's Dilemma games, and finds significant differences between three continuation probabilities (i.e., $\delta = 0, 1/2, 3/4$), such that first round cooperation rates increase with the continuation probability. Particularly, the differences appear to become larger with the experience participants gained. Hence, the prospect of future benefits through mutual cooperation and the fear of missing out on these benefits after initiating defection seem to result in a higher willingness to cooperate.

Similar observations were made by Dal Bó & Fréchette (2011) and Dal Bó & Fréchette (2018). These authors argue that the limited effect of increasing the continuation probability in earlier studies is due to the fact that participants have to gain experience to properly evaluate the effect of this increase. With sufficient experience, participants cooperate when cooperation can be supported in equilibrium, and defect when it cannot. Additionally, cooperation rates in first rounds of infinitely repeated games are systematically higher than cooperation rates in the first rounds of finitely repeated games of the same expected length, especially after the subjects have gained experience with the game they play (Dal Bó, 2005; Dal Bó & Fréchette, 2011, 2018). Namely, in the finitely repeated games, in earlier games the subjects experienced that cooperation will be abused in the final round of the game, and protect themselves against this behaviour by defecting in an earlier stage already. No such behaviour is present in infinitely repeated games; in fact, the cooperation rates tend to increase with the experience of the participants. Notably, because the defecting behaviour of most participants in final rounds of a finitely repeated game implies that future sanctions for behaviour in the penultimate round are not credible, subjects experience less control opportunities in finitely repeated games relative to infinitely repeated games of the same expected length. Consequently, first round cooperation in finitely repeated games may decrease, due to this reason.

Although the evidence consistently shows that first round cooperation increases with the (expected) number of rounds left, there remains substantial heterogeneity in cooperation rates, even in games of approximately the same length. Whereas Cooper et al. (1996) find cooperation rates in finitely repeated games of around 65%, Embrey et al. (2018) find above 80% cooperation and Mao et al. (2017) observes near perfect cooperation, all in the first round, even though all games have a fixed end at round 10 and differences in the payoff matrix are only minor. Differences in economic incentives, however, are likely to explain this difference. In the study by Cooper et al. (1996), only relative payoffs were important, as the player with the highest number of points in each game received a monetary payoff of $1 at the end of each game, while the losing partner got nothing. In Embrey et al. (2018) and Mao et al. (2017), players' monetary payoffs were linearly derived from the number of points they gathered, diminishing relative standings and emphasizing the importance of receiving a high number of points.

## 3.2 Control in endogenously dyadically embedded interactions (repeated games)

The previous section shows that in exogenously embedded dyadic interactions there is a relatively consistent effect of control on cooperation. However, a substantial proportion of real-life interactions, dyadic embeddedness is not imposed exogenously, but rather established intentionally by the actors involved. Dyadic embeddedness also fosters first-round cooperation when it is chosen by the actors involved in an interaction, without having prior information with respect to the subsequent transaction partner [Sokolova, Buskens, & Raub (2021); Schneider & Weber (2013); Brown, Falk, & Fehr (2004); KOLLOCK as well]. In fact, even at the cost of a portion of subjects' payoffs, they are willing to establish a long-term relationship, and are subsequently more likely to behave cooperatively in this relationship compared to behavior in one-shot games (Sokolova et al., 2021).

When dyadic embeddedness is established endogenously, however, not necessarily the effect of control induces more cooperation, as there might also be a selection effect at work. Then, people who are more willing to cooperate are more likely to engage in repeated interactions, and hence cooperation in repeated interactions is higher. Schneider & Weber (2013) show that people who *a priori* indicate a higher willingness to cooperate were indeed more likely to engage in repeated interactions, although this characteristic only explained part of the increase in first round cooperation rates relative to one-shot games. Again, it was shown that a longer, endogenously chosen, duration yields more first round cooperation, similarly to the findings under exogenous dyadic embeddedness (Schneider & Weber, 2013), which is indicative for a control effect. Although systematic testing of the effect of control on cooperation in endogenous dyadic embedded interactions is, to the best of my knowledge, fairly limited, the available evidence suggests that it likely is at least as strong as in exogenously dyadic embedded interactions.

# 4 Control effects of network embeddedness

Control effects under network embeddedness can, like under dyadic embeddedness, be studied in finitely as well as in infinitely repeated games. Yet, most studies employ a finitely repeated game design. Actors are matched randomly in every round of the game, and the actors involved in an interaction can generally see each others reputation in terms of past behaviour. This treatment is generally compared to a treatment where people are matched randomly without the opportunity to see one's partner's reputation, or with the opportunity to only see the history of one's own interactions with a given transaction partner.

Research on repeated interactions under dyadic embeddedness involves two actors forced into a relation with an endogenously or exogenously chosen interaction time. However, in reality, interaction partners may deliberately choose to engage in a relationship (Yamagishi et al., 1994).

Sánchez (2018) remarks in a review that lattices or networks do not support cooperation at all. Even though cooperation in networks generally starts at a high level, with the majority of the actors choosing to cooperate, cooperation rates generally decrease to a fraction of only 20%.

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## 4.1 Control in exogenously embedded interactions in networks

## 4.2 Control in endogenously embedded interactions in networks

# 5 Implications for future research

In the simplest interactions, that is, one-shot interactions in a social vacuum, high levels of cooperation can hardly be sustained (Simpson & Willer, 2015). In this review, it became apparent that embeddedness can foster cooperation between actors due to the possibility to control future payoffs of one's interaction partner. The available evidence rather consistently shows that more control opportunities induce more cooperation. Although the introduction of embeddedness narrows the gap to real-life interactions, an overwhelming amount of the experiments conducted remains rather artificial in nature. This approach has clear advantages, as it allows to separate the slightest sources of variation that would be entangled in survey research and to assess the causal effect of changing certain features of an interaction on cooperation. However, these artificial experiments do little in explaining why humans behave as they behave in real-life encounters, as it is hardly assessed how taking people out of their social context affects their behaviour.

Axelrod Launching 'The Evolution of Cooperation' - "There were several limitations in using people - even skilled people - to study how to best play the Prisoner's Dilemma.

Why does dyadic embeddedness foster cooperation more than network embeddedness. Sigmund (2012) argues that under network embeddedness, many players seem to rely on first-order assessment. That is, actors base their decision to cooperate on the observed cooperativeness of their transaction partners in the past. While this assessment rule might work under dyadic embeddedness, where the reason of one's partner's action can be inferred, it does not do well under network embeddedness. However, tracking whether one's partner's past behaviour against third parties were the result earlier defections against this partner is generally dificult (Milinski, Semmann, Bakker, & Krambeck, 2001 is referred that higher order assessment is cognitively taxing).

## 6 Conclusion

Obviously, there are other explanations possible that allow to explain cooperative behavior, such as relaxing assumptions on the rationality and selfishness of individuals. However, this review deliberately aims to focus on the effect of embeddedness, and in particular on control, to explain cooperative behaviour.

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