Third-Party Effects on Trust in an Embedded Investment Game*

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Abstract

Most theories about effects of social embeddedness on trust define mechanisms that assume someone's decision to trust is based on the reputation of the person to be trusted or on other available information. However, there is little empirical evidence about *how* subjects use the information that is available to them. In this chapter, we derive hypotheses about the effects of reputation and other information on trust from a range of theories and we devise an experiment that allows for testing these hypotheses simultaneously. We focus on the following mechanisms: learning, imitation, social comparison, and control. The results show that actors learn particularly from their own past experiences. Considering third-party information, imitation seems to be especially important.

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Introduction

Imagine that you have decided on a financial investment, for example, for a private pension, and you have to choose among several companies offering similar services. Imagine also that you do not have much experience with this type of investment. You could investigate the past performances of all companies and compare them, but this would take much time, especially if there are many of them. You could ask a friend who did a similar investment in the past about her experience, but this only provides information on one company. You could choose by reputation, simply picking the most "well-known" company, but companies with the most successful marketing strategy do not always offer the best products. Malicious companies might invest your money in a risky manner, making large profits themselves if things go well, while you end up with the costs if the investment goes wrong. Typically, these problems are not solved by "market forces" in markets with asymmetric information between buyer and seller (Akerlof 1970). To make your choice even more complex, the success of your investment will also depend on chance. For example, if you are planning a long-term investment, the behavior of financial markets is hard to predict over longer periods of time. Therefore, part of the information that you are able to gather might be hard to interpret, for example, the failure of a specific investment might have been caused by a "bad" financial advisor, but it could also have simply been due to adverse contingencies. Starting such an investment represents a typical trust problem, whereby trustworthy investors invest money in such a way that it is both in their own and in the costumer's interest. Untrustworthy investors invest only to maximize their own short-term profits without taking the costumer's interests into account.

Such a setting can be analyzed applying existing theories on the effects of reputation and information in trust problems. Here we focus on an actor's (Ego) decision to trust her partner (Alter) based on the relevant information available to her.[1] More specifically, this chapter aims at providing empirical evidence for different types of mechanisms influencing trusting behavior in settings with network embeddedness. Given existing theories about these effects, we investigate the conditions under which these different effects operate. Moreover, interpreting information about a partner's behavior can be more or less difficult depending on uncertainties in the setting. Therefore, we also explore the relation between available information and uncertainty in trust problems.

Experimental research on trust in games has focused primarily on conditions that affect actors' decisions to trust and reciprocate in one-shot games, which are abstract representations of single encounters between strangers (see Berg, Dickhaut, and McCabe 1995; Snijders 1996; Snijders and Keren 2001; Camerer 2003: chapter 2.7). However, most trust problems in real life differ from such abstract situations in many ways. First, in most trust problems, there is a positive probability that the same actors will meet in the future (dyadic embeddedness) and face a similar trust problem again. Second, actors are embedded in a social structure characterized by social relations, ethical norms, laws, institutions, etcetera (network and institutional embeddedness) (Granovetter 1985; Raub and Weesie 2000). Since we want to study the effects of information, we focus on a situation in which pairs of actors repeatedly face trust problems and are embedded in a network of relations from which they obtain information, but we neglect "institutional" aspects such as laws and norms.

The effects of dyadic and network embeddedness on trust problems have been theorized and existing models identify two types of mechanisms: *learning and control* (Buskens 2002; Buskens and Raub 2002). Both mechanisms are related to "reputation" in the literature. Learning refers to the extent to which Ego can learn about unknown characteristics of Alter that affect Alter's behavior in the trust situation. Learning in that sense is closely related to what Kreps and Wilson (1982) call reputation. Control indicates the extent to which Ego can sanction or reward Alter by spreading information about Alter's behavior and is more related to reputation as it is used by Raub and Weesie (1990). These mechanisms are explained in more detail in the theory section. To avoid confusing between the different mechanisms, we minimize the use of the term reputation hereafter.

This chapter addresses two limitation of the existing literature. First, existing theories often make rather strong assumptions about actors' computational abilities, and they neglect the possibility that actors apply simpler heuristics such as imitation, or be influenced by the outcomes obtained by relevant others through a mechanism of social comparison. Second, empirical research on trust problems in situations characterized by network embeddedness is still scarce: Buskens (2002: chapters

5 and 6) provides an empirical test for his learning and control models; Gautschi (2000) and Cochard, Van Phu, and Willinger (2002) investigate trust problems with dyadic embeddedness; Güth et al. (2001), Duwfenberg et al. (2001), Buchan, Croson, and Dawes (2002), and Bolton, Katok, and Ockenfels (2004, 2005, this volume) include a certain degree of network embeddedness in their experiments (see also Burt and Knez 1995 for non-experimental research on the effects of third-party information on trust among colleagues). However, none of these experiments is able to disentangle learning and control effects from dyadic as well as network embeddedness.

We present a laboratory experiment designed to disentangle effects of various types of information stemming from dyadic and network embeddedness. More precisely, this experiment represents an empirical test in which relative complex rational arguments to trust, such as learning and control effects, are compared with other "simpler" heuristics, such as imitation or social comparison. In this experiment, groups of actors embedded in small networks play a repeated Investment Game (Berg et al. 1995) and exchange information concerning their own behavior as well as their partner's behavior in the game. The manipulation of information exchange resembles the experiment conducted by Güth et al. (2001): Egos know exactly what happened to other Egos in some conditions and they know only the choices of the other Egos, but not the related choices of the Alters in other conditions. We also vary uncertainty in the sense that the choices of Alters are ambiguous for Egos in some conditions (see Coricelli, Morales, and Mahlstedt 2002 for a similar manipulation). We first deal with theories and hypotheses in the next section. Thereafter, we describe the experimental design. Results and conclusions are presented and discussed in the last two sections.

Theory and Hypotheses

We consider trust problems as interactions involving two interdependent actors. In correspondence with Coleman (1990: chapter 5), a trust problem is defined by four characteristics: (1) Ego has the possibility to place some resources at the disposal of Alter, who has the possibility to honor or abuse trust. (2) Ego prefers to place trust if Alter honors trust, but regrets placing trust if Alter abuses it. (3) There is no binding agreement that protects Ego from the possibility that Alter abuses trust. (4) There is a time lag between Ego's and Alter's decisions.

This definition is consistent with the game-theoretic formalizations of the *Trust Game* (Camerer and Weigelt 1988; Dasgupta 1988; Kreps 1990) and the *Investment Game* (Berg et al. 1995; see also Ortmann, Fitzgerald, and Boeing 2000 for a replication of the original experiment). These two games differ in the following way. In the Trust Game, "trust" and "trustworthiness" are represented by dichotomous choices – trust versus no trust, honor trust versus abuse trust – while the Investment Game exhibits some "continuity" both in the choice of placing trust and in the choice of honoring or abusing trust. Because this continuity implies that we can distinguish not only between whether Ego trusts Alter or not, but also to what extent she trusts him, we employ the Investment Game in our theoretical analysis as well as in our experiment.

In the Investment Game, the two players start with initial endowments E_1 and E_2. Ego has the possibility to send all, some, or none of her endowment to Alter. The amount of money that she decides to send, say S_1 ($0 \leq S_1 \leq E_1$), is then multiplied by a factor m (with $m > 1$) by the experimenter. Alter receives an amount equal to m times the amount S_1 sent by Ego. The parameter m can be interpreted as the returns Alter makes due to the Ego's investment. Subsequently, Alter can decide to send back to Ego all, some, or none of the money he has received. The amount returned by Alter is denoted R_2 ($0 \leq R_2 \leq mS_1$). After Ego and Alter have concluded their task, Ego earns $P_1 = E_1 - S_1 + R_2$ and Alter earns $P_2 = E_2 + mS_1 - R_2$.

The One-Shot Game

Assuming complete information, standard forward-looking rationality, and selfish actors who are only interested in their own payoffs, the one-shot Investment Game, has a straightforward subgame-perfect equilibrium: Alter maximizes his payoff by returning nothing to Ego (that is choosing $R_2 = 0$). Therefore, Ego, who anticipates this behavior from Alter, maximizes her own payoff by sending nothing to Alter in the first place (that is choosing $S_1 = 0$). Therefore, "send nothing" and "return nothing" are the equilibrium choices and the payoffs in equilibrium are E_1 and E_2. This outcome is Pareto-suboptimal, because both actors would prefer any outcome yielded in a situation in which trust is to some extent placed and honored, $E_1 - S_1 + R_2$ and $E_2 + mS_1 - R_2$, with $S_1 > 0$ and $R_2 > S_1$. The pie that the actors divide reaches its maximum when Ego sends everything ($S_1 = E_1$), which means that

Pareto improvements are always possible if $S_1 < E_1$. Ego gains from trusting Alter if Alter returns more than he received ($R_2 > S_1$), but, once S_1 has been chosen, Alter's decision resembles the move of the dictator in the Dictator Game: he decides how to split the pie of size mS_1. Given Ego's decision, all possible outcomes are Pareto non-comparable, since whatever Alter returns, goes directly to Ego.

Learning through Dyadic Embeddedness

Dyadic embeddedness refers to a situation in which two actors repeatedly play an Investment Game together. Thus, Ego has the possibility to *learn* about the trustworthiness of Alter. Learning models typically assume that actors do not look ahead, but they rather change their behavior adaptively according to the experiences they had in the past. Different types of learning mechanisms can be distinguished (see Camerer 2003: chapter 6, for an overview of such models). The most widely applied families of learning models are *belief learning* and *reinforcement learning.* Reinforcement learning models are specifically based on the payoffs that actors received in previous games: the higher the payoff obtained by a given decision, the more likely it is that a player will make that same decision again. Reinforcement models are straightforwardly applicable to the Investment Game because a heuristic of the type "reward trustworthiness and punish abuse" seems particularly realistic for the Investment Game given the "continuity" of the possible moves in the game. This heuristic, in fact, implies that Ego compares the amount received in previous games with the amount sent in previous games. The more satisfied she is with the amount she receives back, the more she will send in the next game, whereas if she is unsatisfied with the amount she receives back, she will decrease the amount sent in the next game. This reinforcement could depend on both the payoff earned in the previous game (that is, $E_1 - S_1 + R_2$), and on the proportion returned by Alter (that is, R_2/mS_1).[2] Therefore, assuming that subjects playing an Investment Game learn applying a reinforcement rule, we expect the following effect of learning from dyadic embeddedness.

Hypothesis 1 (dyadic learning): The higher the amount earned by Ego (proportion returned by Alter) in previous games, the more Ego sends in the present game.

Control through Dyadic Embeddedness

If we assume a finitely repeated game and complete information, standard game theory predicts that Alter will send nothing back in the last game (because $E_2 + mS_1 > E_2 + mS_1 - R_2$, for any S_1, $R_2 > 0$) and Ego will then send nothing in the last game anticipating the behavior of Alter. Knowing that he has nothing to lose in the last game, Alter will not return anything in the last but one game and accordingly, Ego will send nothing as well. This argument, known as *backward induction* (see Selten 1978 for a prominent application), unravels the whole game back until the first stage making any trust impossible. However, in their articles on sequential equilibrium, Kreps et al. (1982) and Kreps and Wilson (1982) have shown that assuming incomplete information in the sense of Harsanyi (1967-68), cooperation can be sustained in the first games of a finitely repeated Prisoner's Dilemma. Similarly, this argument can be applied to a finitely repeated Investment Game. Assuming that there exist some Alters who do not have an incentive to abuse trust – for example, because they are in some sense altruistic – and that Ego is uncertain about her partner's incentives and will update her beliefs about Alter after obtaining information about him, Ego will send a positive amount in the first game hoping to be playing with a non-selfish Alter. Thus, while a non-selfish Alter will not abuse trust anyway, even a selfish Alter will return an amount $R_2 \geq S_1$, in order to build a trustworthy reputation, if he is aware of Ego's uncertainty. Only when the repeated game approaches its end, a selfish Alter will abuse trust because he has nothing to lose in future interactions.[3] Consequently, Ego will send positive amounts in the early periods of the game because she knows that even a selfish Alter will return positive amounts. The model predicts that toward the end of the game selfish Alters will start to abuse trust and Egos start to withhold trust. As soon as trust has been abused once, Ego knows that Alter is a selfish player and will certainly stop placing trust. Empirically, it is regularly observed in experiments with finitely repeated games that only in the very last periods trust and cooperation rates decrease dramatically (for example, Selten and Stoecker 1986; Camerer and Weigelt 1988). This leads to the following two hypotheses on dyadic control effects.

Hypothesis 2a (dyadic control): The higher the number of expected games in the future, the higher the amount that Ego is willing to send.

Hypothesis 2b (end-game effect): The amount sent by Ego decreases to a larger extent in the last few periods games than in earlier periods of the repeated game.

Learning through Network Embeddedness

The situation analyzed in the previous section represents a repeated interaction between two isolated strangers. However, most transactions in real life take place between actors that are embedded in a social structure. In particular, other actors could have some kind of relation with Ego, Alter, or both. Therefore, we now relax the assumption of isolated actors introducing social networks in the game. We start by adding one other actor. Imagine there are two Egos playing a finitely repeated Investment Game with the same Alter. Moreover, these two Egos can exchange information about their interactions with Alter. Although learning models are widely applied in sociology to study the behavior of groups in social dilemma situations (for example, Heckathorn 1996; Macy and Skvoretz 1998; Flache and Macy 2002), learning models have not yet been applied to study the Investment Game. If two Egos play a repeated Investment Game and can exchange information with each other, every Ego obtains additional information from which she can learn, namely, information concerning games played by the other Ego with Alter. Assuming that this is a game of incomplete information, the additional information concerning games played by Alter with another Ego can reveal to Ego what kind of player Alter is. Therefore, Ego's decision is expected to be influenced by this information.

Now, we introduce some additional complexity in the network. Imagine there is more than one Alter in the network, for example two Alters, each of them playing a repeated Investment Game with two Egos. Moreover, we assume that every Ego can receive information from another Ego playing with the *same* Alter and/or from another Ego playing with *another* Alter. Information concerning another Alter can be relevant if we assume that it affects Ego's idea about the population of Alters as a whole. Positive information about any Alter can then increase Ego's expectation that "her" Alter is trustworthy as well.[4] For example, if Ego is informed that another Alter has been returning a high proportion of what he receives to another Ego, Ego will raise her estimate of her Alter's propensity to return a high proportion and she will be more inclined to send a higher amount to her Alter. Barrera and Buskens (forthcoming) found some evidence for effects of this type of information using a vignette experiment. As for dyadic learning, information utilized by Ego to adjust her expectations about her Alter's behavior can include proportion returned by any Alter to another Ego and/or amount earned by this other Ego. This leads to the following two hypotheses concerning Ego using information about her Alter playing with another Ego and information about another Alter playing with another Ego, respectively.

Hypothesis 3a (network learning): Assuming that Ego receives information concerning previous game(s) played by her Alter with another Ego, the higher the proportion returned by her Alter to another Ego (amount earned by another Ego) in the past, the more Ego sends to her Alter in the present game.

Hypothesis 3b (network learning): Assuming that Ego receives information concerning previous game(s) played by another Alter with another Ego, the higher the proportion returned by another Alter to another Ego (amount earned by another Ego) in the past, the more Ego sends to her Alter in the present game.

Imitation

One of the other possible effects of information stemming from network embeddedness is imitation. Imitation is usually considered a form of learning that plays an important role in socialization processes (for example, Bandura and Walters 1963: chapter 2). In interactions resembling social dilemmas, imitation could be viewed as a parsimonious way to achieve the optimal decision (see Hedström 1998 on "rational imitation"), especially in settings where information is scarce. Some imitation models have been proposed by economists (for example, Pingle 1995; Pingle and Day 1996; Schlag 1998), but these models apply to rather specific situations in which it is assumed that actors are fully informed about the past. In these models, actors make their decisions after receiving some information about the actions chosen by others *and* the outcomes obtained by them. However, the latter information might not always be available. For example, in an Investment Game, Ego could be informed about the choice of another Ego, but she may be unaware of Alter's response in that game. We restrict the term "imitation" to situations in which available information does *not* include the outcomes obtained by others, but only their behavior. Conversely, we use the label "learning" for decisions based on "full" information that includes the outcomes obtained by others.

In the Investment Game, we could imagine a situation in which two Alters play a finitely repeated Investment Game with two Egos each, just like before, but now Egos receive only information concerning the amount sent by other Egos. If an Ego receives information that another Ego has repeatedly sent high amounts for some games to her Alter, she could infer from this information that her Alter is returning high amounts to this other Ego; if this were not the case, this other Ego would stop sending anything to Alter. Therefore, we expect that also such partial information will influence Ego's decision, particularly if full information concerning Alter's behavior is not available. As for hypothesis 3b, if Ego's trusting decision is based on her estimates of the tendency to honor trust of a population of Alters, her decision could be influenced also by information concerning the behavior of another Ego in interaction with *another* Alter. This leads to the following two hypotheses.

Hypothesis 4a (imitation): Assuming that Ego is informed about games played by her Alter with another Ego, the more another Ego has sent to her Alter in previous games, the more Ego sends to her Alter in the present game.

Hypothesis 4b (imitation): Assuming that Ego is informed about games played by another Alter with another Ego, the more another Ego has sent to another Alter in previous games, the more Ego sends to her Alter in the present game.

Social Comparison

In order to account for deviations from standard rationality – such as cooperation in a one-shot Prisoner's Dilemma or Trust Game and contribution in public good type of games – observed in a number of experiments, some scholars have developed models that release the assumption of purely selfish behavior, substituting it with the assumption of partly altruistic behavior.[5] These models assume that subjects are not only interested in their own outcomes, but also, to some extent, in the outcomes obtained by the other player. Thus, in these models, the utility function incorporates different types of "non-standard" preferences, such as *fairness* (Rabin 1993) and *equity* or *inequality-aversion* (Fehr and Schmidt 1999; Bolton and Ockenfels 2000). Rabin's fairness model assumes that actors behave nicely toward those who have been nice to them, and retaliate toward those who have harmed them. Fehr and Schmidt (1999) proposed a model in which actors care about their own outcomes as well as about the difference between their own outcomes and the outcomes obtained by others. According to this model, actors dislike receiving lower payoffs (envy), but also, to a smaller extent, higher payoffs (guilt). Finally, in the model proposed by Bolton and Ochenfels (2000), individual utility depends on both an actor's own payoffs and his/her relative share. Individuals prefer to receive a relative payoff that is equal to the average earned by all other players. These models are applied to settings in which actors are assumed to compare their outcomes with that of their interaction partner, but they are not designed for comparisons within a network of actors who do not directly interact with each other. In particular, if actors are embedded in a network, they might compare their outcomes with those of others who occupy similar positions instead of the outcomes obtained by their interaction partner. Although these social comparison effects are not the main focus of this chapter, we pay attention to the most obvious effect, envy. Egos will sanction Alter if they feel treated unfair compared to other Egos. More specifically, Ego will decrease the amount she sends if she sees that either her Alter or another Alter returns a larger proportion of the received amount to another Ego than the focal Ego obtains herself.

Hypothesis 5a (envy): The higher the (positive) difference between the proportion returned by her Alter to another Ego and the proportion returned to Ego in previous games, the less Ego sends to her Alter in the present game.

Hypothesis 5b (envy): The higher the (positive) difference between the proportion returned by another Alter to another Ego and the proportion returned by her Alter to Ego in previous games, the less Ego sends to her Alter in the present game.

Control through Network Embeddedness

As for dyadic embeddedness, control effects have been theorized for network embeddedness. Buskens and Weesie (2000; see also Buskens 2002, chapter 3) developed a model for a repeated Trust Game with a network of Egos. This game-theoretic model predicts control effects via network embeddedness, but it applies to an infinitely repeated game. Buskens (2003) applied Kreps and Wilson's (1982) finitely repeated Prisoner's Dilemma model to a finitely repeated Trust Game and extended the original model by including an "exit" and a "voice" option for Ego. In the voice model, two Egos can inform each other about the behavior of Alter in previous interactions. This model assumes incomplete information as in Kreps and Wilson (1982) and predicts that Ego's decision to place trust increases with the frequency at which the two Egos can inform each other.

Looking at the embedded Investment Game and assuming that Egos have incomplete information – that is, there are some Alters who do not have an incentive to abuse trust – and that any abuse of trust is type-revealing, Buskens (2003) shows that Egos' possibility to inform each other about the behavior of Alter makes Alter more trustworthy than if Egos play with Alter individually. Thus, while Alters without incentive to abuse trust will not abuse trust anyway, other Alters will mimic this behavior for longer than if they play with one Ego, in order to maintain a positive reputation. Therefore, the effect of the expected duration of the game (hypothesis 1a) should be stronger if Egos can inform each other, because a longer future implies that Ego has the possibility to punish her Alter for abusing trust not only by withholding trust herself in future games, but also by informing other Egos and thus further damaging her Alter's reputation. This argument is summarized in the following hypothesis.

Hypothesis 6 (network control): The more Ego is able to inform other Egos, who are also playing with her Alter, about her Alter's behavior, the stronger the positive effect of the expected duration of the game is on the amount sent by Ego

Uncertainty

In a trust problem as the one described by the Investment Game, Ego might be uncertain about the meaning of the amount that Alter returns. Reconsider again the example in which Ego asks Alter to invest her money. Ego might be uncertain about the actual profit Alter has made in a certain period. Even if Alter is a good investor, he might be luckier at some times than at other times. If, in such a situation, Ego is not able to observe how successful Alter was, Alter could simply return a small amount to Ego and claim that he did not make a large profit, while he actually did. In terms of the Investment Game, this implies that Ego is uncertain about the multiplier m with which the amount sent by Ego is multiplied. Assuming that Ego is uncertain about how much an Alter received, information about Alter's behavior becomes more difficult for Ego to interpret. A low return could be due to a low return on the investment rather than to an abuse of trust. Because information is more difficult to interpret under this kind of uncertainty, all effects of Alter's past behavior on trust are expected to become weaker.

Hypothesis 7a (dyadic learning under uncertainty): If Ego is uncertain about returns on investment made by her Alter, the effect of her Alter's past behavior in interactions with Ego on Ego's trusting decision is smaller.

Hypothesis 7b (network learning under uncertainty): If Ego is uncertain about returns on investment made by any Alter, the effect of this Alter's past behavior in interactions with *other* Egos on Ego's trusting decision is smaller.

Hypothesis 7c (envy under uncertainty): If Ego is uncertain whether or not another Alter, who is interacting with another Ego, has the same returns on his investment as her Alter, the effect of the difference between the amount returned to another Ego and the amount returned to Ego is smaller.[6]

Method

Experimental Procedure

The constituent game in the experiment is the Investment Game (Berg et al. 1995), described in the previous section. The experiment is designed to investigate the effects of dyadic and network embeddedness on Ego's decision in more or less uncertain conditions. Three features are therefore manipulated: the structure of the information network, the amount of information carried by network ties and Ego's uncertainty about the returns on investment. Dyadic embeddedness is also implemented in the experiment since all subjects play three finitely repeated Investment Games, each with one partner. The structure of the information network is manipulated in three different ways – corresponding to the three finitely repeated Investment Games, which we refer to as *supergames* – as illustrated in figure ?.1. Each supergame consists of 15 periods. Each network consists of six subjects, four Egos and two Alters. Each Alter plays the Investment Game with two Egos. This is indicated with straight lines in figure ?.1. Egos are variously connected with each other, and a connection between two actors, denoted by a dotted line, indicates an exchange of information between them. Information available to one node is automatically transmitted to all other nodes with whom the focal node is connected by a dotted line. The software takes care of the transmission of information through the network, which is provided to the subjects in "history boxes" displayed on the computer screens.[7] History boxes are windows at the lower part of the screen and they provide subjects with information about previous games. Thus, when a game is played at time t_n, information about all games previously played from t_1 until t_{n-1} is available to the subjects in their history boxes. Alters are not connected and their history boxes only show outcomes of their own past transactions. We are more specific about the content of the history boxes when we describe how we manipulated information.

FIGURE ?.1 ABOUT HERE

In the first supergame, every Ego receives information from another Ego who is playing with the same Alter. Hereafter, we refer to this other Ego as *Ego 2* and to the Alter who is playing with Ego 2 as well as with the focal Ego as *Alter 1*. A tie connecting Ego and Ego 2 provides Ego with information about interactions involving Alter 1 and Ego 2. Thus, Ego can use this tie to learn or make inferences about the trustworthiness of Alter 1. In the second supergame, every Ego receives information from another Ego who is playing with *another* Alter. Hereafter, we refer to this Ego as *Ego 3* and to the Alter who is playing with Ego 3 as *Alter 2*. Through this tie to Ego 3, Ego can learn or make inferences about Alter 2 who is interacting with Ego 3, but does not obtain information about Alter 1 other than from her own interactions. In the third supergame, every Ego receives information from *two* other Egos, one (Ego 2) playing with her Alter (Alter 1) and the other (Ego 3) playing with another Alter (Alter 2). Thus, the structure of the information network varies within subjects: every participant plays three supergames of fifteen games each, one for every network type, in a fixed order: in the first supergame she has a tie to Ego 2 only, in the second supergame she has a tie to Ego 3 only, and finally, in the third supergame, she has two ties, one to Ego 2 and one to Ego 3. This design is used to analyze how subjects process information coming from different sources. The order of the three parts of the experiment is kept constant for every subject in order to provide subjects with the same sequence such that they have similar amounts of experiences in each of the supergames.

The amount of information carried by the ties between Egos is also manipulated: information can be *full* or *partial*. If a tie carries full information, subjects at both ends receive information about *both* the amount sent by the other Ego *and* the amount returned by the related Alter for every game previously played. By contrast, if a tie only carries partial information, subjects at both ends receive information only about the amount sent by the other Ego, *but not* about the amount returned by the related Alter.

In practice, the manipulation was implanted via the information subjects obtained in their history boxes at the screen. For example, assume that Ego in figure ?.1 has a tie to Ego 2 carrying partial information and a tie to Ego 3 carrying full information. In this case her history box displays the amount sent by herself to Alter 1 and the amount returned by Alter 1 to herself for all games previously played (this information is always available for all players in all experimental conditions). In addition, the history box shows the amount sent by Ego 2 to Alter 1 (but *not* the amount returned by Alter 1 to Ego 2), the amount sent by Ego 3 to Alter 2, and the amount returned by Alter 2 to Ego 3 for all games previously played. The amount of information carried by ties varies both between and within subjects. A given tie of any given actor does not changes from full to partial information or vice versa between supergames, but actors may have one tie carrying full information and one partial information. Therefore, the tie to Ego 2 in the third supergame carries the same information as the tie to Ego 2 in the first supergame. Similarly, the tie to Ego 3 in the third supergame carries the same information as the tie to Ego 3 in the second supergame. Hence, four information conditions are possible: full information on both ties (FF), partial information on both ties (PP), full information on the tie to Ego 2 and partial on the tie to Ego 3 (FP), and vice versa (PF). Note that the positions of the four Egos within one network are symmetrical with respect to the information they receive through their ties.

Finally, uncertainty is implemented by means of the multiplier m: in the treatment without uncertainty m = 3 for all Alters (C), while in the treatment with uncertainty m = 2 or 4, with probability 0.50 each, for all Alters (U).[8] Uncertainty varies only between subjects. In the condition with uncertainty, the value of the multiplier is chosen independently for the two Alters at the beginning of every period and the Alters are informed about the value of m before the Egos make their choices.[9] The value of the multiplier of a given Alter for a given period applies to the amount of points sent by *both* Egos playing with this particular Alter. The Egos do not find out what the value of m is either during or after the game. However, occasionally the choice of Alter may reveal the value of m, for example if, in a game with uncertainty, Alter returns a value $R_2 > 2S_1$, Ego can infer that the value of m for this period was 4. Combining the four information conditions with the two possible conditions for uncertainty (C and U) yields eight possible experimental conditions. The eight conditions with the number of subjects that participated in each condition are summarized in table ?.1. All information concerning network embeddedness, amount of information transmitted, and uncertainty is common knowledge: all players have the same information and everybody knows that everybody has the same information.

TABLE ?.1 ABOUT HERE

Each session of the experiment had eighteen subjects, except for one session in which only twelve subjects participated. The experiment runs as follow: the participants are divided in groups of six subjects and every participant is randomly assigned a role, Ego or Alter. Each group consists of four Egos and two Alters. Subjects keep the same role throughout the experiment. The experiment consists of three supergames. During each supergame, two Egos are anonymously matched with one Alter, and they play the Investment Game with him fifteen times. Therefore, each Ego plays one Investment Game every period, whereas each Alter plays two games per period, one with each Ego. Before the beginning of the first supergame, subjects run through a tutorial in which they have to answer some questions on whether they understand the stage game. If they give wrong answers they receive feedback on what the correct answer is and why this is the correct answer. They are allowed to ask questions to the experimenter if they would still not understand the instructions. Then, they play two times an Investment Game against the computer, in order to learn how the game works. They know that they play these two periods against the computer, that the answers are preprogrammed, and that this is only to practice without actual payment.

After these practice rounds, all subjects are assigned to a group of six; they do not know who the other subjects in their group are. Then, the first supergame starts. At the beginning of every period, all players receive an initial endowment of 10 points (1 point = 0.01 Euro). The Egos then have the possibility to send all, some, or none of their points to their Alter. They are instructed that the points they receive are completely at their disposal and they can freely decide whether they want to send something to their Alter and if so how much. The amount of points that they decide to send is then multiplied by a factor m by the experimenter, where $m = 3$ in the condition without uncertainty and $m = 2$ or 4 in the condition with uncertainty. The Alters receive an amount equal to m times the amount sent by the Egos. The Alters can decide to send back to Egos all, some, or none of the points they have received. Obviously, the Egos have to decide first and the Alters must wait until all the Egos have entered their decisions. After a subject has made a choice, a waiting screen appears on her monitor instructing him or her to wait until all other subjects have entered their decisions. When all the Egos have completed their task the Alters have to decide how much they want to return to each of their two Egos separately. The two decisions that Alters have to make in every period appear simultaneously on their screen, and the game does not proceed until every Alter has entered both decisions. After all subjects have completed a period, the computer displays their earnings and the history boxes are updated. The history boxes of the Alters contain information about: the period number, the amount of money received from each of the two Egos and the amount returned to each of the two Egos. The history boxes of Egos contain the period number, the amount of money sent and returned, *and* information about the other Egos with whom they are tied. The information displayed in the history boxes of both Ego and Alter is reported for all periods previously played and it remains available to the subject until the end of the supergame.

After all tasks have been completed and the history boxes have been updated, a new period starts. After fifteen periods have been played, the supergame finishes and subjects move on to the next supergame. The Egos are always matched to a different Alter in every supergame and they are (partially) embedded with new Egos.[10]

Statistical Model

The dependent variable we want to predict in the analyses is how much does subject *i* trust his or her partner at time *t*, operationalized as the amount sent by subject *i* at time *t*, say y_{it}. We assume that y_{it} can be described as a linear function of the predictors *x*, which have been discussed in the theory section. However, we take into account the panel structure of the data, namely, that we have multiple observations per subjects. Therefore, we estimate the model

$$y_{it} = x_{it}\beta + \nu_i + \varepsilon_{it}$$

where ν_i is the random effect at the subject level and ε_{it} is the random effect at the observation level. Both random effects are assumed to be normally distributed, to be independent from each other, and to have a mean equal to zero. The vector x_{it} of predictors includes variables for learning, imitation, envy, and control.

The dependent variable is measured by the amount of points, varying between 0 and 10, a subject sends to the partner. Theoretically, the latent dependent variable trust is a continuous property of subjects. Therefore, we assume that our measurement of trust can be interpreted as an interval measurement for the actual trust level. For example, if a subject sends one point, this implies that his or her trust level corresponds with sending some value between 0.5 and 1.5 points. Similarly, the intervals are determined for sending two until nine points. Because a subject cannot send more than ten points, sending 10 points only indicates that a subject wants to send something larger than 9.5. Therefore, the upper bound of the interval for sending ten points is set to infinity. Defining the appropriate interval of trust levels related to sending nothing is even more difficult. We assume that there are many different levels of distrust that all lead to sending nothing, implying that we set the lower bound of the interval around zero at minus infinity.[11] Regression models in which the observed values represent intervals are called *interval regression models*, we estimated a panel version of this type of models using the `xtintreg` command in Stata 8.2 (Stata Corporation 2003: 108-114).

In principle, adding only a random effect at the subject level is not enough to account for all interdependencies in the data. Two additional random effects accounting for the clustering of the observations that belong to the same triad – in supergame one and three – and of the observations that belong to the same experimental network – in supergame two and three – should be added to the statistical model because the choices of subjects in the same network are interdependent. However, we did not have statistical tools in which we could estimate interval regression models with three additional random effects. Alternatively, we estimated standard linear multilevel regression models with multiple random effects. These analyses showed that adding more random effects than only the subject-level effect led to only very marginal changes. However, when we compared the standard linear model with the interval regression model, both with a random effect at the subject level, some though not many of the somewhat weaker results changed in the analyses. For this reason, we decided to present the results obtained with the interval regression model since this model is theoretically more appropriate given the distribution of our dependent variable. Still, we will be carefully interpreting results that are only just significant at the five percent level.

Independent Variables

For dyadic learning (hypothesis 1), we looked both at the amount earned in the past and at the proportion returned by Alter 1 in the past. The amount earned by Ego in previous periods is operationalized by taking a discounted sum of the difference between the amount sent in previous periods and the amount returned in previous periods. Assuming that recent experiences are more important, experiences are discounted by a weight w_1 ($0 \leq w_1 \leq 1$) for each period they are further in the past. Thus, at time t,

$$\text{amount earned}_t = \sum_{i=1}^{t-1} w_1^{t-i-1}(E_{1i} - S_{1i} + R_{2i}),$$

where S_{1i} and R_{2i} are the amounts sent and returned at time i. Similarly, the proportion returned by Alter 1 in the past is operationalized by adding the proportion returned by Alter 1 in all previous periods, discounted by a weight w_2 ($0 \leq w_2 \leq 1$). Thus, at time t,

$$\text{proportion returned}_t = \sum_{i=1}^{t-1} w_2^{t-i-1} \frac{R_{2i}}{mS_{1i}}.$$

Under uncertainty, we also computed proportion returned assuming $m = 3$ since in this case m is equal to 2 or 4, both with probability 0.50. Moreover, we include in the analyses one variable for the amount sent by Ego in the past. This variable captures the individual propensity to trust and to stick to past decisions. This variable is operationalized by adding the proportion sent by the subject in all previous periods discounted by a weight w_3 ($0 \leq w_3 \leq 1$).[12] Thus, at time t,

$$\text{proportion sent}_t = \sum_{i=1}^{t-1} w_3^{t-i-1} \frac{S_{1i}}{10}.$$

Dyadic control (hypothesis 2a) is operationalized simply by taking the number of periods still to go before the end of the supergame, while for the end-game effect (hypothesis 2b) we use a dummy variable that has value one in the last period of a supergame and zero otherwise. More complicated operationalizations for end-game effects did not improve the model. The variables for network learning (hypotheses 3a and 3b) are constructed in a similar way as the variables for dyadic learning.

We took a discounted sum (w_4, $0 \leq w_4 \leq 1$) of the proportion returned from Alter 1 to Ego 2 for hypothesis 3a and a discounted sum (w_5, $0 \leq w_5 \leq 1$) of the proportion returned from Alter 2 to Ego 3 for hypothesis 3b.[13] For imitation, assuming that subjects react to observed behavior of other Egos when the behavior observed differs from their own behavior, we took a discounted sum of the difference between the amount sent by the subject and the amount sent by Ego 2 in previous games for hypothesis 4a. Thus at time *t*,

$$\text{Difference in proportion sent}_t = \sum_{i=1}^{t-1} w_4^{t-i-1} \frac{S_{1i}^{\text{Ego 2}} - S_{1i}^{\text{Ego}}}{10},$$

where S_{1i}^{Ego2} is the amount sent by Ego 2 at time *i* and S_{1i}^{Ego} is the amount sent by the focal subject at time *i*. For hypothesis 4b, we took the same difference with respect to Ego 3, discounted by w_5.[14] For social comparison (envy, hypothesis 5a), we took a discounted difference between the proportion returned from Alter 1 to Ego 2 and the proportion returned from Alter 1 to the subject in previous periods. Thus, at time *t*,

$$\text{envy}_t = \sum_{i=1}^{t-1} w_4^{t-i-1} \max[0, \frac{R_{2i}^{\text{Ego 2}}}{mS_{1i}^{\text{Ego 2}}} - \frac{R_{2i}^{\text{Ego}}}{mS_{1i}^{\text{Ego}}}],$$

where the superscript indicates who received or sent the indicated amount, and *m* is equal to 3.[15] Similarly, we looked at the same difference with respect to Ego 3 in interaction with Alter 2, discounted by w_5 for hypothesis 5b.[16] For network control, we constructed an interaction term between the number of periods remaining before the end of the supergame and a dummy variable taking the value one when the tie to Ego 2 carries full information. We operationalized network control in this way because the effect described in the theory and hypotheses section only applies if Egos can exchange full information. If Egos receive only partial information, the advantage of such exchange as derived by Buskens (2003) disappears. Uncertainty is included in the analyses as a dummy taking the value one in the experimental conditions with uncertainty and zero otherwise.

At the end of the experiment, subjects filled in a short questionnaire concerning some individual characteristics, such as gender, age, field of study, and number of friends participating in the same session. Moreover, we included a set of eighteen items on trusting attitude mainly adopted from Yamagishi and Yamagishi (1994) and Wrightsmann (1974), and a set of items measuring the responsiveness of the subject to third-party information, based on Bearden, Netemeyer, and Teel's (1989) scale of susceptibility to personal influence. Both the items measuring trust and those measuring susceptibility to interpersonal influence were entered in a factor analysis and in both cases two factors were found and the standardized scores were used as scales.

Results

Description of the Data

Two hundred eighty-two subjects participated in this experiment: each of the eight experimental conditions was implemented twice, every time with three networks of six subjects each, except in one case in which we only had two networks of six subjects. Since we focus on the behavior of the Egos, only two thirds of the subjects are included in the analyses, while all the Alters are excluded. Every subject participated in three supergames of fifteen games each. Thus, the total number of observations is 45 × 188 = 8460 choices made by subjects in the role of Ego.[17]

Most trust is placed in the conditions in which there is full information between Egos who are playing with the same Alter. In the first supergame, subjects sent on average over fifteen periods 6.44 points if they obtained only partial information from Ego 2, while they sent 7.21 points if they obtained full information (see left part of figure ?.2). This difference is significant (p = 0.020). In the third supergame, the average amount sent with partial and full information between Ego and Ego 2 is 6.42 and 7.35 points, respectively (see the left part of figure ?.3). Also this difference is significant (p = 0.018). There is hardly any difference between certainty and uncertainty conditions depending on the amount of information that is carried by the tie between Ego and Ego 2. However, in the right parts of figures ?.2 and ?.3, we see that, under uncertainty subjects sent more points if information from Ego 3 was partial than if information from Ego 3 was full. This differences is significant in the second supergame (p = 0.007), but not in the third supergame (p = 0.12).

In order to analyse the dynamics and take into account the clustering of subjects within networks, we run also interval regression models with a random term for subjects, as explained in the methods section. In these regression models, we include dummy variables for the main effects of uncertainty and information conditions concerning the relevant ties, as well as interaction effects between uncertainty and information conditions. These analyses confirm that information about Ego 2 has a positive effect on trust in the first as well as the third supergame, while information about Ego 3 has a negative effect on trust in the second supergame under uncertainty. In the third supergame the level of trust seems, under uncertainty, to be slightly lower for full than for partial information about Ego 3 likewise, but this difference is not statistically significant. We will pay more attention to this unexpected negative effect of information about Ego 3 when we analyze the dynamics in more detail in the following subsection.

FIGURE ?.2 ABOUT HERE

FIGURE ?.3 ABOUT HERE

Figures ?.2 and ?.3 also show that trust declines over time. Although this reduction seems to depend on the conditions, we did not find interaction effects between conditions and the number of periods to be played, on the amount sent to Alter. The end-game effect can be observed by the strong decline in trust in the last period of the second and third supergame. It seems that subjects need some experience to realize that trust can easily be abused in the last period and that they could have been more cautious in the first supergame. Additional descriptive information on the results of the experiment, including separate tables and graphs for each experimental condition, can be found in Barrera (2005: chapter 3).

Tests of the Hypotheses

Because different subsets of mechanisms are applicable in each supergame and because there might be spillover effects between supergames, the three supergames are analyzed separately. For every supergame, two models are presented. Model 1 includes only main effects and model 2 includes also the interaction terms with uncertainty. In the first supergame, Ego has a tie to Ego 2 but not to Ego 3 and vice versa in the second supergame. In the third supergame, both ties are present. Therefore, all variables related to Ego 2 are included in the analyses of the first and third supergame but not in the second, while all variables related to Ego 3 are included in the analyses of the second and the third supergame but not in the first. For all variables referring to past experience, it seems reasonable to assume that more recent experiences have a stronger effect on current decisions than experiences from longer ago. Therefore, a discount parameter was applied to all past variables as explained in the operationalizations. The discount parameters were estimated iteratively and the values of the parameters that gave the best fit, based on the log-likelihood of the models, were chosen. Nine variables referring to past experience are included in the analyses: three for Ego's own past (amount sent in previous periods, points earned in previous periods, and proportion returned by Alter 1 in previous periods), three for Ego 2's past (proportion returned by Alter 1 in previous periods, difference between the amount sent by Ego 2 and the amount sent by Ego, and difference between the proportion returned to Ego 2 and the proportion returned to Ego), and the same three variables for Ego 3 in games played with Alter 2. We used three different weights for own past, one for each variable, but we used only one weight for Ego 2's past and one for Ego 3's past. Initially, we tried also different values for different types of past with respect to the third parties, but whatever combination we tried, the conclusion was always the same: only third-party experiences from the last period matter for Ego's current decision. Thus, the weights related to Ego 2 and Ego 3's past are equal to zero. This is in line with results by Buskens (2004) in a similar experiment on the Trust Game.

Also for amount earned by Ego in the past, the discount parameter w_1 is estimated to be zero. The proportion returned to Ego seems to loom longest, since for that parameter w_2 is estimated at 0.9. Finally, the estimated discount parameter for amount sent by Ego w_3 is 0.5. These discount parameters were estimated independently for all three supergames and the estimations proved rather consistent. Therefore, the same values of the discount parameters were fixed for all analyses. We were not able to estimate simultaneously the discount parameters and the random-effects interval regression model. For this reason, we do not have confidence interval for the estimations of the discount parameters and the standard errors in the analyses presented here are conditioned on the assumption that the discount parameters indeed equal the estimated value.[18]

Analyses of all three supergame are displayed in table ?.2. The first three variables are two dummies for whether the information carried by the tie to Ego 2 and/or Ego 3 is full and a dummy for uncertainty. We could have added also interactions between these dummies to control even further for differences in conditions. We added only these because they are used in interaction with other variables, but we did not want to make the model more complex than necessary, given that none of the controls for conditions are significant after introducing variables for the substantive mechanisms for which we developed the hypotheses discussed in the theory section. Thus, we are able to explain the differences identified in the previous subsection with our theoretical mechanisms.

We added a dummy variable for first period in order to control for how subjects start the game. This variable is positive and significant in all models, showing that Egos, on average, start investing relatively much of their initial endowment. The next variable in the model is *Ego's past sending behavior,* which accounts for individual propensity to stick to one's own trust decisions. This variable is strongly significant in all analyses, implying that subjects' own past decisions determine their current choices to a considerable degree. Hypotheses 1a and 1b on *dyadic learning* are consistently supported in all models. Amount earned in the past as well as proportion returned in the past have a strong positive effect on Ego's trusting decision. Hypotheses 2a and 2b on *dyadic control* are also consistently supported. The end-game effect ("last round") is not significant in the two models referring to the first supergame, but it becomes increasingly significant in the two following supergames. This can be seen also in figures ?.2 and ?.3. This result indicates that subjects experience in the first supergame that trust is likely to be abused in the last round, and therefore they become more careful in last rounds of subsequent supergames. Summarizing, we find strong and consistent support for all the hypotheses at the dyadic level. These results are also robust for all alternative model specifications.

Now, we turn to the network effects. Only two times an effect of *network learning* is weakly significant throughout the analyses shown in table ?.2. Therefore, hypotheses 3a and 3b are not supported. Actors do neither learn from the behavior of Alter with respect to Ego 2 nor from behavior of another Alter with Ego 3. It is especially surprising that the behavior of Alter with Ego 2 is not affecting Ego's behavior, given that she is playing with this Alter herself and given that full information about the behavior of Alter with Ego 2 leads to more trust on average.

Imitation is the effect of the behavior of other Egos in the past on Ego's decision in the present. We included this variable twice in order to control separately for the effects of behavior of other Egos when information about the related Alter's returning decisions was available (full information) and when it was not available (partial information). This distinction is important because for subjects that receive only partial information from other Egos imitation is the only way to adapt their behavior, while subjects who receive full information can be affected by the behavior of Alter as well. The variables for imitation are constructed using an interaction term of the imitation variable – as explained in the subsection on the independent variables – once with a dummy with value one if information was full, and once with a dummy with value one if information was partial. Both these variables are strongly significant, which means that actors imitate both when information is partial and when information is full. Therefore, hypothesis 4a is supported in both supergames with information about Ego 2. The combination of the effects of network learning and imitation under full information gives an indication about the extent to which Egos actually learn or just imitate what Ego 2 does. In both supergames involving Ego 2, imitation is much more important than learning. If either learning or imitation is added as explanatory variable in the analysis, learning is at best marginally significant while the imitation effects are always strongly significant independent of which model specification we choose. Hypothesis 4b is not supported. In the second supergame, the results show some weak support for the hypothesis that Egos imitate Ego 3 only when information concerning the behavior of Alter 2 is not available (partial information), otherwise they ignore it. Apparently, Egos do not become more or less trustful toward their own partner from observing Ego 3 interacting with Alter 2. We do not have an explanation for the negative imitation effect related to Ego 3 under full information in the third supergame. Both effects related to imitating Ego 3 are only significant at the five percent level and they depend on the model specification. Therefore, we can only conclude that there is hardly evidence that Egos take the choices of Ego 3 into account in their decisions.

Concerning envy, we find mixed results. Hypothesis 5a is supported in the first supergame, but not in the third supergame although this effect is in the expected direction. The strong negative effect in the first supergame implies that if Alter 1 returned more to Ego 2 than to Ego in the past, Ego punishes him by sending significantly less in the current period. Again, the much weaker effect in the third supergame might be caused by the increased complexity, which decreases subjects' concern with this rather subtle effect. Concerning envy toward an Ego 3 who is playing with Alter 2, we particularly expect an effect under certainty, because under uncertainty returns to Ego 3 are difficult to evaluate for Ego, since the multiplier of Alter 2 can be different from the multiplier of her Alter. In the second supergame we do not find effects of envy toward Ego 3 at all. However, in the third supergame, there is a negative effect for envy toward Ego 3 under certainty, while the interaction effect with uncertainty shows that this effect does not exist under uncertainty. One problem with testing the hypotheses with respect to envy is that we can only test them in a meaningful way if Alters provide Egos with a reason to be envious. We know that Alters tend to behave consistently toward the two Egos with whom they are playing and this consistency increases in later supergames. Therefore, Egos do not often have reasons to be envious toward Ego 2, especially in the third supergame. By contrast, since the two Alters are not informed about each others' behavior, one could expect more possibilities for envy between the focal Ego and Ego 3.

Network control is not significant, thus hypothesis 6 is not supported. Theoretically, another effect of network control might be hypothesized, namely that the end-game effect occurs later under full information than under partial information. However, this alternative formulation of network control is also not supported. This might be due to the fact that the end-game effect starts already very late in all conditions. We do not have a final explanation for the lack of evidence for network control. Certainly, network control is not a straightforward effect for Egos, because it requires that Egos place themselves in the shoes of Alter and anticipate that Alter takes into account that information about his behavior will spread through the network, affecting his reputation and hence his final profit. Although we do not analyze in detail Alters' behavior in this paper, we observe that the reason for Egos to place more trust under full than under partial information is that Alters return larger amounts in this experimental condition. Therefore, although Egos do not anticipate this effect on Alters' behavior, Alters actually behave as if they care about their reputation under full information. The positive effect of information from Ego 2 on Egos' behavior results indirectly, mainly via learning from own experiences with Alter and via imitation of Ego 2.

Finally, *uncertainty* does not seem to affect dyadic and network learning effects. Uncertainty has no effect on imitation, because imitation is not based on the returns of an Alter anyway, so it is not affected by whether Ego knows how much an Alter can return. All interactions with dyadic and network learning are not significant. Hence, hypotheses 7a and 7b are not supported. Only in the third supergame, we find the clear and well-interpretable interaction with envy, which we already discussed in the paragraph about envy. Thus, we find some support for hypothesis 7c.

TABLE ?.2 ABOUT HERE

In preliminary analyses, we included variables accounting for individual attributes in these models, namely gender, age, number of friends participating in the same experimental session, field of study, measurements for an intrinsic tendency to trust, and of the scale measuring susceptibility to interpersonal influence. Because of a random assignment of subjects to conditions, it is unlikely that individual characteristics influence the results of our analyses. Still, in order to exclude even further that these results are codetermined by individual characteristics, we ran several analyses to investigate main and interaction effects of subject characteristics. None of the substantive findings depend on whether the variables for individual characteristics are included. Moreover, the main effects for individual characteristics are rather unstable. The only consistent finding is that economists trust less than students from other disciplines (in this case mostly sociology and psychology). Even the items that should measure trust did not affect the extent to which subjects trust others. However, given the relatively small number of subjects in the experiment and the limited variation in some of these variables, it is not surprising that we hardly found significant individual differences. Some more details on the effects of individual characteristics can be found in Barrera (2005: chapter 3).

Conclusion and Discussion

In this chapter, different effects of third-party information on trust are compared. A trust problem is defined and operationalized by means of the Investment Game. Hypotheses are tested in a laboratory experiment in which subjects play a repeated Investment Game and simultaneously exchange information about the games played. Two types of embeddedness are discussed, dyadic embeddedness, referring to the situation in which two actors play the Investment Game repeatedly with each other, and network embeddedness, referring to the situation in which two actors play the

Investment Game while being part of a network of actors that exchange experiences about their past interactions. Existing theories stress the importance of mechanisms such as learning, control, imitation, and social comparison. The experiment allowed us to test hypotheses reflecting all of these mechanisms in a controlled environment. Moreover, since effects of information are expected to be particularly important under uncertainty, uncertainty was manipulated together with information conditions. The analyses focused on actors' trusting behavior, while the other actor's trustworthiness was used as one of the predictors for trusting behavior.

The effects of dyadic embeddedness on trust are strong and consistent in all experimental conditions. Egos are particularly influenced by their own past experience with their Alter (dyadic learning), and by the length of the expected future with their Alter (dyadic control). For network embeddedness, not all predicted effects are supported. We found strong support for imitation of behavior of other Egos playing with the same Alter as the focal Ego.

The most striking result from this experiment is that the Egos adapt their behavior in the direction of the behavior of another Ego playing with the same Alter, while this adaptation does not seem to be influenced by the amount Alter returned to the other Ego. In other words, Egos imitate other Egos rather than that they learn whether Alter should be trusted by observing Alter's behavior toward these other Egos. Thus, the increase in the level of trust observed under full information is caused by a chain of mechanisms: Alters return higher amounts in this experimental condition, supposedly because they are concerned about their reputation; consequently, through a mechanism of dyadic learning, Egos' trust in Alter increases; finally, Egos' trust in Alter is reinforced by observing the behavior of the other Ego through a mechanism of imitation. By contrast, Egos are hardly influenced by the behavior of other Egos involved with another Alter. This seems to contradict earlier findings where Egos' choices were found to be affected by information about other Alters (see Barrera and Buskens, forthcoming). However, in the experiment presented by Barrera and Buskens (forthcoming), Egos had *either* information about their Alter *or* about another Alter. Our experiment shows that if Egos have a combination of both types of information, information about another Alter becomes largely irrelevant.

Another new result in the context of Investment Games is that we found some support for effects of social comparison. In the network configuration characterized by only one tie between two Egos playing with the same Alter, the focal Ego punished her Alter if Alter treated the other Ego better than herself. Conversely, in another network configuration in which every Ego had two ties, one to another Ego playing with the same Alter and one to another Ego playing with another Alter, Egos reacted punishing their Alter when they saw that the other Alter was being more generous than their own Alter. Finally, there was neither support for network control nor for mitigation of learning and social comparison effects by uncertainty.

Summarizing, this chapter provides new and complementary evidence for learning and control mechanisms on trust (see Buskens and Raub 2002). While in Buskens and Raub (2004) evidence for learning and control effects was provided from a survey on IT transactions and two vignette experiments, here we find similar evidence in a laboratory experiment. Moreover, this experiment provided possibilities to distinguish between learning, imitation, and social comparison, while the earlier studies focused on learning only. Especially challenging is the strong support found for imitation effects, as opposed to the weak support found for a real learning mechanism. It seems to indicate that our subjects preferred to opt for more parsimonious heuristics rather than thoroughly evaluate all the information available to them. Although this might be due to the complexity of our experimental design, it induces the theoretical question whether it is possible to predict under which conditions learning or imitation is the more prevalent mechanism.

We chose to use the Investment Game in order to obtain a more fine-grained measurement of trust compared to the standard Trust Game in which actors can only choose between trusting Alter or not. The disadvantage is that, in the Investment Game, the behavior of Alter is more difficult to interpret. For example, a low return might simply indicate that Alter is untrustworthy, but it might also be a sign of Alter's disappointment due to an offensively low investment of Ego. In addition, as our analyses show, multiple mechanisms including imitation and envy might lead Ego to increase or decrease the amount sent and these mechanisms depend mainly on Ego's own interpretation of Alter's motives. However, the behavior of Alter remains still largely uninvestigated. Preliminary analysis of our data show that Alters return a higher proportion of the amount received if the multiplication factor is lower and a slightly higher proportion if there is full information exchange between the two Egos with whom a given Alter is playing. In addition, Alters are strongly affected by the end-game effect and return less in the last or even in the last two periods. More detailed analyses of Alters' behavior would require new theory development on how Alters adapt their choices depending on their experiences with the Egos, but this exceeds the scope of this chapter. Furthermore, given the difficulties related to the complexity of the Investment Game, a comparison of our results with results of standard Trust Games played in the same setting could be rather informative.

Finally, the results presented here support a range of different mechanisms operating simultaneously, while the predictions are derived from different theoretical arguments rather than an integrated theoretical model. Building such an integrated model is a challenge for future research and the outcomes of this study provide useful information on the importance of certain assumptions related to the importance of third-party information such a model should include. More specifically, such a model should include forward-looking arguments related to control, backward-looking arguments on learning and imitation, and even sideward-looking arguments on social comparison and other-regarding preferences (cf. Macy and Flache 1995; Flache 1996).

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Figure ?.1 Experimental networks

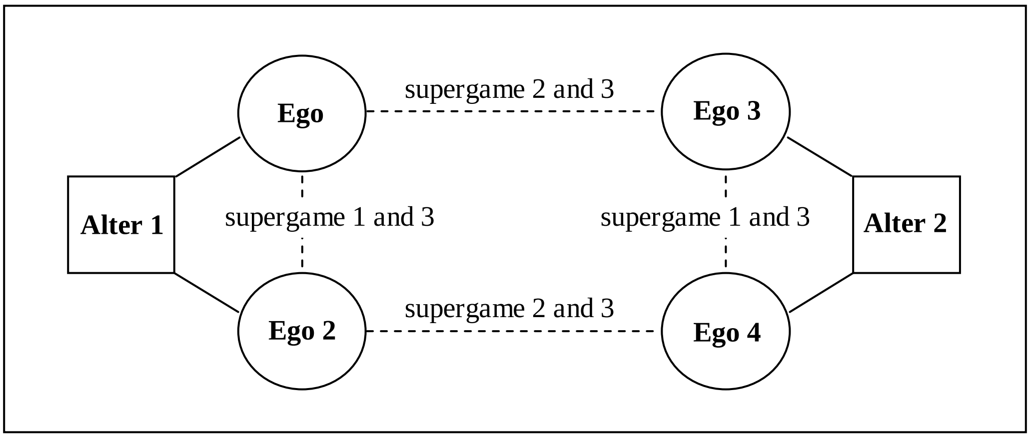

Figure ?.2 Average amount sent per period in the first and second supergame depending on uncertainty and information at the ties to Ego 2 and Ego 3

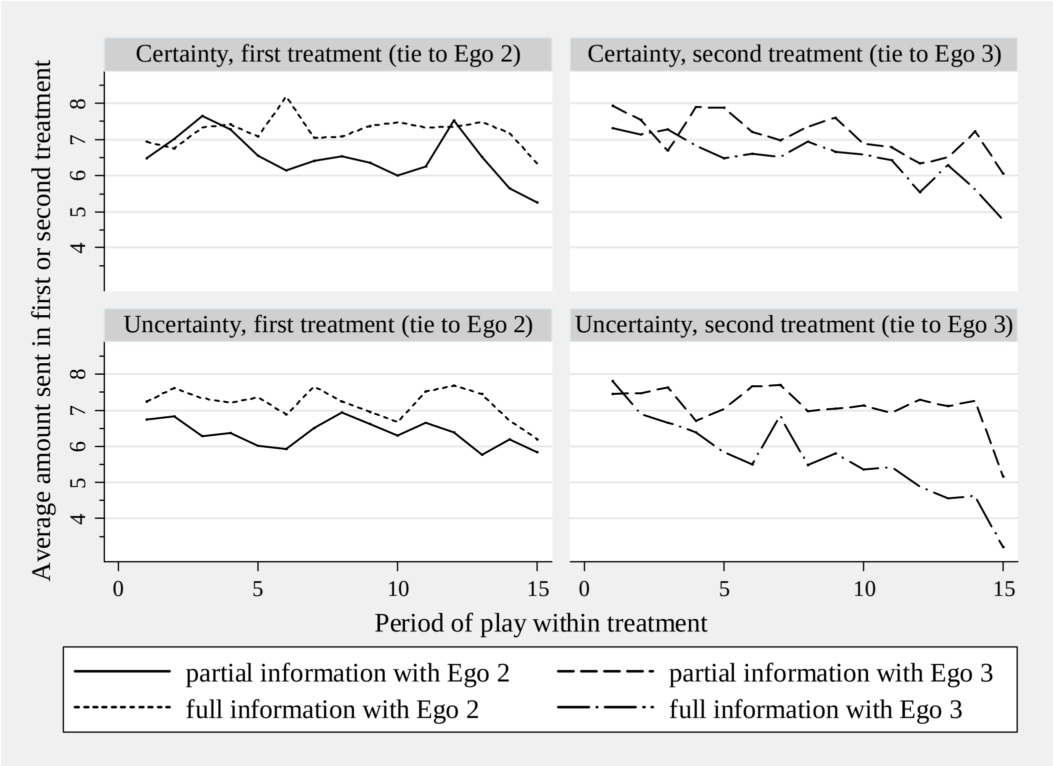

Figure ?.3 Average amount sent per period in the third supergame depending on uncertainty and information at the ties to Ego 2 and Ego 3

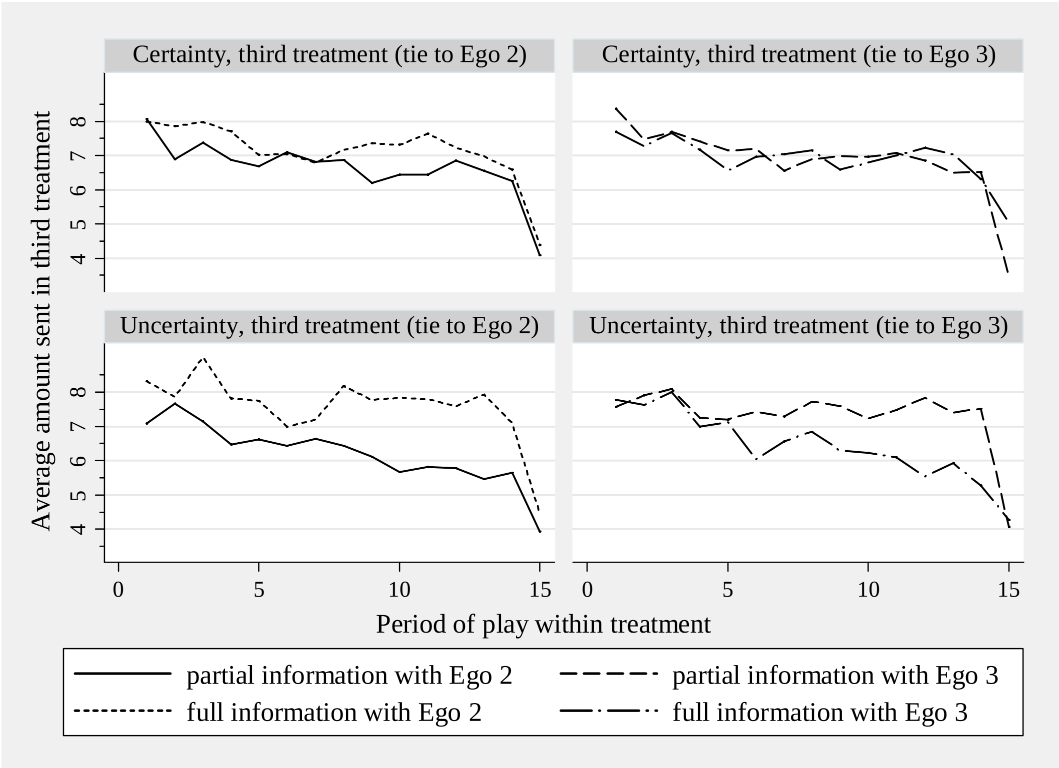

Table ?.1. **Experimental conditions (with the number of subject per condition in brackets)**

	FFC (*N*=36)	FFU (*N*=36)	PPC (*N*=36)	PPU (*N*=36)	FPC (*N*=36)	FPU (*N*=30)	PFC (*N*=36)	PFU (*N*=36)
Tie to Ego with *her* Alter	full	full	partial	partial	full	full	partial	partial
Tie to Ego with *another* Alter	full	full	partial	partial	partial	partial	full	full
Multiplier *m*	3	2 or 4	3	2 or 4	3	2 or 4	3	2 or 4

Table ?.2. **Random-effects interval regression with a random effect at the level of the subjects**

			1st supergame (tie to Ego 2)		2nd supergame (tie to Ego 3)		3rd supergame (tie to Ego 2 and Ego 3)	
Hyp.	Variables	Expected sign	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Full information with Ego 2		0.40	0.40			0.41	0.41
	Full information with Ego 3				-0.63	-0.65	-0.68	-0.68
	Uncertainty		0.30	0.03	-0.19	0.09	0.23	0.51
	First round		3.70**	3.69**	5.68**	5.69**	5.97**	5.89**
	Ego's past trustfulness		3.16**	3.15**	3.72**	3.73**	3.93**	3.85**
1	Dyadic learning 1 (amount earned)	+	0.24**	0.24**	0.33**	0.33**	0.43**	0.43**
1	Dyadic learning 2 (proportion returned)	+	0.71**	0.64**	2.38**	2.53**	1.62**	1.63**
2a	Dyadic control	+	0.22**	0.22**	0.51**	0.51**	0.41**	0.42**
2b	Last round	–	-0.53	-0.53	-1.48**	-1.48**	-3.83**	-3.80**
3a	Network learning (Ego 2)	+	1.30*	1.10			-0.61	-0.04
3b	Network learning (Ego 3)	+			0.26	0.09	1.24	2.12*
4a	Imitation (Ego 2) × full information	+	1.11**	1.11**			2.40**	2.32**
4a	Imitation (Ego 2) × partial information	+	1.33**	1.33**			1.29**	1.30**
4b	Imitation (Ego 3) × full information	+			0.01	-0.01	-1.12*	-1.06*
4b	Imitation (Ego 3) × partial information	+			0.74*	0.76*	-0.43	-0.43
5a	Envy (Ego 2)	–	-3.31**	-3.32**			-0.75	-0.74
5b	Envy (Ego 3)	–			-0.03	0.01	-2.06	-3.96*
6	Network control	+	-0.02	-0.02			0.05	0.04
7a	Dyadic learning 2 × uncertainty	–		0.15		-0.29		0.07
7b	Network learning (Ego 2) × uncertainty	–		0.48				-1.26
7b	Network learning (Ego 3) × uncertainty	–				0.27		-2.11
7c	Envy (Ego 3) × uncertainty	+				-0.04		3.97*
	Constant		0.31	0.46	-3.56**	-3.71**	-2.58**	-2.72**
	Standard deviation of subject level random effect		1.65	1.66	1.78	1.76	2.15	2.18
	Standard deviation of residual		3.60	3.60	4.58	4.58	4.56	4.55
	Log likelihood		-4943.4	-4942.9	-4369.7	-4369.1	-4080.1	-4077.9
	Number of observations		2700	2700	2700	2700	2700	2700
	Number of subjects		180	180	180	180	180	180

**, * Indicate significance levels of $p < 0.01$, $p < 0.05$, respectively. One-sided significance for effects for which hypotheses are indicated in the table and two-sided significance for the other variables.

[1] For reader friendliness we will refer to Ego using female pronouns and to Alter using male pronouns.
[2] Other effects due to the amounts returned by Alter are possible if Ego interprets such returns in a different way. For example, a low return following a low investment could simply mean an abuse of trust, but it could also be interpreted as disdain caused by an offensively low investment.
[3] Strictly speaking, Kreps et al.'s (1982) sequential equilibrium is based on a learning mechanism. However, we discussed this model in the section on control because it applies forward-looking rationality, whereas the learning models discussed before apply backward-looking rationality.
[4] To prevent confusing between which Alter is meant, we will refer to the Alter playing with the focal Ego as "her" Alter and the other Alter as "another" or "the other" Alter whenever this seems necessary.
[5] There is experimental evidence that some actors do indeed have altruistic preferences. Cox (2004) combines an Investment game and a Dictator Game to show that cooperation in the one-shot Investment Game can be attributed partly to a reciprocity norm governing the behavior of Alters, on which Egos anticipate, and partly to altruistic preferences observed in a non-trivial number of subjects. Conversely, see Hoffmann et al. (1994) for an experimental study on conditions facilitating the observation of self-regarding preferences.
[6] As illustrated in the method section, the returns on investment m are always the same for parallel interactions with the same Alter. Therefore, this hypothesis can only be tested for envy toward an Ego who is involved with another Alter. We formulate this hypothesis in terms of amount returned rather than proportion returned because the proportion is unknown if m is unknown.
[7] The experiment was programmed and conducted with the software z-Tree (Fischbacher 1999).
[8] Duwfenberg et al. (2001) manipulate uncertainty in a similar way, but in their experiment m was private information held by Ego and not by Alter. In other words, Duwfenberg et al. (2001) treat m as a property of Ego.
[9] This way of manipulating m is consistent with the interpretation that the multiplier represents exogenous circumstances affecting the return of an investment such as good or bad luck, and is independent of Alter's goodwill or competence.
[10] The complete instructions of the experiment can be obtained from the authors.
[11] We compared our analysis with plausible other implementations such as setting the lower bound related to sending zero at zero. Also we compared the analysis with alternatives such as a tobit regression in which we consider only sending ten as a left-censored observation and ordinary random-effects regression considering the amount sent as an interval variable. All these alternative analyses substantially led to the same conclusions although significance levels might slightly vary.
[12] We also estimated a model with the same discount parameter w for all three variables operationalizing own past, but the model with three different weights fitted the data better.
[13] Clearly, we could include two parallel effects as we did for dyadic learning, adding a variable related to the amount earned by the other Ego. However, the two effects can be disentangled for the dyadic effects because we have more observations and the effects are stronger. We run into collinearity problems if we try to disentangle these effects for third-party information. Therefore, we restrict ourselves here to the stronger effect, because substantially these two effects represent the same mechanism anyway. Moreover, the proportion returned by Alter 2 to Ego 3 seems a better operationalization for network, learning because this information is more easily accessible to Ego since it requires fewer calculations.
[14] We use the same discount parameters w_4 and w_5 for all variables operationalizing information concerning Ego 2 and Ego 3, respectively. A justification for this can be found in the results section.
[15] For all variables constructed with the proportion returned by Alter 1 or Alter 2 in previous periods, we assumed $m = 3$ in the experimental conditions with uncertainty.
[16] The effects of "guilt" could also be tested by looking at how Egos react when they are treated *better* than other Egos. However, preliminary analyses showed that actors only reacted when they were treated worse than other Egos, but did not care if they were treated better. Therefore, we include only envy in the analyses displayed here.
[17] Eight times an undergraduate student subject was replaced by a stand-in, mostly a Ph.D. student. We excluded the choices of the Ph.D. students from the analyses because some of the Ph.D. students have specific knowledge about the scope of the experiment. Still, excluding these subjects did not significantly affect the results of our analyses.
[18] We realize that this is a second aspect that compromises our standard errors. We were able to do the simultaneous estimation for simpler models. In these models, the standard errors became only marginally larger, but still we will interpret effects that are significant only at the five percent level with caution.