Embedded Trust: An Experiment on Learning and Control Effects

Vincent Buskens, Werner Raub, and Joris van der Veer

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Department of Sociology / ICS, Utrecht University
Heidelberglaan 2, 3584 CS Utrecht, Netherlands
v.buskens@uu.nl, w.raub@uu.nl

Abstract
The paper discusses a laboratory experiment in which pairs of trustors play finitely repeated Trust Games with the same trustee. We study trustfulness of the trustors as well as trustworthiness of the trustee. We distinguish between learning and control effects on trustfulness and trustworthiness. Learning effects are related to an actor's information on past behavior of the partner. Control effects are related to opportunities for sanctioning a trustee in future interactions. The experiment includes two conditions that represent different types of "embeddedness" of Trust Games. In one condition, each trustor only knows what happens in her own games with the trustee. In the other condition, each trustor also knows what happens in the games of another trustor with the trustee. Thus, with respect to trustfulness of the trustor, the design allows for disentangling learning effects from own experience of the trustor with the trustee and learning effects through third-party information, i.e., information on experiences of the other trustor with the trustee. Also, the design allows for disentangling control effects on trustfulness and on trustworthiness through own sanction opportunities of the trustor and through opportunities for third-party sanctions, i.e., sanctions implemented by the other trustor.

1 Introduction

Social and economic exchange often presupposes trust between actors. When lending a book to a colleague, we trust the colleague to return the book in good shape. A buyer of a second-hand car trusts the dealer to be honest about hidden defects of the car. We may be more inclined to trust a colleague who has often returned our books in good shape in the past. The more information you have from your friends on their good experiences with a second-hand car dealer, the more you may be inclined to buy a car yourself from the dealer unless, maybe, you happen to know that the dealer is about to retire and close down his outlet. These examples illustrate the intuition that trustfulness may be fostered by positive information about trustworthiness of the trustee in the past. The last example illustrates that trustfulness and trustworthiness might become problematic when opportunities for future sanctioning of the trustee's present behavior become infeasible.

Our examples are related to the "embeddedness" of trust problems and exchange in the sense of [17]. Embeddedness refers to repeated transactions over time between the same partners and to transactions between partners who share a network with third parties. In [7], Buskens and Raub distinguish two mechanisms through which embeddedness affects trust[1]: learning and control. On the one hand, actors can learn that a trustee has been trustworthy in the past and may infer from this that the trustee is likely to be trustworthy now as well. On the other hand, actors can base trust on sanction opportunities in the future. The more extensive future sanctions can be, the more likely that the trustee realizes that his short-term incentives from abusing trust do not compensate for the long-term losses he will incur due to the sanctions of the trustor. Consequently, the more extensive the sanction opportunities of the trustor, the more likely it is that the trustor can trust the trustee because it is more likely that the trustee will be trustworthy. Buskens and Raub also distinguish between two levels of embeddedness: the level of the dyad and the network level. They argue that learning and control operate at both of these levels (see also [27, pp 138-139] for a similar discussion of learning and control through network embeddedness). Trustors can learn through own experiences and through experiences of others. Sanctions can be executed by the trustor herself or by third parties such as other trustors of the trustee.

Learning and control effects on trust through dyadic and network embeddedness are intimately connected to reputation effects on trust. Roughly (see, e.g., [22, pp. 629-633] for an extensive discussion), the reputation of an actor is a characteristic or an attribute that partners ascribe to the actor. The empirical basis of an actor's reputation is his observed past behavior. Thus, the trustee's present reputation for trustworthiness ascribed to him by a given trustor depends on the trustor's own prior experiences with the trustee as well as on third-party information on the trustee that the trustor receives from other trustors. The trustee's present reputation for trustworthiness thus depends on dyadic learning as well as on network learning of the trustor and will affect the trustor's trustfulness. In addition, the trustee's present trustworthiness will affect his future reputation for trustworthiness vis-à-vis the trustor with whom the trustee interacts today as well as vis-à-vis other trustors who receive information on the trustee's present behavior. Reputation effects on trust can thus be conceived as learning and control effects on trust through dyadic and network embeddedness.

Experimental as well as survey research provides evidence for effects of embeddedness on trust (see [8] for an overview). The problem with most of the evidence is that effects of learning and control are hard, if at all, to disentangle. Therefore, *how* embeddedness affects trust is a largely unresolved question. This paper provides new evidence on learning and control effects on trust through dyadic embeddedness and network embeddedness from a laboratory experiment in which subjects have to make incentive-guided choices. The experiment complements earlier research in four ways. First, learning and control mechanisms can be clearly disentangled. Second, the design of the experiment ensures that embeddedness characteristics are exogenously given rather than being themselves results of individual choices. This facilitates the interpretation of empirical findings on embeddedness effects. Third, subjects are pre-

[1] The noun "trust" is used as shorthand for "trustfulness *and* trustworthiness." Only when used as a verb or in conjugations such as "abuse trust" and "honor trust," trust refers exclusively to "trustfulness."

cisely and truthfully informed on the incentive structure and their payments depend on their own and others' choices. While the external validity of experimental designs remains questionable in principle, the assumption of external validity becomes plausible to a considerable extent when results that have been found employing other research designs such as surveys are replicated in this experiment. Finally, we analyze effects of embeddedness through learning and control not only on trustfulness of the trustor but also on trustworthiness of the trustee.

2 Embedded Trust: Hypotheses

We define a trust situation as an interaction with strategic interdependence between two actors, the trustor and the trustee. If the trustor trusts the trustee, the trustee has the possibility and an incentive to act opportunistically, i.e., to abuse trust. Compared to the situation when she does not trust the trustee, the trustor regrets being trustful if trust is abused but she is better off after trusting the trustee if the trustee does not behave opportunistically. A trust situation can be represented as the well-known Trust Game shown in Figure 1. The Trust Game is a game-theoretic representation of a trust situation [11, 12, 13, 20]. The Trust Game starts with a move by the trustor, who trust (i.e., she is "trustful") or does not trust. If the trustor does not trust, the game is over, with trustor and trustee each obtaining a payoff P. If the trustor trusts, the trustee chooses between honoring trust (i.e., he is "trustworthy") and abusing trust. If the trustee honors trust, trustor and trustee each receive $R > P$. If the trustee abuses trust, the trustor receives $S < P$, while the trustee receives $T > R$.

In our experiment, Trust Games are played in triads comprising two trustors and a trustee. Clearly, a triad represents a small network between the actors. First, one of the trustors, say, trustor 1, plays a Trust Game with the trustee. After this Trust Game has been finished, the other trustor, trustor 2, plays a Trust Game with the same trustee. This pair of two games is played 15 times. All actors, trustors and trustee, have complete information about the whole structure of the game such as the number of

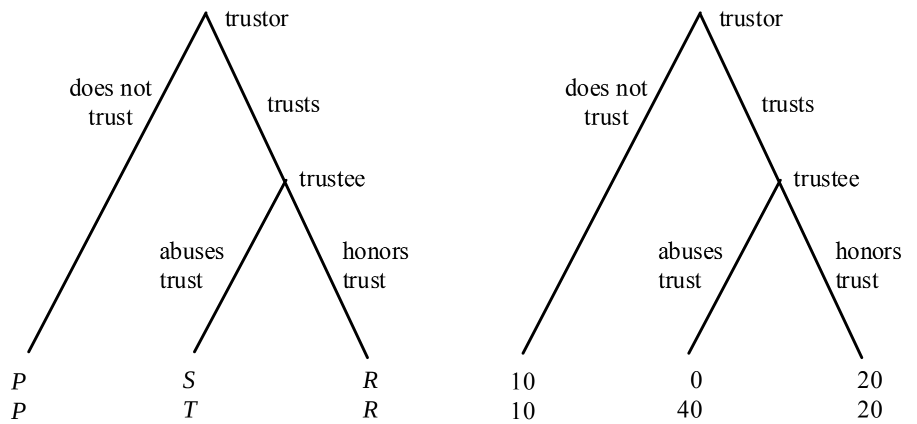

Fig. 1. Extensive form of a Trust Game. $T > R > P > S$. The right-hand Trust Game is the numerical example used in the experiment

rounds to be played, each actor's payoff function, etc. The experiment employs two information conditions and actors know in which information condition they are:

1. *No information exchange between trustors*: each trustor only knows what happens in her own Trust Games with the trustee but is not informed about what happens in the games of the other trustor playing with the same trustee.
2. *Full information exchange between trustors*: after each Trust Game, also the trustor not involved in that game receives information on the choices made in that game.

Assume now that subjects differ in the way they value outcomes because of their social orientations [24, 26] or preferences for fairness or reciprocity [3, 14, 21]. This means that actors' utilities may differ from their own material payoffs. Also, while knowing their own utility function, actors may be incompletely informed on the utility functions of other actors. Thus, our basis for learning is the trustors' uncertainty about trustees' utility from the payoffs in the games and the possibility that these utilities might be such that some trustees do not have an incentive to abuse trust. A detailed discussion of theoretical models that include such assumptions is beyond the scope of this paper (see, e.g., [6, 11, 13]). However, it is intuitively clear that trustors might now believe that some trustees will not abuse trust. If trustors have doubts about the behavior of at least some trustees, this can have consequences even for those trustees who do have an incentive to abuse trust. Namely, such trustees can profit from appearing trustworthy in early rounds of a finitely repeated Trust Game and can thus have an incentive for reputation building, while they will abuse trust towards the end of the game.

We can now derive hypotheses on learning effects through embeddedness on trustfulness of trustors from various backward looking learning models (see [10, 16] for overviews of such models). They typically imply (see [9] for details) that trustfulness is more likely if trust has been honored more frequently and also, accounting for discounting of past experiences, more recently. On the other hand, trustfulness will become less likely after trust has been abused. The behavior of the trustee is expected to be largely determined by his concern to build and keep up a good reputation and, therefore, is expected to be mainly driven by control effects. We thus test the following two hypotheses on learning effects on trustor behavior:

Hypothesis 1 (dyadic learning): The more a trustor's trustfulness has been honored in the past, the more likely it is that this trustor is trustful; the more a trustor's trustfulness has been abused in the past, the less likely it is that this trustor is trustful.

Hypothesis 2 (network learning): The more information a trustor has that trustfulness of another trustor has been honored in the past, the more likely it is that she will be trustful herself; the more information a trustor has that trustfulness of another trustor has been abused in the past, the less likely it is that she will be trustful herself.

In addition to learning effects and in line with arguments on incentives for reputation building for the trustee, we can derive hypotheses on control effects. The theoretical basis for these hypotheses are models for games with incomplete information [19] that assume rational forward looking behavior with learning in the sense of Bayesian updating of beliefs (see [4, 6, 11, 13] for applications of such models to finitely repeated Trust Games). The basic intuition is that a trustee will be more likely to be trustworthy and, therefore, the trustor more likely to be trustful, the more the trustee has to lose in future games after he would abuse trust. The losses come from trustors not being trustful anymore because they experienced abused trust themselves or hear about it from another trustor. Trustor 2 can profit less from this network information at the end of the game because there is one game less to be played after her game compared to the trustor 1's game in the same round. This leads to the following hypotheses on control effects on trust and trustworthiness (see [9] for details):

Hypothesis 3 (dyadic control – trustor): The more rounds left in the game, the higher the likelihood that a trustor is trustful; the likelihood of trustfulness decreases faster in the last few rounds of the game than in earlier rounds (end-game effect).

Hypothesis 4 (network control – trustor): In the condition with full information exchange between trustors, compared to the condition with no information exchange, the likelihood of trustfulness is higher and will decrease less in early rounds. The end-game effects will be stronger for trustor 2 than for trustor 1.

Hypothesis 5 (dyadic control – trustee): The more rounds left in the game, the higher the likelihood that trust will be honored; the likelihood of trustworthiness decreases faster in the last few rounds of the game than in earlier rounds (end-game effect).

Hypothesis 6 (network control – trustee): In the condition with full information exchange between trustors, compared to the condition with no information exchange, the likelihood of trustworthiness is higher and will decrease less in early rounds. The end-game effect will be stronger in games with trustor 2 than in games with trustor 1.

3 The Experiment

In the experiment, the outcomes of the Trust Games are points that subjects earn. If the trustor is not trustful, this yields 10 points for both trustor and trustee; when trust is honored, each actor receives 20 points; when trust is abused, the trustee receives 40 points, leaving the trustor with no points (see the right-hand Trust Game in Figure 1). Subjects are paid 1 eurocent for each point they earn at the end of the experiment.

The experiment was programmed using z-Tree software [15]. Subjects play the Trust Game in supergames of 15 rounds. Subjects are matched in groups of three, one trustee and two trustors, which we call triads. In each of the 15 rounds, the trustee plays one Trust Game with each of the two trustors. During the 15 rounds, the trustee plays with the same two trustors in each round. Therefore, in every round, while trustors play one Trust Game, the trustee plays two Trust Games, adding to 30 Trust Games played per supergame by one trustee. The trustee not necessarily needs to make a choice in all 30 games: when the trustor does not trust, the trustee has no choice to make.

In every round, the trustee always plays with the same trustor first, while the other trustor has to wait, and always plays second with this trustee. Thus, within a supergame, the trustors always move in the same order. The trustors are referred to as trustor 1 and trustor 2, respectively.

As already mentioned, there are two conditions in the experiment. In both conditions, the trustee is immediately informed on the trustor's move in the current Trust Game. Between conditions the amount of information is varied that is shared among the two trustors playing with the same trustee. In the "no information exchange between trustors" condition, trustors do not share any information. In the "full information exchange between trustors" condition, trustors playing with the same trustee do share all information about each other's games. In this condition, as soon as a game has been played, either the first or the second game in the round, also the other trustor receives information on the choices made in this game. Information is provided automatically by the computer and is always truthful. All subjects know in what information condition they are and thus also know what information is available to the other two actors in their triad. All subjects see the outcomes of the games they played themselves in previous rounds on their screens. In the condition with full information exchange, each trustor also sees the outcomes of the previous Trust Games of the other trustor on the screen. Note that the experimental design ensures that embeddedness is exogenous and is not itself a result of subjects' choices.

Every subject played three times a supergame as described above, once as a trustee, once as trustor 1, and once as trustor 2. Each subject played all three supergames in the same information condition. In between the three supergames, the subjects were rematched to other subjects. Subjects were never rematched to other subjects they already played with in a previous supergame. This was made common knowledge to all subjects.

The experiment was conducted in the ELSE laboratory of Utrecht University, in a computer room specially designed for experiments: every subject was seated behind a PC in his or her own cubicle, with a separate cubicle for the experimenters. Each session comprised 18 subjects. When all 18 subjects were present, instructions on paper were provided and the treatment was started. Within a session, the instructions were the same for everyone and this was also made common knowledge to the subjects. Subjects were explained how the game worked they were about to play, and that they would receive 1 eurocent for every point they earned.

After reading the instructions, a few questions were asked on the computer screen so that subjects could check whether they understood the instructions. In case of incorrect answers, subjects were provided the correct answers and a brief explanation. Subjects also played two practice rounds in which they could not earn any points yet. These rounds were not played with other subjects, but with the computer to guarantee standardized moves of the "partners" in these rounds.

Then the three supergames were played. At the end of the experiment, subjects had to fill in a short questionnaire, including items concerning their general trustfulness and trustworthiness. Meanwhile, the experimenters prepared closed envelopes with the earnings for each subject. The sessions took between 55 and 70 minutes. Subjects earned on average €10.67, with an average of €11.10 for subjects in the condition with full information exchange and €10.25 for those in the no information exchange condition. The minimum and maximum earnings were €7 and €12.40.

The information about the structure of the experiment such as the number of rounds, roles (i.e., being trustor or trustee), and what subjects would get to know was honestly provided and subjects were never deceived or in another situation than told. In order to prevent inducing normative associations, the names of the different roles and their possible moves were rendered neutrally. For instance, the moves of the trustee were labeled “down” and “right” rather than “honor trust” and “abuse trust.”

In total, 72 subjects participated in the experiment, 28 male and 44 female, mostly undergraduate students from different fields, most of them students of social sciences. Subjects were recruited using the online recruitment system ORSEE [18]. Four sessions were scheduled and 18 subjects participated in each session. Two sessions were played in the condition with no information exchange between trustors and two sessions in the condition with full information exchange.

4 Data and Statistical Model

The experiment comprised four sessions, with six triads per session and three supergames of fifteen rounds per subject, each round comprising two Trust Games. Thus, $4\times6\times3\times15\times2 = 2160$ Trust Games were played in total. Note that trustee behavior is observed only in those games in which the trustor is not trustful. There are 485 games in which there was no trust, leaving 1675 games (78% of the total number of games played) in which the trustee’s behavior is observed. Trustors are more trustful in the full information exchange condition (in 913 of the 1080 games) than in the no information exchange condition (in 762 of the 1080 games) and trustfulness decreases over rounds. Also, trustworthiness decreases over the rounds. These descriptive findings are in line with our hypotheses. Figure 2 displays the descriptives graphically.

The descriptives are in line with earlier experiments (see [8, 10, pp. 446-453] for overviews). Trustfulness and trustworthiness are high for most of the rounds, with strong end-game effects in the last couple of rounds. We observe that repeating the Trust Game with the same partner, i.e., dyadic embeddedness (also known as “partner matching” in the experimental literature), and the availability of third-party information, i.e., network embeddedness, have complementary effects. This could not be concluded from otherwise closely related earlier experiments [2]. Summarizing, the descriptive analyses show that dyadic embeddedness leads to rather high levels of trustfulness and trustworthiness, higher than is normally found in one-shot Trust Games, including series of one-shot Trust Games, each played with a different partner (also known as “stranger matching” in the experimental literature). Still, additionally providing information about Trust Games of the trustee with another trustor induces even more trustfulness and trustworthiness.

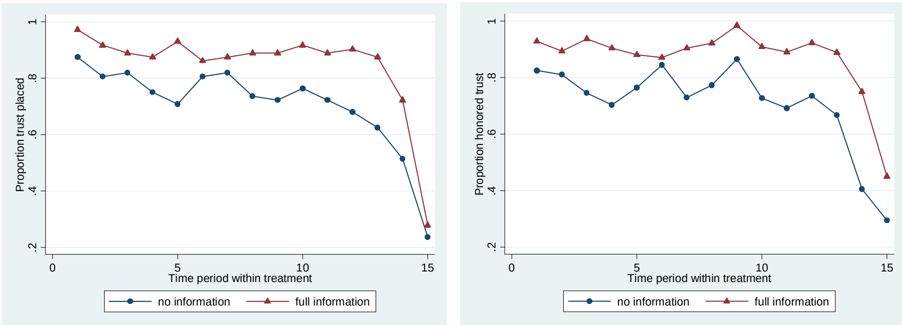

Fig. 2. Proportion of games in which trust was trustful (left) and trust was honored (right), per round, and per experimental condition.

Our dependent variables identify the behavior of the trustor and the trustee. Various independent variables represent past experiences. First, for each round *t*, we construct the weighted number of times a trustee honored trust in the past as

$$\text{PASTHONOR\_OWN} = \sum_{\tau=1}^{t-1} w_1^{\tau}\,\text{HONOR\_OWN}_{\tau}. \tag{1}$$

We define PASTHONOR_OWN = 0 for the first round of a supergame. Similarly, we define a variable for the number of times trust was abused in the past:

$$\text{PASTABUSE\_OWN} = \sum_{\tau=1}^{t-1} w_1^{\tau}\,\text{ABUSE\_OWN}_{\tau}. \tag{2}$$

Note that ABUSE_OWN and HONOR_OWN can be equal to 0 simultaneously, namely, when the trustor is not trustful. Therefore, the effects of the two variables just defined should be interpreted relative to the number of times the trustor was not trustful. The parameter w_1 is estimated in the statistical model. We assume that w_1 is the same for honored trust and for abused trust in the past.

In the condition with full information exchange, each trustor also receives information about the games of the other trustor. To complete the set of independent variables needed for testing hypotheses on learning effects for the trustor, we thus define variables for such third-party information:

$$\text{PASTHONOR\_OTHER} = \sum_{\tau=1}^{t-1} w_2^{\tau}\,\text{HONOR\_OTHER}_{\tau};\ \text{PASTABUSE\_OTHER} = \sum_{\tau=1}^{t-1} w_2^{\tau}\,\text{ABUSE\_OTHER}_{\tau}. \tag{3}$$

Information from the other trustor might be forgotten or discarded faster than own experiences. Therefore, we introduce the parameter w_2. The variables PASTHONOR_OTHER and PASTABUSE_OTHER are always set to 0 in the condition without information exchange between trustors.

The variables representing control effects are straightforward. FUTURE is the number of rounds left. FUTUREFULL represents network control. This variable is the interaction of FUTURE with a dummy for whether subjects are in the condition with full information exchange between trustors. In addition, we use dummies that indicate the last but one and the last round of the repeated game: ROUND14, ROUND15. These variables are again interacted with dummies for the information condition: ROUND14FULL, ROUND15FULL. We also distinguish between the games with trustor 1 and with trustor 2 in the last two rounds for the information condition. Therefore, two dummies are used for the games with trustor 2 in the full information condition in these two rounds: ROUND14TR2FULL, ROUND15TR2FULL.

The statistical model used to analyze the data is a three-level logistic regression model. Based on the difference in attractiveness between the two possible moves of the trustor and assuming that there is some randomness in the extent that we know the attractiveness, we can estimate a logistic regression model for the probability that trustor *j* in triad *i* is trustful at time *t*:

$$P_{ijt}^{Trustful} = \frac{e^{\beta_1 \cdot (\text{own learning}) + \beta_2 \cdot (\text{TP-learning}) + \beta_3 (\text{own control}) + \beta_4 (\text{TP-control}) + u_i + v_{ij} + \varepsilon_{ijt}}}{1 + e^{\beta_1 \cdot (\text{own learning}) + \beta_2 \cdot (\text{TP-learning}) + \beta_3 (\text{own control}) + \beta_4 (\text{TP-control}) + u_i + v_{ij} + \varepsilon_{ijt}}}, \quad (4)$$

where the β's indicate the vectors of regression coefficients for the respective groups of independent variables, namely, variables representing own learning, learning through third-party information, own control opportunities, and control opportunities involving third parties. Furthermore, u_i is a random component for the triad in which the decision is made, v_{ij} is a random component for the trustor within the triad who makes the decision, and ε_{ijt} is the random component for each individual decision. This is a hierarchical three-level model (see, e.g., [25]). Strictly speaking, we have a cross-classified nesting because trustors are involved twice in a series of 15 Trust Games with different partners. However, estimating this more complex structure affects the outcomes of the analyses only marginally. Also, the random component related to trustors has a similar size in this more complex estimation.

The statistical model for the probability that trustee *i* in his triad honors trust with trustor *j* in this triad at time *t* looks rather similar:

$$P_{ijt}^{Honor} = \frac{e^{\beta_1 (\text{control}) + \beta_2 (\text{TP-control}) + u_i + v_{ij} + \varepsilon_{ijt}}}{1 + e^{\beta_1 (\text{control}) + \beta_2 (\text{TP-control}) + u_i + v_{ij} + \varepsilon_{ijt}}}, \quad (5)$$

where the β's again represent the regression coefficients; u_i is a random component for the trustee making the decision. In this case, this is equivalent to the triad in which the decision is made; v_{ij} is a random component for the trustor in the triad with whom the trustee is playing a specific Trust Game; and ε_{ijt} is the random component for each individual decision. Again, the specification of the random components could have been more complex, because each trustor is involved in two triads and, therefore, the random component for trustors could have been specified as a cross-classified model in which the random component represents randomness related to a specific subject playing as a trustor. Because random components related to the trustors are consistently estimated to be 0 in the models for explaining trustees' behavior, we stick to the simpler hierarchical model in which we control for nesting of trustees' decisions within trustors.

5 Results

We first analyze trustfulness of trustors. As a baseline model, we report a logistic regression of the likelihood that a trustor is trustful with a dummy (FULL INFORMATION) for the experimental condition, a dummy for whether trustor 2 is involved rather than trustor 1 (TRUSTOR2), and two dummies for the second and the third supergame (TREATMENT2, TREATMENT3) in Table 1. This model shows that there is more trustfulness in the condition with full information exchange between trustors than in the condition with no information exchange. Trustfulness also increases over the supergames, as indicated by the significant difference between the first and the third supergame, while the second supergame is in between. The random parts at the triad and trustor level show that about 28% of the variance can be attributed to the triad, while

Table 1. Three-level logistic regression of the likelihood for a trustor to be trustful (2160 decisions by 144 trustors in 72 triads).

		Baseline model		Full model	
	Hyp.	Coeff.	Std. err.	Coeff.	Std. err.
FULL INFORMATION	+	0.983**	0.332	-0.691	0.625
TREATMENT2		0.381	0.379	-0.031	0.251
TREATMENT3		0.911*	0.385	0.448	0.282
TRUSTOR2		-0.059	0.124	-0.031	0.192
PASTHONOR_OWN	+			1.788**	0.176
PASTABUSE_OWN	−			-1.539**	0.238
PASTHONOR_OTHER	+			0.746**	0.250
PASTABUSE_OTHER	−			-1.142**	0.396
FUTURE	+			0.076**	0.029
FUTUREFULL	−			0.059	0.050
ROUND14	−			-0.791*	0.385
ROUND15	−			-1.943**	0.439
ROUND14FULL				-0.424	0.778
ROUND15FULL				-1.742*	0.738
ROUND14TR2FULL	−			-0.284	0.825
ROUND15TR2FULL	−			0.274	0.728
ROUND1TREATMENT1				1.369*	0.559
ROUND1TREATMENT2				1.621**	0.615
ROUND1TREATMENT3				1.838*	0.810
CONSTANT		0.784*	0.321	-0.207	0.386
Variance triad level		1.364	0.332	0.150	0.154
Variance trustor level		0.251	0.114	0.304	0.194
Variance decision level		3.290		3.290	
Loglikelihood		-972.51		-616.38	

*, ** indicate significance at $p < 0.05$ and $p < 0.01$, respectively (two-sided tests).

only 5% can be attributed to a specific trustor within a triad. Through separate analyses we found that almost all the variance at the trustor level is due to the no information exchange condition, while there is hardly any variance that can be attributed to the individual trustors in the full information exchange condition.

In the full model, the main effect of the full information condition vanishes, indicating that the difference between the experimental conditions is mainly due to the learning and/or control variables in the full model. The full model provides clear evidence for Hypothesis 1 on effects of dyadic learning as well as for Hypothesis 2 on network learning. Trustors are more trustful after experiencing themselves more honored trust and they are less trustful after experiencing themselves more abused trust. In addition, when they observe that the other trustor's trustfulness is honored more often, this also increases their likelihood to be trustful themselves, while their own trustfulness decreases if they observe more abused trust of the other trustor in the same triad. In addition, it can be seen that the effect of experiencing honored trust in the trustor's own games is larger than the effect of information about honored trust in games of the trustee with the other trustor. It is striking that the effect of information about abused trust in games of the trustee with the other trustor is almost as large as the effect of experiencing abused trust in the trustor's own games with the trustee. The significance of the effect of information about abused trust in games with the other trustor is smaller as can be inferred from the larger standard error, but that could be due to the fact that there are less data on these experiences because they only occur in the condition with full information exchange.

Considering control effects on trustfulness, we see a clear dyadic control effect of the rounds still to be played. Also, the end-game effects are strong, starting in round 14, while dummies for earlier rounds did not add to the explained variance. These results provide support for Hypothesis 3. However, there is not much evidence for Hypothesis 4 about of network control effects on trustfulness. The interaction of the number of rounds left with the full information exchange condition is not significant, indicating that the general decrease of trust is not less strong in the condition with full information exchange between trustors. In addition, there is no main effect left of the full information condition after controlling for learning, which would indicate a network control effect. The end-game effects are about twice as strong in the full information condition as in the condition with no information condition and this difference is significant for round 15. These steeper network effects are mainly due to earlier experiences of honored trust in the condition with full information exchange through which the level of trustfulness is higher before it starts to decrease. The two additional dummies that interact the variables indicating the two final rounds in the full information condition with a variable indicating the trustor who is playing are not significant. This implies that we also do not find evidence for the second part of Hypothesis 4. As we will see below, the trustee does anticipate on the network control opportunities of the trustors, which is also the main explanation why trust remains higher in the full information condition, but the trustors do not seem to anticipate themselves on this anticipation of the trustee. Finally, the controls for the first rounds show that the starting level of trust slowly increases over the treatments, indicating that trustors realize more and more that trustfulness can be beneficial in the beginning of a supergame.

We now turn to the analysis of the trustworthiness of trustees. The baseline model in Table 2 shows that there is more trustworthiness in the condition with full information exchange between trustors than in the condition without information exchange. While trustors develop some more trustfulness over the treatments, it is not the case that the trustees' behavior changes significantly over the treatments. Controlling for these treatment variations, we see that no unexplained variance is attributed to the trustor level and that 28% of the unexplained variance is attributed to the trustee level. The remaining 72% of the unexplained variance is at the decision level.

The full model provides the results of the tests of the hypotheses on trustworthiness. Notice that the difference between the two experimental conditions is not explained away by the hypothesized effects for the trustee. With respect to control effects on the likelihood of trustworthiness, the effect of dyadic embeddedness (FUTURE) is strongly significant. However, the interaction term with the full information condition (though non-significant) shows that dyadic control is only present in the condition without information exchange between trustors. Apparently, control is so strong in the condition with information exchange (which is also indicated by the remaining main effect of full information) that the likelihood of trustworthiness remains at or even above the 90%-level throughout the first thirteen rounds of a supergame. The fact that the main effect of full information is positive and that trustworthiness does not decrease in the first 13 rounds in the full information condition thus indicates that there is an additional control effect of network embeddedness over and above dyadic control. After round 13, there is a clear drop in the likelihood of trustworthiness in both information conditions. When we study these end-game effects in

Table 2. Three-level logistic regression of the likelihood to honor trust (1542 decisions with 144 trustors by 72 trustees in 72 triads).

		Baseline model		Full model	
	Hyp.	Coeff.	Std. err.	Coeff.	Std. err.
FULL INFORMATION	+	1.405**	0.317	2.263**	0.576
TREATMENT2		0.295	0.385	0.314	0.510
TREATMENT3		0.439	0.383	0.378	0.507
TRUSTOR2		-0.051	0.147	0.004	0.164
FUTURE	+			0.080*	0.031
FUTUREFULL	−			-0.072	0.050
ROUND14	−			-1.914**	0.463
ROUND15	−			-2.588**	0.704
ROUND14FULL				1.292	0.823
ROUND15FULL				-0.371	1.095
ROUND14TR2FULL	−			-1.798*	0.810
ROUND15TR2FULL	−			-2.764*	1.217
CONSTANT		0.681*	0.318	0.305	0.480
Variance triad level		1.289	0.352	2.474	0.658
Variance trustor level		0	0	0	0
Variance decision level		3.290		3.290	
Loglikelihood		-657.32		-593.65	

*, ** indicate significance at $p < 0.05$ and $p < 0.01$, respectively (two-sided tests).

more detail, we see that the trustee is much less trustworthy with trustor 2 in the full information condition than with trustor 1. This indicates an additional network control effect, because trustor 2, compared to trustor 1, has less (or no) control opportunities especially in these last two rounds. Summarizing, these results provide quite some support for Hypothesis 5 as well as for Hypothesis 6.

6 Conclusion and Discussion

In this paper, we have discussed an experiment in which pairs of trustors play Trust Games with the same trustee. This is the simplest set-up for simultaneously studying effects of dyadic embeddedness and network embeddedness on trust. We distinguished between learning and control effects of embeddedness. We have analyzed how both trustfulness and trustworthiness are affected by embeddedness.

Learning effects at the dyadic and the network level are both strong determinants of trustfulness of trustors. We also find dyadic control effects on trustfulness, but we do not find evidence for network control effects on trustfulness. The higher levels of trustfulness under network embeddedness are actually caused by the trustees anticipating on the stronger sanction opportunities of the trustors. The trustees are more trustworthy under network embeddedness, which has the consequence that the trustors have more positive learning experiences leading to more trustfulness. The effects on trustfulness are very consistent with earlier findings [7, 8]. For trustees, we find dyadic control effects as well as network control effects on trustworthiness.

We conclude by briefly returning to our findings that network control opportunities affect trustee behavior while there is evidence for dyadic control effects on trustor behavior but no evidence for network control effects on trustor behavior. These findings nicely correspond to results from survey research on trust problems in buyer-supplier relations [1, 5, 23]. This survey research focuses on how embeddedness affects trustfulness of buyers in the sense of investing less in costly contractual safeguards that mitigate bad performance, including opportunistic behavior, of suppliers such as delivery of inferior quality, delivery delays, or bad service. Also, this survey research focuses on how embeddedness affects supplier performance itself and thus also supplier trustworthiness. Results indicate that suppliers react to network control opportunities of buyers in the sense that more such control opportunities for buyers are associated with better supplier performance [23]. This finding is nicely in line with our experimental result that trustworthiness increases with network control opportunities of trustors. On the other hand, dyadic control opportunities of buyers do affect their investments in costly contractual safeguards [1], but there is hardly any empirical evidence for effects of network control opportunities on buyer behavior [5]. These findings are in line with our experimental results on effects of control opportunities on trustor behavior.

Buskens (see [5, pp. 152-161]) provides various arguments and also some empirical evidence that the lack of effects of network control opportunities on buyer behavior could be at least partly due to design, data, or measurement problems of the survey, including problems due to possible endogeneity of network embeddedness characteristics and sample selectivity. However, these are no plausible arguments for the lack of network control effects on trustor behavior in our experiment. Thus, one might wonder whether the findings for effects of control opportunities through embeddedness indicate limits of strategic rationality. First, consider the situation of the trustee (or, respectively, the supplier). He has a good reason to react to the trustor's dyadic control opportunities *as well as* her network control opportunities when he anticipates that his present trustworthiness might affect future trustfulness of the same or other trustors. Similarly, the trustor has a good reason to react to her dyadic control opportunities when she anticipates that the trustee anticipates on how his present trustworthiness will affect this trustor's *own* future trustfulness. However, the trustor needs to reason "more steps ahead" before having a good reason to react to her network control opportunities. Namely, she has to anticipate that the trustee anticipates on how his present trustworthiness will affect future trustfulness of *other* trustors and that *other* trustors will in fact condition their trustfulness on the trustee's present trustworthiness. It may be less likely that actors reason so many steps ahead, certainly in rather unfamiliar settings such as our experiment. Future research could further explore this conjecture in various ways. For example, if the conjecture is correct, we would expect that effects of network control opportunities on trustor behavior are more easily found when trustors play repeated Trust Games with information exchange between trustors many times and specifically when they are also in the role of the trustee in some of those repeated games.

Finally, note that network embeddedness can and, in our experiment, empirically does affect trustfulness of trustors even if the behavior of trustors themselves is not directly affected by their network control opportunities. Since trustees react to network control opportunities of trustors, network embeddedness increases trustworthiness. Through learning effects on trustor behavior, network embeddedness then also increases trustfulness.

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