

How to Overcome the Detrimental Effects of Noise in Social Interaction: The Benefits of Generosity

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Interpersonal misunderstanding is often rooted in noise, or discrepancies between intended and actual outcomes for an interaction partner due to unintended errors (e.g., not being able to respond to an E-mail because of a local network breakdown). How can one effectively cope with noise in social dilemmas, situations in which self-interest and collective interests are conflicting? Consistent with hypotheses, the present research revealed that incidents of noise exert a detrimental effect on level of cooperation when a partner follows strict reciprocity (i.e., tit for tat) but that this effect can be overcome if a partner behaves somewhat more cooperatively than the actor did in the previous interaction (i.e., tit for tat plus 1). Also, when noise was present, tit for tat plus 1 elicited greater levels of cooperation than did tit for tat, thereby underscoring the benefits of adding generosity to reciprocity in coping with noise in social dilemmas. The Discussion outlines implications of the present work for theories focusing on self-presentation and attribution, communication, and trust and preresolution behavior.

The study of cooperation continues to intrigue numerous researchers and theorists in the social, behavioral, and biological sciences who seek answers to fundamental questions regarding the virtues and vices of various interaction styles. For example, what are the strengths and limitations of matching a partner's behavior, behaving in an eye for an eye fashion? What are the strengths and limitations of behaving somewhat more cooperatively than one's partner? Is there some truth to the saying, "What goes around, comes around?" Although most people may have their own favorite answer to such basic questions, several theories and models in the social and behavioral sciences converge to the same piece of advice: Respond in kind. Concepts such as reciprocal altruism, exchange, and reciprocity, in particular, tend to underline the benefits of interacting with others on a quid pro quo basis.

The present research focuses on the benefits of reciprocity versus generosity in their ability to cope with noise in situations characterized by a conflict between self-interest and collective interest (i.e., social dilemmas). *Noise* is defined as discrepancies between intended and actual outcomes for an interaction partner due to unintended errors (e.g., not being able to respond to an E-mail because of a local network breakdown; Axelrod & Dion,

1988; Bendor, Kramer, & Stout, 1991; Kollock, 1993).¹ Incidents of noise are likely to give rise to misunderstanding (e.g., "He still has not responded to my E-mail!"), which, in the context of social dilemmas, may evoke noncooperative rather than cooperative patterns of interaction (e.g., "Next time, I will make him wait as well"). We suggest that noise is ubiquitous in everyday interactions, given that one's environment typically is not free of noise (e.g., a delayed train may cause a person to arrive too late for an appointment), and eventually everyone is doomed to make a mistake by, for example, accidentally doing the wrong thing (e.g., taking the wrong exit and therefore arriving too late for an appointment).

Inspired by recent work on computer simulation, we advance the central hypothesis that incidents of noise exert detrimental effects on cooperation and quality of outcomes when a person adopts a strictly reciprocal strategy and that one can largely overcome such detrimental effects by adding generosity to reciprocity; that is, by behaving a little more cooperatively than the other partner did in the previous interaction. Thus, the major purpose of the present research is to demonstrate that the detrimental effects of noise can

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¹ We should note that noise has been defined in terms of both (a) misimplementation of behavior, or errors on the part of the actor, and (b) misperception of behavior, or errors on the part of the observer. This distinction between misimplementation and misperception serves important theoretical purposes, and—we believe—could inspire fruitful avenues of research (for a discussion, see Axelrod & Dion, 1988; Kollock, 1993). Given the preliminary nature of empirical research on noise, we do not elaborate on this distinction and define and operationalize noise in terms of both misimplementation and misperception (i.e., a discrepancy between intended and actual outcomes that is known to the actor but unknown to the partner). Also, by defining noise in terms of discrepancies between intended and actual outcome, we do not wish to imply that these intended outcomes are necessarily a product of conscious or systematic thought. We assume that intended outcomes may also involve very little or even no conscious or systematic thought at all (see also Rusbuldt & Van Lange, 1996).

be overcome more effectively by behaving a little more cooperatively than the partner did rather than behaving in a strictly reciprocal manner.

Virtues and Vices of Strict Reciprocity

One of the most convincing cases supporting the benefits of reciprocity has been made in *The Evolution of Cooperation* (Axelrod, 1984), which provides compelling evidence in support of the effectiveness of the tit for tat (TFT) strategy in eliciting and maintaining patterns of cooperative interaction. TFT is a strictly reciprocal strategy that begins with a cooperative choice and subsequently imitates the other person's previous choice. Axelrod's (1984) well-known computer tournament studies revealed that, relative to alternative strategies that were submitted by several experts, TFT elicited greater levels of cooperation from the social environment and yielded greater outcomes than did any of the other strategies that were submitted. Both the methodology, which inspired several important computer simulation studies, and the general findings had a major impact on theory and research in several disciplines. TFT was the simplest strategy submitted to the tournament, and many scientists were quite surprised by its success.

Why was TFT, as the exemplar of strict reciprocity, the winner in this tournament? Axelrod (1984) argued that TFT effectively elicits patterns of mutual cooperation—thereby enhancing the long-term outcomes for both the actor (who follows TFT) and the dyad—because of four features. TFT is *nice* because it never initiates noncooperation, it is *forgiving* because it never responds to a noncooperative choice prior to the last behavior, it is *retaliatory* because it immediately matches the other person's noncooperative behavior, and it is *clear* because interdependent others soon learn the contingencies between their own actions and the subsequent matching by TFT. Empirical research using actual participants has revealed that TFT is among the strategies that are most effective in eliciting and maintaining cooperation between individuals (e.g., Komorita & Parks, 1995; Pruitt, 1998) and groups, despite the fact that interactions between groups tend to be substantially less cooperative and more competitive than are interactions between individuals (Insko et al., 1998). Moreover, TFT is especially effective in eliciting cooperation from individuals whose primary goal is to enhance outcomes for themselves (i.e., individualists; Kuhlman & Marshello, 1975), and it tends to drive away those who seek to beat a partner's outcomes (i.e., competitors; Van Lange & Visser, 1999). Also, compared with some less reciprocal strategies, TFT is generally judged as being both fair and intelligent (McClintock & Liebrand, 1988; Sattler & Kerr, 1991). Thus, there is good reason to believe that TFT provides an interaction style (or strategy) that individuals can use fruitfully in ongoing interactions to elicit and maintain mutual cooperation.

However, TFT is not without limitations. For example, it is not clear whether the effectiveness of TFT or variants thereof can be generalized to larger groups, to interdependence structures other than the prisoner's dilemma, or to settings in which the number of interactions is rather limited (Axelrod, 1984; Komorita & Parks, 1995). But, more important, in social environments in which TFT's cooperative behavior (e.g., the first choice) is not always reciprocated, TFT is almost bound to be trapped in a cycle of noncooperative interactions in which individuals continue to re-

spond noncooperatively to one another's noncooperative behavior (e.g., Tetlock, McGuire, & Mitchell, 1991). The only way out of this pattern of negative reciprocity, or *echo effect* (Axelrod, 1984), is that one or both persons initiates cooperation. Because TFT does not initiate cooperation, it does not actively contribute to breaking out of the pattern of negative reciprocity; if anything, TFT supports the echo effect.

Noise and Misunderstanding

What could be the sources of the echo effect? First, an individual may intentionally make a noncooperative choice. For example, one might want to get ahead or make absolutely sure that the partner is not getting ahead and, therefore, make a noncooperative choice. For example, unlike individuals pursuing joint outcomes or personal outcomes, individuals with a competitive orientation do not develop patterns of cooperation with TFT but usually end up in stable patterns of negative reciprocity (Kuhlman & Marshello, 1975; Van Lange & Visser, 1999). Second, an individual may unintentionally make a noncooperative choice. That is, there may be discrepancies between intended and actual outcomes for an interaction partner because of unintended errors, which we earlier referred to as noise (Axelrod & Dion, 1988; Bendor et al., 1991; Kollock, 1993; Nowak & Sigmund, 1993; cf. trembling hand; Selten, 1978). For example, a colleague may be ill prepared for a meeting not because of a lack of motivation but because some events prevented him or her from preparing well (e.g., the colleague's neighbors had a loud party that night).

Although several dimensions have been identified to classify different types of noise, the distinction between positive noise and negative noise is directly relevant to understanding the effects of noise in social dilemmas.² Positive noise exists when the actual outcome for the partner is more positive (or less negative) than intended by the actor. Suppose that after work, Peter goes to a nearby cafe, intending to drink with his friends and have a good time. After noticing that none of his friends is there, he goes home early, to the delight of his wife, who is very grateful. Negative noise exists when the intended outcome for the partner is less positive (or more negative) than intended by the actor. Examples of negative noise come easily to mind—in fact, nearly all of the examples we have discussed so far are examples of negative noise (e.g., not responding to an E-mail; not preparing well for a meeting).

Although both forms of noise can lead to misunderstanding, we suggest that negative noise rather than positive noise is particularly likely to give rise to misunderstanding along with reduced levels of cooperation. Often, the partner (unlike the actor) only has access to information about the actual outcomes and has no complete knowledge about the outcomes that the actor intended to bring about.

² As noted by Kollock (1993), one might advance a distinction between incidents of noise that are (a) internally caused, when an internal but uncontrollable event prevents an actor from attaining intended outcomes (e.g., he or she says the wrong thing), or (b) externally caused, when an external (and uncontrollable) event prevents an actor from making the intended choice (e.g., the phone line is busy). Such a conceptualization of noise is congruent with the distinction between the attribution dimensions of internality (internal vs. external) and controllability (controllable vs. uncontrollable; Weiner, 1979).

Given that negative noise implies not so good outcomes for the partner (at least, worse than intended by the actor), whereas positive noise implies good outcomes for the partner (at least, better than intended by the actor), negative noise is likely to have more impact on perceptions and judgments of the actor's intentions than positive noise. One reason is that individuals are especially motivated to form personality impressions and make attributions when their own outcomes are affected in a negative manner rather than a positive manner (e.g., Kanouse & Hanson, 1971; Weiner, 1985). A complementary reason is that because individuals tend to depart from globally positive beliefs when forming impressions and tend to hold positive expectations regarding their own outcomes, another person's behavior that produces negative outcomes stands out more and is therefore more salient than another person's behavior that produces positive outcomes (Peeters & Czapinski, 1990; Reeder & Brewer, 1979; for an empirical illustration of this negativity effect in social dilemmas, see De Bruin & Van Lange, 1999). A further reason is that individuals exhibit a very strong tendency to explain behaviors and their effects in terms of the actor's underlying traits and intentions rather than in terms of the situational variables that may in fact have produced the behaviors and their effects (cf. fundamental attribution error; Ross, 1977; correspondence bias; Jones, 1990; see also Allison & Kerr, 1994). Thus, differing lines of reasoning indicate that partners are likely to form not so benign impressions of actors when actors' choices are affected by negative noise, whereas impressions should remain benign—or become even more benign—when actors' choices are affected by positive noise.

Presumably, the formation of personality impressions serves to summarize evaluations regarding a partner's behavior and responses in past interactions as well as to guide one's own behavior and responses in future interactions with this partner (cf. Fiske, 1992; Rusbult & Van Lange, 1996). Consistent with previous evidence, we suggest that cooperative behavior is somewhat probable when a partner forms benign impressions of the actor, whereas noncooperative behavior is very probable when a partner forms not so benign impressions of the actor (e.g., De Bruin & Van Lange, 1999; Van Lange & Kuhlman, 1994). The formation of not so benign impressions should especially be associated with lower levels of cooperation, thus yielding a pattern of interaction very similar to the echo effect that we described earlier. As a case in point, Wu and Axelrod (1995) describe the case of a South Korean airliner that mistakenly flew over the Soviet Union and subsequently was shot down by the Soviets, killing all 269 people aboard. Thereafter, echo effects were observed in a short but sharp escalation of the Cold War tensions (Goldstein, 1991, p. 202). Thus, noise—especially negative noise—may often have detrimental effects such that an actor's behavior that produces negative outcomes undermines the partner's benign impressions of the actor as well as the partner's willingness to behave cooperatively, which eventually may result in continuing cycles of noncooperative interaction (i.e., the echo effect).

How to Overcome the Detrimental Effects of Noise

Previous work that supports the success of TFT is based on environments in which there is no discrepancy between intended and actual outcomes. But what if such environments are affected by noise? What if intended and actual outcomes are not always the

same, as is usually true in real-life interactions? Because TFT reciprocates an actor's actual behavior (not an actor's intended behavior), the echo effect may fairly rapidly be instigated by incidents of negative noise. In fact, for two persons following TFT, even a single incident of negative noise affecting one of the partners' behavior may yield an echo effect. Axelrod (1984) acknowledged that it might well be that TFT would fare less well when one or both persons may have problems implementing their behavior and when there is uncertainty regarding the other's intended behavior.

One way of dealing with the echo effect, suggested by Axelrod (1984, pp. 186–187), is to add *generosity* to reciprocity by behaving somewhat more cooperatively than the partner. An example of adding generosity is a modified TFT strategy that cooperates 10% of the time that it would otherwise not cooperate. Generosity may not help reduce echo effects when the source of these effects is intentional, such as in noise-free environments simulated by Axelrod (1984) and used in many empirical studies that support the effectiveness of TFT (e.g., when the partner is competitive; Kuhlman & Marshello, 1975; McClintock & Liebrand, 1988; Van Lange & Visser, 1999). Yet when the source of the echo effect is unintentional (i.e., due to noise), generosity may in fact be quite effective in reducing the detrimental consequences of noise. Recently, computer simulations have been conducted to examine the effects of generosity in coping with noise. These studies reveal that noise exerts detrimental effects that could be overcome more effectively by generous versions of TFT than by either strict TFT (Axelrod & Dion, 1988; Bendor et al., 1991; Kollock, 1993) or a win–stay, lose–shift strategy that behaves cooperatively unless in the previous trial either the self or the other was exploited (Wu & Axelrod, 1995; this is important because the latter strategy, called Pavlov, has been argued to be superior to TFT; e.g., Nowak & Sigmund, 1993).

Although the evidence regarding the benefits of generosity and why generosity may help overcome the detrimental effects of noise may be compelling, we know of virtually no efforts toward examining these issues in empirical research using actual participants. Such efforts complement and extend computer simulations in at least two major ways. First, the results of computer simulations are obviously dependent on the strategies that are included in the simulation, which tend to be variants of reciprocal strategies. Given that it is not known, at least not with sufficient confidence, what strategies individuals use in real-world interactions and how they are shaped by the presence of other strategies, the results of computer simulations may not be directly relevant to understanding functional strategies in real-world interactions. Indeed, one cannot rule out the possibility that people adopt strategies that are somewhat less reciprocal, more generous, or more exploitative than those included in computer simulations. If, for example, people tend to adopt exploitative or competitive strategies, generous versions of TFT may actually elicit lower levels of cooperation than does strict TFT, perhaps even more so when there is noise. After all, generosity may invite exploitation, especially if exploitative attempts cannot be perceived as resulting from noise.

Second, although computer simulations are very useful tools for understanding the logic underlying very complex interaction phenomena, they cannot provide insight into the “psychologic” underlying interaction phenomena. For example, the formation of benign or not so benign impressions may be affected by the

presence of noise, which may then help us understand the psychological mechanisms that support the functionality of generosity versus reciprocity in noisy situations. Thus, as noted by several computer simulation researchers, it is essential that simulation research is complemented and extended by empirical research (e.g., Bendor et al., 1991; Signorino, 1996).

Research Design and Hypotheses

The present research uses a social dilemma task in which we focus on the degree of cooperation (rather than the dichotomous choice involving cooperation or noncooperation) and examine the effects of negative noise (rather than positive noise) that affected either both persons' behavior, only the participant's choices, or only the partner's choices. We discuss each of these features in turn. To begin with, the present research uses a specific social dilemma task in which participants had to decide how many coins to give away to the partner, allowing us to examine the *degree of cooperation*. As noted by Kollock (1993), this dilemma addresses limitations of the classic 2×2 prisoner's dilemma, which only allows a dichotomous choice: to cooperate or not cooperate. Examining a social dilemma that includes different degrees of cooperation may serve at least two complementary purposes. First, it is consistent with several social dilemmas outside of the laboratory that involve degrees of cooperation (e.g., how well one prepares for a joint meeting); similarly, noise may also often take a gradual form rather than an all-or-nothing form (e.g., being less than well prepared because of external constraints). Second, by examining degrees of cooperation, actors and partners are able to use strategies by which they can (behaviorally) communicate much more profoundly (and perhaps more effectively) than in a prisoner's dilemma, which involves only a dichotomous choice. Indeed, by programming the strategy followed by the partner, we compared a TFT partner, who reciprocated exactly the number of coins that he or she was given in the previous trial, with a TFT + 1 partner, who gave the participant one more coin than he or she received in the previous trial (see also Kollock, 1993). The TFT + 1 strategy represents a reciprocal interaction style, complemented by a little generosity that is communicated at each interaction trial. Adding a relatively small level of generosity may be adaptive because the act of generosity involves only relatively minor costs (i.e., adding only one coin) and is therefore less vulnerable to attempts toward exploitation than are more generous strategies (e.g., strategies that add more than one coin at each interaction trial).

Moreover, the present research examines negative noise rather than positive noise because we assumed that negative noise may be relatively more prevalent in real-life interaction situations and more likely to elicit both (a) misunderstanding (i.e., incidents of negative noise challenge, benign impressions of the partner) and (b) continuing cycles of noncooperative interaction (i.e., the echo effect). Indeed, a recent computer simulation provided evidence in support of the notion that negative noise is more likely than positive noise to elicit the echo effect (Signorino, 1996).

Finally, the present research compares a no-noise condition with three noise conditions, in which negative noise affected (a) both persons' choices, (b) only the participant's choices, or (c) only the partner's choices. These three conditions serve two purposes. A

first purpose is to explore possible differences among the three noise conditions. We assumed that the detrimental effects of noise come into being through incidents of negative noise in one of the person's choices; as noted earlier, we assumed that it takes only one person's noncooperative behavior, intended or unintended, to evoke noncooperative interaction (i.e., the echo effect). This assumption is derived from the idea that most people behave in a largely reciprocal manner and that, if they deviate from reciprocity, they tend to do so in a self-serving or self-protective manner rather than in a generous manner (cf. behavioral assimilation; see Kelley & Stahelski, 1970; Liebrand, Jansen, Rijken, & Suhre, 1986; Van Lange, 1999). This line of reasoning led us to anticipate no strong differences among the three conditions involving noise; hence, we advanced no formal hypothesis regarding differences among the three conditions involving negative noise. A second and more important purpose is to examine the generality of our central hypothesis across the three conditions involving negative noise. Following our earlier reasoning, we predicted that, relative to no noise, the three conditions involving noise would exert a detrimental effect on cooperation for a TFT partner; this detrimental effect should be less pronounced for a TFT + 1 partner.

The central hypothesis is that noise exerts detrimental effects on level of cooperation when a partner follows TFT, whereas these effects are less pronounced when a partner follows the more generous version of TFT, referred to as TFT + 1. We also hypothesized that under conditions of no noise, TFT and TFT + 1 might elicit comparable levels of cooperation, but that under conditions of negative noise, TFT + 1 is likely to elicit greater levels of cooperation than TFT. Indeed, evidence in support of this latter hypothesis suggests the benefits of generosity.

Method

Participants and Experimental Design

Two hundred five participants (65 men, 140 women) with an average age of 21 years took part in the present research. Each participant was paid 15 Dutch guilders in exchange for participation (NFL 15.00 equals about \$6 in American currency). The experimental design was a 2 (partner's strategy: TFT vs. TFT + 1) \times 4 (noise: absent, present in both persons' choices, present in only the participant's choice, or present in only the partner's choice) \times 9 (blocks of trials) analysis of variance, with the latter variable a within-subject variable (this variable is discussed shortly). The primary dependent variable was level of (intended) cooperation.

Procedure

Eight to 15 participants attended each research session. On arrival, each participant was greeted and escorted to 1 of 15 cubicles, which prevented participants from communicating with each other. The entire experiment was conducted with Apple Macintosh computers, using a program written in Authorware Professional.

The social dilemma task. The instructions for the experimental task began by explaining the social dilemma task. This task offered the participant a choice among 11 options, varying systematically from least to most

cooperative (see also Van Lange, 1999; Van Lange & Kuhlman, 1994).³ The social dilemma was presented as a give-some situation in which each participant could choose among giving no coins, giving 1 coin, giving 2 coins, up to maximally giving 10 coins to the other. Each coin held by the participant had a value of NFL 0.50 to the participant and a value of NFL 1.00 to the partner. Similarly, each coin held by the partner had a value of NFL 0.50 to the partner and a value of NFL 1.00 to the participant. The situation represents a social dilemma in that (a) each individual obtains greater outcomes to the extent that he or she gives fewer coins away (i.e., individual rationality) and (b) both individuals end up with greater outcomes to the extent that they simultaneously give more coins to each other (i.e., collective rationality; for more information regarding a similar social dilemma task, see Van Lange, 1999; Van Lange & Kuhlman, 1994). The total set of 121 possible outcomes to each person was presented to the participant in the form of an 11×11 matrix, which was presented on a sheet of paper that participants could consult throughout the social dilemma task.

The number of coins and the consequences of giving away coins were displayed on the participant's computer screen. As can be seen in Figure 1 (Panel A), the participant faced a virtual table, divided into the participant's side, on which 10 green coins for the participants were displayed (i.e., "you"), and the partner's side, on which 10 blue coins for the partner were displayed (i.e., "the other"). The consequences of the participant's own choices and the consequences of the partner's choices for the participant's

number of coins and the partner's number of coins were displayed through animated graphics. As can be inferred from Figure 1 (i.e., indicated in Panel B), the coins that were given away by the participant literally moved from the participant's side to the partner's side of the table, and vice versa for the coins given away by the partner. The outcomes with which the participant and the partner proceeded (Figure 1, Panel A) and ended an interaction trial (Figure 1, Panel B) were displayed at the right of the table. Finally, throughout the interactions, we used variable time intervals for displaying the number of coins given by the partner to mimic the variability in decision time that characterizes the choices of real people in social dilemmas.

The social dilemma task included nine equivalent blocks of 6 trials, except for the ninth block, which included 5 trials (as we describe shortly). Participants were not informed about the total number of 53 trials but were informed that before proceeding to the next trial they would receive information about the partner's choice (and the partner would receive information about the participant's choice). After explaining the social dilemma task, we administered 10 questions to check the participants' comprehension of the task. It appeared that 10 participants answered four or more questions incorrectly; hence, the data of these participants were not included in the analyses (i.e., the same criterion was used in previous research; e.g., Van Lange & Kuhlman, 1994).

The outcomes in the social dilemma task were presented in Dutch guilders (see Figure 1). As in previous experiments (e.g., Van Lange, 1999; Van Lange & Visser, 1999), we informed participants that the amount of money was hypothetical but that by earning more money they would increase their chances of winning a 25-guilder book certificate (i.e., a gift certificate for buying books at any bookstore in the Netherlands).⁴ That is, we stated that the amount of hypothetical money earned for themselves corresponded to the number of tickets in a raffle for the book certificates, making clear that their chances would increase by the amount of money they earned more than the other participants in this experiment. We used an absolute standard, and the number of certificates was not fixed, to prevent participants from thinking that outperforming others is needed to gain the book certificate (for identical procedure, see Van Lange & Visser, 1999). (In the actual raffle, held after the entire experiment was completed, each participant had an equal chance of winning the book certificate).

Manipulation of partner's strategy. Both the TFT partner and the TFT + 1 partner were programmed to begin by giving 6 coins, a moderately cooperative choice. These partners did not begin with giving 10 coins because selecting the most cooperative choice of the 11 options is rather unrealistic (in fact, even in a 4-coin paradigm used in earlier research (Van Lange, Ouwerkerk, & Tazelaar, 2001), we observed that only 6% of the

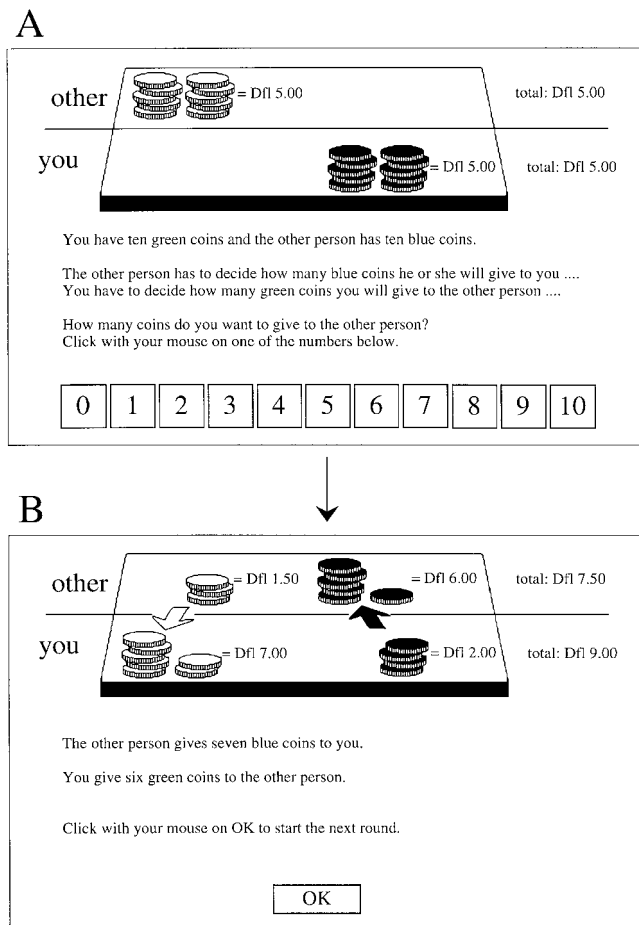


Figure 1. The virtual table displaying the number of coins with which participants proceeded an interaction trial (Panel A) and ended an interaction trial (Panel B) in the social dilemma task.

³ Prior to this study, we conducted our first study on noise in social dilemmas (Van Lange, Ouwerkerk, & Tazelaar, 2001). In this study, we manipulated both positive noise and negative noise and used a 4-coin paradigm in which participants had to decide among five options: giving no coins, 1 coin, 2 coins, 3 coins, or 4 coins to the other. The instructions for the present study, which uses a 10-coin paradigm, were virtually identical to this earlier research. However, we designed a 10-coin paradigm because we anticipated that participants would be less likely to give the maximum number of coins (so that TFT + 1 does not come through) or no coins at all (so that negative noise does not come through) when they have 11 options rather than 5 options.

⁴ We attempted the use hypothetical amounts of money that were neither too small nor too large so that participants could easily imagine that they would indeed give and receive such benefits (i.e., that they acted as if it were real money). It should be clear that the experiment would be very costly if we were to pay participants according to outcomes given in the matrix (i.e., it would amount to NFL 530.00 per participant per hour, if all interactions were maximally cooperative).

participants began with giving all 4 coins to the partner, whereas a majority of 71% gave 1 coin or 2 coins). However, consistent with the conceptual definition of TFT (and TFT + 1), we wanted these partners to be at least moderately nice, so we decided that both partners' first choice was moderately cooperative (i.e., giving 6 of 10 coins). We acknowledge that this choice is somewhat arbitrary, and it would be interesting for future research to explore variations in initial niceness, because the very first behavior may exert important influences on subsequent interactions (see Komorita & Parks, 1995).

In subsequent trials, TFT was programmed to give exactly the same number of coins that the participant gave it in the previous interaction trial, and TFT + 1 was programmed to give 1 more coin than the participant gave it in the previous interaction trial. Thus, in this 10-coin paradigm, the TFT + 1 partner adds 1 coin from 10 coins in total to the participant's previous choice. Finally, as noted earlier, the TFT + 1 partner cannot add a coin if it received the maximum number of 10 coins from the participant in the previous interaction trial. It appeared that, on average, participants actually gave 10 coins in nearly 16 of 53 trials ($M = 15.81$), indicating that the TFT + 1 partner actually gave 1 more coin than it received in 70.2% of the interactions.⁵

Manipulation of noise. Prior to making choices in the social dilemma task, participants in the three noise conditions were told that we were interested in examining how people make decisions in "situations in which the actual decision(s) by both persons [one person] may every now and then be different from the decision(s) one intends to make." We reasoned that an incident of noise would very likely be attributed to the partner's intended behavior if participants were told nothing about the possibility of noise in the experimental laboratory (i.e., there is no reason for participants to believe that the experimenter will change their choice). Also, the instructions emphasized that although the actor would receive information when his or her choice was changed, the partner would not be informed about a change in the actor's intended choice. The incidents of noise were also illustrated by an example so that the participants could see how the computer might change a decision and how the computer would inform the actor about such changes. Obviously, these instructions were not included in the no-noise condition. Thus, in the noise conditions, we aimed to establish a basic understanding of noise and a realization that choices made by the participant and the partner would be changed every now and then. Presumably, this is consistent with real-life interactions, such that people understand noise and often are aware that situations may be somewhat noisy (e.g., when another person does not respond to an E-mail, one does take into account that the other might not have received the E-mail; cf. Weiner, 1985). We note that throughout the instructions, we did not use value-laden words such as *misunderstanding* or *errors* to prevent tendencies toward reactivity. Subsequently, in the conditions in which noise every now and then influenced both persons' choices, the participant's choices, or the partner's choices, participants were informed about the possibility of noise, learning that the computer would change in some trials both persons' choices, only their own choices (and not the other's choices), or only the other's choices (and not their own choices).

As noted earlier, the social dilemma task included 53 interaction trials, consisting of eight structurally equivalent blocks of trials, in that each block included 5 normal interaction trials plus 1 interaction trial involving noise. Block 1 included the first 6 trials, with the 6th trial involving noise; Block 2 included Trials 7–12, with the 12th trial involving noise; and so on. The final block of trials, Block 9, included only 5 normal interaction trials. This block did not end with a trial involving noise, because this trial could not affect subsequent levels of cooperation.

In each of three noise conditions (i.e., noise–both, noise–participant, noise–partner), the choices in 8 interaction trials were influenced by noise, thus holding constant the total frequency of noise across the three conditions (noise frequency = 15%; 8 of 53 trials). Also, in each of the three noise conditions, we operationalized negative noise by subtracting two coins from the intended choice. We subtracted two coins so as to induce a

reasonable noise intensity that was unlikely to go by unnoticed. Finally, in the condition in which noise affected both persons' choices, the incidents of negative noise alternated, beginning with noise affecting the participant's choice (6th trial), followed by noise affecting the partner's choice (12th trial), and so on.

Obviously, when the participant or partner intends to give no coins, incidents of negative noise in reality do not affect that choice. As noted earlier, we anticipated that in the 10-coin paradigm noise would be more likely to come through than in a paradigm involving fewer options (e.g., a 4-coin paradigm, which we have used in previous research). As expected, the number of times noise came through was very high in the noise–both condition ($M = 7.33$), in the noise–participant condition ($M = 7.26$), and in the noise–partner condition ($M = 7.58$); moreover, a one-way analysis of variance revealed no significant differences among these three conditions, $F(2, 137) = 1.22, ns$. Thus, although noise did not come through all the time, it did so most of the time (i.e., in more than 7 of 8 incidents of noise, on average).

After the social dilemma task, we asked in the three noise conditions whether the computer had changed both persons' intended choices, the participant's intended choices, or the partner's intended choices. It appeared that 10 participants answered this question incorrectly. The data of these participants and 1 participant who exhibited suspicion during the social dilemma task were excluded from the analyses, leaving a total of 184 participants.

On completion of the social dilemma task, participants proceeded with a postexperimental questionnaire. This questionnaire included eight items assessing benign impressions of the partner. The scale included positive items and negative items. Positive items were "The other was . . . generous, nice, forgiving, kind," and negative items were "The other was . . . selfish, greedy, competitive, stingy" (Cronbach's $\alpha = .87$). After the postexperimental questionnaire, participants were debriefed, thanked for their participation, and paid.

Results

As noted earlier, the social dilemma task involved 53 trials, consisting of eight equivalent blocks of 5 trials without noise and 1 trial with noise and a ninth block of only 5 trials. Level of cooperation was analyzed in a 2 (partner's strategy: TFT vs. TFT + 1) \times 4 (noise: absent, present in both persons' choices, only present in the participant's choices, or only present in the partner's choices) \times 9 (blocks of trials) analysis of variance, with the latter variable a within-subject variable.⁶ Because we hypoth-

⁵ It is of some interest to note that this overall percentage is virtually identical to the overall percentage observed in an earlier experiment conducted by us (Van Lange et al., 2001). Further, it is not surprising that this percentage was lower for the no-noise condition (39.6%) than for the noise conditions (78.4% in the noise–both condition, 74.3% in the noise–participant condition, and 88.9% in the noise–partner condition; contrast of noise vs. no noise, $F[1, 85] = 30.19, p < .01$). Differences among these percentages within the noise conditions were not significant. Generally, these findings are not surprising because, as outlined earlier, the presence of negative noise should exert detrimental effects on level of cooperation, including the frequency of maximal cooperation.

⁶ We also assessed the mean quality of outcomes that the partner obtained (i.e., quality of partner's outcomes) and the mean quality of outcomes that the participant and the partner obtained together (i.e., quality of collective outcomes). These two measures correspond to individual-level and group-level functionality (cf. Sober & Wilson, 1998). Correlational analyses revealed that the level of cooperation was very highly correlated with the quality of the partner's outcomes, $r(184) = .98$, and the

esized that the absence of noise condition would differ from the three conditions involving noise (in both persons' choices, participant's choices, or partner's choices), we computed three orthogonal contrasts. The most important contrast compares the noise-absent condition with the three noise-present conditions, which we refer to as the *noise-versus-no-noise* contrast. The other two contrasts were used to explore possible differences among the three noise-present conditions: (a) a contrast comparing the noise in both persons' choices condition with the noise in participants' choices condition and the noise in partner's choices condition (i.e., a *both-vs.-single* contrast), and (b) a contrast between the noise in participant's choices condition versus the noise in partner's choices condition (i.e., a *self-vs.-other* contrast). Because the latter two contrasts were not directly hypothesis relevant and because they generally exerted no significant effects, these contrasts are only discussed if they exert significant effects.

Level of Cooperation

A 2 (partner's strategy) \times 4 (noise) \times 9 (blocks of trials) analysis of variance revealed a main effect for partner's strategy, $F(1, 176) = 6.30, p < .05$, indicating that across the four noise conditions, the TFT + 1 partner ($M = 6.60$) elicited greater cooperation than did the TFT partner ($M = 5.72$). The analysis also yielded a significant main effect for noise, $F(3, 176) = 4.14, p < .01$. Complementary analyses revealed a significant noise-versus-no-noise contrast, $F(1, 176) = 10.84, p < .001$, indicating greater levels of cooperation when noise was absent ($M = 7.20$) than when noise was present, irrespective of whether the noise affected both persons' choices ($M = 6.00$), only the participant's choices ($M = 6.04$), or only the partner's choices ($M = 5.50$). Thus, noise exhibited a detrimental effect on level of cooperation.

More important, these main effects were qualified by an interaction of partner's strategy and noise, $F(1, 176) = 2.73, p < .05$. The means relevant to this interaction are summarized in Table 1 (see the level of cooperation data). Planned comparisons revealed a significant interaction of partner's strategy and the noise-versus-no-noise contrast, $F(1, 176) = 7.74, p < .01$. As can be seen in Figure 2, a TFT partner elicited high levels of cooperation under no noise and relatively low levels of cooperation when noise was present. Indeed, simple main effects analyses within the TFT condition revealed a main effect of noise, $F(3, 176) = 6.52, p < .01$, as well as a significant effect of the noise-versus-no-noise contrast, $F(1, 176) = 18.30, p < .01$. However, for a TFT + 1 partner, the level of cooperation was not significantly affected by the presence versus absence of noise; indeed, the simple main effects analyses within TFT + 1 revealed neither a significant

quality of collective outcomes, $r(184) = .99$, and the latter variables were also highly correlated, $r(184) = .97$. Quality of partner outcomes and quality of collective outcomes yielded exactly the same findings as for level of cooperation. The only exception was that for the partner's outcomes, the analysis did not reveal a main effect of the partner's strategy, $F(1, 176) = 0.35, ns$. The outcomes for a TFT partner ($M = 7.86$) were indeed similar for the outcomes for a TFT + 1 partner ($M = 7.97$). As for level of cooperation, quality of collective outcomes was greater when the partner followed TFT + 1 ($M = 16.77$) rather than TFT ($M = 15.58$), as evidenced by a main effect of partner's strategy, $F(1, 176) = 12.65, p < .01$.

Table 1
Means and Standard Deviations for Level of Cooperation and Benign Impressions as a Function of Partner's Strategy and Noise

Partner's strategy	Noise			
	Absent	Both persons	Participant's choices	Partner's choices
Level of cooperation				
TFT				
<i>M</i>	7.63	5.15	5.47	4.60
<i>SD</i>	2.02	2.53	2.48	2.24
TFT + 1				
<i>M</i>	6.77	6.81	6.57	6.30
<i>SD</i>	2.43	2.33	2.70	2.50
Benign impressions				
TFT				
<i>M</i>	5.04	3.76	4.36	4.34
<i>SD</i>	0.95	1.14	1.08	1.08
TFT + 1				
<i>M</i>	5.74	5.57	5.92	5.33
<i>SD</i>	0.86	0.82	0.68	0.93

Note. TFT = tit for tat; TFT + 1 = giving one more coin than the other gave in the previous interaction.

main effect of noise, $F(3, 176) = 0.19, ns$, nor a significant effect of the noise-versus-no-noise contrast, $F(1, 176) = 0.09, ns$.

The significant interaction of the partner's strategy and the noise-versus-no-noise contrast can also be interpreted in terms of the relative performance of TFT and TFT + 1 partners through an examination of whether TFT + 1 might actually elicit greater cooperation than TFT when choices are affected by noise. Within the no-noise condition, a TFT partner and a TFT + 1 partner did not significantly differ in terms of the level of cooperation they elicited, $F(1, 176) = 1.39, ns$. However, within the three conditions, we found that a TFT + 1 partner elicited significantly greater levels of cooperation than did a TFT partner, $F(1, 176) = 11.06, p < .01$. (Contrasts within the three noise conditions were not significant.)

Thus, consistent with our central hypothesis, noise exhibited a detrimental effect on level of cooperation in interactions with a TFT partner but not in interactions with a TFT + 1 partner. Moreover, in support of the benefits of generosity, when noise affected the participant's choices, the partner's choices, or both persons' choices, TFT + 1 elicited greater levels of cooperation than did TFT.⁷

Finally, the analysis revealed two effects involving blocks of trials. First, there was a main effect for blocks of trials on level of cooperation, $F(8, 169) = 16.61, p < .01$, indicating that level of cooperation increased gradually over the first five blocks ($M_s = 4.56, 5.25, 5.79, 6.19, \text{ and } 6.58$ in Blocks 1–5, respectively), after which increases were somewhat less pronounced

⁷ We should note that the results were very similar in analyses that included participants who were excluded in the analyses described above. For example, the interaction of the partner's strategy and the noise-versus-no-noise contrast was significant in all analyses that included participants failing the comprehension check, participants failing the manipulation check, the participant who exhibited suspicion, or all three groups (i.e., all participants).

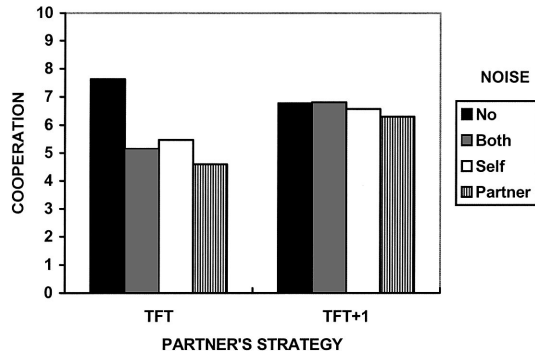


Figure 2. Mean levels of cooperation elicited by a TFT partner and a TFT + 1 partner under no noise and three noise conditions, with noise affecting both persons' choices, only the participant's choices, or only the partner's choices. TFT = tit for tat; TFT + 1 = giving one more coin than the other gave in the previous interaction.

(M s = 6.70, 6.72, 6.89, and 6.92 in Blocks 6–9, respectively). Second, the analysis revealed an interaction of noise and blocks of trials, $F(24, 513) = 2.21, p < .01$. Complementary analyses revealed a significant interaction of the noise-versus-no-noise contrast with blocks of trials, $F(8, 169) = 2.95, p < .01$. There was a stronger increase in cooperation when noise was absent (from $M = 4.49$ in Block 1 to $M = 8.31$ in Block 9; a mean increase of $M = 3.82$) than when noise was present, either in both persons' choices (from $M = 4.90$ in Block 1 to $M = 6.34$ in Block 9; a mean increase of $M = 1.44$), in the participant's choices (from $M = 4.33$ in Block 1 to $M = 7.08$ in Block 9; a mean increase of $M = 2.75$), or in the partner's choices (from $M = 4.54$ in Block 1 to $M = 5.97$ in Block 9; a mean increase of $M = 1.43$).⁸ These findings provide evidence for the notion that the detrimental effects of noise are interaction based. That is, when there is no noise, there is an increase in cooperation over successive interactions (at least in the context of TFT and TFT + 1 strategies). Thus, the presence of noise seems to inhibit learning over successive interactions.⁹

Benign Impressions

A 2 (partner's strategy) \times 4 (noise) analysis of variance on benign impressions revealed effects that were similar to those observed for level of cooperation. First, a main effect of partner's strategy, $F(1, 176) = 81.78, p < .01$, revealed that participants formed more benign impressions of a TFT + 1 partner ($M = 5.65$) than of a TFT partner ($M = 4.37$). The analysis also revealed a main effect of noise, $F(3, 176) = 5.21, p < .01$. Complementary analyses revealed a significant effect for the noise-versus-no-noise contrast, $F(1, 176) = 9.33, p < .01$, indicating more benign impressions when noise was absent ($M = 5.39$) than when noise was present, affecting either both persons' choices ($M = 4.68$), only the participant's choices ($M = 5.17$), or only the partner's choices ($M = 4.87$).

The analysis also revealed an interaction of partner's strategy and noise, $F(3, 176) = 3.26, p < .05$, and complementary analyses revealed a significant effect for the noise-versus-no-noise contrast, $F(1, 176) = 5.40, p < .05$. Paralleling an earlier noted effect for level of cooperation, participants formed more benign impressions of a TFT partner under no noise than under noise (see Table 1

under the Benign impressions subheading). In contrast, participants formed benign impressions of a TFT + 1 partner, and these impressions were relatively unaffected by the presence or absence of noise. Simple main effects within TFT revealed a significant main effect for noise, $F(3, 176) = 6.78, p < .01$, and a significant effect for the noise-versus-no-noise contrast, $F(1, 176) = 14.78, p < .01$. Within TFT + 1, neither the main effect of noise, $F(3, 176) = 1.99, ns$, nor the effect of the noise-versus-no-noise contrast, $F(1, 176) = 0.06, ns$, was significant. Thus, impressions of the TFT partner were less benign under noise than under no noise, whereas impressions of a TFT + 1 partner were not affected by noise.

Mediation by Benign Impressions

Is there evidence that benign impressions might mediate the effects observed for level of cooperation? At the outset, we should note that, conceptually, benign impressions should both (a) summarize the evaluations of past behavior and interactions and (b) guide behavior and interactions in future trials. However, benign impressions were only assessed after the social dilemma task because we did not want the measurement of impressions to affect behavior and interaction in the social dilemma task. From the perspective of testing mediation, this order of measurement can only yield very preliminary evidence because we assessed the presumed mediator (i.e., benign impressions) after measuring the criterion variable (i.e., level of cooperation).

Nevertheless, these analyses reveal some interesting patterns. First, benign impressions exhibited a significant correlation with level of cooperation, $\beta = .39, p < .01$. Given that the main effects of the partner's strategy and noise (and the noise-vs.-no-noise contrast) as well as their interaction (including the interaction involving the noise-vs.-no-noise contrast) were significant for both

⁸ It is, of course, interesting to examine whether the interaction of the partner's strategy and noise, revealing support for our central hypothesis (i.e., TFT suffering more from noise than TFT + 1), is further shaped by blocks of trials. The analyses revealed a marginal three-way interaction of partner's strategy, noise, and blocks of trials, $F(24, 513) = 1.45, p < .10$. Complementary analyses revealed evidence (albeit weak) for an interaction of partner's strategy, the noise-versus-no-noise contrast, and blocks of trials, $F(8, 169) = 2.08, p < .10$. We briefly note that the patterns associated with these effects indicate that our support for the central hypothesis was established in the third block of trials, as evidenced by an interaction of strategy and the noise-versus-no-noise contrast in Block 3, $F(1, 176) = 4.21, p < .05$. This interaction was absent in Block 1, $F(1, 176) = 0.52, ns$, and failed to be significant in Block 2, $F(1, 176) = 2.55, p < .11$, but was consistently significant in Blocks 4–9 (except for a marginal interaction effect in Block 4). Taken together, these findings suggest that even a few incidents of negative noise (in this case, two incidents) may exert a detrimental effect on the level of cooperation elicited by a TFT partner, whereas it had no effect on the level of cooperation elicited by a TFT + 1 partner.

⁹ We also observed a significant interaction between the self-versus-other contrast and the block of trials, $F(8, 169) = 2.25, p < .05$, indicating a somewhat stronger increase in cooperation when the participant's choices (from $M = 4.33$ in Block 1 to $M = 7.08$ in Block 9) rather than the partner's choices were affected by noise (from $M = 4.54$ in Block 1 to $M = 5.97$ in Block 9). The interaction between both-versus-single contrast and block of trials was not significant.

level of cooperation and benign impressions and given that there was a positive association between these two variables, we conducted a 2 (partner's strategy) \times 4 (noise) analysis of variance, adding benign impressions as a covariate. In addition to a significant effect for the covariate, $F(1, 175) = 30.96, p < .01$, this analysis revealed that the main effect of partner's strategy dropped to nonsignificance, $F(1, 175) = 0.79, ns$; (without covariate: $F[1, 176] = 6.30, p < .05$; a significant reduction, $Z = 4.67, p < .01$). The main effect of noise was now marginal, $F(3, 175) = 2.45, p < .10$ (without covariate: $F[3, 176] = 4.14, p < .01$; a significant reduction, $Z = 2.50, p < .01$); the noise-versus-no-noise contrast remained significant, $F(1, 175) = 4.94, p < .05$ (without covariate: $F[1, 176] = 10.84, p < .01$), but was significantly reduced ($Z = 2.61, p < .01$). Finally, the interaction of partner's strategy and noise dropped to nonsignificance, $F(3, 175) = 1.92, p = .13$ (without covariate: $F[3, 176] = 2.73, p < .05$; a significant reduction, $Z = 2.05, p < .05$), and the interaction of partner's strategy and the noise-versus-no-noise contrast remained significant, $F(1, 175) = 4.02, p < .05$ (without covariate: $F[1, 176] = 7.74, p < .01$), but was significantly reduced ($Z = 2.14, p < .05$).¹⁰

Thus, the findings reveal some preliminary evidence indicating that benign impressions mediated the main effect of partner's strategy, the effects of noise (vs. no noise), and the interaction of noise (vs. no noise) with partner's strategy on level of cooperation. As to the latter effects, participants may have exhibited lower cooperation under noise than under no noise because they formed less benign impressions of the partner under noise than under no noise—a TFT + 1 partner seems to be able to overcome such detrimental effects of noise on both level of cooperation and benign impressions.

Discussion

The present research provides evidence in support of the central hypothesis that adding generosity to reciprocity helps overcome the detrimental effect of noise on cooperation in social dilemmas. Specifically, results reveal that noise exerted a detrimental effect on level of cooperation when the partner followed TFT and that this detrimental effect was significantly less pronounced (in fact, virtually absent) when the partner followed a slightly more generous version of TFT, which we refer to as TFT + 1. Also, in support of the benefits of generosity, results reveal that under three conditions of negative noise, TFT + 1 elicited greater levels of cooperation than did TFT. Finally, it is also noteworthy that participants formed not so benign impressions of a TFT partner when there was negative noise (vs. no negative noise), whereas their impressions of the TFT + 1 partner were not significantly affected by negative noise. In the following, we discuss the major findings, consider some of their implications, and outline some strengths and limitations of the present research.¹¹ We begin by addressing explanations of the present findings.

Why Generosity Helps Overcome the Detrimental Effect of Noise

In addressing this basic question, it is important to note that the present findings are consistent with several computer simulations, including Kollock's (1993) simulation study, which compared

TFT with several other strategies, including TFT + 1. This consistency in findings may well be understood in terms of features of the created social environment with which strategies interact in computer simulations (i.e., the strategies that are included in the simulation) as well as features of the actual social environment with which strategies interact in the laboratory (i.e., the strategies followed by the participants). That is, the computer simulations generally include several variants of reciprocity (e.g., Bendor et al., 1991; Kollock, 1993; Reeves & Pitts, 1996), presumably in part because of Axelrod's (1984) original tournament supporting TFT's success (in noise-free situations) and in part because of the widely held belief in the functionality (and evolutionary strengths) of reciprocity. We suggest that, as do most strategies included in simulation studies, actual participants involved in iterated social dilemmas also tend to behave in a fairly reciprocal manner, often yielding interactions in which both cooperate or neither cooperates (e.g., Kelley & Stahelski, 1970; for reviews, see Komorita & Parks, 1995; Pruitt, 1998). Such high levels of reciprocity could to some degree be understood in terms of tendencies toward enhancing equality in outcomes, which appears to be a pronounced motivation with which individuals approach and interact with others in social dilemmas and related interdependence situations (e.g., Messick & Sentis, 1985; Van Lange, 1999).

In the context of this environment, noise should exert detrimental effects when the partner follows TFT because neither the partner nor the participant may be especially inclined to rebuild trust and communicate benign intent after incidents of negative noise. That is, after negative noise, two persons who follow largely reciprocal strategies (without adding generosity) will pull each other in the direction of less cooperation: As noted in the introduction, for two persons following TFT, only one incident of negative noise may yield a continuing echo effect. In support of such reasoning, the present findings reveal that, with a TFT partner, it takes just one incident of noise to exert detrimental effects on level of cooperation, or, more precisely, to exert inhibiting effects on increased cooperation over interaction trials. In contrast, a TFT + 1 partner communicates at each interaction trial (except those affected by noise) benign intent by giving away just a bit more than it received from the participant in the previous trial. Presumably, a TFT + 1 partner communicates trust and benign intent, thereby contributing to an interpersonal atmosphere in which occasional errors matter less than they do in an atmosphere created by TFT (i.e., the building of trust). Moreover, each time a

¹⁰ The significance of the reductions in the effects of the main effects and interaction effect on level of cooperation was tested using a regression approach (see Kenny, Kashy, & Bolger, 1998) using the formula discussed at <http://nw3.nai.net/~dakenny/mediate.htm>

¹¹ In our first study on noise in social dilemmas, we simultaneously manipulated positive noise and negative noise (i.e., four incidents of positive noise and four incidents of negative noise in both persons' choices) and used a four-coin paradigm (Van Lange et al., 2001). This experiment revealed similar results in that the presence of noise exhibited detrimental effects on level of cooperation, but only with a TFT partner, not with a TFT + 1 partner. This experiment did not reveal that under noise TFT + 1 elicited greater levels of cooperation than did TFT (although TFT + 1 yielded greater collective outcomes under noise than did TFT). Perhaps the presence of positive noise may make the benefits of generosity somewhat weaker.

participant's beliefs of trust and benign intent are challenged because of negative noise, a TFT + 1 partner restores such beliefs by behaving generously, eventually pulling most participants (i.e., those who follow reciprocal strategies) into the direction of more rather than less cooperation (i.e., the restoring of trust).

Also, consistent with the above line of reasoning, the present research reveals that participants developed much less benign impressions of a TFT partner under negative noise than under no negative noise, whereas the impressions of a TFT + 1 partner were very benign, irrespective of the presence of negative noise. Mediation analysis provides some preliminary evidence in support of partial mediation (the evidence is preliminary for reasons outlined earlier). Thus, we suggest that our measure of benign impressions supports the line of reasoning that focuses on beliefs of trust and benign intent that are challenged by negative noise and are overcome by adding a bit of generosity to TFT. A complementary advantage of TFT + 1 is that because it gives 1 more coin than it received, it logically confronts the participant with a violation of fairness (e.g., "I owe this person"). Moreover, it does so at each interaction at only a small cost (e.g., adding only 1 coin in the 10-coin paradigm), so that the possibilities of exploitation are similarly small. In the perception of the participant, this recurring violation of fairness can only be restored, at least behaviorally, if the participant starts to behave more cooperatively as well (up to the level of giving the maximal number of coins).

We should briefly comment on the fact that the present findings are very similar to the findings obtained by computer simulations by Kollock (1993). In light of this consistency and the fact that computers do not form impressions, one might ask: How can the findings regarding benign impressions contribute to an explanation of the present findings? In addressing this question, it may be argued that computer simulations provide insight into the logic underlying the effectiveness of particular interaction styles, in that they may provide "demonstrations that certain qualitative effects can be produced by simple sets of idealized assumptions" (Hastie & Stasser, 2000, p. 88). As a general point, we suggest that the psychology examined in empirical studies may to some degree follow from (or support) the logic that is demonstrated in computer simulations. To illustrate, recent computer simulations have revealed that the functional value of generosity decreases with increasing group size—in fact, when group size exceeds seven or eight people, it tends to become functional to behave in a self-serving manner (Gallucci, Van Lange, & Ouwkerk, 2001). It is possible that, after repeated interactions with groups of different sizes, individuals at some level detect this logic, which in turn may activate several psychological mechanisms, such as decreases in identification, perceived self-efficacy, or identifiability, that support a decline in generous and cooperative behavior in larger groups (e.g., Kerr, 1989; Komorita & Parks, 1995; Van Lange, Liebrand, Messick, & Wilke, 1992).

As for the present findings, individuals' functioning may have evolved in such a manner that they may readily develop negative impressions of others who unintentionally (or intentionally) behave less cooperatively than the individuals themselves and subsequently reciprocate that reduced level of cooperation. The latter effect is often observed in computer simulations, whereas the former effect reflects a psychological mechanism that supports the decline in cooperation with a TFT partner among real people. In the same way, participants may maintain benign impressions of a

TFT + 1 partner because this partner contributes to the building of trust and, after an incident of noise, to the restoring of trust. Therefore, findings of computer simulations and empirical research tend to go hand in hand, complementing each other in ways that may provide a more comprehensive account of the strengths and limitations of reciprocity and generosity.

Boundaries of Generosity

Is adding generosity to reciprocity always effective in coping with noise? We would like to draw attention to three boundaries of generosity. First, as have nearly all computer simulations, the present research uses the social dilemma as a situation in which to examine the benefits of generosity in coping with noise. Clearly, the social dilemma represents just one interdependence structure, characterized by a fairly strong conflict of interest (i.e., moderate to strong levels of noncorrespondence; Kelley & Thibaut, 1978). Generosity is unlikely to work when the dilemma takes the form of a coordination situation in which outcomes are largely corresponding rather than conflicting. For example, some individuals may exhibit tendencies toward exchanging more and more expensive gifts (even though they both want to avoid that), up to the point that one or both persons can no longer afford such exchanges. In such situations, there are no benefits attached to generosity, because by exhibiting seemingly generous behavior, the individuals pull each other in a direction that they both do not desire. We suggest that the benefits of generosity may be most pronounced when that which is given to the other is more valuable to the recipient than to the giver; these tend to be exchange situations with moderate levels of noncorrespondence. In discussing the origins of trust, Kelley and Thibaut (1978), noted that "it is in the middle regions of the continuum of outcome correspondence, in which elements of both conflict and cooperation are present as temptations, that attributions of trust have their origins" (p. 237). Likewise, we suggest that the effects of negative noise and the effectiveness of generosity may be most pronounced in the middle regions of the continuum of outcome correspondence. Future research may examine these issues in structures neighboring the prisoner's dilemma.

Second, we suggest that generosity works only when the frequency of noise is not too overwhelming. When the frequency of noise is so high that it becomes nearly impossible to communicate trust and benign intent, one might just as well simply pursue direct self-interest. Computer simulations suggest that when situations are very noisy (e.g., noise in every other trial or more), a self-centered version of reciprocity (TFT - 1) becomes more functional than TFT or TFT + 1 (see Kollock, 1993). Thus, for generosity to work, there must be an environment that is not too noisy, so that trust and benign intent can still be communicated. Future research could assess the functionality of generosity, reciprocity, and, perhaps, stinginess under various levels of noise.

Finally, even in the context of the prisoner's dilemma and even when the amount of noise is not too large, the benefits of generosity are dependent on the social environment. For example, generosity will be exploited and is unlikely to cope well with noise if the social environment primarily consists of individuals who seek to enhance relative advantage over others; that is, when competitive motivation prevails. As such, it may be risky to

behave generously in contexts in which competitive motivation is quite pronounced (e.g., intergroup interaction; Insko et al., 1998).

Implications of Noise and Misunderstanding

Given that noise and misunderstanding have received very little attention in the social-psychological literature, it is useful to outline some theoretical implications of the present research, the concept of noise in particular. First, it should be clear that we regard noise in social dilemmas as intimately linked with the interpersonal processes involving trust, benign intent, and misunderstanding. Moreover, we suggest that such processes entail communication, which includes *self-presentation* on the part of the actor and *attribution* on the part of the observer (or partner). Even in noise-free environments, self-presentation and attribution are very basic to understanding social interaction processes, because behaviors in settings of interdependence can often be guided by various goals and intentions (cf. Kelley & Thibaut, 1978). For example, should a cooperative choice be explained in terms of the motivation to enhance joint outcomes or the motivation to enhance long-term personal outcomes? Noise adds to the importance of self-presentation and attribution because it obscures the association between behavior and intentions. For example, attributional tendencies toward explaining negative behavior in terms of negative intentions and traits (e.g., Allison & Kerr, 1994; Reeder & Brewer, 1979) may be quite costly if one considers their potential interpersonal consequences—interpersonal misunderstanding and reduced cooperation. Perhaps such interpersonal costs could be prevented to some degree if the actors realize that there may be a discrepancy between intended outcomes and actual outcomes (i.e., that there is noise); that is, if actors are willing and able to inhibit correspondent inferences or reserve judgment. As such, the concept of noise can give rise to novel lines of future research that might bring together social-cognitive activities, with a focus on informational goals (self-presentation and attribution), which may illuminate social interaction phenomena.

Second, there are also close links between noise and communication. Interpersonal communication may often serve to exchange information about preferences relevant to pursuing interdependence opportunities and solving interdependence problems. For example, two persons' decision about where to have a vacation may be partially determined by both persons' preferences for quality of culture, food, and climate. Clearly, informing one another about such preferences is an important function of communication (Kelley & Thibaut, 1978; Rusbult & Van Lange, 1996). A second function of communication may be to discuss noise, especially because incidents of noise are typically known to the actor but unknown to the partner (or at least not known with complete confidence). Hence, individuals may explain discrepancies between intentions and actual behavior in an effort to prevent or resolve misunderstanding and to promote cooperation and quality of interaction outcomes (e.g., "I did not mean to hurt you"). Research could address the benefits of communication (e.g., the content, timing, and credibility of communication) in noisy social dilemmas, which is likely to contribute to the classic discussion about the functions of communication in social dilemmas (e.g., Kerr & Kaufman-Gilliland, 1994; Orbell, Van de Kragt, & Dawes, 1988). A related topic for future research is noise as an excuse,

whereby individuals communicate noise to convey cooperative intentions even if the intentions were not cooperative; that is, if noise was absent (e.g., embellishing congestion on freeways as an excuse for arriving late).

Third, as illustrated by some earlier examples, we assume that noise plays a key role in ongoing interactions and relationships. One of the most dangerous interaction patterns that challenge the quality and future of a relationship is negative reciprocity, or cycles of conflict (for evidence, see Gottman, 1994; Rusbult, Verette, Whitney, Slovick, & Lipkus, 1991). Prior research suggests that individuals with low trust or commitment may be especially prone to focus on a partner's negative behavior and explain it in terms of correspondingly negative intentions and traits, thereby (perhaps unintentionally) contributing to a reality of distrust and suspicion (e.g., Holmes & Rempel, 1989; Wieselquist, Rusbult, Foster, & Agnew, 1999). We suggest that the atmosphere of distrust may often be instigated and maintained by noise yet could perhaps be overcome by giving the partner the benefit of the doubt by behaving somewhat more generously. As such, the concept of noise may enhance our understanding of why prorelationship behavior such as acts of self-sacrifice and communal orientation rather than exchange orientation tend to be associated with trust, benign intent, and healthy functioning in relationships (e.g., Clark, 1984; Wieselquist et al., 1999). As such, coping with noise in ways that are not detrimental to the quality or stability of a relationship may well be one of the most challenging activities in the context of ongoing relationships.

We close by outlining some avenues for future research. To begin with, research on computer simulation tends to operate in relative isolation of empirical research using real participants. However, as we alluded to earlier, these approaches complement each other in that they may inform each other about specific models and hypotheses that can then be tested in both research paradigms (for similar reasoning, see, e.g., Hastie & Stasser, 2000; Messick & Liebrand, 1995). Also, computer simulations examine computer-computer interaction (i.e., they involve interactions of preprogrammed strategies), the present research examines computer-participant interaction, and we hope that future research will complement these approaches by examining participant-participant interaction. For example, examining participant-participant interaction may allow us to test hypotheses regarding the intricate links between trust, noise, and cooperation among partners who are involved in an ongoing relationship. Further, we suggest that the concept of noise enhances the ecological validity of research using experimental games (Pruitt & Kimmel, 1977); indeed, it is easy to generate examples of noisy situations outside of the laboratory that lead to interpersonal misunderstanding and noncooperative interaction (e.g., "Why didn't you respond to my E-mail?"). In this regard, several aspects of noise (positive vs. negative noise, noise frequency, noise intensity) deserve further attention. Also, one might extend the present research to small groups, which would allow one to explore whether group performance is negatively influenced by the presence of noise and whether generosity by one or more members may help overcome such effects. As such, future research on social interaction, interpersonal relations, and group relations would benefit from greater theoretical and empirical attention to situations in which acci-

dents and incidental errors do occur, just as they occur and shape interactions in everyday life.

Concluding Remarks

One cannot fully understand social interactions if one does not consider the important fact from interpersonal life that intended outcomes may sometimes be different from actual outcomes. Incidents of noise in social dilemmas give rise to misunderstanding in that they may challenge benign impressions, thereby instigating patterns of noncooperative rather than cooperative interaction. One can overcome such detrimental effects of noise by behaving a little bit more cooperatively than the partner did in a previous interaction rather than by behaving in a strictly reciprocal manner. Therefore, the recognition of noise in social interaction helps us understand the interpersonal functions of generosity and why such behavioral tendencies have survival value in interpersonal relationships.

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