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Cognitive conflict in social dilemmas: An analysis of response dynamics

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Abstract

Recently, it has been suggested that people are spontaneously inclined to cooperate in social dilemmas, whereas defection requires effortful deliberation. From this assumption, we derive that defection should entail more cognitive conflict than cooperation. To test this hypothesis, the current study presents a first application of the response dynamics paradigm (i.e., mouse-tracking) to social dilemmas. In a fully incentivized lab experiment, mouse movements were tracked while participants played simple two-person social dilemma games with two options (cooperation and defection). Building on previous research, curvature of mouse movements was taken as an indicator of cognitive conflict. In line with the hypothesis of less cognitive conflict in cooperation, response trajectories were more curved (towards the non-chosen option) when individuals defected than when they cooperated. In other words, the cooperative option exerted more "pull" on mouse movements in case of defection than the non-cooperative option (defection) did in case of cooperation. This effect was robust across different types of social dilemmas and occurred even in the prisoner's dilemma, where defection was predominant on the choice level. Additionally, the effect was stronger for dispositional cooperators as measured by the Honesty-Humility factor of the HEXACO personality model. As such, variation in the effect across individuals could be accounted for through cooperativeness.

Keywords: social dilemma, response dynamics, cooperation, cognitive conflict, intuition, mouse-tracking, personality, Honesty-Humility.

1 Introduction

Cooperation is a central aspect of human interactions and has been studied extensively by means of social dilemmas (Dawes, 1980; Dawes & Messick, 2000; Kollock, 1998). In social dilemmas, individuals are faced with the choice between two options: They can either defect, thereby maximizing their own payoff, or they can cooperate, thereby maximizing collective payoffs. Social dilemmas are characterized by two properties (Van Lange, Joireman, Parks & Van Dijk, 2013): Defection is typically tempting for the individual because it yields individually superior outcomes. However, if all individuals defect, all are worse off than if they had all cooperated.

One recurring question in research on social dilemmas is which cognitive mechanisms drive decisions in these situations. Recently, it was proposed that intuition and reflection interact to produce decisions in social dilemmas (Rand, Greene & Nowak, 2012). More specifically, Rand and colleagues argued that a cognitive conflict exists between intuition and reflection (deliberation), such that "intuition supports cooperation … and … reflection can undermine these cooperative impulses" (p. 427). As a theoretical explanation, Rand, Peysakhovich et al. (2014) stated that cooperation is typically advantageous in the context of daily life interactions, and therefore leads to the formation of cooperative intuitions. These intuitions are generalized to other contexts, such as social dilemma experiments, resulting in spontaneous cooperative impulses in these situations as well. However, cooperation might not be advantageous at all in these new contexts, and reflection may override the initial cooperative impulse, adapting behavior towards the context specific optimum (defection).

Empirical studies designed to test the prediction of intuitive cooperation can be grouped into two categories: experimental manipulations designed to influence the degree to which people rely on intuition versus reflection in their decision, and correlational studies focusing on the relationship between process characteristics (such as response times) and decisions in social dilemmas.

Studies using *experimental manipulations* follow the idea that manipulations designed to foster the influence of intuition should increase cooperation, whereas manipula-

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tions designed to foster the influence of reflection should decrease cooperation. In line with this reasoning, asking participants to write about a situation where intuitive decision making had led them in the right direction increased contributions in a public goods game compared to a condition where participants had to write about a situation where careful reasoning worked out well (Rand et al., 2012, Studies 8 & 9). In addition, participants contributed more to a public good when they were forced to decide quickly (i.e., under time pressure) than when they were instructed to reflect and to decide slowly (Rand et al., 2012, Studies 6 & 7). However, in another series of experiments no effect of time pressure on cooperation was found (Tinghög et al., 2013), leading to an ongoing controversy about the stability and potential moderators of this effect (Rand, Greene & Nowak, 2013; Rand & Kraft-Todd, 2014; Rand, Newman & Wurzbacher, in press; Rand, Peysakhovich et al., 2014; Verkoeijen & Bouwmeester, 2014). One possible caveat concerning time pressure may be that, rather than increasing the influence of intuition, time pressure may lead to an increase in guessing[1] or a decrease in the amount of information searched (from givens or from memory)—neither of which necessarily foster cooperation.

In addition to experimental manipulations, research investigating the link between intuition and cooperation has also examined the process characteristics of decisions (Rand et al., 2012). These process characteristics are taken as indicators for the degree to which a decision was intuitive. If the hypothesis put forward by Rand and colleagues holds, there should be a positive relationship between cooperation and indicators of intuition. So far, studies have focused on one specific attribute of the process, namely speed.[2] The basic assumption is that intuitive responses are faster than reflective responses (Kahneman, 2011). In line with their hypothesis that cooperation is intuitive, Rand and colleagues (2012) report that faster decisions were more cooperative than slower decisions across several studies. For example, response time negatively predicted contributions to a public good (Studies 1 & 5). Similarly, response time was negatively associated with the probability of cooperative choices in different variants of the prisoner's dilemma game (Studies 2–4).

Evidence on the relationship between response time and cooperation is, however, also not consistent in the literature. In line with Rand et al. (2012), several other studies reported a negative relationship between response time and cooperation in public goods games (Lotito, Migheli & Ortona, 2013; Nielsen, Tyran & Wengström, 2014). Yet, the opposite pattern was found in a dictator game in which faster participants made more egoistic choices (Piovesan & Wengström, 2009). A more complex relationship between response time and cooperation was found in studies assessing the social value orientation of participants, where individualists had shorter response times than both cooperators and competitors (Dehue, McClintock & Liebrand, 1993; Fiedler, Glöckner, Nicklisch & Dickert, 2013; Liebrand & McClintock, 1988). In their recent working paper, Evans, Dillon, and Rand (2014) find evidence for an inverted-U relationship between response time and cooperation in both the public goods game and the prisoner's dilemma game in two studies and a meta-analysis. They conclude that "self-paced reaction times should not be treated as a direct proxy for the degree of reflection [vs. intuition], as other psychological variables may also influence decision speed" (p. 29, brackets added). Indeed, although it is commonly assumed that intuitive processes are fast, short response times could well be produced by mechanisms other than intuition (e.g., very limited information search or pure guessing).

Part of the difficulty, we conjecture, lies in the reliance on theoretical constructs that are insufficiently specified on the level of testable cognitive processes (Glöckner & Witteman, 2010). Specifically, it is difficult to test a dissociation between intuitive and deliberative processing because these are rather vague labels (Gigerenzer, 1998) that have been understood to mean quite different things (Keren & Schul, 2009). For example, some have implied that intuition drives the use of heuristics (Gigerenzer, 2007; Kahneman, 2003)—and thus strategies for effort reduction (Shah & Oppenheimer, 2008)—whereas others equate intuition with effortless integration of large amounts of information (Betsch & Glöckner, 2010; Hogarth, 2001; Seligman & Kahana, 2009) and thus quite the opposite of what effort-reducing heuristics do (Hilbig, Scholl & Pohl, 2010). Also, in-depth analyses imply that there may be some gradual differences rather than distinct modes of thinking (Horstmann, Ahlgrimm & Glöckner, 2009). Finally, even though intuitions are often understood to be fast, one cannot assert that fast processes are intuitive and it has also been argued that some intuition can be notably slow and time-consuming (Dijksterhuis & Nordgren, 2006). In summary, the intuitive-reflective-dichotomy makes it difficult to test the underlying theoretical idea of Rand et al. (2012).

Thus, rather than trying to test a dissociation between intuition and deliberation per se, it seems prudent to rely on specific process measures that can be used to test the proposed relationship. That is, one can focus on process variables for which the assumptions made by Rand et al.

[1] Rand, Peysakhovich et al. (2014) however suggest that the effect of time pressure on cooperation in Rand et al. (2012) cannot be explained by more random behavior in the time pressure condition, as the average contribution in this condition is not closer to 50% (which should result from random behavior) compared with the time delay condition.

[2] Recently, text analyses of open ended survey responses have also been used to investigate the relationship between intuition and cooperation in social dilemmas (Rand, Kraft-Todd & Gruber, 2014; Roberts et al., 2014).

(2012) make clear-cut predictions, independent of the labels intuition and deliberation. One such process characteristic is the cognitive conflict involved in making a decision. If cooperation is the "effortless", "spontaneous", "initial" or "intuitive" response (Rand et al., 2012), defection should entail more cognitive conflict than cooperation. To measure cognitive conflict one can employ a recently proposed and promising method: the analysis of response dynamics. Response dynamics provide researchers with implicit measures of the growth of a preference leading up to the decision (Koop & Johnson, 2011; Spivey & Dale, 2006). From this method, measures for cognitive conflict can be derived. In the following, we will briefly introduce the logic of response dynamics and report an experiment applying this type of measure to social dilemma choices.

1.1 Response dynamics

The basic response dynamics paradigm for computerized experiments involves the continuous tracking of mouse movements while participants choose between options that are spatially separated on a screen (also referred to as mouse-tracking; Freeman & Ambady, 2010). The assumption behind the paradigm is that cognitive processing is continuously revealed in motor movements (Spivey & Dale, 2006). More specifically, it is assumed that mouse movements reveal the tentative commitments to the different choice options during the decision process (Freeman, Dale & Farmer, 2011). In that sense, an option that is strongly considered at one point during the decision process exerts a "pull" of the mouse movement in the direction of this option. Therefore, the mouse movement as a whole (the so-called response trajectory) and different measures derived from it can be used to draw inferences about the cognitive processes that take place during the formation of the decision (Koop & Johnson, 2011).

One property of the response trajectory that is of particular interest for our purposes is its curvature. The basic idea is that the more seriously an ultimately non-chosen option is considered during the decision process, the more will the trajectory deviate in direction of this option. In other words, the degree of curvature represents the spatial attraction towards the non-chosen option (Freeman & Ambady, 2010; Spivey & Dale, 2006), which can be taken as a proxy of the overall degree of cognitive conflict. An early experiment by Spivey, Grosjean, and Knoblich (2005) validates this interpretation. Participants were repeatedly asked via headphones to click on one of two images displayed on the screen (e.g., "Click the candy."). The requested object ("candy") was paired with a distractor that was either phonologically similar (e.g., "candle") or phonologically dissimilar (e.g., "jacket"). As expected, response trajectories were more curved towards the distractor if the distractor was phonologically similar, suggesting that the increased curvature was caused by the increasing attraction of the distractor in this condition. More recently, a validation study of the response dynamics paradigm was also provided for the area of preferential choice (Koop & Johnson, 2013, Experiment 1). In a series of trials, participants had to indicate which of two images they preferred. Importantly, images were selected from a well-normed set of stimuli (International Affective Picture System; Lang, Bradley & Cuthbert, 2008), and the a priori difference in pleasantness of the pictures in a pair was varied continuously. As expected, the curvature of the response trajectories increased with increasing similarity in pleasantness, validating the interpretation that curvature reveals the competition between choice options for the domain of preferential choice.

Both behavioral and neurophysiological evidence has corroborated the assumptions behind the response dynamics approach (Spivey, 2007). Following the pioneering work by Spivey et al. (2005), the paradigm has been successfully applied to a variety of cognitive domains, including language, social cognition, and learning (see Freeman et al., 2011, for a review). More recently, response dynamics have also been used to study judgment and decision making processes (Dshemuchadse, Scherbaum & Goschke, 2013; Koop, 2013; Koop & Johnson, 2011, 2013). However, to the best of our knowledge, no study has considered response dynamics as process indicators in social dilemma decision making.

The experiment reported below takes advantage of the response dynamics paradigm to test a hypothesis derived from the theoretical framework by Rand et al. (2012) that considers cooperation as the spontaneous response in social dilemmas. Building on the previously outlined theoretical and empirical arguments, we expect a main effect of decision (cooperation vs. defection) on cognitive conflict (as indicated by the curvature of mouse trajectories) in social dilemmas. More specifically, defection should entail more cognitive conflict (greater curvature) than cooperation.

1.2 Individual differences

In their studies, Rand et al. (2012) observed that the notion of intuitive cooperation appears to hold for some individuals, whereas both intuition and reflection lead to little cooperation for other individuals. Consequently, Rand et al. have stressed the importance of identifying individual difference factors that might moderate the effect. Indeed, it has been emphasized that one should not only test for effects on the aggregate but also consider to what extent an effect holds per individual—both in judgment and decision making research and experimental psychology in general (Baron, 2010). Optimally, then, such interindividual variation in the effect could also be explained by some moderating factor. Therefore, an additional goal was to investigate whether there are between-participant differences in the hypothesized relation between decision and cognitive conflict, and if so, to explain these through moderating factors.

Regarding the relationship of intuition and cooperation, two moderating factors have been uncovered so far, namely (a) the cooperativeness of interaction partners in daily life and (b) prior experience with laboratory experiments. Faster responses were found to be positively related to cooperation only for individuals who reported having many cooperative daily-life interaction partners (Rand et al., 2012). Besides, time pressure increased cooperation only for individuals who had little prior experience with laboratory experiments (Rand, Peysakhovich et al., 2014) and were thus arguably less often exposed to situations in which defection is positively reinforced. An additional study that assessed both factors in combination even showed evidence for an interaction, namely, that time pressure increased cooperation only when participants both had little prior experience with economic games and reported to have mainly cooperative interaction partners (Rand & Kraft-Todd, 2014).

Although these specific factors fit nicely with the reasoning of Rand, Peysakhovich et al. (2014), they refer more to prior experiences than to individual differences in the sense of basic, dispositional tendencies such as personality traits. However, it is straightforward to predict that personality traits reflecting cooperativeness and pro-social tendencies should explain the difference in cognitive conflict when people defect versus cooperate. Dispositionally cooperative individuals should be particularly inclined to cooperate spontaneously and their decisions should be characterized by particularly strong conflict whenever they defect. In other words, especially for highly cooperative individuals a large positive difference in cognitive conflict between defection and cooperation should be expected. In turn, the overall hypothesized effect (that cooperation yields less conflict) may diminish or even reverse for dispositionally uncooperative individuals.

One personality trait that specifically reflects dispositional cooperativeness is the Honesty-Humility (HH) factor of the HEXACO personality model (Ashton & Lee, 2007; Ashton, Lee & de Vries, 2014). HH is defined as the "tendency to be fair and genuine in dealing with others, in the sense of cooperating with others even when one might exploit them without suffering retaliation" (Ashton & Lee, 2007, p. 156). In line with this definition, HH has been found to predict cooperation in a variety of paradigms from behavioral economics ranging from the dictator game (Hilbig & Zettler, 2009; Hilbig, Zettler, Leist & Heydasch, 2013) and social values (Ackermann, Fleiß & Murphy, in press; Hilbig, Glöckner & Zettler, 2014), to social dilemmas such as the public goods game (Hilbig, Zettler & Heydasch, 2012) and the prisoner's dilemma game (Zettler, Hilbig & Heydasch, 2013).

Table 1: Formal payoff structure of the social dilemmas used in the current experiment. Each player chooses either to cooperate or to defect and the resulting payoff is displayed in the matrix (Player 1 | Player 2).

	Player 1	
Player 2	Cooperates	Defects
Cooperates	$R \mid R$	$T \mid S$
Defects	$S \mid T$	$P \mid P$

Note. R = reward, T = temptation, S = sucker, P = punishment.

Building on the theoretical definition of HH and corresponding empirical findings, HH should predict between-participant variation in the hypothesized effect of decision on cognitive conflict, that is, function as a moderator. Specifically, individuals high in HH should be particularly inclined to cooperate spontaneously and should find it more difficult to counteract this impulse when ultimately deciding to defect. In other words, the difference in conflict between defection and cooperation decisions should be larger for individuals high in HH. For their counterparts low in HH, this difference should be considerably smaller or it might even reverse.

2 Method

The hypotheses outlined above were tested in a fully incentivized lab experiment, where participants played simple two-person social dilemma games with the two options cooperation and defection. Depending on the combination of players' choices, the individual payoff varied following a specific payoff structure. (See Table 1 for the general structure.) If both players cooperated, both received the same payoff called reward (R). Similarly, if both players defected, both received an inferior payoff called punishment (P). If one player cooperated but the other defected, the cooperative player received the sucker's payoff (S) while the defecting player received the payoff called temptation (T). By modifying the order of the different payoffs, different types of social dilemmas were created such that different motivations for cooperation versus defection existed.

To increase variation in cooperation rates, three different types of social dilemma games were implemented. First, the prisoner's dilemma game (PDG; Rapoport & Chammah, 1965) was used ($T > R > P > S$), in which two mechanisms—temptation ($T > R$) and fear ($P > S$)—motivate defection. Second, the chicken game (Rapoport & Chammah, 1966) was employed ($T > R > S > P$), where temptation still motivates defection ($T > R$), but fear is no longer present ($P < S$). Third, the stag hunt game (Gächter, 2004) was used ($R > T = P > S$), where fear motivates defection ($P > S$), but temptation is no longer present ($T < R$). All three game types have in common the previously outlined characteristics of a social dilemma (Van Lange et al., 2013). That is, in each game, there is a non-cooperative option that is (at least sometimes) more attractive for the individual than the cooperative option. However, if both individuals decide to pursue this non-cooperative option, they end up worse off than if they had both cooperated ($R > P$ for all three game types).

For the experiment, we constructed five variants of each of the three previously described game types. Within each game type, the cooperation index (Rapoport & Chammah, 1965; Vlaev & Chater, 2006) was held constant and only the specific payoff values were varied, meaning that the relative attractiveness of cooperation versus defection did not differ across variants. All payoff matrices used in the current experiment can be found in Appendix A.

2.1 Materials & procedure

Basic personality factors and the HH dimension in particular were assessed using the German version (Moshagen, Hilbig & Zettler, 2014) of the 60-item HEXACO-Personality-Inventory-Revised (HEXACO-60; Ashton & Lee, 2009; for further information on the inventory and all items see http://hexaco.org). To maintain the structure of the inventory, all 60 items—including those pertaining to personality factors not of interest here—were assessed and answered on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). However, in the analysis only the individual scores on the HH scale (i.e., individual means across the 10 items corresponding to this factor) were considered.[3] The internal consistency and descriptive statistics of this scale (Cronbach's α = .78, M = 3.31, SD = 0.64) were comparable to other samples using the German version of the HEXACO-60 (Moshagen et al., 2014) and its English counterpart (Ashton & Lee, 2009). The HEXACO-60 and a short demographic survey were administered either online at least 48 hours before the laboratory experiment (68% of participants) or directly before the laboratory experiment (32% of participants).[4]

After providing informed consent, participants worked on the social dilemma games (followed by other tasks not pertinent to the current investigation). The experiment was implemented in OpenSesame (Mathôt, Schreij & Theeuwes, 2012) and conducted full-screen with a resolution of 1680 x 1050 pixel. First, participants were familiarized with the general procedure. Specifically, they were told that they would play fifteen rounds and one of the other participants currently present would be randomly assigned to them as their interaction partner in each round. It was stressed that every pairing was anonymous and neither player would learn about the decision of the other. Once all fifteen decisions had been made, five of the fifteen rounds would be randomly selected and participants would be paid contingent on the outcome of these rounds (i.e., based on their decisions and the decisions of their interaction partners). Points were transformed into monetary payoffs with a rate of 0.50 € (approx. 0.70 USD) per 100 points. Next, participants were introduced to the structure of the games using an exemplary PDG payoff matrix. The consequences resulting from each combination of the players' choices were explained in detail. At the end of the instructions, participants made one practice decision without consequences followed by the fifteen consequential rounds. The order of these fifteen rounds was randomized between the experimental sessions; however, it was the same for all participants within the same experimental session.

To reduce noise in participants' mouse movements, a start screen was presented before each round. Participants had to click on the start button in the lower center of the screen to ensure that the starting position of the mouse cursor was comparable across trials (Freeman & Ambady, 2009, 2010).[5] On the decision slide, the payoff matrix was shown in the center of the screen (see Figure 1). Participants were instructed to choose an option by clicking on the corresponding box in the upper left ("Option A") or upper right ("Option B") corner of the screen. Throughout the experiment, these neutral option labels were used (instead of "cooperate" or "defect") to avoid socially desir-

[3] The items are reprinted with permission. * indicates reverse scoring.
I wouldn't use flattery to get a raise or promotion at work, even if I thought it would succeed.
If I knew that I could never get caught, I would be willing to steal a million dollars.*
Having a lot of money is not especially important to me.
I think that I am entitled to more respect than the average person is.*
If I want something from someone, I will laugh at that person's worst jokes.*
I would never accept a bribe, even if it were very large.
I would get a lot of pleasure from owning expensive luxury goods.*
I want people to know that I am an important person of high status.*
I wouldn't pretend to like someone just to get that person to do favors for me.
I'd be tempted to use counterfeit money, if I were sure I could get away with it.*

[4] This procedural difference had no significant influence on cooperation rates or average HH values. Also, the main results could be replicated when including the procedural difference as a factor in the analyses.

[5] After the start button was clicked, the cursor was relocated to the coordinates of the center of the start button to ensure that the starting position was exactly identical across trials.

Figure 1: Screenshot of a decision slide used in the experiment (with enlarged font size and original relative distances preserved). Original instructions were in participants' native language (German).

able responding (e.g., Moshagen, Hilbig & Musch, 2011). Whether the cooperative choice option was presented left (as "Option A") or right (as "Option B") was counterbalanced across participants to avoid presentation order effects (Hehman, Stolier & Freeman, in press). In addition to the choice and response time, the mouse trajectory (i.e., the x-, y-coordinates of the cursor) was recorded at a rate of 100 Hz (higher than or comparable to other mouse-tracking applications; Freeman & Ambady, 2010; Koop & Johnson, 2011). Participants were not told that their mouse movements were recorded nor were they given special instructions regarding the movements of the mouse (Koop & Johnson, 2011, 2013).

2.2 Participants

Participants were recruited from a local participant pool. In total, 116 individuals participated in the experiment. Their age ranged from 18 to 36 years (*M* = 22.5, *SD* = 4.0), 79 were female, and 107 were students from various disciplines. On average, participants earned 2.56 € (approx. 3.50 USD) in the social dilemma game which lasted for about fifteen minutes. The obtained sample size yields high statistical power ($1 - \beta = .94$) to detect a small effect (*d* = 0.30) in a paired *t*-test given an α error probability of .05 (Faul, Erdfelder, Lang & Buchner, 2007).

3 Results

To assess whether the variability in participants' cooperation/defection decisions was sufficient, we first computed the individual cooperation rate per participant across all games. On average, participants cooperated in 58% of their decisions (*SD* = 19%). Inspection of the individual cooperation rates revealed that 115 participants (99% of participants) chose each option (cooperation and defection) in at least one of the fifteen rounds. The remaining participant always cooperated and was excluded from all further analyses.[6] In line with the notion that two mechanisms foster defection in the PDG but only one mechanism does so in each of the other games, participants cooperated less in the PDG (25%) than in the other games, as confirmed by a generalized linear-mixed model using a binomial link function,[7] z = -18.63, $p < .001$. In addition, the probability of cooperation was higher in the stag hunt game (86%) than in the chicken game (63%), z = 9.12, $p < .001$.

Next, we tested the first hypothesis that defection entails more cognitive conflict than cooperation. As a first descriptive indicator of conflict, we inspected the average response trajectories. Following previous studies employ-

[6]This was done to allow the use of simpler analysis methods (e.g., a paired *t*-test for our first hypothesis). However, all results were replicated using the complete dataset and more complex analysis methods (e.g., linear-mixed models) that allow for missing cells.

[7]The model was estimated using the glmer function of the lme4 package (Bates, Maechler, Bolker & Walker, 2014) in R (R Core Team, 2014).

Figure 2: Average time-normalized response trajectory per decision. Pixels indicate difference from horizontal screen center and lower end of screen respectively.

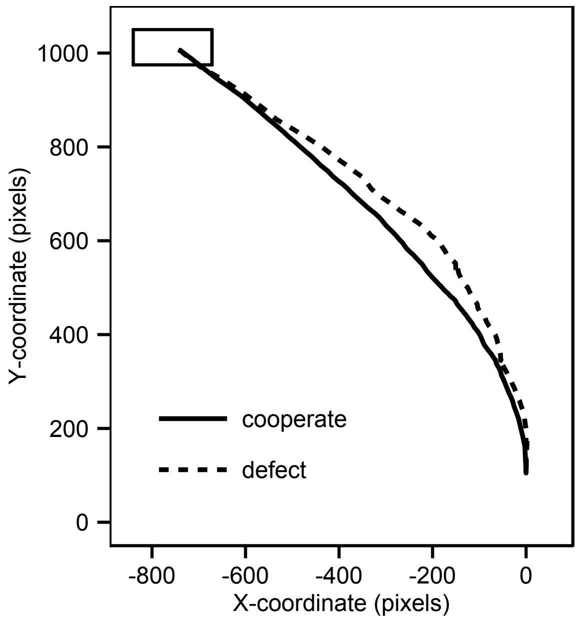
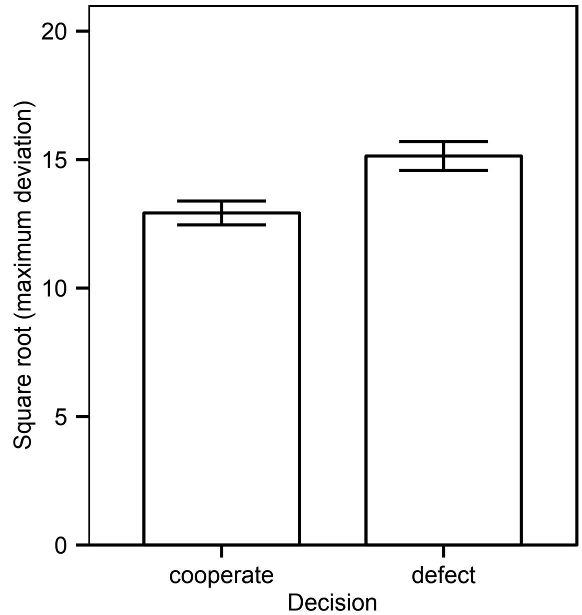


Figure 3: Mean (square root transformed) maximum deviation per decision. The error bars represent one standard error of the mean.



ing the mouse-tracking paradigm (e.g., Freeman & Ambady, 2010; Koop & Johnson, 2011; Spivey et al., 2005), we mapped all trajectories to one side, time-normalized trajectories into 101 time bins,[8] and aggregated them first within and then across participants separately for the different decisions. The resulting average trajectories for cooperation and defection are depicted in Figure 2. In line with the hypothesis, trajectories of defection decisions were characterized by a greater curvature and thus greater attraction towards the non-chosen option (cooperation) than vice versa.

To statistically test this curvature pattern, we calculated the maximum deviation (MD, in pixels) for each single trajectory. The MD is defined as the maximum perpendicular deviation between the actual trajectory and its idealized trajectory, which is the straight line connecting the trajectory's starting point and end point (Freeman & Ambady, 2010; McKinstry, Dale & Spivey, 2008). MD serves as an index of the maximum attraction towards the non-chosen option (Freeman & Ambady, 2010), and thus as an indicator of the maximum conflict during the decision. Whereas the following analyses use the MD towards the non-chosen option as dependent variable, Appendix B reports additional analyses based on other measures.

Given the skewness of the MD distribution, we square root transformed the MD values and used these values for all following analyses (but replicated all results using the untransformed MD values, see Appendix B). Next, we averaged the MD per decision and participant (Wojnowicz, Ferguson, Dale & Spivey, 2009). As can be seen in Figure 3, the mean MD was higher when participants defected ($M = 15.14$, $Mdn = 14.33$, $SD = 6.03$) than when they cooperated ($M = 12.92$, $Mdn = 12.31$, $SD = 4.98$). This difference was statistically significant in a paired t-test, $t(114) = 3.40$, $p < .001$, $d = 0.32$, hence confirming statistically the observed differences in the average response trajectories.[9]

Furthermore, we examined whether the effect of decision was robust across the different game types. For each game type, the qualitative pattern was as expected, as the mean MD was higher for defection than cooperation (see Table 2). As several participants did not choose both cooperation and defection at least once per game type, we analyzed the aggregated mean MD per participant, decision, and game type in a linear-mixed model using participants as random intercept and decision, game type, and their interaction as predictors.[10] As expected, there was a main effect of decision, $F(1, 434.84) = 15.58$, $p < .001$. Be-

[8]Potential initial phases without mouse movements were removed before time-normalization.

[9]Given the large amount of information participants needed to take into account in the task, their mouse trajectories might be prone to influences other than their preference developments, e.g., reading movements. To rule out that our results are somehow driven by these irrelevant mouse movements, we replicated the main results excluding trials with "reading" or highly chaotic movements. (See Appendix B for details on trial exclusion and results.)

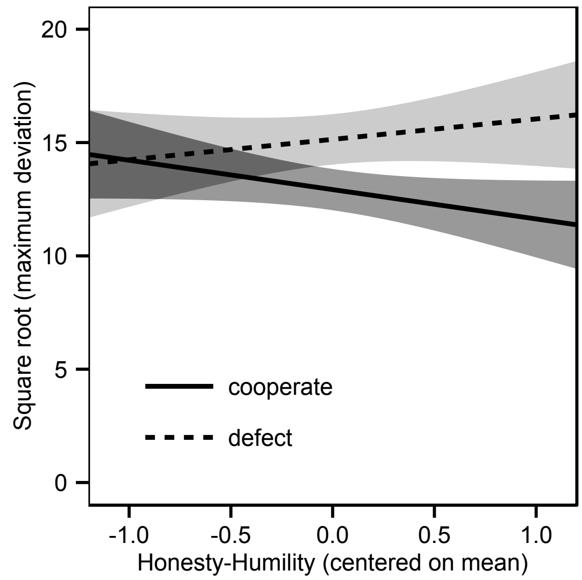
[10]p-values were obtained using the mixed function of the afex package (Singmann, 2014) in R (R Core Team, 2014), which calculates type 3 like p-values using the Kenward-Roger approximation for degrees-of-freedom.

Table 2: Mean (square root transformed) maximum deviation averaged per game type and decision.

	Decision					
	Cooperate			Defect		
Game type	*n*	*M*	(*SD*)	*n*	*M*	(*SD*)
Chicken	104	14.28	(6.68)	90	16.43	(8.19)
Prisoner's dilemma	63	11.75	(7.42)	109	14.15	(6.26)
Stag hunt	114	12.23	(5.65)	39	15.25	(8.62)

Note. The sample size per cell differs because not all 115 participants decided to both cooperate and defect in each game type.

Figure 4: Predicted mean (square root transformed) maximum deviation conditional on Honesty-Humility and participants' decision. Confidence bands represent the 95% confidence interval.



sides, there was a main effect of game type, $F(2, 425.99) = 5.82$, $p = .003$. Importantly, the interaction between decision and game type was not significant, $F(2, 428.30) = 0.16$, $p = .85$. Hence, defection decisions entailed more conflict than cooperation decisions regardless of the game type and thereby regardless of differences in the specific structure of the payoff matrix. Moreover, it is noteworthy that even in the game encompassing the lowest cooperation rates (25% cooperation in PDG) the mean MD for defection was significantly higher than for cooperation, $F(1, 89.31) = 6.54$, $p = .01$. Thus, even though defection was predominant on the choice level, cooperation still entailed less cognitive conflict than defection.

To investigate between-participant differences in the effect of decision on cognitive conflict, we computed the difference of mean MD between defection and cooperation per participant. Directly replicating our previous analysis, the mean difference of 2.22 was significantly greater than zero, $t(114) = 3.40$, $p < .001$, $d = 0.32$. However, as indicated by a *SD* of 6.99, there was also considerable variation in the size of the effect. Specifically, although the difference was positive for the majority of participants (63%), a substantial proportion of participants showed the reversed difference (37%).

To account for this variation across individuals we tested the hypothesized moderating factors as outlined above. First, we examined whether the overall cooperativeness of participants in the current study (as indicated by their individual proportion of cooperative choices across all trials) predicted the MD difference between cooperation and defection, and, as a more distal factor, we asked whether the individual HH scores predicted the MD difference. In line with expectations, both predictors significantly (positively) predicted the MD differences in separate correlational analyses ($r = .46$, $t(113) = 5.51$, $p < .001$, for cooperativeness, and $r = .20$, $t(113) = 2.18$, $p = .03$, for HH). As displayed in Figure 4, the relationship between mean MD and HH was as hypothesized: For individuals high in HH, defection yielded more conflict than cooperation; for their counterparts low in HH there was no such difference or even a tendency for the reversed effect.

Finally, we asked whether the effect of HH was actually driven by the situational cooperativeness of participants in the current study. To this end, we conducted a mediation analysis following the steps proposed by Baron and Kenny (1986). As reported above, HH predicted the difference score, $\beta = 0.20$, $t(113) = 2.18$, $p = .03$. In addition, HH also predicted cooperativeness, $\beta = 0.34$, $t(113) = 3.79$, $p < .001$. When including both HH and cooperativeness in a regression to predict the difference score, only cooperativeness was a significant predictor, $\beta = 0.44$, $t(112) = 4.98$, $p < .001$, whereas HH was no longer significant, $\beta = 0.05$, $t(112) = 0.58$, $p = .56$—thus confirming a full mediation. Correspondingly, the indirect effect of HH was statistically significant, Sobel's $Z = 2.98$, $p = .003$.[11] That is, the situational cooperativeness of participants in the current study mediated the effect of HH on the difference in cognitive conflict between defection and cooperation. In summary, these analyses help explain the substantial variation in the main effect across individuals.

[11] A path analysis using the lavaan package (Rosseel, 2012) in R (R Core Team, 2014) with bootstrap standard errors led to comparable results ($p = .002$ for indirect effect).

4 Discussion

In the current experiment, we tested a hypothesis derived from the recently proposed assumption that cooperation is intuitive in social dilemmas, whereas defection requires effortful deliberation (Rand et al., 2012). To this end, we presented a first application of the response dynamics paradigm (Koop & Johnson, 2011) to social dilemmas. Specifically, given that intuition and reflection are inherently difficult to tease apart because they represent a rather vague dichotomy, we tested a more specific implication: that defection should entail more cognitive conflict than cooperation as indicated by participants' mouse movements during the decision process. In line with this hypothesis, response trajectories were more curved (towards the non-chosen option) when individuals defected than when they cooperated. In other words, the cooperative option exerted more "pull" on mouse movements in case of defection than the non-cooperative option (defection) did in case of cooperation. This effect was robust across different types of social dilemmas and occurred even in the prisoner's dilemma where defection was predominant on the choice level. The effect of more conflict in defection held for the majority of individuals, but there was also notable interindividual variation in the effect. This interindividual variation could be accounted for by individuals' situational cooperativeness which, in turn, was driven by their dispositional cooperativeness in terms of the basic personality factor Honesty-Humility as specified in the HEXACO model (Ashton & Lee, 2007).

The current experiment extends previous research that has primarily focused on response times to examine the relationship between intuition and cooperation. Specifically, one main argument for the hypothesis that cooperation is intuitive stems from correlational studies demonstrating that shorter response times are associated with increased cooperation (Rand et al., 2012). However, such a negative relationship between response times and cooperation has not been consistently found in the literature, and recently it was argued that response times should not be taken as a direct indicator of intuitive versus reflective processing (Evans et al., 2014). The current experiment provides a solution for this problem by considering an alternative process variable—cognitive conflict—for which specific predictions can be derived based on the hypothesis that cooperation is the "spontaneous", "initial", "effortless" response in social dilemmas while defection requires effortful deliberation (Rand et al., 2012). Indeed, cooperation decisions entailed less conflict. This is also in line with growing evidence that prosocial behavior in general may stem from intuitive, reflexive, and automatic processes (see Zaki & Mitchell, 2013, for a short summary).

Moreover, the current experiment further specifies extant findings on interindividual variation in how much of a spontaneous, initial response cooperation tends to be (Rand, Peysakhovich et al., 2014). While previous studies have identified individual differences in terms of prior experiences as moderators (Rand et al., 2012; Rand & Kraft-Todd, 2014; Rand, Peysakhovich et al., 2014), we demonstrated the moderating influence of a basic personality trait. The HH factor of the HEXACO personality model has recently been identified as the basic trait driving active cooperativeness in various domains (for overviews see Ashton et al., 2014; Hilbig et al., 2014). Correspondingly, we found that particularly decisions of individuals high in HH were characterized by more cognitive conflict when defecting than when cooperating. Furthermore, the effect of HH was mediated by the situational cooperativeness of participants in the current study.

Finally, the current experiment demonstrates the usefulness of the response dynamics paradigm for investigating complex decision making tasks. Whereas earlier studies used the response dynamics paradigm primarily to investigate basic cognitive tasks with objectively correct response options, the paradigm has recently been extended to study complex decision making tasks that also include preferences (Koop & Johnson, 2011). In these studies, response dynamics have offered novel insights and availed tests for which existing response output data (i.e., choices and response times) were not sufficient—in areas such as risky decision making (Koop & Johnson, 2013, Experiment 2), moral decision making (Koop, 2013), and intertemporal choice (Dshemuchadse et al., 2013). We add to this recent development and extend the application of response dynamics to social dilemma decision making.

Nevertheless, the application of the response dynamics paradigm to more complex tasks without objectively correct response options also bears some methodological challenges. Previous research with basic cognitive tasks usually involved a correct or desired response option and the primary comparison dimension of the response trajectories could be experimentally manipulated (e.g., the phonological similarity of the distractor in the experiment by Spivey et al., 2005). By contrast, the current experiment involved preferences, and the final choice (cooperation vs. defection) constituted the comparison dimension of interest. This implies a loss of experimental control over the comparison dimension, because the frequency of each response type depended entirely on the participant. This dependence could result in missing cells and other analytical challenges (Koop & Johnson, 2013). To address this problem, we decided to not only rely on the classic social dilemma, the PDG, in which cooperation rates are typically low, but to also implement two additional social dilemmas that should render cooperation more likely. This modification was successful, as observations for both responses were obtained for all participants but one. Nevertheless, the comparison dimension of the response trajectories in our experiment was an observed predictor, not under full experimental control.

The amount of information that people needed to take into account when making their decision was also considerably larger in the current experiment than in previous applications of response dynamics. Nevertheless, in line with previous applications of response dynamics we refrained from instructing participants to move the mouse in a specific way (Koop & Johnson, 2011, 2013). As a consequence, several response trajectories in our dataset contained analysis-irrelevant mouse movements (e.g., "reading" movements). We accounted for this increased level of noise by performing the analyses both with the unfiltered dataset and after excluding trials with irrelevant mouse movements. Importantly, the results remained stable regardless of the criterion used for excluding trials (see Appendix B). Future studies could find procedural solutions to reduce the noise in the mouse movements, for example, by simplifying the task or by modifying the temporal order in which the task information is presented—similar to solutions used in other decision making applications of response dynamics (Dshemuchadse et al., 2013; Koop, 2013).

Finally, although the different curvatures of response trajectories for cooperation and defection decisions support the idea that cooperation is the spontaneous and less conflicting response in social dilemmas, they do not necessarily imply that there are actually two distinct systems (intuition and reflection)—as assumed by Rand et al. (2012)—that interact to produce decisions in social dilemmas (Horstmann et al., 2009). Instead, these response trajectory differences could also be explained by a single system assuming functional differences in the evidence accumulation process (see Dshemuchadse et al., 2013, for a similar argument in intertemporal choice). Future studies should address this problem, following Koop and Johnson (2011, 2013), who emphasized the potential of response dynamics for distinguishing between different model classes. A particularly promising approach is a recent study combining response dynamics and eye tracking that tested quantitative predictions derived from a simple evidence accumulation model for risky decision making (Koop & Johnson, 2013, Experiment 3). Future studies could use a similar approach to discriminate between different model classes and test their specific predictions for social dilemmas.

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Appendix A. Material

Table A1. Payoff matrices used in the current experiment.

Game type	*R*	*T*	*S*	*P*
Chicken	80	160	40	0
	90	180	45	0
	100	200	50	0
	110	220	55	0
	120	240	60	0
Prisoner's dilemma	80	160	0	40
	90	180	0	45
	100	200	0	50
	110	220	0	55
	120	240	0	60
Stag hunt	140	60	20	60
	158	68	23	68
	175	75	25	75
	193	83	28	83
	210	90	30	90

Note. Points were transformed into monetary payoffs with a rate of 0.50 € (approx. 0.70 USD) per 100 points. *R* = reward, *T* = temptation, *S* = sucker, *P* = punishment.

Table B1. Replication of main results for different dependent variables. Main effect of decision *(d)* and correlation between Honesty-Humility and difference score *(r)* are reported.

Variable	*d*	*r*
Square root transformed maximum deviation	0.32***	.20*
Untransformed maximum deviation	0.33***	.22**
Maximum absolute deviation	0.30***	.23**
Maximum x coordinate	0.34***	.19*
Number of directional changes along x-axis	0.35***	.19*
Number of crossings of y-axis	0.25**	.15

Note. Since both tests refer to directed hypotheses, *p*-values are one-tailed. * $p < .05$, ** $p < .01$, *** $p < .001$.

Appendix B. Additional analyses

To ensure that the reported results do not depend on the specific variable in the analyses (square root transformed MD), we repeated our analyses using a number of different measures. Specifically, we tested the main effect of decision (defection vs. cooperation) and the correlation between HH and the difference score (mean difference between defection and cooperation) for all alternative measures. The results are displayed in Table B1.

First, we replicated our results using the untransformed MD values. Next, we employed a different MD measure. Since we were interested in the maximum attraction towards the non-chosen option, we calculated the MD as maximum deviation towards the *non-chosen* option (i.e., with a lower bound of 0). However, previous studies have used the maximum absolute deviation assigning a minus to those trajectories that maximally deviated in the direction of the *chosen* option (Koop & Johnson, 2011; McKinstry et al., 2008). We replicated our results using the maximum absolute deviation. Besides, MD and maximum absolute deviation highly correlated in our dataset ($r = .97$ ignoring participants, $r = .96$ average correlation within participants).

Another concern about using a MD measure is that it is influenced both by movements in the direction of the x- and of the y-axis; however, specifically deviations in the x-axis direction are of interest here. Therefore, we repeated our analyses using the maximum x value of a trajectory as dependent variable. This variable also was highly correlated with the untransformed MD ($r = .94$ ignoring participants, $r = .89$ average correlation within participants) and the results were replicated.

In addition, it is an open question whether the results also generalize to variables that relate more closely to changes of mind or preference reversals. In this regard, Koop and Johnson (2013) distinguish between two measures. They propose that the number of directional changes along the x-axis represents reversals of the momentary valences, whereas the number of crossings of the y-axis (assuming that the y-axis is at the horizontal center of the screen) represents general reversals of preference. We repeated our analyses for these measures as well. Again, the results were replicated, although the effect of HH failed to reach a conventional level of statistical significance when using the number of crossings of the y-axis as dependent variable ($p = .051$, one-tailed).

Table B2. Replication of main results for different trial exclusion criteria using square root transformed maximum deviation as dependent variable. Main effect of decision *(d)* and correlation between Honesty-Humility and difference score *(r)* are reported.

Trial exclusion criterion	*d*	*r*
None (all trials)	0.32***	.20*
Moderate (15% of trials excluded)	0.27**	.16*
Strict (32% of trials excluded)	0.24**	.16*

Note. Since both tests refer to directed hypotheses, *p*-values are one-tailed. * $p < .05$, ** $p < .01$, *** $p < .001$.

Finally, we repeated our analyses applying different filter criteria that excluded mouse trajectories with potentially analysis-irrelevant mouse movements. Specifically, the individual trajectories were coded by an independent rater (blind to the purpose of this experiment and the decision of the participant), as to whether a trajectory likely involved “reading” movements (indicated by directed movements to one or more of the payoff matrix cells) or whether it displayed highly chaotic movements (e.g., several up and down movements). We repeated all analyses using a moderate (15% of trials excluded) and a strict (32% of trials excluded) criterion for exclusion, and analyzed the data for those participants for whom at least one cooperation and one defection decision remained. In both subsets, all results could be replicated, as can be seen in Table B2.