



Article

Fairness and Trust in Virtual Environments: The Effects of Reputation

Mirko Duradoni ¹, Mario Paolucci ² , Franco Bagnoli ³ and Andrea Guazzini ^{3,4,*} 

¹ Department of Information Engineering, University of Florence, Via Santa Marta 3, 50139 Firenze, Italy; mirko.duradoni@unifi.it

² Laboratory of Agent Based Social Simulation (LABSS), Institute of Cognitive Science and Technology (ISTC), National Research Council (CNR), Via Palestro 32, 00185 Rome, Italy; mario.paolucci@istc.cnr.it

³ Center for the Study of Complex Dynamics (CSDC), University of Florence, Via di San Salvi 12, 50135 Firenze, Italy; franco.bagnoli@unifi.it

⁴ Department of Education and Psychology, University of Florence, Via di San Salvi 12, 50135 Firenze, Italy

* Correspondence: andrea.guazzini@unifi.it

Received: 7 May 2018; Accepted: 2 June 2018; Published: 9 June 2018



Abstract: Reputation supports pro-social behaviors in a variety of social settings and across different ages. When re-encounters are possible, developing a positive reputation can be a valuable asset that will result in better outcomes. However, in real life, cooperative acts are ambiguous and happen in noisy environments in which individuals can have multiple goals, visibility is reduced, and reputation systems may differ. This study examined how reputation within a virtual environment affects fairness in material allocations and trust in information exchange, in a three-actors interaction game in which each player had an incentive to deceive the others. We compared the results of two experimental conditions, one in which informers could be evaluated, and one without reputational opportunities. A reputational system appeared to enhance both trust and fairness even within a virtual environment under anonymous condition. We tested adolescents and adults finding that they were consistently more generous when visibility was increased, but they showed significantly different patterns in resources allocation and information exchange. Male and female participants, across ages, showed other interesting differences. These findings suggest that reputational effects increase fairness and trust even in a noisy, ambiguous and uncertain environment, but this effect is modulated by age and gender.

Keywords: reputation; fairness; trust; virtual environment; social cognition

1. Highlights

- The introduction of a “Reputational System” promotes fairness during a web-based multiplayer social dilemma game.
- The reputation of an agent within the real environment of our experiment, appears to affect its “Social Influence” (i.e., the tendency of an interacting receiver of accept its suggestion) on the others, disregarding the real usefulness of its advices.
- A positive reputation of the interactor within our virtual environment is associated to a more coherent behaviour of the subject.
- According to age people presented different behavioral patterns about reputation management.
- Men and women were affected in different ways by reputational concerns.

2. Introduction

Fairness, trust and social influence dynamics have received an increasing attention in relation to virtual environments in latest years. In fact, these constructs appear to play a fundamental role in a plethora of virtual social interactions, e.g., e-market, virtual workgroups, crowdsourcing [1,2]. In virtual environments “reputational systems” have been widely used because of their capability to positively impact the aforementioned psychosocial dynamics. Nevertheless, a model explaining the potential impact of such systems in affecting online human dynamics, for instance within a social dilemma situation (i.e., where individuals have conflicting interests), is still missing.

Our study shows that in a virtual environment the introduction of a reputational system, structured to be independent and not affecting the goal given to the subjects, has a significant impact on the decision dynamics (i.e., the problem solving strategies) adopted by the players. In particular, when the reputational system was present we observed an increasing in the fairness and trust levels, as well as in the players’ average social influence on the others. We also found age-related differences in reputation usage (i.e., adolescents avoided asking information to bad and ambiguous reputed individuals), and management (i.e., adolescents obtained a lower level of reputation overall), while gender effects appeared quite small.

Reputation Effects on Prosocial Behaviors between Real and Virtual Environment

Fairness and trust are two important aspects of social interactions. A concern for relative payoffs between oneself and another individual, and the willingness to rely on someone’s help or suggestion are important aspects of social exchanges [3,4]. Understanding why and how humans act pro-socially is a challenging question, and several mechanisms have been proposed among which reputation has gained important recognition in the last decade [5–8]. Computational models [9,10], and laboratory experiments [11–13], emphasize the role of reputation as a motive supporting pro-social behaviours through indirect reciprocity [14]. Indeed, reputation allows to discriminate between pro-social and selfish individuals through informal and inexpensive social control [15–17], and thanks to gossip cheaters can be identified, and their selfish choices punished [18]. Interestingly, reputation still influences people’s decision making even when it comes from a complete unknown source and it is earned from an obscure situation [19]. Analogously, in online markets information sharing is a powerful means to build trust and enforce norms [20], and reputation systems based on online feedback mechanisms [21] make possible to have large scale interactions between complete strangers living in faraway places. Moreover, the information and communication technologies (ICT) revolution introduced brand new factors affecting trust and reputation dynamics impacting on both cyber communities as well as real ones [22–25]. In particular, very recent research highlights how a transaction could be completed in virtual environments because of reputation, even in the absence of any other enforcement [26].

Reputation can be considered as a collective phenomenon and a product of social processes [27], that goes well beyond single beliefs of impressions in the mind of any single individual. We can think of reputation as a product of natural evolution that equips human groups with a higher collective intelligence potential. In such sense, reputation is an evolutionarily stable strategy [17] that fosters the emergence and maintenance of pro-social behaviours. Not surprisingly, humans learn very early how to handle reputation during their development. The progressive achievement of a complete Theory of Mind [28,29], and the maturation of the reward system [30] might provide the bases for the development of a capacity to track others’ reputation and to manage one’s own. During ontogeny reputation management develops and people learn to use reputation in a more structured and strategic way [31]. For instance, adolescents unlike adults show high levels of trust but low reciprocity [32]. Moreover, reputation is a mechanism that acts on a pre-existing social structure characterized by roles and status. For this reason, men and women, could be influenced differently by reputation [33,34]. Previous literature about human interactions in virtual environment highlighted even how anonymity, physical isolation, low identifiability and group salience could affect social influence dynamics [35,36].

The interaction between these factors could lead to different outcomes, among which, when the social identity is salient, a greater adherence to local norms. Reputation represents a proxy for local norms [37]. Therefore, according to the Social Identity Model of Deindividuation Effects, anonymous individuals could be influenced more by reputation if the reference group's importance is stressed. Under these circumstances reputation's social influence should appear to foster more pro-social behaviours in virtual environment.

In the present work, we tested whether the introduction of a reputation system increased fairness in resource allocation, and whether there was an effect on trustworthiness and trust dynamics during the process of information provision, within adolescents and young adults. We developed a novel experimental paradigm, modifying a previous experiment by Feinberg et al. [38], in which reputation was implemented as the opportunity to like or dislike an Observer who could provide Receivers with suggestions about a deal proposed by a Donor. Receivers had only partial information about the deal (i.e., they knew the offer amount without be acknowledged about the requested amount), therefore a truthful suggestion from the Observer could help them make a more accurate/safety decision. An important detail of the game was that Observers do not get any direct or indirect benefits from providing wrong or right suggestions, even when they did not acknowledge the Receivers identity. In the experimental condition, we introduced the opportunity for Receivers to punish Observers by giving them bad evaluations as well as to reward them with positive feedbacks. Both the presence of a reputational mechanism within the game/setting, as well as the reputation level of the Observers should enhance the fairness and the trust within an anonymous virtual/cyber community.

Overall, the following are the main hypotheses tested in the present study:

Hypothesis 1. *The introduction of a "Reputational System" affects Donors' pro-social behaviour (i.e., fairness) in our web-based multiplayer social dilemma game.*

Hypothesis 2. *A positive reputation have a greater social influence upon the others than the other types of reputational status (i.e., negative, ambiguous) exerting more frequently trust-related behaviours (i.e., suggestion request, suggestion following).*

Hypothesis 3. *The age of the participants elicits different behavioural patterns about reputation management and usage.*

Hypothesis 4. *Men and women differ in reputation management skills.*

3. Experiment

3.1. Sampling

The research was conducted in accordance with the guidelines for the ethical treatment of human participants of the Italian Psychological Association (AIP). The participants were recruited with the snowball sampling strategy. All participants signed an informed consent and could withdraw from participation at any time.

The participants were 226 (108 female). All participants were volunteers and their anonymity was preserved through the use of nicknames during the game. All the participants completed the experiment. At the end of each experiment a debriefing session took place to give participants more information about the aims of the study, clarify their doubts and to identify participants who were able to guess the research hypothesis. Since none of the participants succeeded to identify the aims of the experiments, none of them has been excluded from the subsequent analysis.

3.2. Study 1

Participants (N = 154, 70 women; M = 15.7 years, SD = 1.3) recruited in a high school in the city of Prato (Italy) completed the study on a voluntarily basis with no monetary incentives. The testing

sessions were conducted in the computer lab inside the school. Instructions were read aloud by the experimenter and also shown on the participants' screens. Participants played in groups of six and each session lasted a maximum of 30 min.

3.3. Study 2

Participants (N = 72, 38 women; M = 22 years, SD = 3.7) recruited from the University of Florence completed the testing sessions in the computer lab of the Faculty of Psychology. Not differently from the study 1 participants, the subjects of the second study did not have monetary incentives. Instructions were read aloud by the experimenter and also shown on the participants' screens. Participants played in groups of six and each session lasted a maximum of 30 min.

The subjects' distribution across the two conditions is reported in Table 1.

Table 1. Number of participants in each condition divided according their sample type.

	Experimental Design			
	Reputation Treatment		Control Condition	
	Adolescents	Adults	Adolescents	Adults
Number of participants	78	36	78	36

4. Materials and Methods

All measures and manipulations of the studies are disclosed in the following section.

The Bargaining Game

The game consisted of 45 independent rounds, in which a Donor interacted with a Receiver and an Observer. Participants were anonymous and identified through nicknames. Participants played in groups of six, and each participant played all the roles of the game for fifteen times in a certain sequence determined by a computer program. The initial role for all the player was random. However, to minimize and standardize the influence of the tasks order upon players' problem solving we balanced the turn shifting (i.e., the same kind of action occurred after three turns). Overall, each participant interacted three times with every other group member in each role. We selected three matches to guarantee that two participants in each role could interact more than once, while maintaining the duration of the game sessions within 30 min. At the beginning of the game, each player was endowed with three kinds of resources, labelled Gold, Power, and Happiness, which were functionally equivalent. Among these resources, one was set equal to 50 units and the other two were set at a minimal level of 5 units each. According to this rule, resources were randomly distributed by the software at the beginning of the session, and the player with the highest amount of the minimum resource at the end of the game was the winner. So, if Player A had at the end of the 45 rounds 25 Gold, 13 Power and 17 Happiness and Player B had 10 Gold, 30 Power and 25 Happiness, Player A score will be represented by his amount of Power while for Player B the score will be calculated upon his quantity of Gold.

The players could see both their score and those of their opponents for the whole duration of the game. To prevent any influence upon participants' decision making resulting from the previous turns memories with a certain individual, players were not aware of which player they were interacting. In the game screens, the nicknames of the other players were omitted apart from the general ranking board. Thus, for instance, the Player A interacted with the Player B without knowing anything about him except his role. The only additional information about another player (i.e., the Observer) was constituted by his reputation in the Reputation Treatment condition. Not further information in both condition was permitted. We specify that once the players were appointed to one condition (i.e., Reputation Treatment or Control Condition) no shifting was allowed. Therefore, the players in the

Reputation Treatment had always at their disposal the Observers’ reputation, while the individuals in the Control condition never experienced this additional information.

Furthermore, to avoid any sort of “end game” effect participants in all conditions were unaware of the game session duration (i.e., number of rounds).

The players in each role had different tasks and goals (see Table 2).

Table 2. Summary of the actions played in the two conditions.

Roles	Reputation	
	ON	OFF
Donor	Offers her maximum resource and asks the Receiver her minimum resource	Offers her maximum resource and asks the Receiver her minimum resource
Observer	Has the opportunity to make a suggestion (accept or to decline) about the Donor’s offer and can receive a like or a dislike from the Receiver	Has the opportunity to make a suggestion (accept or to decline) about the Donor’s offer
Receiver	Accepts or declines the Donor’s deal with no additional information or asks for the Observer suggestion. Once the deal is completed the Receiver can rank the Observer’s suggestion with a like or a dislike.	Accepts or declines the Donor’s deal with no additional information or asks for the Observer suggestion.

The Donor’s task was to make an offer and a request to the Receiver. The Donor offers some amount of her greatest resource, among the three at her disposal, and asks in return some amount of her minimum resource to the receiver. Actual quantities were adjusted by means of sliders. The Receiver could only see the amount and type of the resource offered by the Donor, but was unaware of what and how much the Donor had asked in return. The Receiver could “accept” or “reject” the donor’s deal right away, or could require the Observer’s suggestion (by clicking on the “ask suggestion” button). The Observer had the opportunity to evaluate the Donor’s offer and request, knowing both the amount and the type of resources involved in the deal. In accordance with that information, the Observer could provide a hint to the Receiver, clicking on the button “suggest to accept”, “no hint” or “suggest to refuse”. The Observer had 10 s to make her choice. When the reputation system was active (in the so-called Reputation Treatment), the Receiver had access to the rating (i.e., the number of like and dislike accumulated) of the Observer. Once the offer is accepted or rejected, the Receiver becomes aware of the Donor request (i.e., deal information was shown on the player’s screen). If the Receiver accepted the deal than the resources were transferred otherwise were not. In the Reputation Treatment, if the Receiver had asked for the suggestion, she had the opportunity to give a like or a dislike to the Observer. Observers were not aware of the single evaluations received, nor of their overall reputation. The receiver had 18 s to make her decisions. More time was given to the Receivers as they could potentially perform more actions than the other roles (i.e., ask for a suggestion, decide on the deal, feedback Observers). For all the roles, if a decision was not made within the available time frame, default options were set by the computer.

The bargaining game was developed as a multiplayer virtual game implemented through Google Apps, using the Google Script programming language.

For clarity reasons, we combine the presentation of the results of the two studies.

5. Results

5.1. Data Analysis

The preconditions necessary to inferential analyses were verified on the data produced by the experiments. For all the continuous variables that were under investigation, the normality of

the distribution was assessed through the analysis of asymmetry and kurtosis values. When the distribution was not quasi Gaussian (i.e., skewness and kurtosis ranging between -1 and $+1$), a logarithmic transformation was applied. On continuous variables that do not respect the preconditions a discretization were made, using the median as a reference, and thus defining two levels for each variable. Because of the repeated measures structure of the experimental data, the inferential analyses were conducted using a general linear mixed model (GLMM) approach [39]. The difference in sample size has always been offset by either the type of data analysis or by random resampling through bootstrap method.

Descriptive Statistics

In Table 3 the descriptive statistics for both studies are presented, and they are visualized according to gender. The upper part of the table presents those variables that have been measured in both condition (i.e., Reputation Treatment and Control Condition), while the bottom part reports those that have been recorded in the Reputation Treatment.

Table 3. Descriptive statistics of all the game variables.

	Study 1		Study 2	
	Female	Male	Female	Male
	Average (s.d.)	Average (s.d.)	Average (s.d.)	Average (s.d.)
Amount offered	4.02 (2.0)	4.83 (2.1)	5.12 (2.2)	5.12 (2.2)
Amount requested	6.26 (4.1)	6.80 (3.9)	4.77 (1.7)	5.68 (3.6)
Diff. offered-requested	-2.3 (8.60)	-1.86 (9.11)	-0.04 (5.09)	-0.58 (7.56)
Suggestion (-1, 0, +1)	0.19 (0.84)	0.00 (0.88)	0.23 (0.88)	-0.15 (0.90)
Suggestion required (0, 1)	0.41 (0.49)	0.53 (0.40)	0.58 (0.49)	0.64 (0.48)
Acceptance (-1, 0, +1)	0.15 (0.94)	0.02 (0.94)	0.03 (0.98)	-0.27 (0.92)
Suggestion coherence (-1, +1)	0.19 (0.71)	0.23 (0.85)	0.27 (0.86)	0.27 (0.86)
Score	10.45 (8.39)	10.5 (3.62)	11.52 (7.16)	13.52 (8.80)
Variables related to the activation of the reputation system (Rep. On)				
Final reputation	-1.06 (2.55)	-0.56 (2.53)	2.54 (6.49)	1.86 (6.10)
Dislike/Like (-1, 0, +1)	10.7%/10.5%	15.7%/12.2%	9.7%/16.2%	18.5%/22.2%
Mean Like received	2.05 (1.0)	2.17 (1.3)	3.59 (1.8)	4.59 (2.9)
Mean Dislike received	2.29 (1.4)	2.27 (1.4)	2.11 (1.2)	3.62 (2.1)
Suggestion request coherence	46.5% (+)	41.5% (+)	46.8% (+)	57.7% (+)
Acceptance coherence	44.4% (+)	42.9% (+)	54.7% (+)	49.2% (+)
Feedback coherence	10.9% (+)	13.4% (+)	15.1% (+)	22.2% (+)

Amount offered: Quantity of the resource offered; **Amount requested:** Quantity of the resource requested; **Diff. offered-requested:** difference between the amount offered and requested in return by the Donors; **Suggestion:** to refuse (-1), no suggestion provided (0), to accept (1); **Suggestion required:** the Receiver did not request the Observer’s suggestion (0), the Receiver benefited of the Observer’s advice (1); **Acceptance:** The Receiver accepted the deal (1), refused the deal (-1) or did not take any action within the time limit (0); **Suggestion coherence:** The Observer provided a “good” suggestion (1) (i.e., suggested to accept a deal when the variable “Diff. offered-requested” is major or equal to 0, and to refuse a deal when “Diff. offered-requested” is smaller than 0), or a “bad” suggestion (-1); **Score:** The quantity of the minimum resource for each player; **Final reputation:** Difference between the number of the positive feedbacks (i.e., like) and the negative ones (i.e., dislikes); **Dislike/Like:** The Receiver rated with a like (1), a dislike (-1) or did not take any action within the time limit (0); **Mean Like received:** Average of the likes received by the players; **Mean Dislike received:** Average of the dislikes received by the players; **Suggestion request coherence:** The Receiver requested the suggestion when paired with a good rated Observer (+); **Acceptance coherence:** The Receiver followed the suggestion received by a good rated Observer (+); **Feedback coherence:** The Receiver rated positively an Observer who provided a “good” suggestion and negatively an Observer who gave a “bad” advice (+).

5.2. Manipulation Check

We operationalized fairness as the difference between offers and requests and we asked whether introducing an evaluation of the Observer, as a proxy for reputation, could affect participants’ behaviors. The answer is yes, and this happened both in the resource exchange part of the game,

and in the information exchange (i.e., feedback actions). When reputation was on, Donors' offers were characterized by a larger positive difference between the donation and the request (Table 4). To evaluate information sharing, we termed "prosocial" a useful suggestion from the Observer and the consequent like by the Receiver, and "antisocial" a wrong suggestion. Receivers can be antisocial in two ways: either they dislike a correct suggestion (thus decreasing the Observer's reputation), or they like a wrong one. Figure 1 shows that during the game, and regardless of the presence of reputation mechanisms, the Observers were prosocial 50.6% of the times. Also, 15.2% of the likes received by the Observers were justified (i.e., prosocial), showing a cooperative use of this tool. The number of participants who did not provide an observation was marginal (23.3%), and not too different from the percentage of those giving antisocial suggestions (26.1%). Subjects did not provide a feedback to the observer's reputation in 72.4% of the interactions, while 12.4% of the times Receivers provided wrong feedbacks (giving a like to an Observer who suggested an unfair deal or the other way around). Overall, the introduction of reputation changed Donors' and Receivers' behaviors, even if only one player, the Observer, was subject to peers' evaluation.

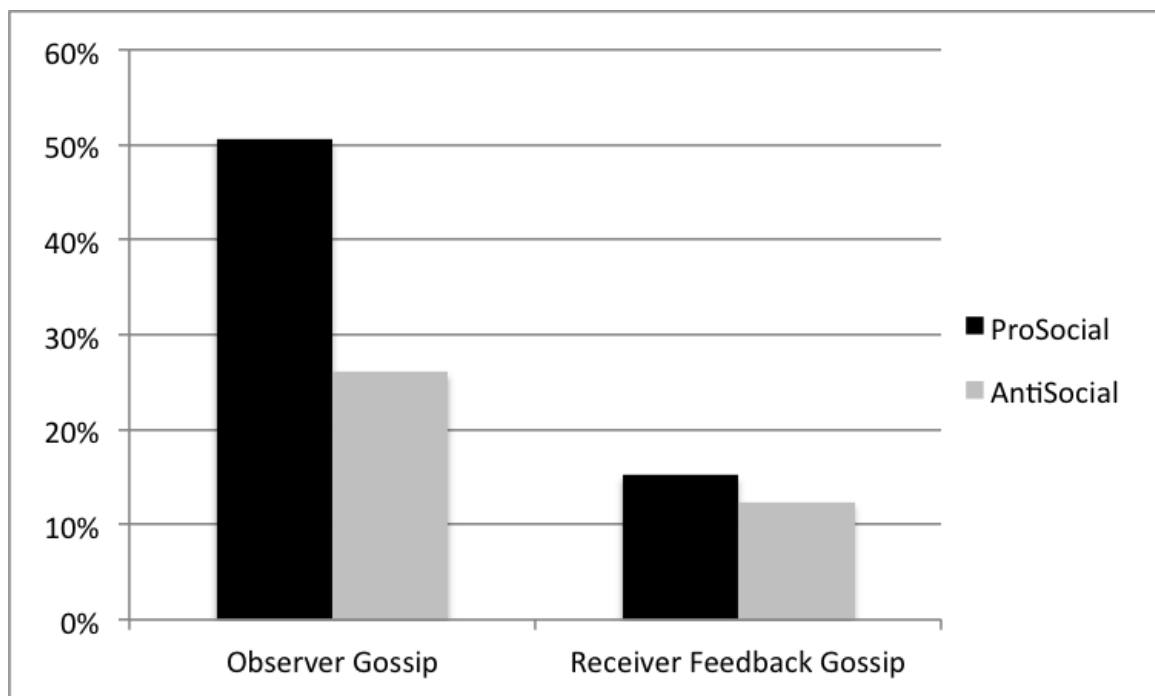


Figure 1. Distribution of the informative behaviors for both treatments. Percentage of pro-social and antisocial feedback for the Observers' advice and for the Receivers' feedback.

5.2.1. Hypothesis 1

Table 4 reports the results of the Generalized Linear Mixed Models (GLMM) analysis for the Donor role. Regarding the offers, we found a significant effect of Age and Gender, but also two interaction effects (i.e., Age*Gender, Condition*Gender). In general, the adolescents offered lower amounts than the undergraduates. Gender also played a role, with the females offering more than the males. Interestingly however, the males offered more without the reputation system and adolescent females appeared to offer less than their adult counterpart. Instead, no gender effects were found for the Donors' resource request behaviour, which was affected by Age and Condition. In particular, the adolescents demanded a larger amount of resources and the overall level of asked resources was higher when reputation was absent. However, when the reputation system was absent the adolescents reduced their demands.

Table 4. GLMM—Donor’s behaviours: Donation and Requested amounts and Fairness of the deals (CC: Control condition; RT: Reputation treatment; A: Adolescent; U: University Student; M: Male).

General Models					
Target	Akaike ¹	F	df(1)	df(2)	Precision
Donation ^d	65.002	52.01 ***	5	3151	55.7%
Requested ^d	66.209	4.11 ***	5	3155	54.3%
Fairness ^d	65.658	6.63 ***	5	3155	54.0%
Fixed Effects and Parameters-Donation ^d					
Parameter	F	B ²	Student t		
Age (A)	109.5 ***	−0.601	−10.64 ***		
Gender (M)	42.94 ***	−0.273	−4.41 ***		
Age(A)*Gender (M)	28.99 ***	0.639	9.71 ***		
Condition(CC)*Gender (M)	42.94 ***	0.337	5.38 ***		
Fixed Effects and Parameters-Requested ^d					
Parameter	F	B ²	Student t		
Age (A)	3.43 *	0.356	2.32 *		
Condition (CC)	4.52 **	0.526	3.18 ***		
Condition(CC)*Age (A)	11.46 ***	−0.601	−3.38 ***		
Fixed Effects and Parameters-Fairness ^d					
Parameter	F	B ²	Student t		
Age (U)	15.97 ***	0.662	4.66 ***		
Condition (RT)	19.70 **	0.670	4.38 ***		
Condition(RT)*Age (A)	13.32 ***	−0.599	−3.65 ***		

^d: Discretized with respect to the median; ¹: Correct Akaike coefficient; ²: Standardized coefficient; ***: $p < 0.001$; **: $p < 0.01$; *: $p < 0.05$.

Also, the analysis for the fairness of the deals (i.e., difference between the amount offered and the amount requested in return), did not show any gender effects. The average level of fairness seemed to be higher in the Reputation Treatment and among young adults. Surprisingly, the adolescents have sent unfair offers more frequently when the reputation system was present.

5.2.2. Hypothesis 2

To understand whether Receivers’ behaviors changed after the introduction of an evaluation on Observers, we carried out a Generalized Linear Mixed Models (GLMM) analysis. The final models about the reputation capability to influence the Receiver’s decision making are reported in Table 5.

The decision about asking for a suggestion resulted influenced by the interaction between the Reputation score and the Age of the participants. The adolescents payed more attention to the reputation of their partners, avoiding asking untrustworthy Observers. As regards the use of the reputational information to decide about the Donor’s deals (i.e., coherence of acceptance) we observed different patterns of compliance. Our participants relied on their partners’ reputation more often if this was positive, whereas when interacting with an illreputed Observer our participants trusted his/her suggestions significantly less. Finally, the tendency to leave a feedback resulted influenced by the Reputation level and by Gender. Observer with an ambiguous reputation were less frequently being evaluated. Furthermore, the males showed themselves more inclined to feedback their partner.

Table 5. Reputation (i.e., number of Like—number of Dislikes) influence final model. Suggestion required (Requested), Coherence on Acceptance (Coh. Acc.), Feedback (Feedback), Suggestion Followed (Followed) (0: Ambiguous reputation; -: Negative reputation; A: Adolescents; M: Male).

General Models					
Target	Akaike ¹	F	df(1)	df(2)	Precision
Requested ^d	47.359	12.99 ***	5	1598	58.3%
Coh. Acc. ^d	14.985	29.18 ***	1	473	77.1%
Feedback ^d	40.708	19.53 ***	3	798	60.6%
Followed ^d	22.580	14.66 ***	2	619	71.1%
Fixed Effects and Parameters-Requested ^d					
Parameter		F	B ²	Student t	
Reputation (0)*Age (A)		7.83 ***	−1.036	−4.36 ***	
Reputation (-)*Age (A)		7.45 ***	−0.360	−1.85 *	
Fixed Effects and Parameters-Coh. Acc. ^d					
Parameter		F	B ²	Student t	
Reputation (-)		29.18 ***	−1.258	−5.40 ***	
Fixed Effects and Parameters-Feedback ^d					
Parameter		F	B ²	Student t	
Reputation (0)		22.13 ***	−0.848	−5.41 ***	
Gender (M)		13.82 ***	0.432	7.72 ***	
Fixed Effects and Parameters-Followed ^d					
Parameter		F	B ²	Student t	
Reputation (0)		14.66 ***	−1.064	−4.35 ***	
Reputation (-)		14.66 ***	−1.039	−4.94 ***	

^d : Discretized with respect to the median; ¹: Correct Akaike coefficient; ²: Standardized coefficient; ***: $p < 0.001$; **: $p < 0.01$; *: $p < 0.05$.

5.2.3. Hypotheses 3 and 4

To test the effects of age and gender in relation to reputation management and usage we carried out new GLMM analyses. Obviously, such analyzes considered only the game sessions in the Reputation Treatment condition. The results are presented in Table 6.

Deciding whether to ask for a suggestion appeared influenced by the interaction between the reputation level of the Observer and the Age. The adolescents preferred not to ask Observers with a bad or an ambiguous (e.g., number of Like-number of Dislikes = 0) reputation, but were less inclined to provide a dislike to Observer who had already several, irrespective of their direct experience. Indeed, the adolescents tended to refrain from providing a feedback to Observers who already had a bad or an ambiguous level of reputation.

To take into account the effect of gender differences within and between the two samples and among the two conditions (i.e., Reputation Treatment and Control Condition), we run a set of GLMM. However, for those behaviours present only in the Reputation Treatment (i.e., Reputation level, Acceptance Coherence, Feedback) the GLMM considered only Gender, Age and their possible interaction effects as predictors.

Table 6. GLMM—Reputation (i.e., number of Like—number of Dislikes) and Age influence upon Suggestion request and Feedback behaviours (0: Ambiguous reputation; -: Negative reputation; A: Adolescents).

General Models					
Target	Akaike ¹	F	df(1)	df(2)	Precision
Requested ^d	47.359	12.99 ***	5	1598	58.3%
Feedback ^d	45.874	18.60 ***	5	1598	72.4%
Fixed Effects and Parameters-Requested ^d					
Parameter	F	B ²	Student t		
Reputation (0)*Age (A)	7.83 ***	-1.036	-4.36 ***		
Reputation (-)*Age (A)	7.5 ***	-0.360	-1.85 *		
Fixed Effects and Parameters-Feedback ^d					
Parameter	F	B ²	Student t		
Reputation (-)	19.33 *	0.407	1.95 *		
Age (A)*Reputation (-)	4.52 ***	-0.386	1.95 *		
Age (A)*Reputation (0)	4.52 ***	-0.929	-3.12 ***		

^d: Discretized with respect to the median; ¹: Correct Akaike coefficient; ²: Standardized coefficient; ***: $p < 0.001$; **: $p < 0.01$; *: $p < 0.05$.

The average level of reputation obtained by the Observers within the Reputation Treatment condition resulted to be affected directly by both Gender and Age and no interaction effects were found. The adolescents achieved a lower level of reputation while the females succeeded to obtain a higher reputation degree compared to the males (Table 7).

Table 7. GLMM—Observer’s behaviour: Reputation (i.e., number of Like—number of Dislikes) (A: Adolescent; M: Male).

General Models					
Target	Akaike ¹	F	df(1)	df(2)	Precision
Reputation ^d	33.184	52.01 ***	2	1600	65.0%
Fixed Effects and Parameters-Reputation ^d					
Parameter	F	B ²	Student t		
Age (A)	76.41 ***	-1.126	-7.29 ***		
Gender (M)	4.56 *	-0.398	-2.26 *		

^d: Discretized with respect to the median; ¹: Correct Akaike coefficient; ²: Standardized coefficient; ***: $p < 0.001$; **: $p < 0.01$; *: $p < 0.05$.

Participants’ gender and age affected the Receivers’ search for information (Table 8), with the adolescents and the females less likely to ask Observers for suggestions. The tendency to trust the suggestion (i.e., decide to accept the deal if the Observers suggest to the Receivers to accept it and to refuse the Donors’ offer if the hint received was to decline it) was also connected to Gender (both directly than by the interaction Gender*Condition) and Age: the adolescents trusted (called “Suggestion Followed”) the Observer’s suggestions less frequently while the females seemed to be more sensitive about the suggestion. Furthermore, when reputation was not present the males trusted the Observer’s information even less.

Table 8. GLMM—Receivers’ behaviours: Suggestion required (Requested), Coherence on acceptance (Coh. Acc.), Feedback (Feedback), Suggestion Followed (Followed) (A: Adolescent; M: Male; CC: Control condition).

General Models					
Target	Akaike ¹	F	df(1)	df(2)	Precision
Requested ^d	36.12	25.70 ***	2	3158	57.4%
Coh. Acc. ^d	33.161	2.64 *	1	1455	52.9%
Feedback ^d	32.647	9.82 ***	2	1598	72.4%
Followed ^d	59.884	32.48 ***	5	1653	57.6%
Fixed Effects and Parameters-Requested ^d					
Parameter		F	B ²	Student t	
Age (A)		52.32 ***	−0.664	−6.15 ***	
Gender (M)		20.41 ***	0.245	1.98 *	
Fixed Effects and Parameters-Coh. Acc. ^d					
Parameter		F	B ²	Student t	
Age (A)		6.63 **	−0.376	−2.41 *	
Fixed Effects and Parameters-Feedback ^d					
Parameter		F	B ²	Student t	
Age (A)		11.50 ***	−0.226	−1.97 *	
Gender (M)		17.99 **	0.676	3.59 ***	
Fixed Effects and Parameters-Followed ^d					
Parameter		F	B ²	Student t	
Age (A)		40.02 ***	−0.237	−3.62 ***	
Gender (M)		95.28 ***	−0.264	−3.87 ***	
Condition (CC)*Gender (M)		17.25 ***	−0.297	−4.15 ***	

^d: Discretized with respect to the median; ¹: Correct Akaike coefficient; ²: Standardized coefficient; ***: $p < 0.001$; **: $p < 0.01$; *: $p < 0.05$.

Nevertheless, trust in the reputation of the Observer to decide whether to accept or decline the offers (called “Acceptance Coherence”) did not result connected to Gender and only seemed to vary as a function of Age. The adolescents appeared to rely less on the Observer’s reputation when deciding about the Donor’s deal. Receivers could also leave feedbacks about Observers’ trustworthiness, deciding between no feedback, a positive one and a negative one. The males were more inclined to feedback the Observer with which they had interact compared to the females, while the adolescents were less prone to leave a feedback.

6. Discussion

When individuals experience “deindividuation” in an anonymous virtual group interaction, they rely more on reputation to orientate their own behaviors. Under such a psychological state, reputation appears to exert a greater social influence. In this sense, reputation seems able to promote pro-social behaviors (i.e., fairness), as well as to discriminate between social partners, exerting more trust-related behaviours (i.e., suggestion request, suggestion following) towards good-rated individuals. Differently from previous works on Prisoner’s Dilemma, in our game reputation levels (i.e., high, low and ambiguous) were treated differently by participants for orienting their choices [19].

Overall, our work contributes to the literature on the role of reputation in supporting fairness and trust-related behaviors by showing that reputational dynamics have a broad impact, changing individuals’ behaviors both directly and indirectly. Furthermore, some trends seem to suggest that

adolescents and undergraduates could have and rely on different behavioral patterns with regard to reputational concerns and usage.

Even in a competitive environment in which information can be strategically manipulated in order to increase one's scores, we observed a predominance of reliable suggestions from Observers, with and without reputational opportunities.

As pointed out by previous research, Donors in a social dilemma situation appear to be very sensitive to some game-related features and adjust their behaviour consequentially [40,41]. In our case, even if the Donors were not identified by any reputational score, they adjusted their behaviour when facing a virtual environment characterized by reputational mechanisms. Indeed, we observed how the Donors raised the amount of resources offered while they decrease their demands, thus increasing the fairness of the proposed deals.

Furthermore, the level of the acquired reputation (i.e., positive, negative, ambiguous) influenced the level of trust related behaviours shown by Receivers. Reliable partners were more often required for a suggestion and their prescriptions were more frequently followed. While generally, Observers with an ambiguous or a negative reputation had less influence on the Receivers' decisions.

Moreover, the reputation capability to exert an influence on trust behaviours within an anonymous virtual group, appeared almost entirely disconnected from gender, age and psychological features. This phenomenon could be account by the psychological state of "de-individuation" [42]. Indeed, the anonymity and the physical isolation of our virtual setting could have triggered such a state, and thus induced subjects to rely less on their individual characteristics, and more onto the set of local norms (i.e., reputation) to adjust their behaviour.

One striking aspect of our results is that reputational concerns worked even indirectly, through players' expectations. Donors became more generous because they expected Observers to be more reliable in the Reputation Treatment, even if Observers were not aware of their reputation and could not strategically increase or decrease it. This is a very interesting result which adds to the fairness literature on the effects of reputational concerns. When playing as Observers, participants did not care about their reputation, probably because they had no access to this information.

Although in the last few years the importance of reputation in supporting fairness and trust has been widely acknowledged (see [5,43] for two recently published reviews on the topic), the importance of individual factors, like age and gender, in reputation-mediated social interactions deserves more attention. The ontogeny of fairness and trust has received growing attention in recent years [44,45], and reputation management abilities appear relatively early in ontogeny [46], but less is known about the transition from adolescence into adulthood. During this period, two elements become characteristics in adolescents' behavior: the susceptibility to peer influence and the sensitivity to peer rejection, both mediated by reputation. Social approval and positive reputation might affect the development of self-processes, and perceived support from others can protect adolescents from stress and anxiety [47]. A growing body of research shows the existence of a link between reputation management and delinquency in adolescence [48], with adolescents actively engaging in the acquisition of a non-conforming social reputation. The search for social approval could explain why adolescents became unfairer when playing as Donors in the Reputation Treatment, but it could also explain why they were cautious with reputational information. Reputation is a safeguard against ostracism [49] but it also functions as a way of attaining higher status within the peer's group [48]. Adolescent behavior is motivated by social goals and purposeful reputation-enhancing strategies [50], because acquiring a reputation has also implications for how an adolescent regards herself. In such a context, adolescents in our game paid more attention to their partners' reputations, consistently avoiding asking untrustworthy Observers, but they also achieved a lower level of reputation overall. Our results highlight the importance of reputation and status during adolescence, showing that these concerns orient individuals' behaviors also in the lab. Further research is needed to understand the extent to which age interacts with the environment (competitive and cooperative), or with self-presentation issues which were ruled out by anonymity in the lab.

Another promising direction of research is on gender differences in fairness and trust-related behaviors, as in our study. The evidence on the topic is inconclusive, partially because different kinds of social preferences can explain it. Some studies suggested that women are more prosocial than men (e.g., [51,52]), but in a review paper by Croson and Gneezy [53] the inconsistencies between studies reporting opposite effects, or even no gender effects are revealed. The emergence of gender differences in social dilemmas could be mediated by a set of contextual factors [54], like mixed-sex vs. same sex dilemmas. Recent works reignited the debate by suggesting that women are more altruistic than men in the Dictator game [55,56]. Women are expected to behave more pro-socially than men and this may drive their allocation behavior. Nevertheless, in our work no gender effect was detected regarding fairness. In our study, women were more inclined to follow the Observers' suggestions, thus showing higher levels of trust (i.e., following actions). However, such behaviour of women could be differently interpreted, for example, by a lack of self-confidence or a greater tendency to pay more attention to the others' suggestions culturally promoted. Interestingly, women seemed to show better reputation management skills, gaining a more positive reputation during the game, even if previous research had reported different results [34]. In any case, the effect of gender does not seem to be too strong in ours experiments.

To conclude, our results illustrate that reputational concerns may promote pro-social choices even indirectly, and in ambiguous and noisy (i.e., virtual) environments, but also that fairness and trust are mediated within virtual environments and social dilemmas games by reputation. As in Shakespeare's words: *Reputation, reputation, reputation! Oh, I have lost my reputation! I have lost the immortal part of myself, and what remains is bestial. My reputation, Iago, my reputation!*

Author Contributions: The authors declare the following roles during the development of the present paper. Conceptualization, M.D. and A.G.; Methodology, A.G.; Software, F.B. and A.G.; Validation, M.P, A.G. and M.D.; Formal Analysis, M.P.; Investigation, M.D.; Resources, A.G. and F.B.; Data Curation, M.D.; Writing—Original Draft Preparation, M.D.; Writing—Review & Editing, M.D. and A.G.; Visualization, A.G.; Supervision, F.B.; Project Administration, M.D.; Funding Acquisition, F.B. and A.G.

Acknowledgments: A.G. and F.B. acknowledge partial financial support from European Commission (Grant No. FP7-ICT- 2013-10), Proposal No. 611299 SciCafe 2.0. F.B. Acknowledges support from CNR, Institute of Complex Systems, Experiment "Dynamics of Complex Systems". M.P. acknowledges partial financial support from EC project FuturICT 2.0 (FLAG-ERA JTC 2016). We want to thank Daniele Vilone for early comments on the project.

Conflicts of Interest: The authors confirm no conflict of interest.

References

1. Luse, A.; McElroy, J.C.; Townsend, A.M.; Demarie, S. Personality and cognitive style as predictors of preference for working in virtual teams. *Comput. Hum. Behav.* **2013**, *29*, 1825–1832. [[CrossRef](#)]
2. Perfumi, S.C.; Cardelli, C.; Bagnoli, F.; Guazzini, A. Conformity in virtual environments: A hybrid neurophysiological and psychosocial approach. In *International Conference on Internet Science*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 148–157.
3. Dawes, C.T.; Fowler, J.H.; Johnson, T.; McElreath, R.; Smirnov, O. Egalitarian motives in humans. *Nature* **2007**, *446*, 794. [[CrossRef](#)] [[PubMed](#)]
4. Fehr, E.; Schmidt, K.M. On inequity aversion: A reply to Binmore and Shaked. *J. Econ. Behav. Organ.* **2010**, *73*, 101–108. [[CrossRef](#)]
5. Milinski, M. Reputation, a universal currency for human social interactions. *Phil. Trans. R. Soc. B* **2016**, *371*, 20150100. [[CrossRef](#)] [[PubMed](#)]
6. Maurer, C.; Chambon, V.; Bourgeois-Gironde, S.; Leboyer, M.; Zalla, T. The influence of prior reputation and reciprocity on dynamic trust-building in adults with and without autism spectrum disorder. *Cognition* **2018**, *172*, 1–10. [[CrossRef](#)] [[PubMed](#)]
7. Trček, D. A Brief Overview of Trust and Reputation over Various Domains. In *Trust and Reputation Management Systems*; Springer: Berlin/Heidelberg, Germany, 2018; pp. 5–19.
8. Cook, K.S.; Santana, J.J. Trust and Rational Choice. In *The Oxford Handbook of Social and Political Trust*; Oxford University Press: Oxford, UK, 2018; p. 253.

9. Nowak, M.A.; Sigmund, K. Evolution of indirect reciprocity by image scoring. *Nature* **1998**, *393*, 573. [[CrossRef](#)] [[PubMed](#)]
10. Vilone, D.; Giardini, F.; Paolucci, M. Exploring Reputation-Based Cooperation. In *New Frontiers in the Study of Social Phenomena*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 101–114.
11. Beersma, B.; Van Kleef, G.A. Why people gossip: An empirical analysis of social motives, antecedents, and consequences. *J. Appl. Soc. Psychol.* **2012**, *42*, 2640–2670. [[CrossRef](#)]
12. Milinski, M.; Semmann, D.; Krambeck, H.J. Reputation helps solve the ‘tragedy of the commons’. *Nature* **2002**, *415*, 424. [[CrossRef](#)] [[PubMed](#)]
13. Piazza, J.; Bering, J.M. Concerns about reputation via gossip promote generous allocations in an economic game. *Evolut. Hum. Behav.* **2008**, *29*, 172–178. [[CrossRef](#)]
14. Nowak, M.A.; Sigmund, K. Evolution of indirect reciprocity. *Nature* **2005**, *437*, 1291. [[CrossRef](#)] [[PubMed](#)]
15. Giardini, F.; Conte, R. Gossip for social control in natural and artificial societies. *Simulation* **2012**, *88*, 18–32. [[CrossRef](#)]
16. Gluckman, M. Papers in honor of Melville J. Herskovits: Gossip and scandal. *Curr. Anthropol.* **1963**, *4*, 307–316. [[CrossRef](#)]
17. Ohtsuki, H.; Iwasa, Y. How should we define goodness?—reputation dynamics in indirect reciprocity. *J. Theor. Biol.* **2004**, *231*, 107–120. [[CrossRef](#)] [[PubMed](#)]
18. Ellickson, R.C.; Ellickson, R.C. *Order Without Law: How Neighbors Settle Disputes*; Harvard University Press: Cambridge, MA, USA, 2009.
19. Capraro, V.; Giardini, F.; Vilone, D.; Paolucci, M. Partner selection supported by opaque reputation promotes cooperative behavior. *Judgm. Decis. Mak.* **2016**, *11*, 589–600.
20. Diekmann, A.; Jann, B.; Przepiorka, W.; Wehrli, S. Reputation formation and the evolution of cooperation in anonymous online markets. *Am. Sociol. Rev.* **2014**, *79*, 65–85. [[CrossRef](#)]
21. Dellarocas, C. The digitization of word of mouth: Promise and challenges of online feedback mechanisms. *Manag. Sci.* **2003**, *49*, 1407–1424. [[CrossRef](#)]
22. Jabeen, F.; Hamid, Z.; Akhunzada, A.; Abdul, W.; Ghouzali, S. Trust and Reputation Management in Healthcare Systems: Taxonomy, Requirements and Open Issues. *IEEE Access* **2018**, *6*, 17246–17263. [[CrossRef](#)]
23. Fotia, L.; Messina, F.; Rosaci, D.; Sarné, G.M. Using Local Trust for Forming Cohesive Social Structures in Virtual Communities. *Comput. J.* **2017**, *60*, 1717–1727. [[CrossRef](#)]
24. Trček, D. Computational Trust and Reputation Management. In *Trust and Reputation Management Systems*; Springer: Berlin/Heidelberg, Germany, 2018; pp. 21–54.
25. De Meo, P.; Messina, F.; Rosaci, D.; Sarné, G.M. Combining trust and skills evaluation to form e-Learning classes in online social networks. *Inf. Sci.* **2017**, *405*, 107–122. [[CrossRef](#)]
26. Przepiorka, W.; Norbutas, L.; Corten, R. Order without law: Reputation promotes cooperation in a cryptomarket for illegal drugs. *Eur. Sociol. Rev.* **2017**, *33*, 752–764. [[CrossRef](#)]
27. Emler, N. A social psychology of reputation. *Eur. Rev. Soc. Psychol.* **1990**, *1*, 171–193. [[CrossRef](#)]
28. Apperly, I.A. What is “theory of mind”? Concepts, cognitive processes and individual differences. *Q. J. Exp. Psychol.* **2012**, *65*, 825–839. [[CrossRef](#)] [[PubMed](#)]
29. Baron-Cohen, S.; Leslie, A.M.; Frith, U. Does the autistic child have a “theory of mind”? *Cognition* **1985**, *21*, 37–46. [[CrossRef](#)]
30. Panksepp, J. Feeling the pain of social loss. *Science* **2003**, *302*, 237–239. [[CrossRef](#)] [[PubMed](#)]
31. Farmer, Y. Ethical Decision Making and Reputation Management in Public Relations. *J. Media Eth.* **2018**, *1*–12. [[CrossRef](#)]
32. Gutiérrez-Roig, M.; Gracia-Lázaro, C.; Perelló, J.; Moreno, Y.; Sánchez, A. Transition from reciprocal cooperation to persistent behaviour in social dilemmas at the end of adolescence. *Nat. Commun.* **2014**, *5*, 4362. [[CrossRef](#)] [[PubMed](#)]
33. Eagly, A.H.; Crowley, M. Gender and helping behavior: A meta-analytic review of the social psychological literature. *Psychol. Bull.* **1986**, *100*, 283. [[CrossRef](#)]
34. Jones, D.; Linardi, S. Wallflowers: Experimental evidence of an aversion to standing out. *Manag. Sci.* **2014**, *60*, 1757–1771. [[CrossRef](#)]
35. Postmes, T.; Spears, R.; Sakhel, K.; De Groot, D. Social influence in computer-mediated communication: The effects of anonymity on group behavior. *Personal. Soc. Psychol. Bull.* **2001**, *27*, 1243–1254. [[CrossRef](#)]

36. Spears, R.; Postmes, T.; Lea, M.; Wolbert, A. When are net effects gross products? *Communication. J. Soc. Issues* **2002**, *58*, 91–107. [[CrossRef](#)]
37. Baumeister, R.F.; Zhang, L.; Vohs, K.D. Gossip as cultural learning. *Rev. Gen. Psychol.* **2004**, *8*, 111. [[CrossRef](#)]
38. Feinberg, M.; Willer, R.; Stellar, J.; Keltner, D. The virtues of gossip: Reputational information sharing as prosocial behavior. *J. Personal. Soc. Psychol.* **2012**, *102*, 1015. [[CrossRef](#)] [[PubMed](#)]
39. McCulloch, C.E.; Neuhaus, J.M. *Generalized Linear Mixed Models*; Wiley Online Library: Hoboken, NJ, USA, 2001.
40. Calseyde, P.P.; Keren, G.; Zeelenberg, M. The hidden cost of insurance on cooperation. *J. Behav. Decis. Mak.* **2017**, *30*, 1182–1192. [[CrossRef](#)]
41. Lenton, P.; Mosley, P. Incentivising trust. *J. Econ. Psychol.* **2011**, *32*, 890–897. [[CrossRef](#)]
42. Postmes, T.; Spears, R. Deindividuation and antinormative behavior: A meta-analysis. *Psychol. Bull.* **1998**, *123*, 238. [[CrossRef](#)]
43. Wu, J.; Balliet, D.; Van Lange, P.A. Reputation management: Why and how gossip enhances generosity. *Evol. Hum. Behav.* **2016**, *37*, 193–201. [[CrossRef](#)]
44. Warneken, F.; Hare, B.; Melis, A.P.; Hanus, D.; Tomasello, M. Spontaneous altruism by chimpanzees and young children. *PLoS Biol.* **2007**, *5*, e184. [[CrossRef](#)] [[PubMed](#)]
45. Benenson, J.F.; Pascoe, J.; Radmore, N. Children's altruistic behavior in the dictator game. *Evol. Hum. Behav.* **2007**, *28*, 168–175. [[CrossRef](#)]
46. Leimgruber, K.L.; Shaw, A.; Santos, L.R.; Olson, K.R. Young children are more generous when others are aware of their actions. *PLoS ONE* **2012**, *7*, e48292. [[CrossRef](#)] [[PubMed](#)]
47. Wentzel, K.; Fillisetti, L.; Barry, C.M. Prosocial behavior. In *Encyclopedia of Adolescence*; Springer: Berlin/Heidelberg, Germany, 2011; pp. 2188–2195.
48. Carroll, A.; Houghton, S.; Durkin, K.; Hattie, J.A. Establishing and Maintaining Reputations through Risk-Taking Behavior. In *Adolescent Reputations and Risk*; Springer: Berlin/Heidelberg, Germany, 2009; pp. 89–104.
49. Williams, K.D. Ostracism. *Ann. Rev. Psychol.* **2007**, *58*. [[CrossRef](#)] [[PubMed](#)]
50. Emler, N.; Reicher, S. Delinquency: Cause or consequence of social exclusion. In *The Social Psychology of Inclusion and Exclusion*; Psychology Press: London, UK, 2005; pp. 211–241.
51. Mesch, D.J.; Rooney, P.M.; Steinberg, K.S.; Denton, B. The effects of race, gender, and marital status on giving and volunteering in Indiana. *Nonprofit Volunt. Sect. Q.* **2006**, *35*, 565–587. [[CrossRef](#)]
52. Willer, R.; Wimer, C.; Owens, L.A. What drives the gender gap in charitable giving? Lower empathy leads men to give less to poverty relief. *Soc. Sci. Res.* **2015**, *52*, 83–98. [[CrossRef](#)] [[PubMed](#)]
53. Croson, R.; Gneezy, U. Gender differences in preferences. *J. Econ. Lit.* **2009**, *47*, 448–474. [[CrossRef](#)]
54. Balliet, D.; Mulder, L.B.; Van Lange, P.A. Reward, punishment, and cooperation: A meta-analysis. *Psychol. Bull.* **2011**, *137*, 594. [[CrossRef](#)] [[PubMed](#)]
55. Brañas-Garza, P.; Capraro, V.; Rascon-Ramirez, E. Gender differences in altruism on mechanical turk: Expectations and actual behaviour. *Econ. Lett.* **2018**, Forthcoming. [[CrossRef](#)]
56. Rand, D.G.; Brescoll, V.L.; Everett, J.A.; Capraro, V.; Barcelo, H. Social heuristics and social roles: Intuition favors altruism for women but not for men. *J. Exp. Psychol. Gen.* **2016**, *145*, 389. [[CrossRef](#)] [[PubMed](#)]

