Humans vs. Computers: Impact of Emotion Expressions on People's Decision Making

Celso M. de Melo, Jonathan Gratch, and Peter J. Carnevale

Abstract—Recent research in perception and theory of mind reveals that people show different behavior and lower activation of brain regions associated with mentalizing (i.e., the inference of other's mental states) when engaged in decision making with computers, when compared to humans. These findings are important for affective computing because they suggest people's decisions might be influenced differently according to whether they believe emotional expressions shown in computers are being generated by algorithms or humans. To test this, we had people engage in a social dilemma (Experiment 1) or negotiation (Experiment 2) with virtual humans that were either perceived to be agents (i.e., controlled by computers) or avatars (i.e., controlled by humans). The results showed that such perceptions have a deep impact on people's decisions: in Experiment 1, people cooperated more with virtual humans that showed cooperative facial displays (e.g., joy after mutual cooperation) than competitive displays (e.g., joy when the participant was exploited) but, the effect was stronger with avatars (d = .601) than with agents (d = .360); in Experiment 2, people conceded more to angry than neutral virtual humans but, again, the effect was much stronger with avatars (d = 1.162) than with agents (d = .066). Participants also showed less anger towards avatars and formed more positive impressions of avatars when compared to agents.

Index Terms—Human vs. Computers, Emotion Expression, Decision Making

1 Introduction

RECENT decades have seen a growing interest on the interepersonal effects of emotion in decision making [1], [2]. Researchers have now acknowledged that emotion expressions help regulate social interaction and serve important social functions such as communicating one's beliefs, desires, and intentions to others [3], [4], [5], [6]. These functions are important in decision making contexts where people look for cues that others might be willing to cooperate [7], [8], [9], [10] and emotion expressions are one such cue. Indeed, the social effects of emotion have now been reported in negotiation [11], [12], trust games [13], ultimatum games [14], public good dilemmas [15], dispute resolution [16], and daily life [17]. From a computational perspective, the impact of computers' emotion expressions on people's behavior has also been studied in pedagogical, video game, health and, to a less extent, decision making settings [18], [19]. Since computers are becoming more pervasive in society and people are engaging regularly in online or computer-mediated transactions, it is important we understand whether emotion expressions communicated by computers can impact people's decisions; in particular, do the interpersonal effects of emotion on people's decision making we see in human-human interaction carry to human-computer interaction?

To answer this question, we look at two contrasting theoretical perspectives. First, the "computers are social actors" theory [20], [21] argues that as long as machines display social cues (e.g., interactivity or nonverbal behavior) people will treat them in a fundamentally social manner. The argument is that people "mindlessly" treat computers that exhibit social traits like other people as a way to conserve cognitive effort and maximize response efficiency [22]. Mindlessness here can be best understood as the failure to draw novel distinctions [23], [24]. These automatic responses to contextual social cues trigger scripts and expectations, making active information processing impossible. Moreover, Sundar and Nass [25] assume that people not only respond mindlessly, but also have the tendency to use cognitive shortcuts and heuristics, and therefore use the easily accessible social rules from human-human interaction and apply them to human-computer interaction–due to the perceived functional similarity between humans and computers. Therefore, a strict interpretation of this theory predicts that emotion expressions by computers leads to the same social effects on people's decisions as emotion expressions by humans.

Blascovich et al.'s threshold model of social influence [26], [27] provides a different perspective. According to this theory, social influence will be greater the higher the perceived agency of the computer. Agency refers to people's theories of mind regarding the computer, i.e., the perceived mindfulness or sentience (e.g., attributions of consciousness, free will). In this sense, they distinguish between computers that are driven by humans, or *avatars*, and computers that are driven by computer algorithms, or *agents* [28]. Earlier findings in the human-computer interaction literature have shown that this distinction matters. These studies suggest people can experience, in certain contexts, higher social presence [29], [30], inhibition [31], learning [32], flow [33], arousal [34], [35] and engagement [30] with avatars than agents. In the context

- *C. M. de Melo is with the USC Marshall School of Business, Los Angeles, CA 90089-0808. E-mail: demelo@usc.edu.*
- *J. Gratch is with the USC Institute for Creative Technologies, 12015 Waterfront Drive, Building #4, Playa Vista, CA 90094-2536. E-mail: gratch@ict.usc.edu.*
- *P.J. Carnevale is with the USC Marshall School of Business, Los Angeles, CA 90089-0808. E-mail: peter.carnevale@marshall.usc.edu.*

of decision making, the theory thus predicts that, everything else being equal, people will be more likely to be influenced by humans (or avatars) than computers (or agents).

Research in the behavioral sciences on perception and theory of mind also support the contention that people treat computers differently than humans. In general, people seem to naturally attribute more mind to humans than computers or robots [36], [37]. In decision making settings, research in the emerging field of neuroeconomics shows that people systematically reach different decisions and show different patterns of brain activation with computers in the exact same decision making tasks, for the exact same financial incentives, when compared to humans. Gallagher et al. [38] showed that when people played the rock-paper-scissors game with a human there was activation of the medial prefrontal cortex (MPFC), which had previously been shown to be involved in mentalizing (i.e., inferring of other's beliefs, desires and intentions); however, no such activation occurred when people engaged with a computer that followed a predefined algorithm to make the choice. McCabe et al. [39] found a similar pattern when people played the trust game with humans in comparison to a probabilistic algorithm; Riedl et al. [40] further replicated this result with virtual humans, i.e., computers with three-dimensional virtual bodies and faces. In the prisoner's dilemma, Rilling et al. [41] and Krach et al. [42] showed that people tended to cooperate more with humans than computers and, once again, brain regions associated with mentalizing such as the MPFC, the rostral anterior cingulate cortex and the right temporo-parietal junction, were only activated with humans; in contrast, Kircher et al. [43] showed no difference in cooperation rates between humans and computers, despite reporting the usual increased brain activity with humans. In an influential paper, Sanfey et al. [44] showed that people were more willing to accept unfair offers in the ultimatum game from a computer than from a human. Moreover, their results revealed that the bilateral anterior insula–a region usually associated with the experience of negative emotions–showed higher activation when people received unfair offers from humans than from computers, thus suggesting that increased negative emotion explained the discrepancies in decision making behavior. Complementing this work, van't Wout et al. [45] showed that unfair offers in the ultimatum game led skin conductance–an autonomic index of affective state–to rise with humans but not with computers.

The goal of this paper is, thus, to study whether people's decisions when engaging with computers that communicate emotion expressions in social decision making tasks, for clear financial stakes, will differ according to people's beliefs about whether they are engaging with agents–i.e., the emotion expressions are driven by computer algorithms–or avatars–i.e., the emotion expressions are driven by humans. To accomplish this we present two novel experiments where people engaged in a social dilemma (Experiment 1) and in negotiation (Experiment 2) with virtual humans, that showed emotion in their virtual faces, and which were manipulated to be either agents or avatars. In line with Blascovich et al.'s threshold model of social influence, and research in theory of mind and neuroeconomics, our general prediction was that the social effects of emotion expressions on people's decision making would be stronger when people believed they were engaging with humans, rather than computers.

2 Experiment 1: Social Dilemma

In this experiment participants engaged in a social dilemma with emotional virtual humans. Social dilemmas are situations where an individual gets a higher payoff by defecting rather than cooperating, regardless of what others in society do, yet all individuals end up receiving a lower payoff if all defect than if all cooperate [46]. In such dilemmas, people try to infer from non-verbal cues, such as facial expressions of emotion, that others are likely to cooperate [1], [7], [8], [9], [10]. Complementary, emotion expressions can also signal that one has competitive intentions [1], [47], [48]. From a computational perspective, previous experiments [49], [50], [51] had already shown that people can cooperate more with virtual humans that show cooperative facial displays (e.g., joy after mutual cooperation) than virtual humans that show competitive displays (e.g., joy after exploiting the participant). However, these studies did not explicitly manipulate participants' perceptions of whether they were engaging with agents or avatars and the nature of the virtual human was left ambiguous (e.g., virtual humans were always referred to by a name such as "Ethan").

In this experiment we had participants engage with virtual humans, which were either perceived to be agents or avatars, that expressed either cooperative or competitive emotion displays. In line with the threshold model of social influence and recent research in theory of mind and neuroeconomics, we expected that (a) people would cooperate more with cooperative than competitive virtual humans but, (b) this effect would be stronger when virtual humans were perceived to be avatars.

2.1 Methods

Task. People engaged in the iterated prisoner's dilemma [52], a social dilemma commonly used to study emergence of cooperation. The prisoner's dilemma is a two-player game where the payoffs of each player depend on the simultaneous choice of both players. The payoff matrix we used is shown in Table 1. The task represents a dilemma because the rational (i.e., utility-maximizing) choice for both players is to defect, which results in an outcome (mutual defection) that is worse than mutual cooperation. Participants played 20 rounds of this task. Moreover, following the approach by Kiesler, Waters and Sproull [53], the task was recast as an investment game.

Design. The experiment followed a 2 × 2 between-participants factorial design: *Counterpart* (Agent vs. Avatar) × *Facial Expressions* (Cooperative vs. Competitive). Regarding the first factor, agents were always referred to as "computer agents" and were described to the participants as "computer programs that were designed to make decisions just like other people". Avatars were described as "the players' visual representation in the game". Participants were asked to choose an avatar for themselves, of the same gender, and were informed that their avatar "would be visible to the other player" and that the they "would be able to control aspects of the avatar's behavior which would be visible to the other player, and vice-versa". Participants in both agent and avatar conditions chose an avatar for themselves. In avatar conditions, the counterpart's avatar was described to be controlled by another participant. In reality, participants always played with a computer program that followed the same strategy: tit-for-tat, starting with a defection. To make this deception believable, we further implemented a server that matched pairs of participants that were supposed to engage with other participants; participants would then proceed in lockstep throughout the task but the responses they would see always followed the tit-for-tat strategy. The visual representation of the counterpart was always of the same gender as the participant. Lastly, participants were told that the identities of other participants would be concealed and the software always referred to the human counterpart as "anonymous".

TABLE 1
PAYOFF MATRIX FOR THE PRISONER'S DILEMMA

		Virtual Human Cooperation		*Virtual Human* Defection	
Participant	Cooperation	VH:	6 pts	VH:	10 pts
		Partic:	6 pts	Partic:	0 pts
	Defection	VH:	0 pts	VH:	3 pts
		Partic:	10 pts	Partic:	3 pts

Regarding facial expressions, following our previous studies [1], [49], [50], [51], we defined the *expressively cooperative* counterpart (Table 2, top), which displays joy in mutual cooperation and regret when it exploits the participant, and the *expressively competitive* counterpart (Table 2, bottom), which displays joy when it exploits the participant and regret in mutual cooperation. The rationale for the cooperative counterpart is that joy after mutual cooperation signals an intention to cooperate, whereas regret after exploitation acknowledges the transgression; the rationale for the competitive counterpart is that joy after exploitation signals an intention to compete, whereas regret after mutual cooperation signals regret for missing the chance to exploit the participant. We used the same emotion facial displays that were validated and used in our earlier experiments [1], [49], [50], [51]: joy was expressed through a smile and contraction of the corrugator supercilii (eyes); regret was expressed through lowering of the zygomaticus, light blushing, head bowing and gaze aversion. Male and female avatars used in the experiment are shown in Figure 1.

Measures. Our main dependent variable was cooperation rate, i.e., the number of times participants cooperated over all rounds. Our focal effect size was the mean difference in cooperation rate between the cooperative and competitive counterparts. To validate that participants were correctly perceiving some virtual humans as agents

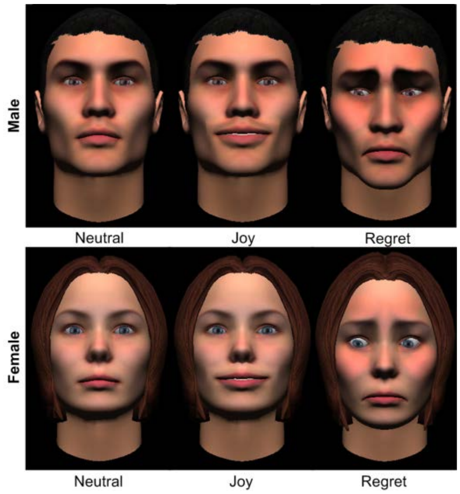

Fig. 1. The facial displays of emotion in Experiment 1.

and others as avatars we asked them, after the task was completed, to rate the virtual human according to the following pairs of adjectives on a 7-point scale (e.g., for Fake-Natural, 1 corresponded to Fake and 7 to Natural): Robot like-Human like; Fake-Natural; Unconscious-Conscious; Artificial-Lifelike; Stagnant-Lively; Mechanical-Organic; Inert-Interactive; Apathetic-Responsive; and, Computer-Human. The selection of these adjectives was based on existent scales pertaining to anthropomorphism [54], the "uncanny valley" effect (e.g. [55]) and the experience of social presence in virtual environments (e.g., [56]). To validate that participants were perceiving some counterparts to be more cooperative than others, we asked how cooperative was the counterpart on a 7-point scale (1, *not at all*, to 7, *very much*).

TABLE 2
THE FACIAL EXPRESSIONS OF EMOTION

Expressively Cooperative		*Virtual Human* Cooperation	*Virtual Human* Defection
Participant	Cooperation	Joy	Regret
	Defection	Neutral	Neutral

Expressively Competitive		*Virtual Human* Cooperation	*Virtual Human* Defection
Participant	Cooperation	Regret	Joy
	Defection	Neutral	Neutral

In exploratory fashion, we also looked at participants' self reported emotions after each round. After the outcome of the round was shown, but before the counterpart's emotion was shown, participants were asked "How do you feel about this outcome?" and selected one of the following options: neutral, happy, sad, angry or regretful. Furthermore, upon completion of the task, we also asked participants to rate, on a 7-point scale (1, *not at all*, to 7, *very much*) how fair, trustworthy, and likable was the counterpart.

Experimental procedure. Participants were greeted into the lab and were randomly assigned a computer. After signing the consent form, they proceeded to read the instructions and complete a tutorial of the task. After being synchronized by the server, they initiated the decision task. Figure 2 shows a screenshot of the software. Each round proceeded as follows: (1) participants made a decision between project green or project blue; (2) participants waited a few seconds for the counterpart to finish deciding; (3) the outcome of the round was shown; (4) participants self-reported how they felt about the outcome of the round; (5) participants saw how the counterpart felt about the outcome of the round; (6) if there were any rounds left, a new round started; otherwise, the task was over. After completing the task, they filled out a questionnaire pertaining to manipulation checks and subjective impressions of the counterpart. Upon completion of the experiment participants were verbally debriefed about the deception pertaining to the avatar conditions.

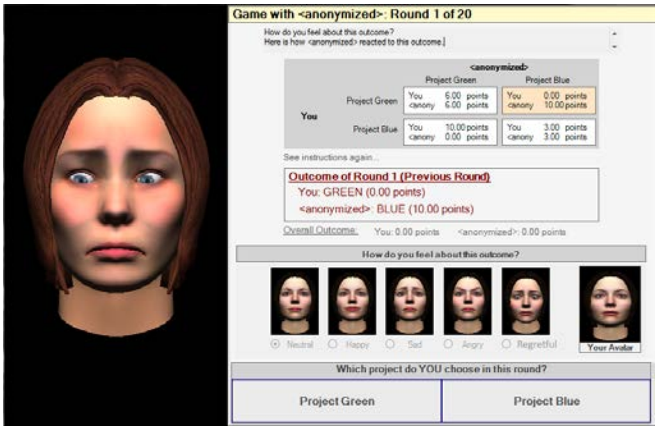

Fig. 2. The software used in Experiment 1.

Participants and incentive. One-hundred and twenty two participants were recruited at USC's Marshall School of Business. This resulted in approximately 30 participants per condition. Regarding gender, 69.7% were males. Age distribution was as follows: 21 years and Under, 70.6%; 22 to 34 years, 29.4%. Most participants were undergraduate students (95.8%) majoring in Business-related courses and with citizenship from the United States (81.5%). The incentive to participate followed standard practice in experimental economics [57]: first, participants were given school credit for their participation; second, with respect to their goal in the task, participants were instructed to earn as many points as possible, as the total amount of points would increase their chances of winning a lottery for $100.

2.2 Results

Participants that did not experience both joy and regret with the counterpart[1]–i.e., our experimental manipulation–were excluded from analysis (though keeping them would lead to the same pattern of results). After exclusion, 84 participants remained for analysis.

Manipulation checks. The nine adjective classification questions were highly correlated (Cronbach a = .972) and, thus, were averaged into a single measure we called anthropomorphism. We then ran an Counterpart × Facial Expressions ANOVA which revealed, as expected, a main effect of Counterpart, $F(1, 80) = 4.48$, $p = .037$, partial η^2 = .053: people perceived avatars (M = 4.87, SD = 1.54) to be more anthropomorphic than agents (M = 4.12, SD = 1.64). With respect to perception of cooperativeness, we found a main effect of Facial Expressions, $F(1, 80) = 5.94$, $p = .017$, partial η^2 = .069: people found cooperative counterparts (M = 5.91, SD = 1.41) to be more cooperative than competitive counterparts (M = 5.03, SD = 1.79).

Cooperation rate. The means and standard errors for cooperation rate are shown in Figure 3. Regarding the main effect of Facial Expressions, people cooperated more with cooperative (M = .69, SD = .27) than competitive (M = .54, SD = .29) virtual humans, $F(1, 80) = 5.68$, $p = .020$, partial η^2 = .066. To test our expectation that the effect of emotion would be stronger with avatars than agents, we, first, split the data across Counterpart; then, we looked at the mean difference in cooperation rates between cooperative and competitive virtual humans–our focal effect size. For agents, this analysis showed that people cooperated more with cooperative (M = .64, SD = .26) than competitive agents (M = .54, SD = .30), but this result was not statistically significant, $t(37) = 1.12$, $p = .269$, Cohen's d = .360, effect size point estimate = .102, 95% CI [-.082, .287]. For avatars, people cooperated more with cooperative (M = .73, SD = .26) than competitive avatars (M = .55, SD = .28) and this result was statistically significant, $t(43) = 2.31$, p = .026, Cohen's d = .601, effect size point estimate = .187, 95% CI [.024, .350].

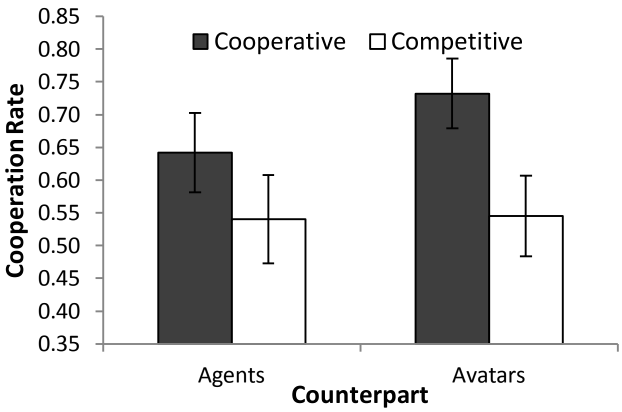

Fig. 3. Means (and standard errors) for cooperation rate. The bars represent standard errors.

Participants' emotions and subjective measures. Regarding participants' emotions, the means and standard deviations are shown on Table 3 (top). We, first, regressed cooperation rate on self-reported joy, sadness, anger, and regret. This multiple regression model explained 49.8% of the variance and the standardized coefficients were: joy, β = .53, p = .000; sadness, β = -.19, p = .034; anger, β = -.19, p = .032; regret, β = -.03, p = .773. We then ran Counterpart × Facial Expressions ANOVA on participants' joy, sadness and anger, since the coefficients associated with these measures were statistically significantly different from zero. We found several main effects of Facial Expressions, with participants self-reporting more joy (p =

[1] Notice this paradigm did not guarantee participants would experience all outcomes in the prisoner's dilemma task.

TABLE 3
PARTICIPANTS' EMOTIONS AND SUBJECTIVE MEASURES IN EXPERIMENT 1

	Agent				Avatar			
	Competitive		Cooperative		Competitive		Cooperative	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Participant's Emotions								
Joy	7.95	5.781	12.58	5.581	7.85	6.491	14.20	5.050
Sadness	1.40	1.957	1.16	2.167	1.35	1.675	1.27	1.981
Anger	2.95	3.252	1.00	.943	.95	1.849	1.28	2.208
Regret	.95	1.849	1.00	1.202	.45	.826	.44	.917
Subjective Measures								
Fair / Trustworthy / Likable	4.45	1.515	5.42	1.623	5.05	1.452	5.65	1.165

Participant's emotions represent the average number of times a certain emotion was self-reported across all rounds. Subjective measures were rated on a 7-point scale (1, not at all, *to 7,* very much*) and the table reports the average across all measures (Cronbach* α = *.880).*

.000, partial η^2 = .193) and less anger (p = .102, partial η^2 = .033) with cooperative than competitive counterparts. We found a trend for a main effect of Counterpart on anger (p = .056, partial η^2 = .045), with people showing more anger towards agents than avatars. More interestingly, we found a statistically significant Counterpart × Facial Expressions interaction for anger (p = .023, partial η^2 = .063) with people showing more anger with competitive agents than competitive avatars.

Regarding the subjective measures, the questions pertaining to fairness, trustworthiness, and likability were highly correlated (Cronbach a = .880) and, thus, we averaged them. The means and standard deviations for this new measure are shown in Table 3 (bottom). An Counterpart × Facial Expressions ANOVA revealed a main effect of Facial Expressions (p = .014, partial η^2 = .073) with people forming more positive impressions of cooperative than competitive counterparts. There was also a slight trend for a main effect of Counterpart (p = .188, partial η^2 = .022) with people forming more positive impressions of avatars than of agents.

2.3 Discussion

The results confirmed that people reach different decisions when engaged with computer algorithms that honestly portray themselves as computers compared to if they portray themselves as human. This mere belief–even though the financial incentives and the virtual human's appearance, decisions, and expressions were identical–had a powerful effect. In support of our prediction, emotion displays shaped participants' willingness to cooperate, but the effect size was much stronger (d = .360 vs. d = .601) when playing against a presumed human opponent. Strikingly, as cooperative emotions promoted greater cooperation rates and thus greater individual rewards, participants were able to earn more money when they were deceived about the true nature of the virtual human. The results also revealed that people showed less anger to competitive humans, when compared to competitive computers. This suggests people either restrained themselves with humans, or experienced more anger when engaging with computers. Finally, participants' impressions of others also revealed that people tended to form more positive impressions of avatars than agents.

3 EXPERIMENT 2: NEGOTIATION

In this experiment participants engaged in negotiation, a domain inherently different from social dilemmas [58], with emotional virtual humans. According to Pruitt and Carnevale [59], negotiation is "a discussion among two or more parties aimed at reaching agreement when there is a perceived divergence of interest". Recently, researchers began looking at the impact of emotion displays on negotiation outcome (for a review see: [2]) and a robust finding is that people concede more when facing an angry than a neutral counterpart [11], [60]. The argument is that people infer the angry counterpart to have high aspirations and, so as to avoid costly impasse, are forced to lower their demand. From a computational perspective, we also showed that people can concede more to angry than happy virtual humans [61]; however, once again, there was ambiguity regarding the virtual human's nature (e.g., they were referred to by a name, such as "Ethan"), and the experiment did not explicitly manipulate participants' beliefs about whether the virtual human was an agent or avatar.

In this experiment we had participants engage with virtual humans, which were either perceived to be agents or avatars, that expressed either angry or neutral facial displays. In line with the threshold model of social influence and recent research in theory of mind and neuroeconomics, we expected that (a) people would concede more to angry than neutral virtual humans but, (b) this effect would be stronger when virtual humans were perceived to be avatars.

3.1 Methods

Task. Similarly to Van Kleef, De Dreu and Manstead's experiment [11], we had people engage in a multi-issue negotiation assuming the role of a seller of a phone company whose goal was to negotiate three issues: the price, the warranty period and the duration of the service contract of the phones. Each issue had 9 levels, being the highest level the most valuable for the participant, and the lowest level the least valuable. Level 1 on price ($110) yielded 0 points and level 9 ($150) yielded 400 points (i.e., each level corresponded to a 50 point increment). Level 1 on warranty (9 months) yielded 0 points and level 9 (1 month) yielded 120 points (i.e., each level corresponded to a 15 point increment). For duration of service contract, level 1 (9 months) yielded 0 points, and level 9 (1 month) yielded 240 points (i.e., each level corresponded to a 30 point increment). It was pointed out to the participant that the best deal was, thus, 9-9-9 for a total outcome of 760 points (400 + 120 + 240). The participant was also told that the counterpart had a different payoff table which was not known. The negotiation would proceed according to the alternating offers protocol, being the counterpart the first to offer, and until someone accepted the other's offer or "time expired"; in reality, if no agreement had been reached, the task would always terminate in round 6.

Design. The experiment followed a 2 × 2 between-participants factorial design: *Counterpart* (Agent vs. Avatar) × *Facial Expression* (Anger vs. Neutral). Regarding the first factor, virtual humans were described in a similar manner as in Experiment 1 (e.g., the agent was always referred to as "computer agent" and the avatar was always described as "anonymous"). In reality, participants always engaged with a computer program that followed the same fixed sequence of offers: 2-3-2, 2-3-3, 2-4-3, 3-4-3, 3-4-4, and 4-4-4. This pattern had been argued before to strike a good balance between cooperation and competition [11]. When participants engaged with avatars, we used a server to implement the deception. In this case, the server would synchronize the participants at the beginning of the task and, from that point onward, the scripted strategy would be played. The counterpart's virtual representation was always of the same gender as the participant. Regarding the second factor, we used the same emotion facial displays that were validated and used in our earlier experiments [1], [61]: anger was expressed through lowering of the zygomaticus, lowering of the corrugator supercilli (frowning), and light reddening of the face. One male and one female avatars are shown in Figure 4. Emotion displays were shown after the participant made an offer in rounds 1, 3 and 5.

Measures. Our main dependent variable was *demand difference*, i.e., the difference in demand level between round 1 (initial offer) and the last round (agreement round or round 6). To calculate demand level, the number of points demanded in each round was summed across all issues of price, warranty and service. Demand difference was then calculated by subtracting demand level in round 1 (first offer) and demand level in the last round (last offer). Notice this measure will tend to be positive as people usually start with a more demanding offer and then concede as the task progresses [11]. Our focal effect size was the mean difference in demand difference between the angry and neutral counterparts. To validate that participants were perceiving some virtual humans as agents and others as avatars we asked them to rate the virtual human on the same adjective pairs as in Experiment 1. In exploratory fashion, similarly to Experiment 1, we also looked at participants' self-reported emotions and subjective impressions of the counterpart (7-point scale: 1, *not at all*, to 7, *very much*): fair, trustworthy, cooperative, and likable.

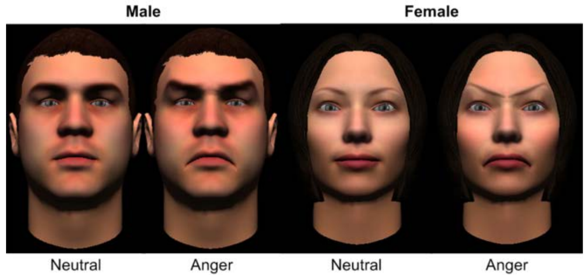

Fig. 4. The facial displays of emotion in Experiment 2.

Experimental procedure. Participants were greeted into the lab and were randomly assigned a computer. After signing the consent form, they proceeded to read the instructions and complete a tutorial of the task. After being synchronized by the server, they initiated the decision task. Figure 5 shows a screenshot of the software. Each round proceeded as follows: (1) participants waited for the counterpart to make an offer; (2) after receiving an offer, participants self-reported how they felt about the offer; (3) participants then decided whether to accept the offer. If the offer was accepted, the task was over; otherwise, if there were any rounds left, participants made a counteroffer; (4) the counterpart showed an emotional reaction to the participants' offer; (5) a new round started. After completing the task, they filled out a questionnaire pertaining to manipulation checks and subjective impressions of the counterpart. Upon completion of the experiment participants were verbally debriefed about the deception pertaining to the avatar conditions.

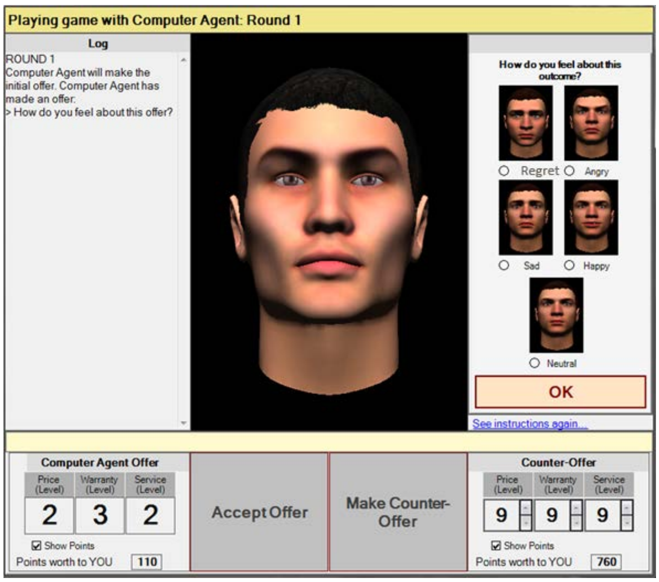

Fig.5. The software used in Experiment 2.

Participants and incentive. Seventy-eight participants were recruited at the paid pool at USC's Marshall School of Business. This resulted in approximately 20 participants per condition. Regarding gender, 45.8% were males.

Age distribution was as follows: 21 years and Under, 52.8%; 22 to 34 years, 47.2%. Most participants were undergraduate (63.9%) and graduate (34.7%) students majoring in diverse fields and mostly with citizenship from the United States (59.7%) and India (27.8%). The incentive to participate followed standard practice in experimental economics [57]: first, participants were paid $20 for their participation; second, with respect to their goal in the task, participants were instructed to earn as many points as possible, as the total amount of points would increase their chances of winning a lottery for $100.

3.2 Results

Participants that accepted the virtual human's first offer or whose first offer was accepted by the virtual human did not see any emotion expression–i.e., our experimental manipulation–and, thus, were excluded from analysis (though keeping them would lead to the same pattern of results). After exclusion, 72 participants remained for analysis.

Manipulation checks. The nine adjective classification questions were highly correlated (Cronbach α = .952) and, thus, were averaged into a single measure we called anthropomorphism. We then ran an Counterpart × Facial Expression ANOVA which revealed, as expected, a main effect of Counterpart, $F(1, 68) = 9.87$, $p = .002$, partial η^2 = .127: people perceived avatars (M = 3.84, SD = 1.29) to be more anthropomorphic than agents (M = 2.98, SD = 1.38).

Demand difference. The means and standard errors for demand difference are shown in Figure 6. Regarding the main effect of Facial Expression, people conceded more with angry (M = 211.72, SD = 190.15) than neutral (M = 129.38, SD = 121.51) virtual humans, $F(1, 68) = 7.09$, p = .010, partial η^2 = .094.To test our expectation that the effects of emotion would be stronger with avatars than with agents, we, first, split the data across Counterpart; then, we compared demand difference between angry and neutral virtual humans–our focal effect size. This revealed that, for agents, demand difference was higher with angry agents (M = 166.75, SD = 160.19) than neutral agents (M = 157.25, SD = 127.38) but this result was not statistically significant, $t(38) = -.208$, $p = .837$, Cohen's d = .066, effect size point estimate = 9.50, 95% CI [-83.14, 102.14]. For avatars, demand difference was higher with angry avatars (M = 286.67, SD = 218.55) than neutral avatars (M = 101.50, SD = 111.57) and this result was statistically significant, $t(30) = -3.182$, $p = .003$, Cohen's d = 1.162, effect size point estimate = 185.17, 95% CI [66.32, 304.01].

Participants' emotions and subjective measures. Regarding participants' emotions, the means and standard deviations are shown on Table 4 (top). We, first, regressed demand difference on self-reported joy, sadness, anger, and regret. This multiple regression model explained 12.7% of the variance and the standardized coefficients were: joy, $\beta = -.06$, $p = .629$; sadness, $\beta = -.40$, $p = .003$; anger, $\beta = -.20$, $p = .123$; regret, $\beta = -.01$, $p = .992$. We then ran Counterpart × Facial Expressions ANOVA on participants' sadness and anger, since the coefficients associated with these measures tended to be statistically significantly different from zero. There was a trend for a significant Counterpart × Facial Expression interaction on displays of anger ($p = .074$, partial η^2 = .046): people showed more anger to angry agents than angry avatars.

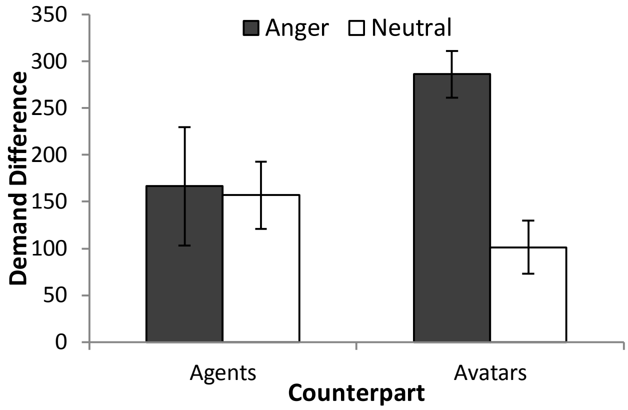

Fig. 6. Means (and standard errors) for demand difference. The bars represent standard errors.

Regarding the subjective measures, the questions pertaining to fairness, trustworthiness, cooperativeness, and likability were highly correlated (Cronbach α = .931) and,

TABLE 4
PARTICIPANTS' EMOTIONS AND SUBJECTIVE MEASURES IN EXPERIMENT 2

	Agent				Avatar			
	Anger		Neutral		Anger		Neutral	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Participant's Emotions								
Joy	.00	.000	.15	.671	.50	1.732	.00	.000
Sadness	1.40	1.759	1.90	2.337	1.00	1.758	1.45	1.761
Anger	2.65	2.110	1.75	2.197	1.25	2.006	2.30	2.473
Regret	.25	.639	.00	.000	.08	.289	.05	.224
Subjective Measures								
Fair / Trustworthy / Cooperative / Likable	2.54	1.052	2.80	.995	3.81	1.617	2.56	1.211

Participant's emotions represent the average number of times a certain emotion was self-reported across all rounds. Subjective measures were rated on a 7-point scale (1, not at all*, to 7,* very much*) and the table reports the average across all measures (Cronbach* α *= .931).*

thus, we averaged them. The means and standard deviations for this new measure are shown in Table 4 (bottom). An Counterpart × Facial Expressions ANOVA revealed a trend for a main effect of Facial Expressions (p = .091, partial η^2 = .042) with people forming more positive impressions of angry than neutral counterparts. There was also a trend for a main effect of Counterpart (p = .076, partial η^2 = .046) with people forming more positive impressions of avatars than of agents. Finally, there was a statistically significant interaction (p = .011, partial η^2 = .092) with people forming more positive impressions of angry avatars than angry agents.

3.3 Discussion

The results showed, once again, that people behaved differently when they perceived virtual humans to be agents when compared to avatars. Virtual humans were unsuccessful in influencing participant behavior when they honestly portrayed themselves as computers (d = .066); however they had a large effect on behavior (d = 1.162) when they portrayed themselves as human, in which case people conceded significantly more to an angry than a neutral avatar. Overall, thus, the results supported our prediction that the effects of emotion would be stronger with avatars than agents. As in Experiment 1, the results showed that people expressed less anger towards angry avatars when compared to angry agents. Finally, the results showed that people formed more positive impressions of angry avatars–in terms of fairness, trustworthiness, cooperativeness and likability–than of angry agents.

4 General Discussion

Our results show that the belief about whether a computer or a human is controlling the emotion expressions of a virtual human can significantly impact people's decision making behavior. In Experiment 1, we had people engage in a social dilemma with virtual humans that showed either cooperative (e.g., joy after mutual cooperation) or competitive displays (e.g., joy after exploiting the participant). The results showed that people cooperated more with the cooperative than the competitive virtual humans but, this difference was stronger when they believed they were engaging with avatars. In Experiment 2, we had people engage in negotiation with virtual humans that showed either an angry or neutral expression. The results showed that people conceded more to the angry than the neutral virtual human but, once again, this difference was much stronger with avatars. Overall, the results suggest that the social effects of emotion expressions on people's decisions are stronger when people believe they are engaging with humans, rather than computers.

The "computers are social actors" theory introduced the idea that people can treat computers in a fundamentally social manner [20], [21]. Indeed, our results showed that people can be influenced by emotion expressions of computers; however, our results extend this theory by demonstrating that there are still important differences in the way people treat computers in social contexts, when compared to humans. Our results seem more in line with Blascovich et al.'s threshold model of social influence [26], [27] which predicts that social influence will be greater the higher people's attributions of a mind to the computer, i.e., the perceived sentience (e.g., consciousness or free will). These results are, therefore, also compatible with the view that people naturally attribute more mind to humans than computers or robots [36], [37], and with recent findings in neuroeconomics that show that people tend to reach different decisions with computers and show higher activation of brain regions associated with mentalizing when engaging with humans [38], [39], [41], [42], [43], [44].

The results reported here seem to reflect people's current suspicion about the ability of a machine to "have a mind", i.e., a mind that is worthy of mentalizing as is the mind of a human. In recent work we argued that a key for the interpersonal effects of emotion expression is the information people retrieve from such expressions pertaining to others' beliefs, desires and intentions [1]. Thus, higher activation of brain regions associated with theory of mind might have meant that people tried harder to infer the mental states of avatars, through the corresponding emotion expressions, and this led to increased cooperation with avatars.

Our exploratory analyses also show that people tend to communicate different emotions to avatars, when compared to agents. A particularly interesting result was that people showed, through their virtual characters, less anger towards competitive avatars than towards competitive agents. One explanation is that people are employing display rules with avatars, i.e., they are masking their true emotion to preserve social harmony [63], maintain professionalism [64] or abide to in-group social norms [65]. An alternative explanation is that people effectively experience more anger when engaging with competitive agents, which is consistent with the literature on prejudice towards the out-group [66]. Future work should, therefore, try to disentangle the role of these two mechanisms.

Analysis of the subjective measures allow us to speculate that people tend to form more positive subjective impressions–pertaining to fairness, trustworthiness, and likability–of avatars than of agents. These results are consistent with the well-documented in-group bias, whereby people tend to favor in-group (i.e., avatars) to out-group (i.e., agents) members [67], [68]. In particular, studies have shown that people tend to favor and trust more in-group members in decision making settings [69].

These results have important implications for the design of intelligent affective computers. Broadly, it is important designers realize people tend to reach different decisions according to whether they perceive computers to be controlled by a human or a computer algorithm. Having acknowledged this, designers can strategically choose to emphasize or de-emphasize perceptions of who or what is controlling the expressions shown by a computer. For instance, in computer-mediated decision making, if the objective is to approximate face-to-face interaction, designers could make it clear to the user that the computer is just a proxy for an actual person on the other side. On the other hand, if the computer makes autonomous decisions, then the system should emphasize the human stakeholders for whose interests the decisions are being made. If it is not easy to identify the stakeholders or preferable not to do so, then designers could simply choose to de-emphasize the fact that the emotions are being generated by computer algorithms.

The limitations in this work suggest promising lines of future inquiry. First, it is important to compare people's behaviors with humans vs. computers in more decision tasks (e.g., trust games, ultimatum game, etc.) and with more emotion displays. Second, our exploratory analyses suggest that participants' emotions and subjective impressions play an important role in how people make decisions with humans and computers and it is important to clarify how this is happening. Finally, this research raises the issue of what is the mechanism behind the effects reported here. Researchers have proposed that people think of other minds in terms of two dimensions [44], [36], [37], [62]: agency, which refers to the capacity to think, plan and act; and, experience, which refers to the capacity to sense and feel emotion. It, thus, remains to be tested if appropriate simulation of these two underlying dimensions in computers would suffice for people to cross the threshold above which they cease to distinguish, in decision making settings with clear financial stakes, computers from humans.

ACKNOWLEDGMENT

This research was supported in part by the following grants: FA9550-09-1-0507 from the Air Force Office of Scientific Research, IIS-1211064 and SES-0836004 from the National Science Foundation. The content does not necessarily reflect the position or the policy of any Government, and no official endorsement should be inferred.

REFERENCES

[1] C.M. de Melo, P.J. Carnevale and J. Gratch, "Reading people's minds from emotion expressions in interdependent decision making," *Journal of Personality and Social Psychology*, vol.106, no.1, pp.73-88, 2014.

[2] G. Van Kleef, C. De Dreu and A. Manstead, "An interpersonal approach to emotion in social decision making: The emotions as social information model," *Advances in Experimental Social Psychology*, vol. 42, no. 10, pp.45-96, 2010.

[3] N. Frijda and B. Mesquita, "The social roles and functions of emotions,"*Emotion and culture: Empirical studies of mutual influence*, S. Kitayama and H. Markus, eds., Washington, DC: American Psychological Association, pp. 51–87, 1994.

[4] D. Keltner and J. Haidt., "Social functions of emotions at four levels of analysis," *Cognition and Emotion*, vol.13, no.5, pp.505–521, 1999.

[5] D. Keltner and A. M. Kring, "Emotion, social function, and psychopathology," *Review of General Psychology*, vol.2, no.3, pp.320–342, 1998.

[6] M. Morris and D. Keltner, "How emotions work: An analysis of the social functions of emotional expression in negotiations," *Research in Organizational Behavior*, vol.22, pp.1-50, 2000.

[7] R. Boone and R. Buck, "Emotional expressivity and trustworthiness: The role of nonverbal behavior in the evolution of cooperation," *Journal of Nonverbal Behavior*, vol.27, pp.163-182, 2003.

[8] R. Frank, "Introducing moral emotions into models of rational choice," *Feelings and emotions*, A. Manstead, N. Frijda and A. Fischer, eds., New York, NY: Cambridge University Press, pp. 422-440, 2004.

[9] R. Nesse, "Evolutionary explanations of emotions," *Human Nature*, vol.1, pp.261-289, 1990.

[10] R. Trivers, "The evolution of reciprocal altruism," *Quarterly Review of Biology*, vol.46, no.1, pp.35-57, 1971.

[11] G. Van Kleef, C. De Dreu and A. Manstead, "The interpersonal effects of anger and happiness in negotiations," *Journal of Personality and Social Psychology*, vol. 86, pp. 57-76, 2004.

[12] G. Van Kleef, C. De Dreu and A. Manstead, "Supplication and appeasement in negotiation: The interpersonal effects of disappointment, worry, guilt, and regret," *Journal of Personality and Social Psychology*, vol. 91, pp. 124-142, 2006.

[13] E. Krumhuber, A. Manstead and A. Kappas, "Facial dynamics as indicators of trustworthiness and cooperative behavior," *Emotion*, vol. 7, pp. 730-735, 2007.

[14] E. van Dijk, G. Van Kleef, W. Steinel and I. Van Beest, "A social functional approach to emotions in bargaining: When communicating anger pays and when it backfires," *Journal of Personality and Social Psychology*, vol. 94, pp. 600-614, 2008.

[15] M. Wubben, D. De Cremer and E. van Dijk, "When and how communicated guilt affects contributions in public good dilemmas," *Journal of Experimental Social Psychology*, vol. 45, pp. 15-23, 2009.

[16] R. Friedman, C. Anderson, J. Brett, M. Olekalns, N. Goates, and C. Lisco, "The positive and negative effects of anger on dispute resolution: Evidence from electronically mediated disputes," *Journal of Applied Psychology*, vol. 89, pp. 369-376, 2004.

[17] B. Parkinson and G. Simons, "Affecting others: Social appraisal and emotion contagion in everyday decision making," *Personality and Social Psychology Bulettin*, vol. 35, pp. 1071-1084, 2009.

[18] D. Dehn and S. Van Mulken, "The impact of animated interface agents: a review of empirical research," *International Journal of Human-Computer Studies*, vol.52, no.1, pp.1-22, 2000.

[19] R. Beale and C. Creed, "Affective interaction: How emotional agents affect users," *Human-Computer Studies*, vol.67, no.2, pp.755-776, 2009.

[20] C. Nass, J. Steuer, and E. Tauber, "Computers are social actors," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1994.

[21] B. Reeves and C. Nass, *The media equation: How people treat computers, television, and new media like real people and places*. New York, NY: Cambridge University Press.

[22] C. Nass, and Y. Moon, "Machines and mindlessness: Social responses to computers," *Journal of Social Issues*, vol.56, pp.81-103, 2000.

[23] E. Langer, *Mindfulness*, Reading, MA: Addison-Wesley, 1989.

[24] E. Langer, "Matters of mind: mindfulness/mindlessness in perspective," *Consciousness and Cognition: An International Journal*, vol.1, no.4, pp.289–305, 1992.

[25] S. Sundar and C. Nass, "Source orientation in human-computer interaction: programmer, networker, or independent social actor?," *Communication Research*, vol.27, no.6, pp.683-703, 2000.

[26] J. Blascovich et al., “Immersive virtual environment technology as a methodological tool for social psychology,” *Psychological Inquiry*, vol.13, pp.103-124, 2002.

[27] J. Blascovich and C. McCall, “Social influence in virtual environments,” in *The Oxford Handbook of Media Psychology*, K. Dill, Ed., New York, NY: Oxford University Press, 2013, pp.305-315.

[28] J. Bailenson and J. Blascovich, “Avatars,” *Encyclopedia of human–computer interaction*, W. S. Bainbridge, ed., Great Barrington, MA: Berkshire Publishing Group, pp. 64-68, 2004.

[29] B. Gajadhar, Y. de Kort and W. Ijsselsteijn, “Shared fun is doubled fun: Player enjoyment as a function of social setting,” in *Proceedings of the Fun and Games Conference*, 2008.

[30] N. Ravaja, “The psychophysiology of digital gaming: The effect of a non co-located opponent,” *Media Psychology*, vol.12, pp.268-294, 2009.

[31] C. Hoyt, J. Blascovich and K. Swinth, “Social inhibition in immersive virtual environments,” *Presence*, vol.12, pp.183-195, 2003.

[32] S. Okita, J. Bailenson and D. Schwartz, “The mere belief of social interaction improves learning,” in *Proceedings of the Annual Meeting of the Cognitive Science Society (CogSci)*, 2007.

[33] D. Weibel, B. Wissmath, S. Habegger, Y. Steiner and R. Groner, “Playing online games against computer- vs. human-controlled opponents: Effects on presence, flow, and enjoyment,” *Computers in Human Behavior*, vol.24, pp.2274-2291, 2008.

[34] J. Katsyri, R. Hari, N. Ravaja and L. Nummenmaa, “The opponent matters: Elevated fMRI reward responses to winning against a human versus a computer opponent during interactive video game playing,” *Cerebral Cortex*, Sep. 2012.

[35] S. Lim and B. Reeves, “Computer agents versus avatars: Responses to interactive game characters controlled by a computer or other player,” *International Journal of Human-Computer Studies*, vol.68, pp.57-68, 2010.

[36] H.M. Gray, K. Gray and D.M. Wegner, “Dimensions of mind perception,” *Science*, vol.315, p.619, 2007.

[37] A. Waytz, K. Gray, N. Epley and D.M. Wegner, “Causes and consequences of mind perception,” *Trends in Cognitive Sciences*, vol.14, pp.383-388, 2010.

[38] H. Gallagher, J. Anthony, A. Roepstorff and C. Frith, “Imaging the intentional stance in a competitive game,” *NeuroImage*, vol. 16, pp. 814-821, 2002.

[39] K. McCabe, D. Houser, L. Ryan, V. Smith and T. Trouard, “A functional imaging study of cooperation in two-person reciprocal exchange,” *PNAS*, vol. 98, pp.11832-11835, 2001.

[40] R. Riedl, P. Moht, P. Kenning, F. Davis and H. Heekeren, “Trusting humans and avatars: Behavioral and neural evidence,” in *Proceedings of the 32nd Int. Conference on Information Systems*, 2011.

[41] J. Rilling, D. Gutman, T. Zeh, G. Pagnoni, G. Berns and C. Kilts, “A neural basis for social cooperation,” *Neuron*, vol. 35, pp.395-405, 2002.

[42] S. Krach et al., “Can machines think? Interaction and perspective taking with robots investigated via fMRI,” *PLoS ONE*, vol.3, pp.1-11, 2008.

[43] T. Kircher, et al., “Online mentalising investigated with functional MRI,” *Neuroscience Letters*, vol. 454, pp.176-181, 2009.

[44] A. Sanfey, J. Rilling, J. Aronson, L. Nystrom and J. Cohen, “The neural basis of economic decision-making in the ultimatum game,” *Science*, vol.300, pp.1755-1758, 2003.

[45] M. van't Wout, R. Kahn, A. Sanfey and A. Aleman, “Affective state and decision-making in the ultimatum game,” *Experimental Brain Research*, vol.169, pp.564-568, 2006.

[46] R. Dawes, “Social dilemmas,” *Annual Review of Psychology*, vol. 31, pp.169-193, 1980.

[47] D. Matsumoto and B. Willingham, “The thrill of victory and the agony of defeat: Spontaneous expressions of medal winners of the 2004 Athens Olympic Games,” *Journal of Personality and Social Psychology*, vol.91, pp.568–581, 2006.

[48] D. Matsumoto, N. Haan, Y. Gary, P. Theodorou and C. Cooke-Carney, “Preschoolers' moral actions and emotions in prisoner's dilemma,” *Developmental Psycholpgy*, vol.22, pp.663-670, 1986.

[49] C. de Melo, P. Carnevale and J. Gratch, “The impact of emotion displays in embodied agents on emergence of cooperation with people,” *Presence*, vol.20, pp.449-465, 2012.

[50] C. de Melo, P. Carnevale and J. Gratch, “Reverse appraisal: Inferring from emotion displays who is the cooperator and the competitor in a social dilemma,” in *Proceedings of 33th Annual Meeting of the Cognitive Science Society*, 2011.

[51] C. de Melo, P. Carnevale and J. Gratch, “Reverse appraisal: The importance of appraisals for the effect of emotion displays on people's decision-making in a social dilemma.” in *Proceedings of 34th Annual Meeting of the Cognitive Science Society*, 2012.

[52] W. Poundstone, *Prisoner's dilemma*. New York, NY: Doubleday, 1993.

[53] S. Kiesler, K. Waters and L. Sproull, “A prisoner’s dilemma experiment on cooperation with human-like computers,” *Journal of Personality and Social Psychology*, vol.70, pp.47-65, 1996.

[54] N. Epley, A. Waytz and J. Cacioppo, “On seeing human: A three-factor theory of anthropomorphism,” *Psychology Review*, vol.114, pp.864-886, 2007.

[55] C. Bartneck, D. Kulic, E. Croft and S. Zoghbi, “Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots,” *International Journal Social Robotics*, vol.1, pp.71-81, 2009.

[56] C. Harms and F. Biocca, “Internal consistency and reliability of the networked minds measure of social presence,” in *Proceedings of 7th Annual Workshop: Presence*, 2004.

[57] R. Hertwig and A. Ortmann, “Experimental practices in economics: A methodological challenge for psychologists?,” *Behavioral Brain Sciences*, vol.24, pp.383-451, 2001.

[58] D. Pruitt and M. Kimmel, “Twenty years of experimental gaming: Critique, synthesis, and suggestions for the future,” *Annual Review of Psychology*, vol.28, pp.363-392, 1977.

[59] D. Pruitt and P. Carnevale, *Negotiation in social conflict*. Pacific Grove, CA: Brooks/Cole, 1993.

[60] M. Sinaceur and L. Tiedens, “Get mad and get more than even: When and why anger expression is effective in negotiations,” *Journal of Experimental Social Psychology*, vol.42, pp.314-322, 2006.

[61] C. de Melo, P. Carnevale and J. Gratch, “The effect of expression of anger and happiness in computer agents on negotiations with humans,” in *Proceedings of Autonomous Agents and Multiagent Systems (AAMAS)*, 2011.

[62] S. Loughnan and N. Haslam, “Animals and androids: implicit associations between social categories and nonhumans,” *Psychology Science*, vol.18, 116–121, 2007.

[63] J. Zeman and J. Garber, “Display rules for anger, sadness, and pain: It depends on who is watching,” *Child Development*, vol.67, no.3, pp.957-973, 1996.

[64] M.W. Kramer and J.A. Hess, "Communication rules for the display of emotions in organizational settings," *Management Communication Quarterly*, vol.16, no.1, pp.66-80, 2002.

[65] D. Matsumoto, "Cultural similarities and differences in display rules," *Motivation and Emotion*, vol.14, no.13, pp.195-214, 1990.

[66] M. Brewer, "The psychology of prejudice: Ingroup love and outgroup hate?," *Journal of Social Issues*, vol.55, pp.429-444, 1999.

[67] M.B. Brewer, "In-group bias in minimal intergroup situation: A cognitive-motivational analysis," *Psychological Bulletin*, vol.86, no.2, 1979.

[68] R.M. Kramer and M.B. Brewer, "Effects of group identity on resource use in a simulated commons dilemma," *Journal of Personality and Social Psychology*, vol.46, no.5, pp.1044-57.

[69] M. Sherif and C.W. Sherif, *Groups in harmony and tension*. New York: Harper, 1953.

Celso M. de Melo received the PhD degree in computer science from the University of Southern California (USC) in 2012. He is a postdoctoral scholar at the USC Marshall School of Business. His research interests focus on: (a) the interpersonal effects of emotion expression on people's decision making and corresponding implications for the design of intelligent human-computer interaction systems; (b) virtual humans, or three-dimensional characters that look and act like humans, as a computational interface for the future and a basic research tool for the behavioral sciences; and, (c) how perceptions of counterpart's mental states and affect influences decision making and its consequences for human-computer and computer-mediated decision making.

Jonathan Gratch received the PhD degree in computer science from the University of Illinois in Urbana-Champaign in 1995. He is an associate director of Virtual Human Research at the University of Southern California's (USC) Institute for Creative Technologies, research associate professor of computer science and psychology at USC, and codirector of USC's Computational Emotion Group. His research interests include computational models of human cognitive and social processes, especially emotion, and exploration of these models' role in shaping human-computer interactions in virtual environments. He studies the relationship between cognition and emotion, the cognitive processes underlying emotional responses, and the influence of emotion on decision making and physical behavior. He is the author of more than 200 technical articles. He is the founding and current editor-in-chief of the IEEE Transactions on Affective Computing, associate editor of Emotion Review and the Journal of Autonomous Agents and Multiagent Systems, former president of the HUMAINE Association, and is a member of the IEEE, the Association for the Advancement of Artificial Intelligence, and the International Society for Research on Emotion.

Peter J. Carnevale received the PhD degree in social psychology from the State University of New York at Buffalo in 1982. He is an associate professor of management and organization at the University of Southern California (USC) Marshall School of Business. He is an expert on negotiation, mediation, group problem solving, and creativity. His work is published in leading psychology and management journals including Journal of Personality and Social Psychology, Organizational Behavior and Human Decision Processes, Psychological Science, Journal of Experimental Social Psychology, and Journal of Applied Psychology, and he has served on numerous journal editorial boards. His book with Carsten de Dreu, Methods of Negotiation Research received an outstanding book award from the International Association for Conflict Management. He was elected a Division Chair of the Conflict Management Division of the Academy of Management, as well as President of IACM.