A Study of
Emotional Contagion with Virtual Characters

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Abstract. In social psychology, emotional contagion describes the widely observed phenomenon of one person's emotions mimicking surrounding people's emotions [10]. In this paper, we perform a battery of experiments to explore the existence of agent-human emotional contagion. The first study is a between-subjects design, wherein subjects were shown an image of a character's face with either a neutral or happy expression. Findings indicate that even a still image induces a very strong increase in self-reported happiness between Neutral and Happy conditions with all characters tested.

In a second study, we examine the effect of a virtual character's presence in a strategic situation by presenting subjects with a modernized Stag Hunt game. Our experiments show that the contagion effect is substantially dampened and does not cause a consistent impact on behavior. A third study explores the impact of the strategic decision within the Stag Hunt and conducts the same experiment using a description of the same strategic situation with the decision already made. We find that the emotional impact returns, implying that the contagion effect is substantially lessened in the presence of a strategic decision.

1 Introduction

Emotional contagion is defined as the tendency to catch the emotions of other people [10]. While initial work focused on documenting its existence, recent research has moved to understanding its impacts on everyday life. Research in administrative sciences has shown emotional contagion to improve cooperation, decrease conflict, and increase perceived task performance in groups and organizations [2]. Small et al. have shown substantial impacts on charitable donation amounts with only a still image [17]. Though its effects are often felt, in-depth understanding of emotional contagion remains an open area of research.

The vast majority of emotional contagion research, however, has come from the social sciences and examines the spread of emotions from humans to other humans. Emotional contagion's impact in virtual agents' interactions with humans, however, is a largely untouched area of research. The effects are assumed to either be nonexistent and therefore overlooked entirely or to mimic human-human emotional influences. However, these assumptions are not supported by our experiments. As virtual

agents enter high-risk and emotionally delicate applications such as virtual psychotherapy [14,15,16], for example, researchers must be cognizant of all potential emotional influences characters can have on users.

This work serves as a first study to find experimental support for the aforementioned results in agent-human emotional contagion. Pursuant of this goal, three sets of studies are conducted. The first study examines the pure contagion case by simply showing subjects a still image of a virtual character with either a happy expression or a neutral expression and then assessing the subject's self-reported happiness thereafter. The use of a still image as a manipulation follows from previous studies in emotional contagion [17,20]. The second study adds the presentation of a game-theoretic situation known as a Stag Hunt along with the character image to assess both the contagion and the behavioral impact of the virtual character in a strategic setting. While studies have shown that emotional contagion can impact one's propensity to trust and enhance perceived cooperation among other findings [2,7], there has been far less work showing behavioral impacts in strategic situations. Thus, we also attempt to examine whether behavioral impacts arise in strategic situations to better understand its potential impacts in real-world agent applications. Finally, the third study examines the post-hoc hypothesis that the presentation of a decision to the user dampens the emotional contagion effect. Specifically, we present the same strategic situation as in the second study, but with the decision already made for the subject.

In this work, we provide the first experimental results supporting the existence of emotional contagion between virtual agents and humans. Results show a very large increase in self-reported happiness from only adding a smile to an otherwise identical still image of a virtual character. In the second study, when the character is placed in the context of a strategic decision, both subject behavior and subject self-reports of happiness are only impacted significantly by one character. The last study, which removes the user's decision from the previous experiment, finds that the character's expression's affect on emotion returns significantly, implying that a strategic decision posed to users will dampen the emotional contagion effect beyond only reading about a situation. These results serve as a preliminary study to alert agent researchers to the impacts that virtual character emotions may have on human users.

2   Related Work

Models of emotional contagion have been explored in a computational context that focus on crowd or society simulation. For example, [4,8,13] each present alternative models of emotional contagion in agent crowds, while [18] proposes a comparison technique to evaluate such models. This body of work is an attempt to mimic human-human contagion and not an exploration of agent-human contagion which we seek to understand here. There also exists a large body of work on the interaction between virtual agents and humans [5,9,19]. The entire area of virtual rapport [9,19], for example, focuses on user opinions of the virtual agents and their interaction. The primary goal is to create agents that users enjoy, appreciate, and relate to. Recent work has looked at the impact of agent expressions in a strategic negotiation setting [5] as well. However, their work

focuses on the behavioral impact of varying the intent of agent expressions on user behavior without examining the emotional impact on users.

In the social sciences, the literature on emotional contagion is more expansive. Hatfield et al. [10] popularized the area by compiling a plethora of situations in which the phenomenon had been observed in their work as well as the work of other researchers. Follow-up research by the co-authors as well as researchers in related fields such as managerial and occupational sciences [2,17] continued to detail the effects of the phenomenon in new domains. Recently, there have been works beginning to quantify emotional contagion and explore cross-cultural variations in attributes that affect emotional contagion [6,12]. A large body of social psychological studies of emotional contagion features an image or video of only a person's face as the origin of the contagion [11,17,20]. We also expect to see a contagion of emotions from an image of a virtual agent's face to humans. Thus, the primary hypothesis of this work is: *The facial display of an emotion by a virtual character will result in emotional contagion with a human.*

3 Pure Contagion Study

In this study, we test the existence of and factors contributing to emotional contagion between an image of a virtual character's facial expression and a human subject. The experiment setup involved a still image of a character, a self-report of emotion, and a character assessment. Participants were randomly assigned to see one of the images shown in Figure 1, and participants were informed that they would be questioned about the character later. Thus, the study was a 4 (characters) $\times$ 2 (expressions) between-subjects design. Ellie is part of the SimCoach[4] project, while Utah is part of the Gunslinger[5] project. Dia was taken from screenshots from Final Fantasy XIII.[6] Finally, Roy was taken from screenshots of the game L.A. Noire.[7] In the self-report of emotion, we asked subjects how strongly they felt each of 8 emotions on a 0-8 Likert scale: angry, joyful, upset, sad, happy, gloomy, irritated, and calm. Only the measure of Happy was used as the other emotions were only included for compliance checking. Specifically, participants that rated both Angry and Joyful higher than 5 and participants that rated Happy and Joyful more than 3 points apart were considered not in compliance.

Finally, a 15-question survey was administered to gauge subjects' perception of the characters shown. Attributes were drawn primarily from the BSRI [3] and included: Aggressive, Affectionate, Friendly, Attractive, Self-Reliant, Warm, Helpful, Understanding, Athletic, Gentle, and Likable. Every question was asked on a 0-8 Likert scale. Compliance tests included duplicating the Attractiveness question and ensuring both occurrences were within 2 points of each other, an Unattractiveness question which could not exceed 5 if Attractiveness exceeded 5, and finally a question that simply asked participants to 'Pick number eight'. Participants were also asked to rate how happy the character seemed.

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[4] http://ict.usc.edu/projects/simcoach

[5] http://ict.usc.edu/projects/gunslinger/

[6] www.finalfantasyxiii.com

[7] www.rockstargames.com/lanoire/
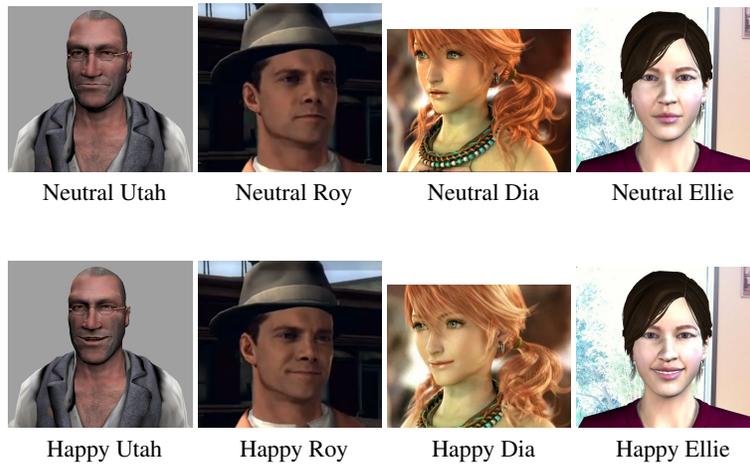
Fig. 1. Characters used, neutral and happy expressions (color)

A total of 415 participants that responded to the experiment, conducted on Amazon Mechanical Turk, passed the compliance tests. Participants were required to be over 18 years of age and were compensated $0.25. The gender distribution was approximately one-third female and two-thirds male, and approximately two-thirds of respondents indicated their ethnicity as Indian.

3.1 Results

We examined whether the facial emotion expressed affected subjects' self-report of emotion. For each of the characters used, participants rated the image used in the Happy condition as significantly happier than the image used in the Neutral condition ($p < 0.001$ for all characters). Based on previous findings in human-human contagion [20], participants should report greater happiness in the Happy condition compared to the Neutral condition. Table 1 shows the means, standard deviations, sample size, and p-values for each experiment. As can be seen, greater happiness was reported in the Happy condition for every character and one-way ANOVA tests revealed significance in every case. This supports our primary hypothesis that an image of a virtual character will cause emotional contagion with a human viewer, since the display of happiness resulted in reports of higher happiness in subjects as compared to the neutral display. Analysis was also conducted to examine a number of additional hypotheses that have been observed in human-human contagion, but none yielded consistent, statistically significant results. These included differences in contagion strength depending on subject gender, ethnicity, perceived character happiness, and perceived character attractiveness.

	Condition	Mean	SD	n	p
Utah	Neutral	3.96	2.54	57	< 0.001
	Happy	5.60	2.12	52	
Roy	Neutral	4.00	2.45	45	< 0.001
	Happy	5.75	1.86	55	
Dia	Neutral	4.04	2.26	46	< 0.001
	Happy	5.96	2.19	47	
Ellie	Neutral	4.49	2.37	66	< 0.001
	Happy	5.27	2.10	47	

Table 1. Happiness statistics for Pure Contagion Study

4 Strategic Situation Study

Having found preliminary experimental support for the existence of agent-human emotional contagion, we extend the research to include a strategic interaction. Studies into the effects of emotional contagion have primarily been in mimicry, self-reports of emotion, and other non-decision-based effects such as changes in trust inventory responses and judge ratings of 'cooperativeness' [2,7]. While there has been some work in behavioral changes due to emotional contagion, such as its impact on donation amounts [17], our work is the first to consider impacts in a strategic context. The experimental setup involved a still image of a character along with the presentation of a strategic situation for which a decision must be made, followed finally by a self-report of emotion.

We used a cooperation situation based on the standard game-theoretic Stag Hunt situation. The actual story used in this experiment casts the Stag Hunt scenario in a less outlandish context in which the subject and a coworker he/she has never met are tasked with decorating specific rooms in the office and can either choose to work separately (taking more time) or work together through both of their assigned rooms (taking less time). The amount of time it would take to perform the decoration task was not explicitly stated. The coworker in question was the character whose image is presented with the situation. Subjects were asked how likely they were to help the character with the task on a 0-8 Likert scale. A total of 572 participants responded to the experiment, which was again conducted via Amazon Mechanical Turk, passed the compliance tests.

4.1 Results

In light of the very strong effect found in the Pure Contagion Study and research indicating that the emotional contagion of happiness leads to more trust [7], we expect to see increased happiness in Happy conditions lead to increased likelihood of cooperation. Indeed, we do find a tight link between likelihood of cooperation and participant happiness as shown in Figure 2. The x-axis plots the happiness rating, and the y-axis indicates the average likelihood of cooperation for all respondents with the given happiness rating across all conditions. As the regression's very high R-squared of 0.852 indicates, the two measures are very tightly linked.

However, only the experiment with Dia yielded a statistically significant change in responses. This suggests that the change results from a character-specific attribute and
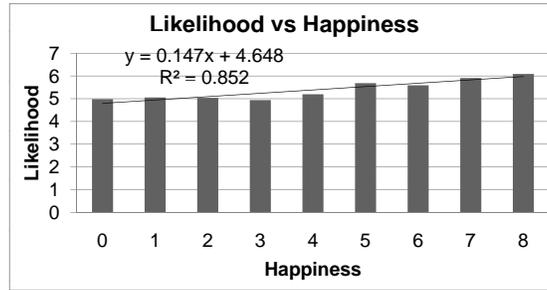
Fig. 2. Likelihood of cooperation versus happiness

not simply an expression-based mechanism. The lack of effect for the other characters is due partially to the regression's low coefficient of 0.147, which implies that huge changes in happiness are required to induce changes in the likelihood of cooperation. However, the Pure Contagion Study *did* find very large changes in happiness that should have been sufficient. A closer look at the emotional influence of our manipulation reveals the second half of the story.

While the Pure Contagion Study reported astoundingly large effects of a smile in a still image of a virtual character, the addition of a strategic situation and decision may have altered the contagion effect. Thus, we examine them in this experiment again. We summarize the overall results for each character in Table 2a. As before, we expect subjects in the Happy condition to report higher happiness than subjects in the Neutral condition across all characters. This was indeed the case, however, the effect sizes are much smaller than in the Pure Contagion Study and, in fact, statistical significance was found only in the experiment using Dia, indicating that something character-specific is allowing her to retain more of her emotional impact while all other characters experienced a much greater dampening of emotional impact. In exploring the attributes surveyed in this work, no candidate for a consistent explanatory variable was found.

(a) Strategic Situation Study

	Condition	Mean	SD	n	p
Utah	Neutral	4.92	2.56	105	0.7638
	Happy	5.02	2.48	125	
Roy	Neutral	4.53	2.38	36	0.2098
	Happy	4.86	2.76	49	
Dia	Neutral	4.37	2.57	41	0.019
	Happy	5.68	2.30	38	
Ellie	Neutral	5.24	2.59	93	0.2231
	Happy	5.69	2.39	85	

(b) Strategic Decision Study

	Condition	Mean	SD	n	p
Utah	Neutral	4.04	2.67	27	0.1329
	Happy	5.09	2.63	32	
Roy	Neutral	4.83	2.33	24	0.2247
	Happy	5.66	2.53	29	
Dia	Neutral	5.88	2.11	48	0.3485
	Happy	6.28	2.08	46	
Ellie	Neutral	4.76	2.33	46	0.008
	Happy	5.95	1.77	41	

Table 2. Self-reported happiness of participants

These results suggest that the presentation of a strategic situation and a trust-based decision dampens the emotional contagion effect. This is in line with findings by researchers in social psychology [17,21] that found that deliberative thinking can dampen emotional influences. However, in light of the tight correlation between the decision and reported happiness, we hypothesize that the decision itself contributes to the dampening effect beyond the impact of simply reading about the situation.

5 Strategic Decision Study

This study was pursued to disentangle the novel effect of making a strategic decision from the previously found effect of reading a situation description [17,21]. It presents subjects with the same situation as in the Strategic Situation Study but removes the decision element from it and simply states that the subject will be cooperating with the character shown to complete the office decoration task. In Table 2b, the overall results of the experiment are shown. As would be expected following findings in social psychology that even reading additional material can dampen emotional influence [17,21], the effect observed in the Pure Contagion Study has not returned in full force. However, the average happiness reported by participants shows a much larger differential than in the Strategic Situation Study, supporting the hypothesis that the decision itself contributed substantially to the dampening of emotional contagion.

6 Conclusion

In this work, we provide a preliminary examination of agent-human emotional contagion across a wide variety of character types. We find support for its existence with a pure contagion study with strong results. In a second study, a strategic decision is added that greatly dampens the contagion effect and, with one exception, did not impact behavior. The final study, which removes the user's decision from the previous experiment, finds that the emotional contagion effect returns significantly. This supports the hypothesis that a strategic decision posed to users will dampen the emotional contagion effect beyond the dampening effect of reading the situation itself. In addition, we find evidence of a gender-based difference in susceptibility to cognitive load's dampening effect on emotional contagion.

Our findings suggest a number of insights for virtual agent researchers. First, emotional contagion with virtual agents appears to be substantial and applications should accurately account for it. We have shown that in some domains even a still image can have an emotional effect. Second, researchers should be wary about assuming that human-human social psychology will directly translate into agent-human interactions. Finally, our work has looked at smiles that are perceived as happy, but there are different types of smiles [1]. Further investigations should be carried out to understand the different effects of character expressions. As virtual agent applications extend beyond entertainment into emotionally-charged domains with very serious repercussions such as psychotherapy and military training, researchers must be ever-vigilant of the emotional impacts their characters might have on users.

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