Preliminary Exploration of Agent-Human Emotional Contagion via Static Expressions

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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 [13]. While it has been observed in human-human interactions, no known studies have examined its existence in agent-human interactions. As virtual characters make their way into high-risk, high-impact applications such as psychotherapy and military training with increasing frequency, the emotional impact of the agents' expressions must be accurately understood to avoid undesirable repercussions.

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 and, to our knowledge, is the first ever study explicitly showing emotional contagion from a virtual agent to a human. We also examine the effects of participant gender, participant ethnicity, character attractiveness, and perceived character happiness and find that only perceived character happiness has a substantial impact on emotional contagion.

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 again, particularly for women, implying that the contagion effect is substantially lessened in the presence of a strategic decision.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence–*Intelligent agents*

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General Terms

Human Factors

Keywords

Virtual Agents, Emotional Contagion, Social Influence

1. INTRODUCTION

Emotional contagion is defined as the tendency to catch the emotions of other people [13]. While initial work focused on documenting its existence, recent research has moved to understanding its impacts on everyday life. In the workplace, researchers have examined its influence on promoting employee efficiency and client happiness [11, 22]. 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 [25]. Though its effects are often felt, in-depth understanding of emotional contagion remains an open area of research.

A variety of hypotheses regarding factors that influence emotional contagion have been explored in social psychology. A popular one examines differences in the strength of emotional contagion felt by men and women, with many researchers finding that women are significantly more responsive to emotional contagion than men [8, 27]. Researchers have also found that contagion increases in cases where the subject shares the same ethnicity as the stimulus [8] and when the expression is stronger [30]. Finally, attraction to the stimulus has been shown to have a positive effect on the contagion experienced by subjects [27].

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. Specifically, while many researchers have worked to understand immersion, rapport, and influence in other contexts [12, 18], far fewer have looked into the emotional impact that the mere presence of virtual character emotions can have on people. The effects are assumed to either be nonexistent and therefore overlooked entirely or to mimic human-human emotional influences. However, as this work demonstrates, these are both poor assumptions to make and can be harmful to users in sensitive domains. As virtual agents enter high-risk and emotionally delicate applications such as virtual psychotherapy [23, 24], for example,

researchers must be cognizant of all potential emotional influences characters can have on users.

Attempting to confirm the aforementioned social psychology findings in agent-human emotional contagion forms the basis of this work. 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 mood thereafter. The use of a still image as a manipulation follows from previous studies in emotional contagion [19, 25, 26, 30].

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 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, 9], there has been far less work showing behavioral impacts in strategic situations. Although people may report themselves to be more trusting, for example, this may not result in any meaningful impact on behavior in a strategic situation. Thus, we also attempt to examine whether behavioral impacts arise in strategic situations from agent-human contagion 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. These studies present the first attempt to assess emotional contagion from virtual characters to human users.

In this work, we begin by providing, to our knowledge, the first confirmation of emotional contagion between virtual agents and humans. Evidence shows a very large increase in happiness from only adding a smile to an otherwise identical still image of a virtual character. We then examine the details of the contagion, finding no support for the hypothesis that women are generally more strongly influenced by emotional contagion than men. Neither the perceived attractiveness nor the perceived ethnicity of the character used appear to affect the contagion consistently either. However, the perceived happiness of the character has a very high correlation with participant happiness. In the second study, when the character is placed in the context of a strategic decision, both subject behavior and subject emotions 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 effect on emotion returns significantly, showing that a strategic decision posed to users will dampen the emotional contagion effect beyond only reading about a situation. Finally, post-hoc analysis suggests that emotional contagion with women may be more resilient to the cognitive load dampening effects of reading about a situation.

2. RELATED WORK

Emotional contagion research in the agents literature falls primarily into three categories: models of emotional contagion, creating rapport between virtual agents and humans, and the impact of agent mood expressions on behavior. Models of emotional contagion have been explored in a computational context that focus on crowd or society simulation. For example, [4, 10, 21] each present alternative models of emotional contagion in agent crowds, while [28] proposes a comparison technique to evaluate such models. Bosse et al. [4] attempt to model the phenomenon of emotions in a crowd spiraling out of control. Durupinar [10] instead uses emotional contagion as a component in a crowd simulation to aid in creating natural variation in crowd types. Pereira et al. [21] model the incorporation of individual susceptibilities and biases into the computation of emotional contagion. 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, 12, 29]. The entire area of virtual rapport [12, 29], 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 or the mechanism by which the change is induced. Neither of these works explicitly examine the impact of virtual character expressions on the emotions of subjects.

3. THEORETICAL BACKGROUND

In the social sciences, the literature on emotional contagion is far more expansive. Hatfield et al. [13] 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, 11, 22, 25] 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 [7, 20].

In light of the extensive evidence of emotional contagion's effects in human-human interactions, our work extends the understanding of this phenomenon into the realm of agent-human interactions. While some studies have been conducted with real people as the stimulus [2, 22], 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 [14, 25, 30]. With the rapid improvements in virtual agent facial displays, and the accepted assumption that the facial display of emotion plays a key role in emotional contagion, we would 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:

HYPOTHESIS 1. *The facial display of an emotion by a virtual character will result in emotional contagion with a human.*

A directly related hypothesis also presented by Hatfield et al. [13] states that the strength of the expression will be correlated with the degree of emotional contagion. This was explored by Wild et al. [30] who tested four degrees of expressions for four different expressions (happiness, sadness, surprise, and pleasure), but found *no* significant systematic effect of expression strength. We examine a similar hypothesis in a virtual character context:

HYPOTHESIS 2. *The perceived happiness of the virtual character's expression will be correlated with the degree of change in the happiness of the human viewer.*

While many recent pursuits in emotional contagion research have looked into the mechanism causing the contagion [14, 15], our focus is on its existence in agent-human interactions. Previous work explored differences in the effect of emotional contagion by gender, and found that women were significantly more strongly impacted than men [8, 27]. Researchers also found that contagion increased in cases where the subject shared the same ethnicity as the stimulus [8]. Finally, attraction to the stimulus was shown to have a positive effect on the contagion experienced in subjects [27]. These results yield the following set of hypotheses:

HYPOTHESIS 3. *Women will experience a stronger contagion effect with a virtual character's facial expression than men will.*

HYPOTHESIS 4. *People will experience a stronger contagion effect with a virtual character's facial expression if the character is perceived to be more attractive.*

HYPOTHESIS 5. *People will experience a stronger contagion effect with a virtual character's facial expression if the character is of the same ethnicity.*

4. 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.

Each character was shown with either a happy or neutral expression. Ellie is part of the SimCoach[1] project, while Utah is part of the Gunslinger[2] project. Dia was taken from screenshots from Final Fantasy XIII.[3] Finally, Roy was taken from screenshots of the game L.A. Noire.[4]

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.

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.

4.1 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). Thus, according to Hypothesis 1, participants should report greater happiness in the Happy condition compared to the Neutral condition.

[1]http://ict.usc.edu/projects/simcoach
[2]http://ict.usc.edu/projects/gunslinger/
[3]www.finalfantasyxiii.com
[4]www.rockstargames.com/lanoire/

	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

Figure 2 shows the happiness reported for each character, with dark bars indicating responses in the Neutral condition and light bars indicating responses in the Happy 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 Hypothesis 1's prediction 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.

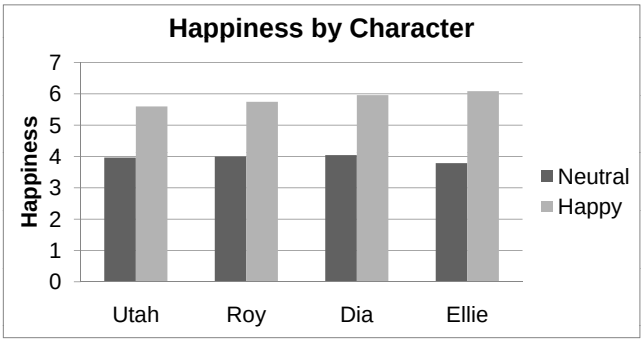


Figure 2: Happiness by character, Pure Contagion Study

4.2 Gender Effects

Hypothesis 3 predicts that women will experience a stronger contagion effect than men. In this context, this suggests that female subjects will report a greater difference in happiness between Neutral and Happy conditions as compared to male subjects. We breakdown the previous results and list the average differences in happiness reported by each gender for each character in Figure 3. The y-axis now shows the difference in participant happiness from the Neutral to Happy condition and the x-axis shows the character. The dark bars represent the increase in the average happiness of men while the light bars show the same measure for women. Therefore, Hypothesis 3 suggests that the bars for female subjects should always be taller than the bars for male subjects.

As can be seen, there was a greater increase in happiness for females in Utah and Roy, but the opposite was true for Dia and Ellie. This does not support Hypothesis 3, but post-hoc analysis suggests a clear cross-gender effect. None of the 11 character attributes surveyed in this study nor the 7 attributes surveyed in the third study showed the same cross-gender trend as exhibited in Figure 3. However, analysis of the perceived happiness of the character shown reveals an alternative explanation.

4.3 Perceived Happiness Effects

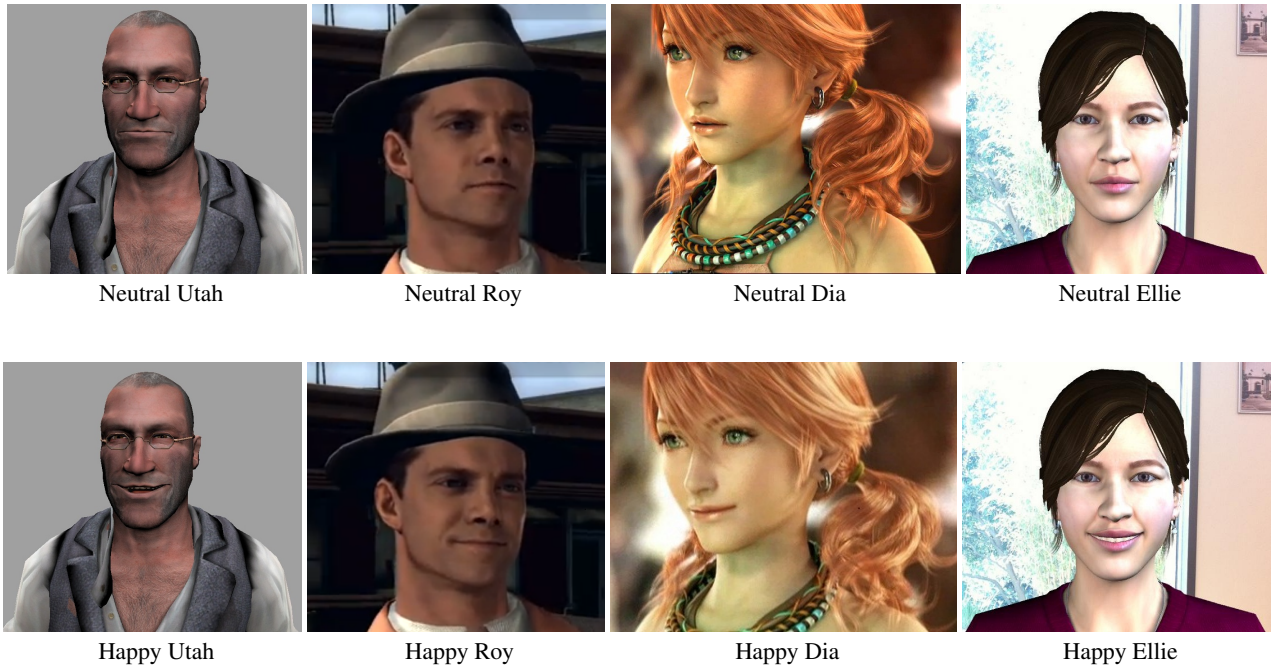


Figure 1: Characters used, neutral and happy expressions (color)

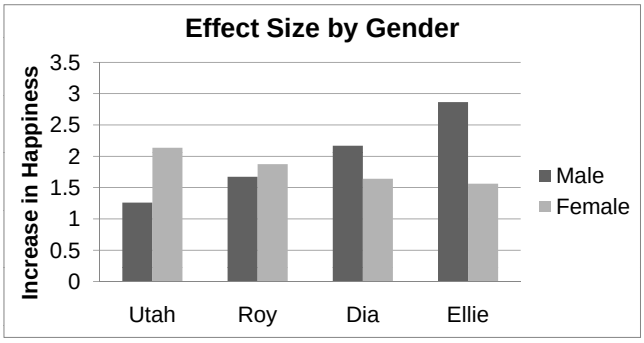


Figure 3: Effect size by gender, Pure Contagion Study

Hypothesis 2 suggests that the perceived happiness of a character will be correlated with the self-report of happiness by subjects. Wild et al. [30] do *not* find systematic support for this hypothesis across the four expressive strengths they tested. In our experiments, however, a Pearson's product moment correlation test reveals that perceived happiness of the character is highly correlated with the self-report of happiness of the participant ($p < 0.001$, $r = 0.6826$). Next, we examine the perceived happiness data on aggregate for each character.

Figure 4 shows the average differences in perceived happiness of the character between Neutral and Happy conditions. If perceived happiness of the characters are highly correlated to respondents' self-reports of happiness, we would expect the exact same trend from Figure 3 to be replicated here, with high increases in perceived happiness occurring with high increases in subject happiness. As can be seen, this is very nearly the case. The trend is identical for female subjects, with light bars exhibiting the same pattern as they do in Figure 3. With the exception of Utah, it is the same for male subjects as well. This suggests that the 'cross-gender' trend seen in Figure 3 may actually be caused by variations in perceived happiness of the characters instead of by gender biases. Of course, the differences in perceived happiness of the characters appears to originate from gender-based effects, but we leave further exploration of this subject to future work.

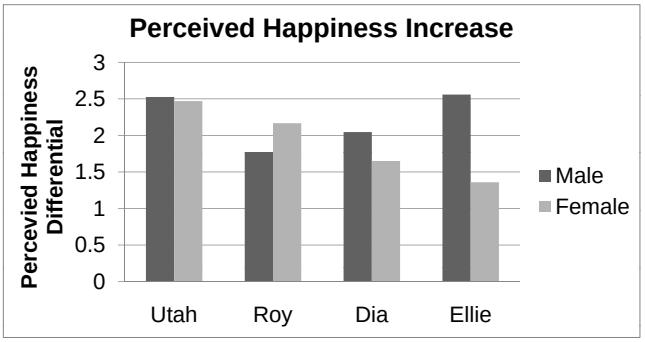


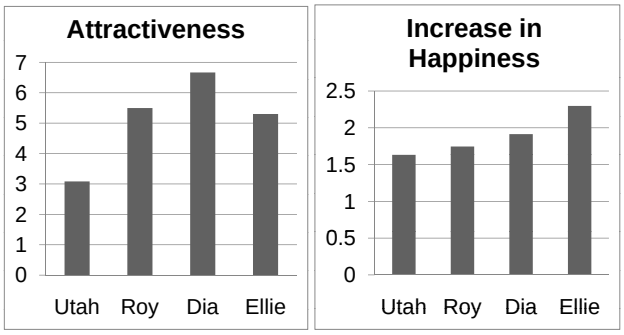
Figure 4: Increase in perceived character happiness by gender

4.4 Attractiveness Effects

Hypothesis 4 suggests that perceived attractiveness of the character should contribute to emotional contagion. A Pearson's product-moment correlation reveals a significant but mild correlation ($p < 0.001$, $r = 0.3918$) between the happiness of participants and the perceived attractiveness of the character shown. For further support, we look to an aggregate analysis of the data, grouping the attractiveness data by character.

Figure 5a shows the average attractiveness rating for each character. As can be seen, Dia is the most attractive, statistically significantly more so than Ellie ($p < 0.001$). Figure 5b shows the increase in respondent happiness between Neutral and Happy con-

ditions. Although Utah is the least attractive and does indeed cause the lowest increase in happiness as per Hypothesis 4, Ellie is actually the character that induces the greatest increase, with Dia substantially lower. This suggests that the attractiveness of the character alone does not provide a strong enough mediating effect in this context to support Hypothesis 4.



(a) Attractiveness (b) Increase in happiness

Figure 5: Pure Contagion Study

4.5 Ethnicity Effects

The study also asked subjects for their ethnicity. In light of the large Indian population, the ethnicities included: Caucasian, Asian (exc. Indian), Indian, African / African-American, Other. However, since the subject pool only contained substantial numbers of Caucasian and Indian respondents ($n > 10$), we restrict analysis to these two ethnic groupings only.

To assess each character's perceived ethnicity, the character assessment also included an element asking the user to respond on a 0-8 Likert scale of '0 - Do not agree at all' to '8 - Very strongly agree' with the statement: The Character is the same ethnicity as I am. As can be seen in Figure 6, all characters were rated much more similar to Caucasians than Indians, with especially large differences for Roy and Utah. All differences were statistically significant ($p < 0.01$ for all but Dia, which was $p = 0.02843$).

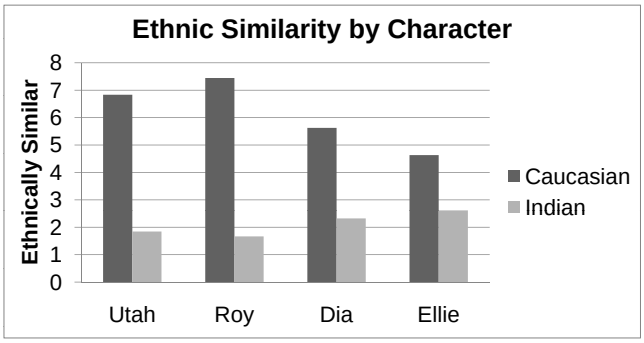


Figure 6: Ethnic similarity for Caucasians and Indians

Figure 7 shows the increase in happiness between Neutral and Happy conditions, broken down by self-reported ethnicity. Hypothesis 5 suggests that since Caucasians find all the characters more similar to themselves, Caucasian respondents should report a greater effect of contagion than Indians. This difference should be especially large for Utah and Roy. However, no such trend emerges. Caucasian subjects show a smaller increase in happiness for Utah than Indian subjects, but also show a larger increase for Roy. Thus, we do not find support for Hypothesis 5 in this experiment.

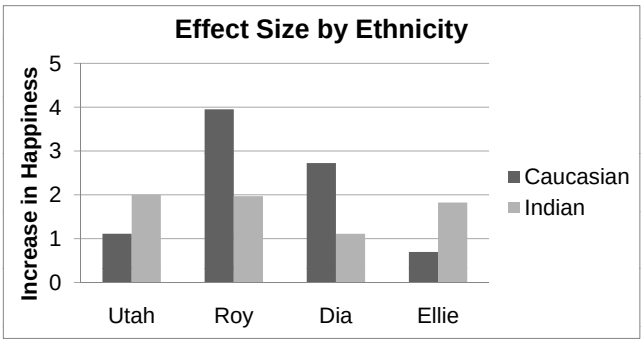


Figure 7: Effect size by ethnicity, Pure Contagion Study

5. STRATEGIC SITUATION STUDY

Having established 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, 9, 14]. While there has been some work in behavioral changes due to emotional contagion, such as its impact on donation amounts [25], 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. The same self-report of emotion used in the first study is employed here.

We used a cooperation situation based on the standard game-theoretic Stag Hunt situation. Originally posed by Jean-Jacques Rousseau, the original story involves two individuals going out on a hunt. Each can commit to hunting a stag or a rabbit and must do so without knowing the other player's choice. An individual can successfully catch a rabbit alone, but the rabbit is worth less than the stag. However, in order to successfully hunt a stag, both hunters must commit to hunting stag. This situation resembles the well-known Prisoner's Dilemma, but differs in that the highest reward comes from both players cooperating. In the Prisoner's Dilemma, the highest reward is achieved by the defector if the other player choose to cooperate. Thus, rational play depends on beliefs about the other player in a Stag hunt, whereas defecting is strictly dominant in a Prisoner's Dilemma.

The actual story used in this experiment casts the Stag Hunt scenario in a modern, 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. Participants were required to be over 18 years of age and were again compensated $0.25 for compliant participation. The gender distribution was once more approximately one-third female and two-thirds male, with approximately two-thirds of

respondents were from India.

5.1 Decision Results

In light of the very strong contagion effect in the Pure Contagion Study and reports of emotional contagion of happiness leading to more trust [9], we expected 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 8. 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.

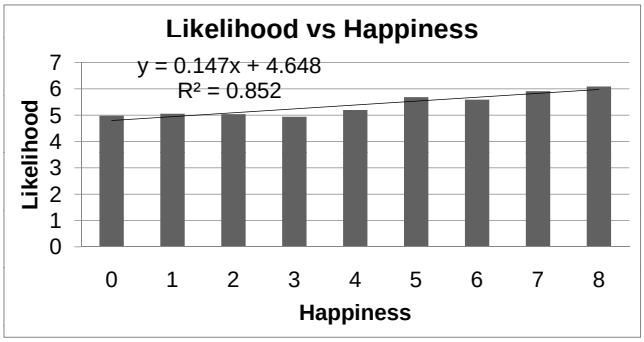


Figure 8: Likelihood of cooperation versus happiness

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 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.

5.2 Contagion Results

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 Figure 9. Each character is shown on the x-axis, with the happiness reported on the y-axis. The dark bars indicate the average happiness reported by subjects who viewed the specified character with a neutral expression while the light bars indicate the average happiness for viewers of the happy expression.

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, as evidenced by the light bars always being higher than the corresponding dark bars. However, the difference between the bars 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 (11 in the Pure Contagion Study, 7 in the Strategic Decision Study), no candidate for a consistent explanatory variable was found. The

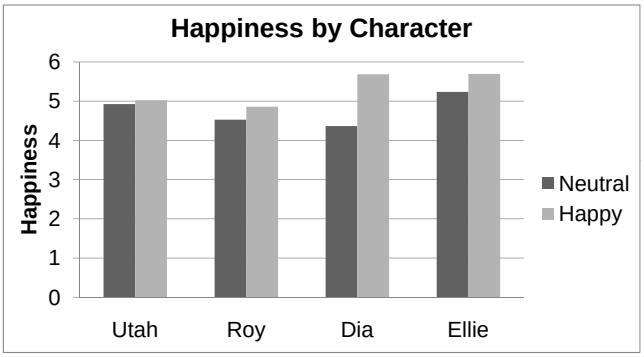


Figure 9: Happiness by character, Strategic Situation Study

	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	

Table 2: Happiness statistics, Strategic Situation Study

full table of statistical test results can be seen in Table 2.

These results suggest that the presentation of a strategic situation and a trust-based decision dampens the emotional contagion effect. This is actually in line with findings by researchers in social psychology [25, 31] 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.

6. STRATEGIC DECISION STUDY

This study was pursued to disentangle the novel effect of making a strategic decision from the previously confirmed effect of reading a situation description [25, 31]. 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. We again specify that the character's room will be decorated first to minimize confounding factors.

In addition to this, we also conducted a second character assessment to target attributes that may contribute to cooperation in the office decoration task to aid in post-hoc analysis. This was done after the self-report of emotion, so it did not impact the original intent of the experiment. A 10-question survey, primarily a subset of the survey used in [16], was administered using a 0-8 Likert scale for each question. Attributes included: Competent, Trustworthy, Knowledgable, Hard-Working, Enthusiastic, Fun, and Artistic. Compliance tests for the character assessment included duplicating the Competence question and ensuring ratings for both occurrences were within 2 points of each other, a Laziness question which could not exceed 5 if Hard-working exceeded 5 as well, and finally a question that simply asked participants to 'Pick number seven'.

In Table 3, the overall results of the experiment are shown, with significance again calculated using a one-way ANOVA. As would

	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 3: Happiness statistics, Strategic Decision Study

	Condition	Mean	SD	*n*	*p*
Utah	Neutral	2.69	2.21	13	0.0302
	Happy	5.00	2.96	14	
Roy	Neutral	4.78	2.44	9	0.1054
	Happy	6.40	1.43	10	
Dia	Neutral	4.94	2.54	16	0.1081
	Happy	5.85	2.54	21	
Ellie	Neutral	4.80	2.27	15	0.1206
	Happy	6.00	1.59	12	

Table 4: Happiness, female subjects, Strategic Decision Study

be expected following findings in social psychology that even reading additional material can dampen emotional influence [25, 31], 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.

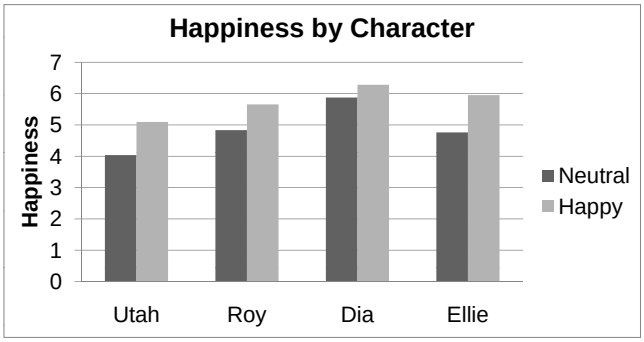


Figure 10: Happiness by Character, Strategic Decision Study

A closer look reveals that gender plays a large role in this study. Figure 11 shows the increase in happiness between Neutral and Happy conditions, split for female and male participants. Notice that for each character, the difference between conditions for females (light bars) is always very high, whereas for men (dark bars), this only occurs with Ellie. It is also interesting to note that the same trend seen in Figure 3 is evident here for women as well. Specifically, greater increases in happiness occurred for characters that were perceived to have a greater increase in happiness between neutral and happy expressions. Table 4 shows the detailed statistical results for female subjects. Notice that all results are either significant or very nearly so. The equivalent table for men, Table 5, reveals that only with Ellie do men have anywhere near a statistically significant response to the stimulus used.

Notice that the effect sizes for women are nearly the same as in

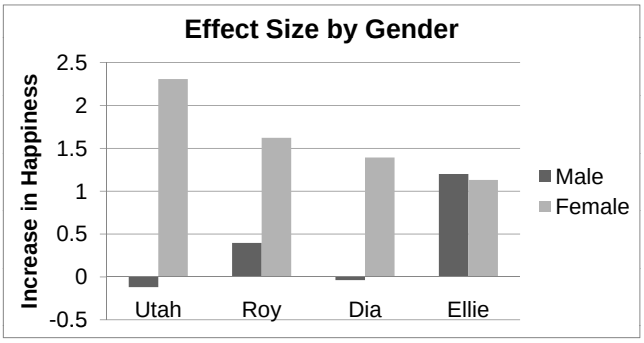


Figure 11: Happiness by gender, Strategic Decision Study

	Condition	Mean	SD	*n*	*p*
Utah	Neutral	5.29	2.49	14	0.8933
	Happy	5.17	2.43	18	
Roy	Neutral	4.87	2.36	15	0.6632
	Happy	5.26	2.90	19	
Dia	Neutral	6.44	1.63	32	0.9322
	Happy	6.40	1.66	25	
Ellie	Neutral	4.8	2.41	30	0.0487
	Happy	5.93	1.87	29	

Table 5: Happiness, male subjects, Strategic Decision Study

the Pure Contagion Study and, in fact, exhibit the exact trend from Figure 3. This supports a variation of Hypothesis 3 that emphasizes resilience of emotional contagion as opposed to magnitude of effect as has been previously reported. Specifically, it appears that emotional contagion to women is less dampened by reading a situation description than for men. However, since this is a post-hoc hypothesis, we leave further exploration of this to future work.

7. CONCLUSION

In this work, we provide the first ever examination of agent-human emotional contagion. We confirm its existence with a pure contagion study with astoundingly strong results. We find no support for gender differences in emotional contagion strength despite numerous studies in human-human contagion in support of the hypothesis [6, 17]. The attractiveness of the character also does not appear to affect the contagion effect, although its perceived happiness does. 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 shows 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 key recommendations for virtual agent researchers. First, emotional contagion with virtual agents is very substantial and applications need to accurately account for it. We have shown that in some domains, even a still image can have a huge emotional effect, but more work must be done to delineate these domains with greater clarity. Second, considering the number of unsupported hypotheses found in this work, 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 and not all smiles reflect positive emotional states [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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