Evaluating Animated Characters: Facial Motion Magnitude Influences Personality Perceptions

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Animated characters are expected to fulfill a variety of social roles across different domains. To be successful and effective, these characters must display a wide range of personalities. Designers and animators create characters with appropriate personalities by using their intuition and artistic expertise. Our goal is to provide evidence-based principles for creating social characters. In this article, we describe the results of two experiments that show how exaggerated and damped facial motion magnitude influence impressions of cartoon and more realistic animated characters. In our first experiment, participants watched animated characters that varied in rendering style and facial motion magnitude. The participants then rated the different animated characters on extroversion, warmth, and competence, which are social traits that are relevant for characters used in entertainment, therapy, and education. We found that facial motion magnitude affected these social traits in cartoon and realistic characters differently. Facial motion magnitude affected ratings of cartoon characters' extroversion and competence more than their warmth. In contrast, facial motion magnitude affected ratings of realistic characters' extroversion but not their competence nor warmth. We ran a second experiment to extend the results of the first. In the second experiment, we added emotional valence as a variable. We also asked participants to rate the characters on more specific aspects of warmth, such as respectfulness, calmness, and attentiveness. Although the characters' emotional valence did not affect ratings, we found that facial motion magnitude influenced ratings of the characters' respectfulness and calmness but not attentiveness. These findings provide a basis for how animators can fine-tune facial motion to control perceptions of animated characters' personalities.

CCS Concepts: • **Information systems** → **Multimedia content creation**; • **Computing methodologies** → *Animation;*

Additional Key Words and Phrases: Facial motion, animation, personality perception, rendering style

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1. INTRODUCTION

Animated characters can evoke social responses from people when carefully designed in a way that is appropriate for their audiences. Indeed, when animated characters are humanlike, people will treat them like other people [Sproull et al. 1996], even responding neurologically to them [Schilbach et al.

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2006]. To improve their appeal and efficacy, designers and animators may want to customize the personalities of animated characters for their roles and application domains. For example, it may be beneficial for characters in entertainment applications to be highly extroverted because extroversion is positively related to social adeptness [Digman 1990; Anderson et al. 2001]. Similarly, characters acting as educators and therapists may benefit from appearing warm and competent, which are qualities that are essential for those roles [Young and Shaw 1999; Ackerman and Hilsenroth 2003].

Modifying the facial characteristics of animated characters may be enough to influence how people perceive their personalities. Prior research suggests that people form impressions of animated characters similarly to how they form impressions of other people (for review, see Cassell [2000] and Bente et al. [2001]), which includes using faces to form impressions of the characters' competence and personalities [Sproull et al. 1996]. Facial cues are important for interpreting many social qualities, including emotion, mental state, and personality [Ekman et al. 1980; Donath 2001; Oosterhof and Todorov 2008; Back et al. 2009]. Even infants can use facial expressions to identify the emotional states of others [Izard 1994]. Faces also reveal information that people use to form quick impressions regarding competence and personality (e.g., Willis and Todorov [2006]). Many times, these impressions are based on stereotypes. A wide-eyed, small nosed, "baby-like" visage results in impressions of trustworthiness, naïveté, kindness, and weakness [Zebrowitz 1997].

Facial cues are also important during conversation because they provide nonverbal information to supplement speech. For example, a forced smile may indicate deceit [Ekman et al. 1988], a wink may suggest a joke, and a nod may indicate understanding. Even changes to the amount or intensity of a person's facial motion can affect people's impressions. People perceive others with expressive facial motion as attractive, likable, and extroverted [Friedman et al. 1988; Riggio and Riggio 2002]. People form social judgments of one another based on these cues, and these social judgments affect subsequent interactions and relationships (for review, see Zebrowitz and Montepare [2008]).

People seem to interpret the facial cues of animated characters as they do cues from real faces. For example, researchers showed that people could recognize emotional expressions from nonphotorealistic faces (e.g., Hess et al. [1997]). However, the quality of the face can affect viewers' abilities to accurately identify facial expressions of emotions: the expressions of photorealistic faces are clearer than those of nonphotorealistic faces [Ellis and Bryson 2005]. Facial motion also clarifies and adds nuances to emotional expressions [Ambadar et al. 2005]. Finally, researchers have found that they can influence how people perceive and interact with animated characters by changing the characters' facial characteristics. McDonnell and colleagues [2012] found that a character's rendering style influenced perceptions of the character's appeal, friendliness, and trustworthiness. Weibel and colleagues [2010] found that enlarging the pupils of characters improved sociability and attractiveness ratings. Furthermore, facial motion can be manipulated to influence social judgments. For example, slowing the blink rates of animated characters increases impressions of sociability and attractiveness [Takashima et al. 2008; Weibel et al. 2010], and using appropriate emotional expressions improves perceptions of believability, warmth, and competence in animated characters relative to inappropriate or absent expressions [Niewiadomski et al. 2010].

In our prior research [Hyde et al. 2013, 2014], we experimented with varying the facial motion magnitude of animated characters by scaling their facial movements. All motion in the characters' faces was scaled by the same factor to produce animations with different levels of intensity [Hyde et al. 2014]. In one experiment, we found that facial motion magnitude positively influenced perceptions of extroversion [Hyde et al. 2013]. In other words, larger facial motions correlated with higher ratings of extroversion. We also found that participants responded differently to facial motion magnitude depending on the rendering style of the animated character [Hyde et al. 2013]. Participants rated cartoon characters as less competent when the characters exhibited more facial motion. However, participants rated competence equally for realistic characters exhibiting different amounts of facial motion. This difference may be attributed to the typical animation style of cartoon characters, which are often depicted as silly and incompetent. It is unclear how much participants' prior exposure to cartoon characters may have influenced their judgments.

Traditionally, animators exaggerated the motion of cartoon characters to create the "illusion of life" [Lasseter 1987; Thomas and Johnston 1981]. There is concern that this style is inappropriate for more realistic characters. Hodgkinson [2009] suggests that realistic characters may require realistic motion to maintain their lifelikeness. These styles have not been experimentally validated, and our prior work [Hyde et al. 2013] suggests that facial motion affects characters differently depending on their rendering style. Collectively, these results suggest that modifying the rendering style and facial motion magnitude of animated characters will influence people's perceptions of the characters' personalities.

We designed two experiments to investigate how the facial motion magnitude of cartoon and more realistic characters affects viewers' perceptions of the characters on measures of extroversion, warmth, and competence. We used active appearance models (AAMs) [Cootes et al. 2001, 2002; Matthews and Baker 2004] to track a real person's facial motion and map it to a character's face during a process called retargeting. In the retargeting step, we manipulated the spatial distance between facial features to exaggerate and damp facial motion. We previously investigated people's sensitivity to facial motion changes in cartoon and realistic characters [Hyde et al. 2013]. We discovered that the participants were sensitive to motion changes in both types of characters. We then examined how facial motion magnitude influenced people's perceptions of the animated characters on scales related to extroversion, warmth, and competence [Hyde et al. 2013]. There was a positive correlation between facial motion magnitude and perceptions of extroversion. People also perceived exaggerated cartoon characters as less competent than damped cartoon characters. Facial motion magnitude showed a slight potential trend toward influencing perceptions of warmth for the realistic characters, but the results were not significant.

In this article, we present more details of this work (in Experiment 1) with a new analysis of results. The new analysis enables us to compare our prior results to findings from new research (Experiment 2) presented herein. The new experiment extends our prior work [Hyde et al. 2013]. Because the results relating facial motion magnitude to ratings of warmth in general were not significant, we examined whether facial motion magnitude might influence ratings of specific aspects of warmth. We focused on the aspects of warmth that are important for educators and therapists (i.e., attentiveness, calmness, and respectfulness) [Ackerman and Hilsenroth 2003]. Participants in the first experiment only rated characters that spoke about positive situations; however, in educational and therapeutic settings, characters may have to speak about negative situations. To generalize results from our first experiment, participants rated positive and negative characters in the new experiment. The findings suggest that exaggerated facial motion will benefit cartoon characters used in entertainment applications and that damped facial motion will improve realistic characters used in education and therapy applications.

2. EXPERIMENTAL STIMULUS CREATION

We are interested in improving animated characters that interact with people. Therefore, we animated our characters with realistic human facial motion to elicit the greatest amount of social response from viewers. To capture realistic facial motion, we tracked actors' faces while they read stories that we developed for our experiments. We used AAMs [Cootes et al. 2001, 2002; Matthews and Baker 2004], a markerless computer vision method, to track motion that we then mapped onto animated characters. This method of animation supports simple adjustment of spatial motion by setting a single parameter. The parameter is used to scale the facial motion magnitude in the entire face. In this article, we provide a more detailed description of our stimulus creation than what appeared in prior work [Hyde et al. 2013].

2.1 Selecting Stories to Animate

In the experiments presented in this article, we evaluated participants' impressions of characters that were animated with different amounts of facial motion. We did not want participants to be affected by repetition in the stories, so we contracted a writer to create unique short stories for the characters to read. In Sections 3 and 4, we describe experiments in which facial motion magnitude was a within-subjects variable with eight levels. For the experiment described in Section 3, we also included story valence (positive, negative) as a between-subjects variable in order to ensure that results were consistent across emotional valence. Therefore, we required 16 short stories to test eight different motion levels presented with two story valences. The writer created 24 stories in first-person perspective. For each story, we recruited 16 to 21 raters using Amazon's Mechanical Turk. The raters evaluated each story's positivity, emotional intensity, interest, and emotional complexity. We used one-way analyses of variance (ANOVAs) to find the 16 most similar positive and negative stories. Eight stories clearly evoked negative emotion. The 14 remaining positive stories had similar emotional complexity, so we used ratings of intensity and interest to determine the eight most similar positive stories.

2.2 Creating Animations

We used a Sony PMW-EX3 camera and an Audio Technica shotgun microphone to record an actor and actress from the shoulders up while they read the 16 short stories. The recordings ranged in length from 1:17 to 1:42 (min:s). To animate our characters, we tracked the actors' facial motion using 2D AAMs. We then mapped the tracked motion to the characters. The animation process is described in more detail in the next section.

We created four cartoon characters (two female, two male) and four comparatively more realistic characters (two female, two male). Therefore, we had the same number of characters as stories of a single valence. Within each gender, characters differed by hair, eye, skin, and shirt color (Figure 1). The animations used the audio tracks from the video recordings.

Prior sensitivity experiments indicated that motion was clearly damped or exaggerated when we altered it by $\pm 40\%$ from the initial movement, independent of character style [Hyde et al. 2013]. Therefore, we selected eight motion levels to use in our remaining experiments: 60%, 70%, 80%, 90%, 110%, 120%, 130%, and 140%. We provide sample images from each motion level in Figure 2. Animations were created for all possible combinations of character, story, and motion level at a resolution of 1086×639 pixels with a presentation rate of 60fps.

2.3 Active Appearance Models

Because people are adept at recognizing social cues from faces, we selected an animation method that created characters with accurate human facial motion. AAMs are capable of tracking subtle facial movements, eye gaze, and blinks. Therefore, we used 2D AAMs [Cootes et al. 2001, 2002; Matthews and Baker 2004] to track and retarget our actors' facial motion (Figure 3). With this computer vision method, a person and character's face shapes and appearance are modeled to form a mapping between the person and character. Once the model of the person is learned, his or her face can be tracked and corresponding points in the character model can be moved.

An AAM consists of two independent models that describe shape and appearance variations. We used these models to define all possible face shapes and appearances for our actors and characters. Our face shapes were vectors of 79 coordinates ($\mathbf{s} = (x_1, y_1, \ldots, x_{79}, y_{79})^T$). We created the shape models with hand-labeled training videos of the actors. The shape model is defined in Equation (1), where $\mathbf{s}$

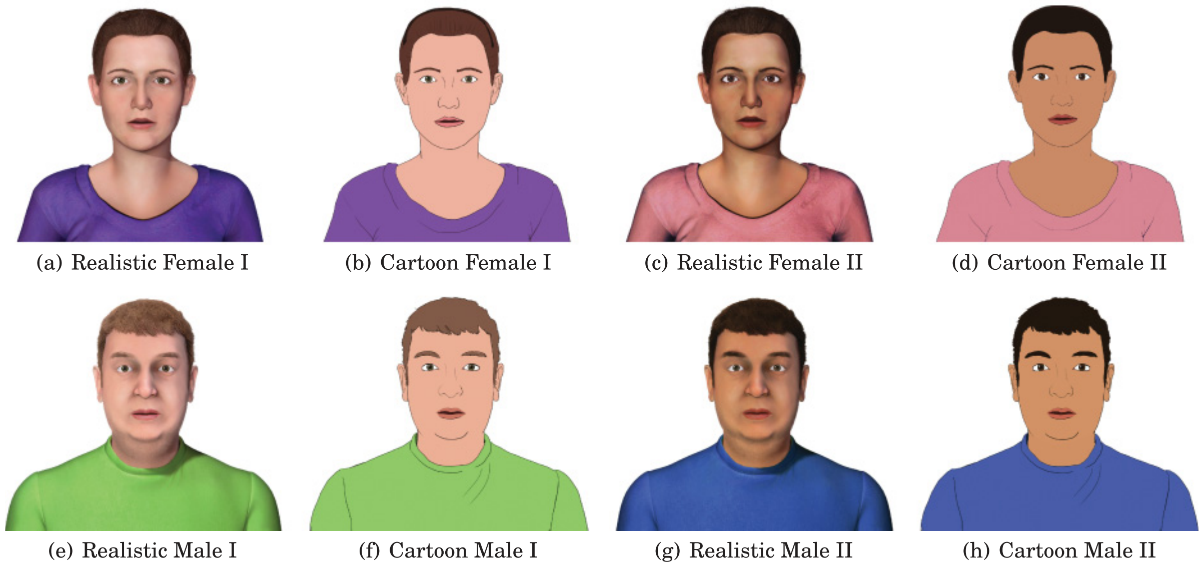


Fig. 1. The eight characters in cartoon and more realistic rendering styles.

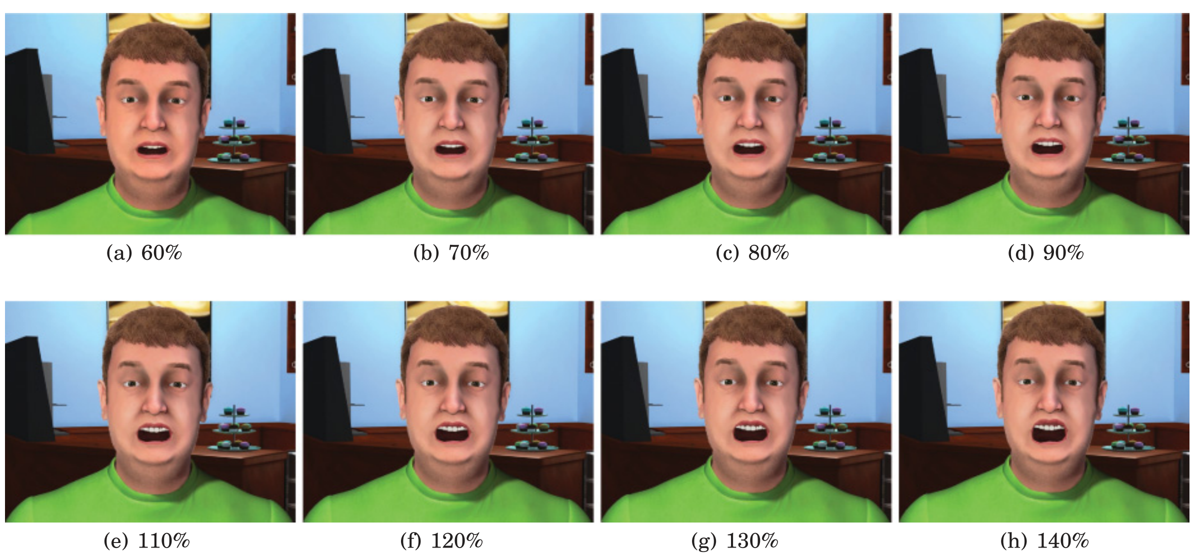
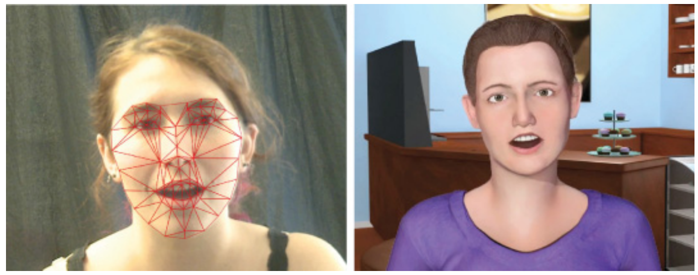


Fig. 2. Sample still frames of the eight different motion levels.

is defined as a new shape, $\mathbf{s_0}$ as the mean shape, and the vectors $\mathbf{s_1}$ through $\mathbf{s_m}$ as the largest basis vectors that span the shape space. The shape parameters, p_i, indicate how much each corresponding basis vector contributes to the overall face shape. A new shape can then be expressed as the mean shape plus a linear combination of the m shape bases.

$$\mathbf{s} = \mathbf{s_0} + \sum_{i=1}^{m} \mathbf{s_i} p_i \tag{1}$$



(a) Tracking (b) Retargeting

Fig. 3. (a) Example of an actor's AAM model overlaid on recorded video during the tracking phase. (b) Example of how an actor's motion is retargeted to animate a character.

The appearance model is defined similarly in Equation (2), with appearance, $\mathbf{x} = (x, y)^T$, defined as the pixels that lie within the mean face shape. $A(\mathbf{x})$ is the new appearance, $A_0(\mathbf{x})$ is the mean appearance, $A_1(\mathbf{x})$ through $A_l(\mathbf{x})$ are the largest bases spanning the appearance space, and the λ_i appearance parameters indicate the amount that each appearance base contributes to the new appearance.

$$A(\mathbf{x}) = A_0(\mathbf{x}) + \sum_{i=1}^{l} \lambda_i A_i(\mathbf{x}) \qquad \forall \mathbf{x} \in \mathbf{s_0} \tag{2}$$

During movement, each AAM vertex changes position. The distance that a tracked vertex travels from its neutral position in the video is used to determine how a corresponding character's AAM vertex should move. We selected a pose with closed eyes and mouth to determine the neutral position. By selecting the specified pose, a character with its eyes and mouth closed always looked the same regardless of whether the motion had been exaggerated or damped. The torsos of our animated characters moved rigidly with respect to a pivot located at the characters' mouths because we did not track actor body motion. The characters also faced forward because they were created from 2D data. To fix problems with tracking in two dimensions when the motion is three-dimensional, we added rigid points around the tops of the characters' heads to prevent warping, and we damped the face borders and nose points by 50% to ensure that the characters' faces and noses did not appear squished or stretched when the actors turned their heads slightly. The nose was not completely rigid to allow for subtle deformations like nostril flares and scrunching.

We followed the procedure from Boker et al. [2009] and Theobald et al. [2009] to exaggerate and damp the facial motion of the characters. We scaled the change in position for each AAM vertex to exaggerate and damp the spatial movements across all features of the face. We exaggerated motion by multiplying the face shape variation by values greater than 1, and we damped motion by multiplying the face shape variation by values less than 1.

We retargeted each actor's motion to all characters of the same gender using all vertices of his or her single individual AAM (thus, all characters had the same degrees of freedom). We did not modify the duration of motion even though our manipulations changed the velocity of motion. The time an actor took to complete a motion, such as opening and closing his or her mouth, was the same regardless of manipulation. However, the actor's smile would be bigger and his or her lips would move faster in the case of exaggeration. Because the duration of motion was unchanged, the actors' audio was still synchronized with the modified motion.

3. EXPERIMENT 1: EFFECT OF FACIAL MOTION MAGNITUDE ON PERCEPTIONS OF EXTROVERSION, WARMTH, AND COMPETENCE[1]

We were interestedin exploring how the facial motion magnitude and rendering style of animated characters affect the perceptions of social traits that are important in entertainment, education, and therapy. This first experiment determined the effects of damped and exaggerated facial motion on perceptions of characters' extroversion, warmth, and competence. Participants evaluated cartoon and more realistic animated characters that displayed varying amounts of facial motion.

3.1 Hypotheses

We expected to find a positive effect of facial motion magnitude on ratings of extroversion, with more movement leading to perceptions of greater extroversion. Research suggests that extroverts move their bodies faster than introverts [Stelmack et al. 1993; Doucet and Stelmack 1997; Wickett and Vernon 2000]. Extroverts also tend to be more expressive and have larger movements [Gallaher 1992; Gifford 1991]. When we exaggerated the characters, we increased the velocity and size of their motions. Therefore, we expected to find a positive relationship between ratings of extroversion and facial motion magnitude (H1.1).

We also expected that a realistic rendering style would lead to perceptions of greater warmth than a cartoon rendering style. We reasoned that a realistic rendering style would seem familiar to people and would be more similar to friends and family than cartoons. Research suggests that people find other people appealing when they are familiar and similar [Moreland and Zajonc 1982]. A study by McDonnell and colleagues [2012] showed a significant effect of the appeal of rendering styles on friendliness and trustworthiness. Similarly, our measure of warmth included items for likability and trustworthiness. We hypothesized that the realistic rendering style would lead to higher ratings of warmth than the cartoon rendering style (H1.2).

Because exaggerated movement is a signature of cartoon-style motion [Thomas and Johnston 1981; Lasseter 1987; Hodgkinson 2009], we expected participants to prefer the exaggerated cartoon characters to the damped cartoon characters. We also expected that participants might associate exaggerated movement of cartoon characters with incompetence, as is frequently the case with many hapless but beloved cartoon characters (e.g., Mr. Magoo, Dr. Zoidberg, Daffy Duck). We therefore hypothesized that exaggerated cartoon characters would receive higher ratings of warmth but lower ratings of competence than damped cartoon characters (H1.3).

3.2 Method

This experiment used a repeated-measures experimental design. Motion level and rendering style were within-subjects factors with eight and two conditions, respectively. As described in Section 2, we created animations of eight characters reading positive (happy) stories at eight different motion levels. Because we wanted participants to form independent impressions of the characters' personalities, we did not allow participants to see any character, story, or motion level more than once. Therefore, each participant evaluated eight animations, where each animation contained a previously unseen character, story, and motion level. We designed the study as a paired, orthogonal Latin square to control for order effects, and we counterbalanced condition pairings [Lewis 1989]. We selected participants' trial conditions and order of characters using the pair of Latin squares such that every character and motion pair occurred twice across all participants.

[1]This article presents further analysis and comparisons with a second experiment that did not appear in our earlier description of this experiment at IEEE Automatic Face and Gesture Recognition 2013 [Hyde et al. 2013].

3.2.1 *Materials.* Each participant completed the Ten-Item Personality Inventory (TIPI) [Gosling et al. 2003] to measure his or her personality before seeing any animations. In a preliminary analysis, participant personality did not affect results. Therefore, we do not refer to it again in the analysis.

For the experiments described in this chapter, we presented all study stimuli and collected all participant responses using Apple 27-inch flat-panel LED cinema displays connected to machines running OSX 10.6, Matlab, and the Psychophysics Toolbox extensions [Brainard 1997; Pelli 1997; Kleiner et al. 2007]. Participants entered their responses using a keyboard.

3.2.2 *Dependent Measures.* In this experiment, participants used rating scales to evaluate the animated characters on items that we selected from known measures of warmth and competence and lists of important traits for educators and therapists [Ackerman and Hilsenroth 2003; Fiske et al. 2002; Young and Shaw 1999]. Participants rated each character on 12 items using five-point rating scales (e.g., *1 = competent, 2 = somewhat competent, 3 = neither competent nor incompetent, 4 = somewhat incompetent, 5 = incompetent*). We performed a principal component analysis and factor rotation on participants' responses to find three reliable factors, and we created scales based on these factors. To combine items into scales, we normalized participant responses using a log transform and then calculated a standardized value. Standardizing centers the response variable by its sample standard deviation. Therefore, a normalized response of 0.5 is half of a sample standard deviation from the sample mean.

Extroversion. This scale included ratings of perceived extroversion, inhibition (reverse scored), dramaticism, and sociability (Cronbach's $\alpha = 0.74$).
Warmth. This scale included ratings of perceived likability, trustworthiness, reliability, warmth, and sincerity (Cronbach's $\alpha = 0.82$).
Competence. This scale included ratings of perceived intelligence, competence, and how well informed the character seemed (Cronbach's $\alpha = 0.75$).

3.2.3 *Participants.* In this experiment, 34 adult participants (age range: 18–62 years; median age: 22.5 years; 18 females) rated eight animated characters on their extroversion, warmth, and competence. We eliminated two additional participants' data because of equipment malfunction.

3.2.4 *Procedure.* Participants arrived at the study location and completed consent forms. An experimenter led participants to the study setup and explained the experiment to participants. Participants then used a computer to complete the TIPI. After completion, participants advanced to an instruction screen explaining that they would see a series of animations, each of which would be followed by a questionnaire asking about their impressions of the character in the animation. The participants then viewed each animation and answered the accompanying questions. A screen before each animation reminded participants that they could take a break. The experimenter stayed by the participant during the study so that participants could ask questions or take breaks at any time. Participants were not told how the animations had been created or manipulated. At the end of the study, the participants were thanked and debriefed. The experiment lasted no longer than 40 minutes.

3.3 Results

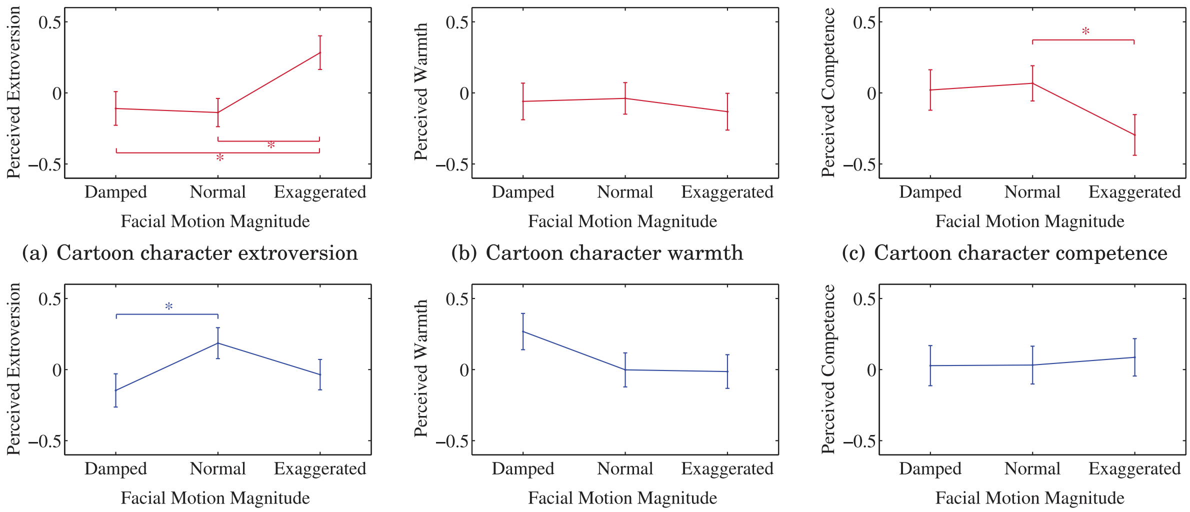
To mitigate the effect of actor differences, we calculated normalized values for each actor's motion. For each recording, we measured the amount of actor motion and calculated the average displacement of each AAM vertex. We then normalized these motion values for each actor. The minimum and maximum normalized motion values for each actor defined the range of normal motion for the purposes of this study (comparing the normal to damped and exaggerated motion). We then multiplied the normalized motion values by the motion scaling factors to get values of facial motion magnitude for each animation. We categorized animations as damped, normal, or exaggerated depending on whether the values of facial motion magnitude fell within or beyond the normal range of motion. Because preliminary analysis indicated that effects were similar across actors, we did not differentiate between actors in further analysis. We conducted a repeated-measures multivariate ANOVA to analyze how facial motion magnitude and rendering style influenced the measures of extroversion, warmth, and competence.

We expected to find a positive relationship between facial motion magnitude and ratings of perceived extroversion (H1.1). We found a nonsignificant trend toward a positive relationship between facial motion magnitude and perceived extroversion across all characters, $F(2, 229) = 2.97$, $p = .0533$. Participants' ratings of perceived extroversion significantly increased between the damped and exaggerated characters, $F(1, 222) = 5.90$, $p = .0160$, and 95% CIs [−.3030, .0467] and [−.0437, .2911], respectively. Although the differences in pairwise ratings between damped and normal characters and between normal and exaggerated characters were not significant ($F(1, 231) = 2.23$, $p = .1363$ and $F(1, 232) = 1.03$, $p = .3105$, respectively), there was still a trend in main effect for the positive relationship between facial motion and perceived extroversion.

We hypothesized that rendering style would influence ratings of characters' warmth (H1.2). We found that rendering style significantly affected perceptions of warmth such that participants perceived the more realistic characters as significantly warmer than the cartoon characters, $F(1, 219) = 3.93$, $p =$ .0486, 95% CIs [−.0937, .2617] and [−.2556, .1017], respectively. Rendering style did not affect any of the other dependent measures.

We then analyzed the influence of motion on cartoon and more realistic characters separately using specific planned contrasts. We expected characters to benefit from "matching" rendering styles and motion combinations. We hypothesized that exaggerated cartoon characters would have higher ratings of warmth and lower ratings of competence than damped cartoon characters (H1.3). Facial motion did not affect the perceived warmth of cartoon characters, but it did affect their perceived competence (Figures 4(b) and 4(c), respectively). Participants perceived the exaggerated cartoon characters as less competent than the normal cartoon characters ($F(1, 234) = 5.49$, $p = .0200$, 95% CIs [−.5789, −.0130] and [−.1787, .3137], respectively). There was a trend in which participants rated the exaggerated cartoon characters as slightly less competent than the damped cartoon characters, although this relationship was not quite significant ($F(1, 234) = 3.43$, $p = .0652$, 95% CI [−.2611, .3023]). As additional support to H1.1, we found that participants perceived the exaggerated cartoon characters as more extroverted than normal and damped characters, $F(1, 243) = 8.69$, $p = .0035$, $F(1, 243) = 6.23$, $p = .0132$, 95% CIs [.0492, .5169], [−.3343, .0574], and [−.3434, .1239], respectively (Figure 4(a)).

There were trends suggesting that participants may have perceived damped realistic characters as slightly warmer than normal realistic characters ($F(1, 227) = 3.37$, $p = .0678$, 95% CIs [.0154, .5199] and [−.2390, .2350], respectively) and even warmer than exaggerated realistic characters ($F(1, 235) =$ 3.59, $p = .0594$, 95% CI [−.2481, .2207]), although these did not quite reach significance (Figure 4(e)). Facial motion did not affect the perceived competence of realistic characters as it did cartoon characters. For the realistic characters, ratings of competence remained relatively constant despite the facial motion changes (Figure 4(f)). Lastly, participants rated the damped realistic characters as significantly less extroverted than the normal realistic characters, $F(1, 232) = 5.14$, $p = .0243$, 95% CIs [−.3776, .0843] and [−.0283, .4005], respectively. However, perceptions of extroversion for the exaggerated realistic characters did not differ significantly from the normal realistic characters, $F(1, 241) =$ 2.49, $p = .1156$, 95% CI [−.2463, .1752] (Figure 4(d)).



(a) Cartoon character extroversion (b) Cartoon character warmth (c) Cartoon character competence

(d) Realistic character extroversion (e) Realistic character warmth (f) Realistic character competence

Fig. 4. Influence of facial motion magnitude on perceptions of the cartoon characters' (a) extroversion, (b) warmth, and (c) competence. Influence of facial motion magnitude on perceptions of the more realistic characters' (d) extroversion, (e) warmth, and (f) competence. The asterisk indicates significance at $\alpha = .05$ or less.

3.4 Discussion

The results indicate that exaggerating and damping the facial motion of animated characters significantly affect people's perceptions of the characters' social traits. There were significant main effects of facial motion magnitude on ratings of extroversion for both cartoon and realistic characters, with pairwise comparisons suggesting that increased facial motion magnitude can result in higher levels of perceived extroversion. The analysis also suggests that cartoon and more realistic characters may be best suited for different types of applications. Participants perceived exaggerated cartoon characters as more extroverted but less competent, suggesting that these characters may be more appropriate for entertainment applications. Exaggeration may have had this effect due to the association of exaggerated movement with classic cartoon characters. Classic cartoon characters with exaggerated movements, like those created by Tex Avery (e.g., Daffy Duck, Porky Pig), were known more for their silliness than for their intelligence. Additionally, participants perceived realistic characters as warmer than cartoon characters. Participants may have felt more familiar and similar to the realistic characters compared to the cartoon characters, thus increasing the realistic characters' appeal and warmth. The participants' perception of realistic characters as generally warm and competent suggests that realistic characters may be best suited for educational and therapeutic applications. Damping the motion of realistic characters may increase perceptions of warmth even more, although the results pertaining to this effect did not reach a significant level. To explore these ideas further and to validate, extend, and generalize these findings, we ran a follow-up experiment.

4. EXPERIMENT 2: EFFECT OF FACIAL MOTION ON PERCEPTIONS OF EXTROVERSION, RESPECTFULNESS, CALMNESS, AND ATTENTIVENESS

In this experiment, participants again watched and rated animated characters that varied in rendering style and facial motion magnitude. We included additional measures of warmth to further explore the weak relationship found previously between facial motion magnitude and the warmth of realistic characters. To explore this possible relationship further, we used more specific aspects of warmth (i.e., attentiveness, calmness, and respectfulness). We selected these aspects of warmth due to their relevance in education and therapy [Young and Shaw 1999]. Additionally, half of the characters in this experiment spoke of negative situations. Because participants in the previous experiment only saw characters in positive situations, we were unsure whether the effects of rendering style and facial motion magnitude would generalize to characters in negative situations. Characters used in education and therapy may need to operate in negative situations; therefore, it is important to understand whether our prior results would generalize to different situations. Because facial motion magnitude had the strongest effect on ratings of extroversion, we reused our extroversion measure in this experiment with a slight modification. We removed the weakest item from the extroversion measure. This was done in part to keep the experiment short so that participants' memories would not affect results. For the same reason, participants did not rate characters on competence in this experiment. In the end, participants completed 16 items per animation for this experiment compared to 12 items per animation in the previous experiment.

4.1 Hypotheses

Based on the results of the first experiment, we identified ways in which facial motion magnitude significantly influenced perceptions of cartoon and more realistic animated characters. For this experiment, we wanted to validate the finding of facial motion magnitude on extroversion, explore further any possible effects of facial motion magnitude on warmth, and generalize the effects to characters in positive and negative situations. We hypothesized that participants would perceive characters with more facial motion as more extroverted than characters with less facial motion (H2.1). Additionally, facial motion previously only had a slight influence on perceptions of realistic characters' warmth. For this study, we divided our measure of warmth into the more specific aspects of respectfulness, calmness, and attentiveness. We believed that our previous measure of warmth may not have been sensitive enough to capture the effect of facial motion magnitude. Warmth is composed of many different aspects that may not be influenced by facial motion in the same ways. When we exaggerated the facial motion magnitude of the animated characters, their facial motion became larger and faster. It is possible that these larger and faster movements may be considered as disingenuous compared to the normal or damped motions. We hypothesized that for realistic characters, perceptions of respectfulness (H2.2), calmness (H2.3), and attentiveness (H2.4) would increase as facial motion decreased. Story valence was a control variable.

4.2 Method

This experiment used the same characters, actors, positive stories, motion levels, equipment, and procedure as the previous experiment. Motion level and rendering style were still within-subjects factors with eight and two conditions, respectively. We added story valence as a between-subjects factor with two conditions (i.e., negative and positive). Similar to the previous experiment, each participant watched eight animations with no repeated character, story, or motion level. Because story valence was a between-subjects factor, each participant saw animations with a single valence.

4.2.1 *Dependent Measures.* After watching each character, participants rated the character on items related to extroversion, respectfulness, calmness, attentiveness, and positivity. We asked participants to rate the characters' positivity to check story valence. We removed the weakest item from the previous extroversion measure to prevent participants from being overwhelmed with too many questions. In total, we asked 16 questions in the form of five-point rating scales. We normalized participants' responses using the same method from the prior experiment. Principal component analysis followed by a factor rotation indicated that 15 questions loaded onto four factors with acceptable reliability (Cronbach's α). In the previous experiment, the extroversion measure had higher reliability than the current extroversion measure. Unfortunately, by removing the question on sociability from the previous extroversion measure, we reduced the reliability of the measure. To determine whether reliability was influenced by the addition of negative stories, we also calculated the reliabilities separately for positive and negative stories. The reliability for extroversion did not significantly improve when we eliminated the negative stories. We did not include the positivity question in the principal component analysis because the question served as a manipulation check.

Extroversion. This scale included ratings of perceived extroversion, inhibition (reverse scored), and dramaticism (Cronbach's $\alpha = 0.51$).
Respectfulness. This scale included ratings of perceived respectfulness, patience, considerateness, acceptance, understanding, humility, and sensitivity (Cronbach's $\alpha = 0.91$).
Calmness. This scale included items of perceived calmness, contentedness, and untroubledness (Cronbach's $\alpha = 0.83$).
Attentiveness. This scale included items of perceived attentiveness and carefulness (Cronbach's $\alpha = 0.56$).

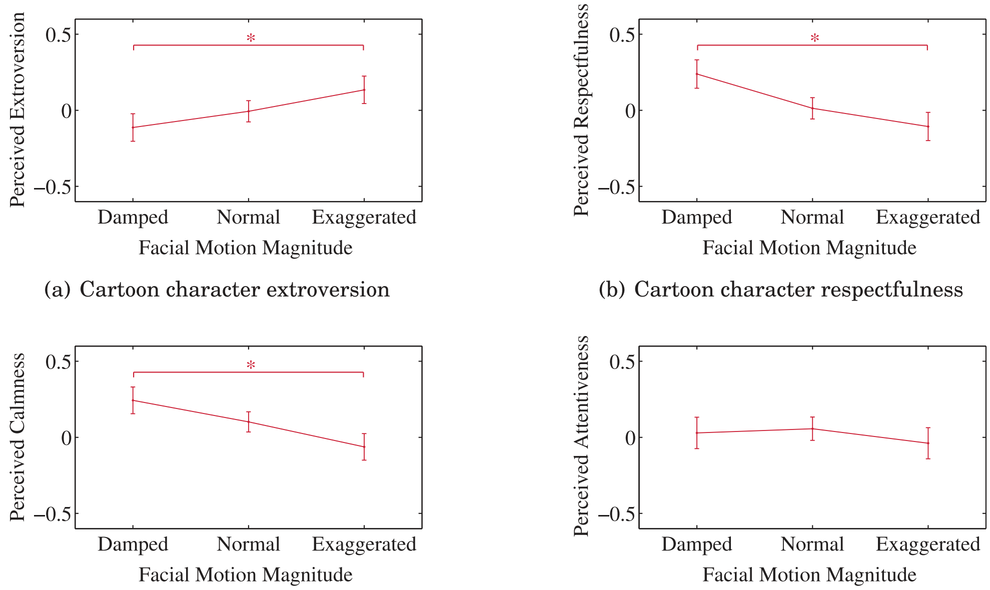
4.2.2 *Participants.* Sixty-four adult participants (age range: 18–58 years; median age: 23 years; 31 females) took part in this study. None of the participants had completed the sensitivity experiments or the previous experiment. We randomly split participants into two groups to determine whether they would see positive or negative characters.

4.3 Results

We categorized animations as damped, normal, or exaggerated as in the previous experiment. Of the 26 animations in the top 10% for amount of motion, 25 were from one actor. Similarly, of the 26 animations in the bottom 10% for amount of motion, 24 were from the other actor. We excluded 23 trials (out of 512 trials) from the analyses to mitigate the effects of actor differences. In a preliminary analysis, we determined that actor differences did not significantly affect results after these 23 trials were removed. Therefore, we did not include actor as a variable in the analysis that follows. We conducted a repeated-measures ANOVA with story valence as the between-subjects variable and with rendering style and facial motion magnitude as the within-subjects variables.

To investigate hypothesis H2.1, we examined the relationship between facial motion magnitude and ratings of perceived extroversion across character rendering styles. We confirmed the hypothesis that perceived extroversion would correlate positively with facial motion magnitude, $F(2, 441) = 7.28$, $p = .0008$. Similar to the previous results, participants perceived damped characters as significantly less extroverted than normal and exaggerated characters, $F(1, 443) = 9.45$, $p = .0022$, $F(1, 440) = 13.86$, $p = .0002$, 95% CIs [−.3786, −.0826], [−.0781, .1282], and [−.0190, .2283], respectively.

We also examined the other dependent measures for other possible effects of motion. We found a significant main effect of facial motion magnitude on perceived respectfulness, $F(2, 450) = 5.59$, $p = .0040$. Participants perceived damped characters as significantly more respectful than both normal and exaggerated characters, $F(1, 453) = 5.21$, $p = .0229$, $F(1, 449) = 11.16$, $p = .0009$, 95% CIs [.0503, .3509], [−.1009, .0963], and [−.2442, .0014], respectively. Similarly, facial motion magnitude significantly affected ratings of perceived calmness, $F(2, 451) = 6.35$, $p = .0019$, with damped characters rated as calmer than normal and exaggerated characters, $F(1, 453) = 5.17$, $p = .0234$, $F(1, 449) = 12.69$, $p = .0004$, 95% CIs [.0508, .3342], [−.0910, .0950], and [−.2469, −.0153], respectively. We found no effect of motion on perceptions of character attentiveness.



(a) Cartoon character extroversion

(b) Cartoon character respectfulness

(c) Cartoon character calmness

(d) Cartoon character attentiveness

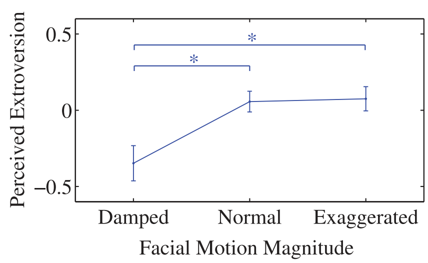
Fig. 5. Influence of facial motion magnitude on perceptions of the cartoon characters' (a) extroversion, (b) respectfulness, (c) calmness, and (d) attentiveness. The asterisk indicates significance at $\alpha = .05$ or less.

To check the story valence manipulation, we examined the relationship between story valence and perceived positivity. As expected, participants perceived characters who told stories with positive valence as significantly more positive than characters who told stories with negative valence, $F(1, 77) = 131.66$, $p < .0001$, 95% CIs [.4381, .7012] and [−.6595, −.3865], respectively. There was no significant effect of story valence on any of the other measures.

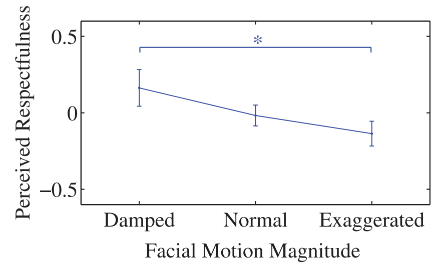
Additionally, we found a main effect of rendering style on ratings of perceived calmness. Participants perceived cartoon characters as calmer than more realistic characters, $F(1, 433) = 4.69$, $p = .0309$, 95% CIs [−.0007, .1888] and [−.1531, .0495], respectively.

As before, we then analyzed the effects of facial motion magnitude on cartoon and more realistic characters separately using specific planned contrasts. With the cartoon rendering style, participants rated damped characters lower in extroversion than exaggerated characters, $F(1, 457) = 4.08$, $p = .0439$, 95% CIs [−.2911, .0650] and [−.0430, .3115], respectively (Figure 5(a)). Participants also considered damped cartoon characters as more respectful and calmer than exaggerated characters, $F(1, 467) = 7.02$, $p = .0083$, 95% CIs [.0550, .4220] and [−.2891, .0759], and $F(1, 467) = 6.22$, $p = .0130$, 95% CIs [.0702, .4163] and [−.2348, .1092], respectively (Figures 5(b) and 5(c)). We found no effect of facial motion on perceptions of cartoon characters' attentiveness (Figure 5(d)).

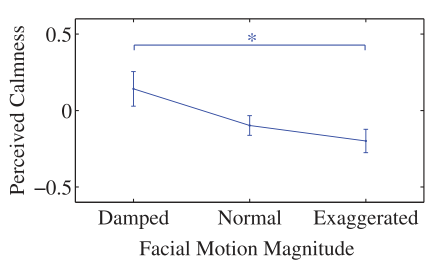
We found similar patterns with the more realistic characters. Participants considered damped realistic characters less extroverted than normal and exaggerated realistic characters, $F(1, 469) = 9.76$, $p = .0019$, $F(1, 462) = 9.79$, $p = .0019$, 95% CIs [−.5750, −.1211], [−.0772, .1902], and [−.0812, .2314], respectively (Figure 6(a)). Supporting our earlier hypotheses (H2.2 and H2.3), participants also perceived damped realistic characters as more respectful and calmer than exaggerated realistic characters, $F(1, 472) = 4.33$, $p = .0379$, 95% CIs [−.0730, .3985] and [−.2958, .0235], and $F(1, 472) = 6.35$, $p = .0120$, 95% CIs [−.0805, .3640] and [−.3499, −.0488], respectively (Figures 6(b) and 6(c)). We



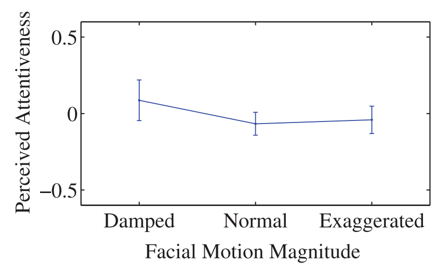
(a) Realistic character extroversion



(b) Realistic character respectfulness



(c) Realistic character calmness



(d) Realistic character attentiveness

Fig. 6. Influence of facial motion magnitude on perceptions of the realistic characters' (a) extroversion, (b) respectfulness, (c) calmness, and (d) attentiveness. The asterisk indicates significance at $\alpha = .05$.

hypothesized (H2.4) that attentiveness would follow a similar pattern, but we found no influence of facial motion magnitude on perceptions of realistic characters' attentiveness (Figure 6(d)).

4.4 Discussion

The results from this experiment confirm the previous findings regarding the positive correlation between facial motion magnitude and perceived extroversion (Section 3). The findings generalize to cartoon and more realistic characters in both positive and negative situations. Additionally, we found that facial motion magnitude negatively influenced perceptions of the characters' respectfulness and calmness. Exaggerated characters displayed larger facial movements that may have been interpreted as insincere and disrespectful. Subtle motions that were made more obvious by exaggeration may have made exaggerated characters appear fidgety and anxious, and therefore less calm. Participants also perceived the cartoon characters as calmer than the more realistic characters. This difference may have been due to the cartoon characters' lack of textural information and subsequent appearance of less movement compared to the realistic characters. The results of this study and our prior study suggest that damped realistic characters would be good for educational and therapeutic applications, because people would perceive them as highly competent, warm, respectful, and calm.

5. GENERAL DISCUSSION

We conducted a series of experiments to examine the effects of rendering style and facial motion magnitude on viewers' perceptions of animated characters. Based on popular belief, we expected realistic characters to benefit from damped or normal motion, and we expected cartoon characters to benefit from exaggerated motion. The results suggest that these facial motion and rendering style combinations should be used for different types of applications. Damped motion improved perceptions of more realistic characters' calmness and respectfulness, but it lowered ratings of extroversion and had no effect on perceived competence. We believe damped realistic characters would be good for education and therapy applications. In contrast, exaggeration increased perceptions of cartoon characters' extroversion, but it lowered perceptions of competence and had no effect on perceived warmth. Therefore, we believe exaggerated cartoon characters would be suitable in applications for entertainment. Participants' previous experiences with animated characters may have influenced the findings. Traditional cartoon characters often exhibit exaggerated movement and perform in silly scenarios, possibly leading to associations between exaggerated motion and sociability and incompetence. To explore this idea further, future work should control for participants' experience with different types of animated characters.

In addition, we found that people were more sensitive to damped facial motion than to exaggerated facial motion. As mentioned in Section 2.3, using AAMs to retarget facial motion to characters has several limitations. The animation method did not create small-scale skin deformations like wrinkles and dimples that may be associated with larger movements. Participants may have failed to discriminate between the unaltered and slightly exaggerated facial motion due to the lack of these expected textures. Similarly, we found that participants were more sensitive to motion changes in the realistic characters than in the cartoon characters. The more realistic characters had more textural detail than the cartoon characters, suggesting that textural detail made motion changes more apparent. Future work could explore this idea further by including characters with more textural detail and skin deformations.

In this study, we also were concerned with the possibility that the lack of natural movements (i.e., head nods and shakes) would be more noticeable in the exaggerated motion condition. Participants may have expected more head nods and shakes from characters exhibiting larger facial movements. Our measure for warmth included likability, and the results indicate that perceptions of warmth did not significantly differ between exaggerated and damped characters. The results indicate that the lack of head movements did not significantly affect the likability of the characters. In the future, other tracking and animation techniques could be used to validate these results.

For the studies presented in this section, we used eight different characters, but only two actors: one male and one female. Therefore, we did not investigate the effects of character gender on perceptions of character personality because actor was confounded with character gender. Future work could investigate possible effects of character gender on participant judgments by using more actors.

6. CONCLUSION

Today, animated characters are used for more than just children's entertainment, so it is important to understand how features of these characters might influence people's perceptions. Animated characters used in educational applications can benefit from appearing respectful, calm, and competent. Our results indicate that realistic characters with damped facial motion best embodied these characteristics. On the other hand, characters for entertainment can benefit from appearing extroverted and warm. In this case, our results indicate that exaggerated cartoon characters would be most appropriate. Our research provides basic, experimentally determined guidelines to help software creators and animators design more effective characters for use in various applications.

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