Bodily Expression of Emotions in Animated Agents

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Abstract. The goal of this research is to identify key affective body gestures that can clearly convey four emotions, namely happy, content, bored, and frustrated, in animated characters that lack facial features. Two studies were conducted, a first to identify affective body gestures from a series of videos, and a second to validate the gestures as representative of the four emotions. Videos were created using motion capture data of four actors portraying the four targeted emotions and mapping the data to two 3D character models, one male and one female. In the first study the researchers identified body gestures that are commonly produced by individuals when they experience each of the four emotions. In the second study the researchers tested four sets of identified body gestures, one set for each emotion. The animated gestures were mapped to the 3D character models and 91 participants were asked to identify the emotional state conveyed by the characters through the body gestures. The study identified six gestures that were shown to have an acceptable recognition rate of at least 80% for three of the four emotions tested. Contentment was the only emotion which was not conveyed clearly by the identified body gestures. The gender of the character had a significant effect on recognition rates across all emotions.

Keywords: Body language · Emotion expression · Animated

1 Introduction

For several decades, psychologists have studied the emotional displays of people through analysis of facial movements, but research into the ability of the body to convey emotions is relatively scarce. The Facial Action Coding System (FACS) is the primary source of knowledge for facial movements that express emotions in people. The FACS is used by both psychologists and animators as reference for emotions that are conveyed by the face. The body has been mostly ignored in regards to the ability to portray emotion until recently [21].

Creation of coding systems such as the Body Action Coding System (BACS) and Body Action and Posture Coding System (BAP) have aided in the ability to identify expressive actions performed by the human body. This research is in its infancy compared to portrayal of emotion using the face [6,19]

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This paper examines emotion expressive body gestures in animated 3D avatars. We focus on bodily expression of four emotions: happy, content, bored, and frustrated. The goal is to identify a set of affective gestures that animated agents can produce to clearly express the four emotional states.

2 Related Work

Classification of Emotion: The animation of virtual agents has relied heavily on Ekman's classification of emotions. Ekman's theory of universal emotions across cultures was discovered on tests of tribes in New Guinea, resulting in identification of fear, anger, joy, sadness, disgust, and surprise as the basic emotions found in all humans, regardless of culture [10]. The emotional gestures of New Guinean tribes people were recognizable to college students in the United States, validating that American citizens were capable of recognizing distinct emotions in people of other cultures [9]. The emotions identified by Ekman have been the principle focus for animators to showcase emotions in virtual agents, as well as used by researchers in the fields on psychology and anthropology. Other classifications of emotions exist, such as Robert Plutchik's eight basic emotions; fear, anger, joy, sadness, acceptance, disgust, expectation, and surprise [28]. More recent work in the field has concluded that there are only four major emotions; happiness, sadness, fear, and anger. Each of these four is attributed to core effects of either reward, punishment, or stress [15]. There is a continuing trend of researchers unable to agree upon a list of basic emotions that would encompass all humans in previous decades, but more recent work trends towards an agreement of universalities in emotion [11].

The measurement of emotions, independent of the classification system used, has relied on Russell's (2003) model of core affect, in which any particular emotion can be placed along two dimensions–(1) valence–ranging from displeasure to pleasure, and (2) arousal–ranging from activation to deactivation. In particular, the work reported in the paper has focused on affective states based on being exposed to instruction, such as frustration (negative valence, high arousal), happiness (positive valence, high arousal), contentment (positive valence, low arousal) and boredom (negative valence, low arousal).

Emotion Expression: Human emotions are expressed using several modalities: vocal and facial expression, arm and hand gestures, trunk rotation, head rotation, and leg movements. The face is cited as being the most used resource in identification of emotional state [26]. The ability of the face to convey emotional states and the gestures associated with varying emotions have been documented in the Facial Action Coding System (FACS) [12]. The work set forth by the FACS presents ways to express emotion in the face through movements of varying muscles into defined shapes. Facial expression of emotion has been heavily researched, but studies relevant to the body are lesser in comparison to that of facial research. A combination of modalities that include both facial and bodily gestures improves recognition rate of emotion compared to facial gestures alone by 35%. The best rate of recognition uses a combination of both gestures with

the inclusion of speech [17]. The hands are an almost equally effective modality of emotion expression as to that of the face. Hands are capable of revealing the emotional state of an individual through gestures alone. The hands themselves can be used for each of the four movement categories previously discussed. The trunk of an individual has the ability to portray a variety of emotions itself. A trunk that is contracted is recognized as sad while anger is a more expanded size and categorized with faster motion [14].

Categorization of emotion expression into databases for research purposes is an emerging trend [21]. Ekman's FACS database is the primary source for facial expression of emotion, and as such, facial expression studies have generally relied on the FACS for verification. Work by psychologists towards a bimodal database of body expression and face expression has been presented to make a readily available collection of affective gestures [16]. The FABO database presented by Gunes and Piccardi is collection of videos that are meant to represent nine different emotional expressions and a neutral expression using a combination of the face and body as stimuli. The FABO database identifies common face and body gestures associated with Ekman's major emotions as well as three other emotions. The emotions identified in the FABO database are uncertainty, anger, surprise, fear, anxiety, happiness, disgust, boredom, and sadness. The Body Action and Posture Coding System (BAP) is a more targeted database that seeks to set forth a collection of identified actions in relation to the modalities that the body is capable producing with the intent of being used in emotion expression research [6]. The BAP database does not identify the emotions that would be associated with movements, but instead identifies the individual motions each modality of the body is capable of producing. The modalities include head orientation, head posture, trunk orientation, trunk posture, whole body posture, arm posture, gaze, head action, trunk action, and arm action. Description are present for each of the behaviors listed. Hand gestures have also been coded into databases, one of which is noteworthy. The Massey Hand Gesture Database is a collection of 2524 images of gestures readily available to the public [1]. The database is comprised of ASL gestures but does not present information pertinent to expression of emotion. Movements of the body can be separated into four categories according to Karg et al. to present information and communicate. The four identified categories are communicative, functional, artistic, and abstract [21]. Each category is used to identify a possible purpose for each of the movements. While communicative can be used to express an emotion of an individual, a functional movement may be as simple as walking to achieve a task. Artistic movements are something you would see at a place such as a ballet performance that have the ability to express an affective state. The final category, abstract, expresses neither emotion nor is used to achieve a task.

Emotion Recognition: Effects of Culture, Gender and Age: Recognition of the emotional state of an individual can be affected by various factors. While Ekman stated that there are basic emotions that people can recognize across cultures, research data show that culture has an effect on recognition of emotion as well as the functional and communicative factors of gestures. Pease and

Pease state that a hand gesture in one culture or country will have a completely different meaning than in other cultures and countries [27]. Researchers such as Archer have identified evidence supporting that while gestures across cultures are interpreted differently, cultures also have a fascination with obscene gestures and that, while the gestures may vary, the purposes behind them remain the same. Cultures will not have the same expressive gestures that convey the same meaning, but cultures will still have a comparable gesture to convey the same meaning [2].

Recent work by psychologists claim that women are better at recognizing gestures and body movements and the emotional state of the individual performing the movements [18,23]. However, psychologists are not certain if women are more emotionally expressive than men [7]. Researchers found that men use the right hemisphere of the brain for recognition of negative emotions, while women use the left hemisphere of the brain [8]. The researchers noted that the results of the study were noted as not having been replicated at the time of publication. There is also documented difference in how gender affects the perceived valence and arousal levels of emotional gestures. Researchers have found that women are more likely to rate an emotion as a higher valence level than men, but inconclusive about the effect gender has on perceived arousal [4]. Further research into the field of gender and its effect must ultimately continue to have a deeper understanding of the factors that gender attributes to emotional recognition. Age is also another factor that can affect the perceived emotion of an individual. Children who have a higher exposure to older people in their everyday life have a higher rate of recognition of emotion in individuals [29]. The increase of age of an individual lead to the decrease in recognition rate of emotions. Older individuals are significantly less accurate in the recognition of negative emotions such as sadness and anger [24]. The primary modalities tested for emotion recognition in relation to age are the vocal and facial expressions. Younger individuals were more capable of recognition of emotion using vocal modalities as a stimulus, but no significant difference was found across all ages using a facial modality stimulus [20]. The Isaacowitz study also found that individuals were capable of identifying fear, sadness, and a neutral expression, regardless of age group, using vocal stimuli, but the recognition of emotion of anger, disgust, happiness, and surprise were recognized more using facial stimuli. This leads to believe that the modalities present in an individual have varying effects on the recognition of certain emotions. Facial movements and vocal expression are better at expressing different emotions in comparison to one another.

Emotion in Animated Characters: The use of animated characters for studies into recognition and expression of emotion is useful as it allows for a new testing instrument for use in studies as opposed to the use of people. In a study to identify differences between using people as the stimuli or animated characters, work by researchers found that stylized characters are more likely to have the emotion recognized as compared to realistic characters [5]. The study by Cissel also claims that there is little difference between body style of a character being either stylized or realistic. This allows for testing of animated body language

using information and databases used in emotion research of realistic bodies. A study conducted by Noel et al. found several important findings related to animated facial expressions. A static or dynamic virtual face is capable of expressing happiness, sadness, and surprise in a recognizable way to a viewer. Disgust was misidentified the most in comparison to the other emotions present in Ekman's classification system [25]. This is supported by findings that disgust is less likely to be identified accurately in an animated character [13]. An animated character is capable of expressing the same emotions that a real person would be capable of presenting to viewers. According to Chaminade, the identification of a motion made by an animated agent is more likely to be seen as biological the less the character is anthropomorphous, and vice versa the more anthropomorphous the character is perceived as being [3]. Usage of virtual characters is then a viable method for emotion recognition and expression research as long as the characters take on the appearance of a person.

3 Methods

Contrary to the early assumption that body movement only indicates emotional intensity, recent studies have shown that body movement and posture also convey emotion-specific information [22]. The goals of this research were to identify and validate body gestures that convey emotion specific information. More specifically, the objectives were to identify and validate four sets of body gestures, each one expressing one of the following four emotional states: happy, content, frustrated and bored. The research comprised of two studies. The objective of the first was to identify those body gestures that are commonly produced when someone is experiencing each of the four individual emotions. The goal of the second study was to validate the emotion-specific information conveyed by the identified sets of body gestures. In the second study, each of the identified 4 sets of gestures were applied to an animated agent and a group of participants were asked to recognize the emotional state of the agent solely from its body gestures.

3.1 Study 1: Affective Body Gestures Identification

Design: The study identified and annotated gestures related to the expression of the four targeted emotions. The researcher reviewed motion capture data of actors to qualitatively determine the emotions specific gestures in the recordings.

Stimuli: The actors were presented with a set of four scenarios; the goal of each scenario was to prompt one of the four emotions. The actors were then asked to express the emotion using body language only, however, they were not given clear instructions on how to perform the body gestures. The performance of each actor was video captured, and motion captured using the Xsens motion capture system and Autodesk Maya. A total of four actors were recruited, two male and two female. Both male actors were students of the Theater program at Purdue University, and one female actor was enrolled in the same program. The second female actor was a dance instructor at Purdue University. The student actors

were all in their early twenties, and the fourth actor was middle aged. Each actor was of average height and average build. Each actor portrayed the four emotions being tested three times, resulting in a total of 48 videos and 48 motion captured takes. Motion capture data was extracted from the Xsens system and mapped onto Gabriel Salas' character models David and Dana (Dana & David, 2020). Each character has the facial features obscured by sunglasses and a face mask. Rotation of the sunglasses and face mask were attached to head rotation of the character to maintain head gestures.

Procedure: Recorded motion capture data was analyzed and annotated for each of the 48 videos. Annotations included total time length of gestures, measured using total amount of frames, emotion recognized, forward arm gestures, downward arm gestures, upward arm gestures, outward arm gestures, inward arm gestures, forward body lean, inward body lean, trunk rotation, head rotation, forward head gesture, and inward head gesture. Each gesture, as it is defined for the purpose of this study, is comprised of head, torso and arm movements. For each emotion tested, the gestures that appeared at least three times among the four participants were used in the secondary study. In the absence of repetition of gestures among actors, the researcher selected the two best recognizable gestures for each emotion, utilizing the FABO database as a reference to ensure they are appropriate gestures for testing. The outcome of study 1 was an identified group of body gestures that portray the four selected emotions. The identified gestures included a set of "happy body gestures", e.g. a set of gestures that people are likely to produce when experiencing happiness; a set of "frustrated body gestures", e.g. a set of body gestures that people are likely to produce when experiencing frustration; a set of "bored body gestures", e.g. a set of body gestures that people are likely to produce when experiencing boredom; and a set of "content body gestures", e.g. a set of body gestures that people are likely to produce when experiencing content.

3.2 Study 2: Emotion Recognition

Design: The study used a within-subjects design to examine recognition of emotion through modalities of body gestures in 3D animated characters. The Independent variables were Body Gesture, Participant Gender, Agent Gender; the dependent variable was Emotion Recognition.

Analysis of the data produced by the initial study was used to test the hypotheses listed below. Gesture sets for the study comprised two full-body gestures for each of the four emotions tested. The first gesture was the gesture produced by the majority of the actors. The second gesture was the gesture performed by the majority of actors but appeared less often than the first gesture. Each gesture was validated as representative of that emotion if the emotion recognition rate was 80% or higher.

H1(abcd): Participants are able to accurately recognize affective displays of happiness, frustration, contentment, boredom in an animated agent who is producing the identified (a) "happy body gestures", (b) "frustrated body gestures",

(c) "content body gestures", and (d) "bored body gestures" respectively, and in the absence of facial expressions and speech.

H2(abcd): There are differences in the participants' ability to recognize the emotional state of the agent ((a) happy, (b) frustrated, (c) content, (d) bored) based on participants' gender.

H3(abcd): There are differences in the participants' ability to recognize the emotional state of the agent ((a) happy, (b) frustrated, (c) content, (d) bored) based on the agent's gender.

Participants: 104 participants were recruited using email announcements, through personal connections and through the Prolific participants platform. No screening occurred prior to participation in the study.

Stimuli: The videos presented to participants featured the animated characters performing the identified affective body gestures. Two gestures for each agent gender and for each each of the four emotions resulted in a total of 16 final videos. The faces of the characters were obscured; motion capture data recorded with female actors was applied to the Dana character, and motion capture data recorded with male actors was applied to the David character (Fig. 1).

Fig. 1. The character models used in the studies

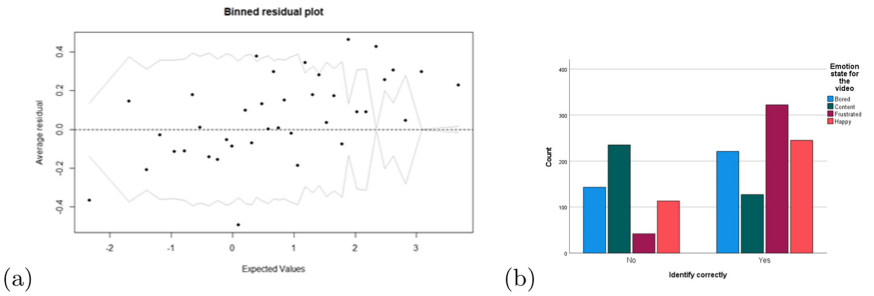
Procedure: The subjects were sent a link to an online survey which included the stimuli videos and one multiple choice question. The question asked the participant to select the emotion displayed by the animated character from 5 choices, e.g. happy, content, bored, frustrated, and unable to recognize. The presentation order of the videos was randomized and participants could play the videos as many times as needed.

4 Results

Demographics: A total of 104 surveys were collected. 13 surveys were discarded for various reasons such as finishing in under 5 min, or not completing at least

one-third of all questions. 91 total surveys were used for the analysis. 50.8% of all respondents had completed high school, with 27.3% having a bachelor's degree. 13% of respondents have acquired a master's degree. Five people indicated they have some high school experience, one had completed trade school, and a further two have a Ph.D. There was almost an even amount of male vs female participants, with 46 females and 44 males. One person identified as non-binary. Out of the 91 participants, 24 indicated that they had some experience with character animation, with the remaining 67 having no experience in animation.

Validity: The data was plotted using a binned residual plot to assess the validity of assumptions, to identify features not captured by the model, and to find problematic data points or clusters. The plot did not reveal any trends in the residual data (Fig. 2).



(a) (b)

Fig. 2. (a) Binned residual plot and (b) recognition rates

Emotion Recognition: Recognition rates of the 4 emotions varied. Participants were correct with their identification if they accurately answered the multiple-choice question, "Cannot identify" answers were placed in the incorrect group. A total of 1448 answers were coded for each of the 16 videos from all 91 participants. For each video, body gestures were identified as being correct representations of the emotions if at least 80% of participants were able to recognize the emotion correctly (see Fig. 2).

Of the four emotions tested, frustrated was the most commonly correctly identified (322 correct responses). Happy followed after with 246 correct responses. Bored was the third most commonly recognized emotion (221 correct responses). Content was the least correctly identified emotion (126 correct responses). The recognition rate for the four emotions were as follows: 60.7% correct recognition rate for bored, 34.6% for content, 88.4% for frustrated, and 67.5% recognition rate for happy. Results support hypothesis H1(b).

Table 1 shows the gestures for each video, with the corresponding emotional state and character gender. Videos identified as having a high recognition rate were videos 5, 6, 9, 10, 11, and 16. Table 2 gives the percentages of correct

Table 1. Video details

Video title	Rand order #	Head action	Trunk action	L-arm action	R-arm action
Female-bored-1	Video 10	Downward head tilt	Forward-backward trunk leaning	Hold	Forward
Female-bored-2	Video 2	Downward head tilt	Trunk action hold	Lateral repetition	Lateral repetition
Female-content-1	Video 15	Upward head tilt	Left-right trunk leaning	Towards the body	Towards the body
Female-content-2	Video 3	Upward head tilt	Left-right trunk leaning	Towards the body	Towards the body
Female-frustrated-1	Video 9	Up-down head shake	Forward trunk lean	Forward	Forward
Female-frustrated-2	Video 5	Up-down head shake	Forward trunk lean	Forward	Hold
Female-happy-1	Video 13	Upward head tilt	Spine straightening	Forward	Forward
Female-happy-2	Video 16	Upward head tilt	Upward/forward chest movement	Upward	Upward
Male-bored-1	Video 1	Downward head tilt	Trunk action hold	Downward	Downward
Male-bored-2	Video 4	Upward head tilt	Trunk action hold	Downward	Downward
Male-content-1	Video 8	Upward head tilt	Trunk action hold	Lateral repetition	Lateral repetition
Male-content-2	Video 12	Upward head tilt	Left-right trunk leaning	Upward	Upward
Male-frustrated-1	Video 11	Head action hold	Forward trunk lean	Frontal repetition	Frontal repetition
Male-frustrated-2	Video 6	Up-down head shake	Forward trunk lean	Frontal repetition	Frontal repetition
Male-happy-1	Video 7	Upward head tilt	Upward/forward chest movement	Upward	Upward
Male-happy-2	Video 14	Upward head tilt	Upward/forward chest movement	Upward	Upward

identification for all 16 videos tested. The videos can be accessed through this link: https://bit.ly/3m9QQCC

All male and female displays of frustrated were identified correctly with a recognition rate of at least 80% for all videos. One video of boredom and one of happiness featuring a female avatar had a similar rate of recognition. Figure 3 shows still frames from videos with 80% or higher recognition rates.

Table 2. Video recognition rates

Video #	Correct identifications	Percentage correct	Emotion state	Avatar gender
1	67/91	73.60%	Bored	Male
2	28/91	30.70%	Bored	Female
3	9/91	9.80%	Content	Female
4	51/91	56.00%	Bored	Male
5	80/91	87.90%	Frustrated	Female
6	80/91	87.90%	Frustrated	Male
7	62/91	68.10%	Happy	Male
8	23/91	25.20%	Content	Male
9	77/91	84.60%	Frustrated	Female
10	75/91	82.40%	Bored	Female
11	85/91	93.40%	Frustrated	Male
12	65/91	71.40%	Content	Male
13	37/91	40.60%	Happy	Female
14	65/91	71.40%	Happy	Male
15	29/91	31.80%	Content	Female
16	82/91	90.10%	Happy	Female

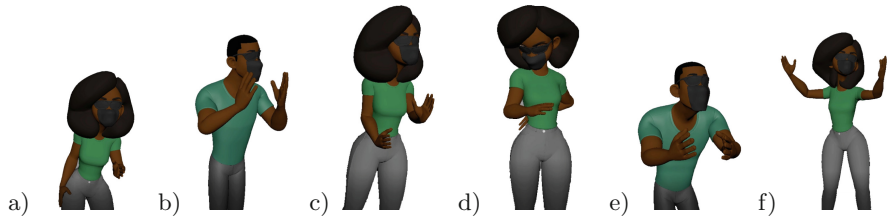


Fig. 3. (a) Video 5-Frustrated gesture with up-down head movement, forward trunk lean, and forward arm actions. (b) Video 6-Frustrated showing up-down head movement, forward trunk lean, and forward arm action with repetition. (c) Video 9-Frustrated showing up-down head movement, forward trunk lean, and forward arm action. (d) Video 10-Bored showing downward head tile, forward-backward trunk leaning, left arm action holding, and a right arm forward action. (e) Video 11-Frustrated showing head action holding, forward trunk lean, and forward arm action with repetition. (f) Video 16-Happy showing upward head tilt, left-right body leaning, and upward arm actions.

An ANOVA test showed that there were significant differences among the recognition rates of the four emotions ata significance level of 0.05 (p-value $<.00001$). A follow-up post hoc analysis shows the differences to be in frustrated with a P-value of $<.00001$, content with a P-value of $<.00001$, and happy with a P-value of 0.048.

Gender of Character. An ANOVA test looking at the recognition rates of emotion based on the gender of the character showed a statistical difference in the ability to recognize emotion (p-value of $<.00001$). The Male avatar had a considerably higher recognition rate compared to the female avatar across all emotions, hence results support hypotheses H3(abcd).

Participants' Gender, Animation Experience, Education and Age. ANOVA tests showed no significant difference in recognition rate based on participants' gender (p-value = 0.273) across all emotions, hence hypotheses H2 (abcd) were not supported. Further, there was no significant difference based on participants' animation experience (p-value = 0.113), no significant difference based on participants education level (p-value = 0.826), and no significant differences based on participants' age (p-value = 0.168). For each age group, the recognition rates were as follows: 16–25 years old-62%, 26–35 years old- 67%, 36–45 years old- 67%, 46–55 years old-75%, and 56+ years old-88%.

5 Discussion and Conclusion

A key finding of this research is that an animated character can clearly express three of the four targeted emotions (e.g. happy, bored, frustrated) using the body gestures identified by the study. Another finding is that emotions expressed through the identified body gestures have different rates of recognition. The easiest emotion to identify by all participants was frustrated (recognition

rate=88.4%). The high recognition rate may be in part due to the fight or flight response of an individual, where a person would benefit from being able to correctly identify hostility towards them. However, additional research would need to be conducted to examine this possibility. Contentment was the only emotion that was misidentified more than it was correctly identified (34.6% recognition rate). This result shows that the identified "content body gestures" are not able to clearly convey the contentment emotion.

The analysis of the videos revealed that an up-down shake of the head with a forward body lean, and a forward movement of the arm either once or in repetition are body movements that convey the frustrated emotional state effectively using an avatar as a means of communication. A bored emotional state can be expressed by downward head movement, with a forward body lean, and the arms having little to no movement at the sides. Avatars that show a happy emotional state may produce upward head movements, with the body moving forward and upward, and the arms having upward actions. Each of these emotional displays were shown to have an emotion recognition rate of at least 80%.

Another important finding is that the avatar gender affects the emotion recognition rate. The emotions displayed by the male avatar were correctly identified 68.8% of the time, while the emotions displayed by the female avatar were correctly identified 57.2% of the time. This finding suggests that male avatars may be better at displaying emotions using body movements than female avatars. However, this might also be due to the male actors who participated in the study being more expressive in their emotional displays than the female actresses, or to the intrinsic design features of the characters.

Although the research yielded important results, it also had several limitations. First, the study used a low number of actors (4) and a relatively small sample size (104 participants). Future studies should include more actors and a larger pool of subjects. Second, the sample did not cover all age ranges (the majority of the participants were young), hence it is not possible to draw meaningful conclusions on the effect of participants' age on emotion recognition. Future studies should use a sample that is more representative of the target population in regard to age.

Third, the characters used for the study were both stylized and their visual style might have influenced the recognition rate. Future studies should include a variety of characters with different visual styles, such as stylized, realistic, iconic. Fourth, several times the avatars had the hands hidden behind another body part due to the motion capture camera placement, which caused an inevitable loss of potential visual stimuli. This could have influenced the ability of the participants to correctly identify the emotion being presented.

The findings from the work reported in the paper have important implications for research and practice. They lay the basis for the development of a coding system of affective body gestures for animated agents. With the growing understanding of the complex interplay between emotions and cognition, there is a need to develop agents that not only provide effective expert guidance/communication, but also believable emotional interactions with the user.

The results of this research can be used to create believable multi modal agents the express emotions effectively through body cues. The findings can also help animation professionals create life-like emotive animated characters for films and games.

References

1. Massey University (2012). https://www.massey.ac.nz/~albarcza/gesture_dataset2012.html
2. Archer, D.: Unspoken diversity: cultural differences in gestures. Qual. Sociol. **20**(1), 79–105 (1997)
3. Chaminade, T., Hodgins, J., Kawato, M.: Anthropomorphism influences perception of computer-animated characters actions. Soc. Cogn. Affect. Neurosci. **2**(3), 206–216 (2007)
4. Cheng, J., Zhou, W., Lei, X., Adamo, N., Benes, B.: The effects of body gestures and gender on viewer's perception of animated pedagogical agent's emotions. In: Kurosu, M. (ed.) HCII 2020. LNCS, vol. 12182, pp. 169–186. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-49062-1_11
5. Cissell, K.: A study of the effects of computer animated character body style on perception of facial expression. Master's thesis, Purdue University, USA (2013)
6. Dael, N., Mortillaro, M., Scherer, K.R.: The body action and posture coding system (BAP). J. Nonverbal Behav. **36**(2), 97–121 (2012)
7. Deng, Y., Chang, L., Yang, M., Huo, M., Zhou, R.: Gender differences in emotional response. PLOS ONE **11**(6), e0158666 (2016)
8. Einstein, G., Downar, J.: Gender/sex differences in emotions. Medicographia **35**(3), 271–280 (2013)
9. Ekman, P.: Universal facial expressions of emotions. Calif. Ment. Health Digest **8**(4), 151–158 (1970). https://www.paulekman.com/wp-content/uploads/2013/07/Universal-Facial-Expressions-of-Emotions1.pdf
10. Ekman, P.: The Face of Man: Expressions of Universal Emotions in a New Guinea Village. Garland STPM Press, University of California (1980)
11. Ekman, P.: What scientists who study emotion agree about. Perspect. Psychol. Sci. **11**(1), 31–34 (2016)
12. Ekman, P., Friesen, E.: Facial Action Coding System: A Technique for the Measurement of Facial Movement. Consulting Psychologists Press, Palo Alto (1978)
13. Fabri, M., Moore, D., Hobbs, D.: Mediating the expression of emotion in educational collaborative virtual environments: an experimental study. Virtual Reality **7**(2), 66–81 (2004)
14. Gross, M.M., Crane, E.A., Fredrickson, B.L.: Effort-Shape and kinematic assessment of bodily expression of emotion during gait. Hum. Mov. Sci. **31**(1), 202–221 (2012)
15. Gu, S., Wang, F., Patel, N.P., Bourgeois, J.A., Huang, J.H.: A model for basic emotions using observations of behavior in Drosophila. Front. Psychol. **10**, 781 (2019)
16. Gunes, H., Piccardi, M.: A bimodal face and body gesture database for automatic analysis of human nonverbal affective behavior. In: 18th International Conference on Pattern Recognition ICPR 2006. vol. 1, pp. 1148–1153 (2006)
17. Gunes, H., Shan, C., Chen, S., Tian, Y.: Bodily expression for automatic affect recognition. In: Emotion Recognition, pp. 343–377. Wiley (2015)

18. Hall, J.A., Matsumoto, D.: Gender differences in judgments of multiple emotions from facial expressions. Emotion **4**(2), 201–206 (2004)
19. Huis In't Veld, E.M.J., Van Boxtel, G.J.M., de Gelder, B.: The Body Action Coding System I: muscle activations during the perception and expression of emotion. Soc. Neurosci. **9**(3), 249–264 (2014)
20. Isaacowitz, D.M., et al.: Age differences in recognition of emotion in lexical stimuli and facial expressions. Psychol. Aging 2**2**(1), 147–159 (2007)
21. Karg, M., Samadani, A.A., Gorbet, R., Kuhnlenz, K., Hoey, J., Kulic, D.: Body movements for affective expression: a survey of automatic recognition and generation. IEEE Trans. Affect. Comput. **4**(4), 341–359 (2013)
22. Lawson, A.P., Mayer, R.E., Adamo-Villani, N., Benes, B., Lei, X., Cheng, J.: Recognizing the emotional state of human and virtual instructors. Comput. Hum. Behav. **114**, 106554 (2021)
23. Matsumoto, D., et al.: A new test to measure emotion recognition ability. J. Nonverbal Behav. **24**(3), 179–209 (2000)
24. Mill, A., Allik, J., Realo, A., Valk, R.: Age-related differences in emotion recognition ability: a cross-sectional study. Emotion **9**(5), 619–630 (2009)
25. Noel, S., Dumoulin, S., Whalen, T., Stewart, J.: Recognizing emotions on static and animated avatar faces. In: 2006 IEEE International Workshop on Haptic Audio Visual Environments and their Applications, HAVE 2006, pp. 99–104 (2006)
26. Noroozi, F., Kaminska, D., Corneanu, C., Sapinski, T., Escalera, S., Anbarjafari, G.: Survey on emotional body gesture recognition. IEEE Trans. Affect. Comput. **12**(2), 505–523 (2021)
27. Pease, B., Pease, A.: The Definitive Book of Body Language. Pease International, Australia (2004)
28. Plutchik, R.: A General Psychoevolutionary Theory of Emotion. In: Theories of Emotion, pp. 3–33. Elsevier (1980)
29. Pollux, P.M., Hermens, F., Willmott, A.P.: Age-congruency and contact effects in body expression recognition from point-light displays (PLD). PeerJ. **4**, e2796 (2016)