

Do We Perceive Emotional Gender Gesture of Virtual Avatar As Intended?

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This study aimed to examine how the user correctly perceives the avatar's gesture emotional status as intended for a target emotion. The designer needs to decide which emotion is challenging to develop for the user's perception. The experiment variables were emotional expression and gender specificities. We developed expressing virtual avatars for emotional expression—fear, sadness, joy, and anger combined with gender. As a total eight types of emotional gesture was provided to the experiment. Eighty-five college students (29 males and 56 females) participated in evaluating the avatar animation. Repeated measures were applied to identify any differences between emotion and gender factors. Participants saw the videos expressing emotion by the gesture of the mock-up avatar. The results indicated that sadness, joy, and anger gestures could express target emotion. However, the fear gestures could be perceived with sadness emotion. Also, there were interaction effects with gender and emotions. The sad female gesture was perceived as more sorrowful than a male gesture. Joy was perceived significantly more with female gestures than with male gestures. The male gestures were perceived with considerably more fear than the female gestures. However, anger gestures did not have any interaction.

Keywords: Emotional gesture, Gender difference, Virtual avatar

Introduction

The advantage of a pedagogical avatar is its role as a learning assistant by prompting social interaction with learners. Emotionally easy to be recognized pedagogical avatar is vital to facilitate friendly communication between the virtual avatar and learners. A virtual avatar that can increase emotional dynamics may motivate learners to pay more attention and engage in more learning activities. The emotional interaction between students and instructors is essential to facilitate conversation for a more satisfying learning experience in a conventional classroom setting. Furthermore, the importance of dynamic exchange can be extended to a computer-based instructional system for students. Students' learning through video lectures may be affected by their emotional state on the screen during instruction in a computer setting.

Therefore, it is crucial to determine whether students correctly perceive the emotions expressed by on-screen avatars in educational videos (Lawson et al., 2021). A pedagogical avatar with characteristics such as facial expressions, gestures, human emotions and an interactive user interface is attractive in facilitating students' learning (Sinatra et al., 2021). Many studies posit that social agency theory with social cues in multimedia messages encourages learners to interpret human-computer interactions parallel to human-to-human conversation (Lin, Ginns, Wang, & Zhang, 2020). These virtual pedagogical avatars provide students with more lifelike interactions that could increase the communication capacity of learning systems and these systems' ability to engage and motivate students, known as the persona effects (Richards & Dignum, 2019). Many learning environments have been integrating virtual pedagogical avatars to encourage and motivate students to make more outstanding learning efforts (Martha & Santoso, 2019). A virtual avatar full of social behavior is fundamental in the learning context.

Virtual avatars with proper facial expressions, emotions, and body postures might produce a higher social presence than a virtual character without them. Avatars showing appropriate social behavior can increase users' social presence (Sinatra et al., 2021). The perception that a virtual avatar is a social entity may result in experiencing social presence with engagement and motivation in a learning environment (Moreno, Mayer, Spires, & Lester, 2001; Sajjadi, Hoffmann, Cimiano, & Kopp, 2019). Social presence improves learning outcomes by increasing engagement and motivation (Zhan & Mei, 2013). By carefully adjusting facial expressions, body posture, arm movements, and hand gestures, virtual avatars can visually increase, encourage, and communicate empathy and motivate verbal problem-solving outcomes. One of the critical components of nonverbal communication, gestures, is the hand, arm, or body movements used to

express an idea, emotion, or message (Wolfert, Robinson, & Belpaeme, 2021). When designing realistic virtual avatars in learning, applying gestures can be substantial for infusing an emotional impression in the learners' social presence.

In social interaction with virtual avatars, the learners' affective perception can also be dependent on the avatar's gender, that is, a gender-dependent perceptual gap. Learners may interpret emotional expressions depending upon the gender of the virtual avatars (Yang & Ryu, 2020). Gender-specific gestures can influence the activation of emotional status more promptly. Although recent studies have investigated the relationship between emotion and body movement using virtual avatars, research about the effect of gender on the perception of emotion from body movement is not a well investigated. This issue is essential for creating expressive social entities that can successfully communicate with humans.

Emotional gesture-based emotion recognition

Virtual avatars used in human–computer interaction are increasingly expressive and can express complex emotions. The virtual avatar's emotional expression allows the user to give the virtual avatar a personality to build the bond between the avatar and the user (Sajjadi et al., 2019). Body gestures, an integral part of nonverbal communication, provide meaningful supplemental information of expressed emotions. In human interaction, people naturally communicate and perceive emotions through physical movements, voices, and facial expressions (Shi, Liu, Ishi, & Ishiguro, 2021). The general conversation of human communication can pursue a simultaneous combination of speech and gesture actions. Therefore, humans can easily recognize emotions displayed with gestures because the concurrent use of various bodily gestures when expressing a message can significantly impact emotions by expanding information channels (Davis & Vincent, 2019). Thus, even when applying a virtual avatar in learning environments, using a combination of gestures and facial expressions allows learners to instantly capture the emotional state of the virtual avatar in context. A virtual avatar's gestures can also provide many examples of the different levels of a character's emotional expression (Neff, Wang, Abbott, & Walker, 2010).

The more realistic the required emotional gesture, the more elaborate the bodily gestures that must be considered. When designing a virtual avatar that expresses natural emotions, the avatar is presented to radiate human emotions. Krämer, Kopp, Becker-Asano and Sommer (2013) posited that an avatar's smiling behavior infuses similar positive emotion corresponding to an avatar's intention. The authors showed that the mimicry and reciprocation of actions between avatars and humans could establish rapport and strengthen social interactions with shared synchronous responses. Emotional gestures for learning were shown to be necessary in making learners comprehend information more directly. Further, the expressive gesture is one of the crucial components of improving realistic levels of avatar behavior.

In the learning context, the virtual pedagogical avatar's emotions affect learning; thus, it is crucial for the learner to accurately recognize the expression of the emotional gesture intended by the virtual avatar. A study by Lawson et al. (2021) investigated how well learners could perceive the various emotions expressed by virtual pedagogical avatars in video lectures. In the study, participants could differentiate between positive and negative emotions much better than between active and passive emotions. This finding suggests that there may be differences in perception that depend on the virtual avatar's emotion. Therefore, confirming the user's perception according to the emotional gesture is an essential first step in designing an avatar gesture.

Gender-specific gesture design for virtual avatars

When designing gestures for virtual avatars, it is important to consider gender-specific gestures because people have gender stereotypes about gestures. Gender stereotypes consist of cognitive schemas (e.g., what females and males should do and how they should behave) based on the gender roles an individual has when assessing unfamiliar people. Gender stereotypes include differences that are supposed to exist only between males and females, where the physical perspective, such as posture and gesture, is the most accessible component of gender stereotypes (Gul Unlu, 2021).

Bailey and Kelly (2015) explained that stereotyped gestures, judged by gender differences, have a potential hierarchical structure based on social force. Thus, females and males are perceived to have different postures based on gender stereotypes. For example, males have a more open and diffuse posture, whereas females have a more closed and retracting stance (de Lemus, Spears, & Moya, 2012). In a study by Gul Unlu (2021), females who behaved like males or males who acted like females were identified by respondents who assessed their gestures. This study demonstrates that humans have gender stereotypes about gestures. Won, Yu, Janssen, and Bailenson (2012) used machine learning to identify gender through human postures and gestures presented in Microsoft Kinetic and confirmed the existence of gender-specific gestures. That means humans' gestures represent their gender, and users can recognize other people's gender with their gestures. Therefore we should consider the gesture to represent gender for the avatar design

process.

Based on this literature review, the potential use of gender-specific and emotional gestures can be assumed to be a possible strategy for promoting more sophisticated social interactions in the development of virtual avatars. In this study, we applied the general emotional gestures used in previous studies to focus on emotional expressions by gestures. Table 1 presents the staple descriptions for each gesture used in this study, based on Wallbott's (1998) emotional classification, organized according to gesture movements. There are four emotional states that can be expressed by gestures: anger, joy, sadness, and fear. We constructed Table 1 to reflect a combination of gestures corresponding to the gender and emotional states used in this study.

Table 1

Gesture descriptions by emotion and gender specificities

Emotion	Gender	Head	Arms	Hands	Movement Quality
Anger	Male	Toward camera	Stretched out frontal	Lateralized movements, opening/closing, many illustrators	High movement activity, expansive movements, high movement dynamics
	Female			Pointing, many illustrators	
Joy	Male	Backward	Stretched out frontal	Opening/closing, many illustrators	High movement activity, expansive movement, high movement dynamics
	Female		Upward		
Sadness	Male	Toward camera	Hanging	No specific activities	Low movement dynamics
	Female	Downward		Self-manipulators	
Fear	Male	Toward camera	Stretched out sideways	Opening/closing, many self-manipulators	No extreme judgements
	Female		Hanging	Many self-manipulators	Low movement activity

The purpose of this study was to examine how the emotional statuses of virtual avatars are perceived differently according to gender-specific gestures. We designed a virtual avatar without facial expressions and gender-specific appearances. Only gender-specific gestures were provided, and participants interpreted the emotional status of the avatar. We investigated whether participants can correctly recognize the intention of the virtual avatar's emotion as it was designed. The result of this study can suggest design principles of emotional messages for considering gender-specific gesture expressions.

Research Questions

- (1) What is the effect of a virtual avatar's gestures expressing their intended emotions (fear, sadness, joy, anger) on perceived emotions?
- (2) What is the effect of a virtual avatar gender-specific gesture (male gestures vs. female gestures) for intended emotions (fear, sadness, joy, and anger) on perceived emotions?

Research Method

Participants

A total of eighty-five college students were recruited for this study by advertisement. These students were enrolled in a flagship public university in the southwest region of South Korea. Participants included 5 freshman (5.9%), 24 sophomore (28.2%), 23 junior (27.1%), and 33 senior (38.8%) undergraduate students, of whom 29 were males (34.1%) and 56 were females (65.9%) with an average age of 22.10 ($SD = 1.76$), ranging from 18 to 26 years. Experiments were conducted with only participants who agreed to participate in the study and who were paid for participation.

Research Design

This study utilized a repeated-measure design with two within-subject factors. The independent variables were the intended emotions (fear, sadness, joy, anger) and gender-specific gestures (male, female). To express the distinct dimension of emotions in a polarized state, we adopted four types of emotions—joy, sadness, anger, and fear—as emerged from Plutchik's (2003) wheel of emotion model. In this model, joy and sadness are both extremes of the vertical axis, and anger and fear are both extremes of the horizontal axis. This study adopted the four emotions that were separated into horizontal and vertical extremes to clearly distinguish emotional states (Kamińska & Pelikant, 2012). We applied four expressive gestures by gender to create a total of eight emotional gestures.

The dependent variable was the participants' perceived emotions. We analyzed how correctly the virtual avatar expresses the intended emotion using gender-specific gestures. The participants' emotional perception was measured by applying the emotional perception questionnaire used in the study by Yang and Ryu (2020). The item question was 'Rate each perceived emotion (fear, sadness, joy, and anger) expressed by the virtual avatar's gesture.' This item was answered on a 5-point Likert scale, ranging from 1: "not at all" to 5: "very much." When the virtual avatar presented a particular emotional gesture, participants assessed the perceived emotional status in four emotional aspects simultaneously with the 5-point scale. Self-reports of current emotional experiences are more likely to be valid (Mauss & Robinson, 2009). Participants watched each virtual avatar and immediately rated their perceived emotions. Participants rated perceived emotion strength in four emotional aspects (fear, sadness, joy, anger) for all eight virtual avatars, one by one.

Experimental Setting

The virtual avatars were created as animations to express gender-specific emotional gestures. We developed the virtual avatars with iClone5, a 3D modeling authoring tool (Reallusion, 2018). Considerable numbers of research in the avatar study have used the iClone to design and develop avatars or virtual characters (Khan, Basak, & Corcoran, 2021; Lee, Launay, & Stewart, 2020). This software is one of the most popular tools to develop avatars. The animation creation application allows researchers to develop human-like looking and animated gestures (Davis, 2018). We developed virtual avatars using Character Creator of iClone (Reallusion, 2018) with motion libraries to express emotional gestures. The default gestures of iClone5 were designed to express emotions of each gender and were applied to the virtual avatars to show the intended gender-specific emotional gestures.

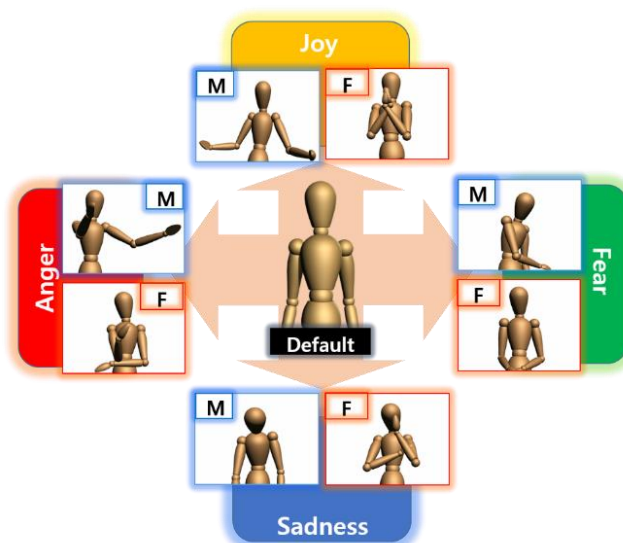


Figure 1. Examples of emotional gestures with gender

The emotional expression of iClone has been used to create an accurate emotion study to fit the emotional

change(Khan et al., 2021). We animated the motions to an avatar without showing gender orientation. Each animation in which the virtual avatar expresses the intended emotion with gestures was about 10 seconds long. The gender of the virtual avatar was the second independent variable. However, we designed this avatar to express gender through only emotional gestures. To control the gender variable, human appearance and facial attributes were removed from the virtual avatar's appearance. To this end, a dummy model without facial expressions was used for this experiment. The virtual avatar did not make any voice sound. Using only two skeleton arms, the avatar freely expressed gestures that matched the intended emotions so participants could focus on the gesture movements.

Figure 1 shows four different emotional modes of a virtual avatar's body motion combined with emotion and gender. We developed a total of eight gender-specific gestures with intended emotional states. The experiment was conducted in a virtual simulation laboratory at the University. The lab was equipped with a curved screen to display eight different emotional gesture videos designed for different genders. A curved screen measuring 368 cm (width) \times 148 cm (height) could increase participants' immersion. Figure 2 shows the experimental setup. Curtains enclosed the experiment room to block out light. A beam projector was placed on the back of the screen to avoid casting shadows that could affect participants' emotional perception. As shown in Figure 2, a virtual avatar as big as a real person was displayed in the curved screen center.



Figure 2. Experiment setting

Procedure and Data Analysis

The study had three phases: 1) introduction, 2) watching an emotional gesture animation, and 3) rating the perceived emotion (perceived emotion questionnaires). The participants were given pre-instruction about the entire procedure of the experiment by the moderator for 1 minute. After a brief introduction, all the participants watched a 10-second animation of the virtual avatar's emotional gesture movement. Given that each animation video of virtual avatars was watched one by one, the perceived emotion questionnaires were provided concurrently with the appropriate animation. All the video materials shown were repeated twice at random to prevent order-effect. In total, the time spent in this study was 5 minutes on average per participant. Figure 3 shows the steps of this study.

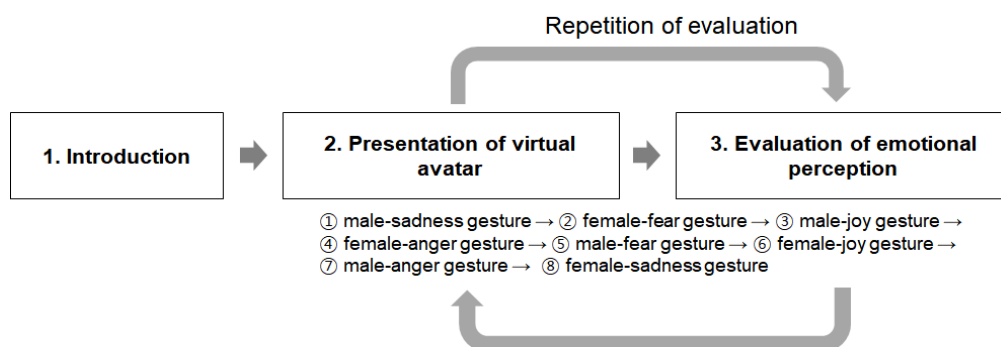


Figure 3. Experimental procedure

The outcome data were analyzed using IBM SPSS version 24.0. One of the within-subject factors was gender (male vs. female), and another factor was the intended emotion (fear vs. sadness vs. joy vs. anger). For each emotional gesture, the participants' perceived emotions were analyzed using MANOVA with repeated measure. The significance level for all analyses was set at $\alpha < .05$. The results were corrected by the Greenhouse–Geisser procedure whenever assumptions of sphericity were violated. A Bonferroni correction was made when multiple comparisons are performed.

Results

The perceived emotion contained four specific strong emotions: fear, sadness, joy, and anger. Table 2 provides the means and standard deviations of the perceived emotions for each intended emotion according to gender-specific gestures. The shading in Table 2 represents the score of the perceived emotions for the targeted gesture in each gender-specific motion.

Table 2

Means and standard deviations of perceived emotions (N = 85)

Gender	Intended Emotion	Perceived Emotion			
		fear	sadness	joy	anger
Male	fear	2.67 (1.39)	2.39 (1.29)	1.54 (1.02)	1.66 (0.96)
	sadness	1.73 (1.07)	3.84 (1.14)	1.13 (0.37)	3.27 (1.16)
	joy	1.06 (0.28)	1.14 (0.49)	3.99 (1.46)	2.28 (1.60)
	anger	1.22 (0.52)	1.59 (0.92)	1.07 (0.26)	4.78 (0.42)
Female	fear	2.13 (1.35)	2.45 (1.41)	2.34 (1.35)	1.39 (0.71)
	sadness	1.81 (1.13)	4.51 (0.95)	1.19 (0.63)	1.62 (1.02)
	joy	1.11 (0.41)	1.08 (0.28)	4.91 (0.29)	1.06 (0.28)
	anger	1.26 (0.62)	1.78 (1.04)	1.19 (0.59)	4.66 (0.57)

Main Effect of Emotions

The results revealed a significant main effect for the intended emotions expressed as gestures ($F_{(12,73)} = 332.46, p = .000$; Wilk's $\lambda = 0.018$, partial $\eta^2 = 0.98$). To examine the differences in perceived emotions, univariate follow-up procedures were conducted for each specific key emotion. The perceived emotions in each specific key emotion were significantly affected by the intended emotions expressed as gestures. There were significant differences in all the key emotions according to the intended emotions expressed as gestures (fear, $F_{(3,252)} = 20.35, p = .000$, partial $\eta^2 = 0.20$; sadness, $F_{(3,252)} = 271.16, p = .000$, partial $\eta^2 = 0.76$; joy, $F_{(3,252)} = 526.19, p = .000$, partial $\eta^2 = 0.86$; anger, $F_{(3,252)} = 953.15, p = .000$, partial $\eta^2 = 0.92$). The graph in Figure 4 shows how the target emotion was perceived. Gestures expressing sadness, joy, and anger were well expressed and recognized as their intended emotions. Seeing this gesture, the participant significantly perceived it as a target emotion rather than another emotion. However, the emotion intended to fear was perceived as fear or sadness, and the difference was not significant. Therefore, the gesture of fear may be mistakenly perceived as sadness.

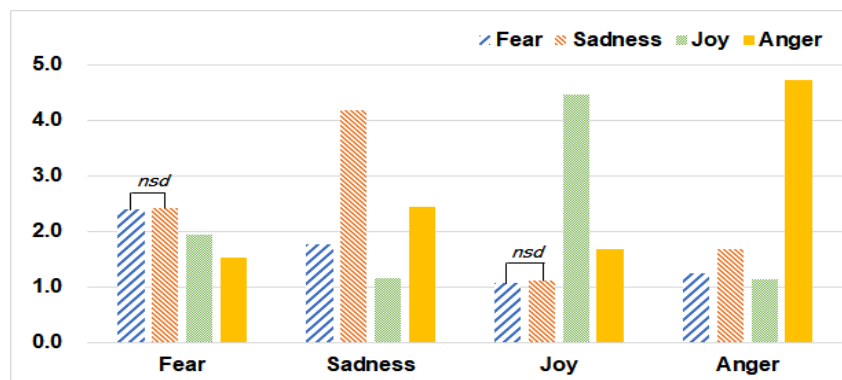


Figure 4. Perceived emotions of each specific key emotion by intended emotional gestures.

Gender-Specific Gesture Effects

Emotions perceived from gender-specific gestures were analyzed using repeated-measures ANOVAs with a Greenhouse–Geisser correction. There was a significant interaction effect between intended emotions and gender-specific gestures ($F_{(12,73)}=16.53, p = .000$; Wilk's $\lambda = 0.269$, partial $\eta^2 = 0.73$). A further ANOVA for each specific key emotion revealed a significant interaction effect in fear, sadness, and joy, except for anger.

In the fear gesture, a significant interaction effect was found, $F_{(3,252)}=9.53, p=.000$, partial $\eta^2 = 0.10$ (see Figure 5).

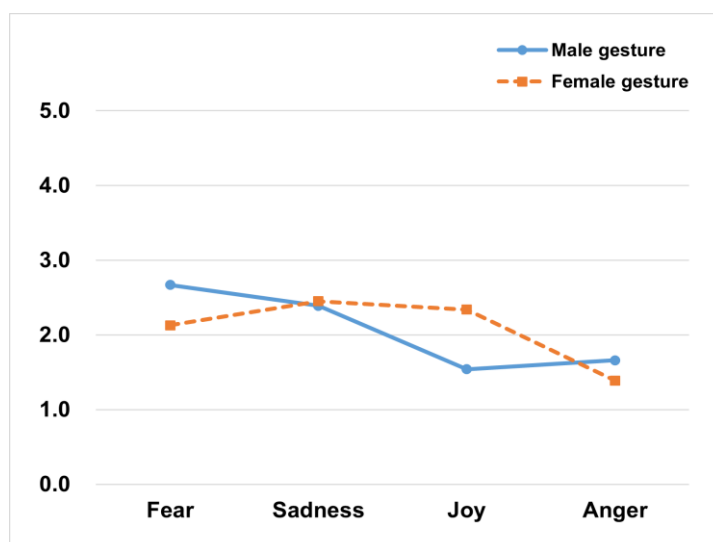


Figure 5. Interaction effect of intended emotion (fear) and gender-specific gestures on fear perception

Simple main effect analysis using the Bonferroni correction procedure further demonstrated a difference in the gender-specific fear gesture. First, the male gesture was perceived significantly with more fear than the female gesture ($p < .01$). This indicates that male fear gestures can be perceived more strongly than female fear gestures. However, there was no difference in the perceived degree of fear and sadness in the male fear gestures ($p > .05$). This suggests that male fear gestures could be perceived as sadness. Second, female fear gestures were perceived as fear, sadness, or joy. There was no significant difference in the perception of these emotions (all $p > .05$). Interestingly, the female fear gesture was perceived as a joy gesture and to a higher degree than the perception of the male fear gesture as a joy gesture ($p < .001$). The perception of the male fear gesture as joy had the lowest score, which is reasonable. However, the female fear gesture can be perceived as a completely opposite emotion.

In the perception of sadness gesture, a significant interaction effect was found ($F_{(3,252)} = 48.59, p = .000$, partial $\eta^2 = 0.37$), and simple main effects were analyzed (see Figure 6). There was a significant difference in sadness perception of male and female gestures ($p < .001$). The female sadness gesture was perceived as sadder than the male sadness gesture. The sadness gesture was also significantly distinguished from other emotions in both male and female gestures, all $p < .01$. However, male sadness gestures were more significantly perceived as anger gestures than female sadness gestures were perceived as anger ($p < .001$).

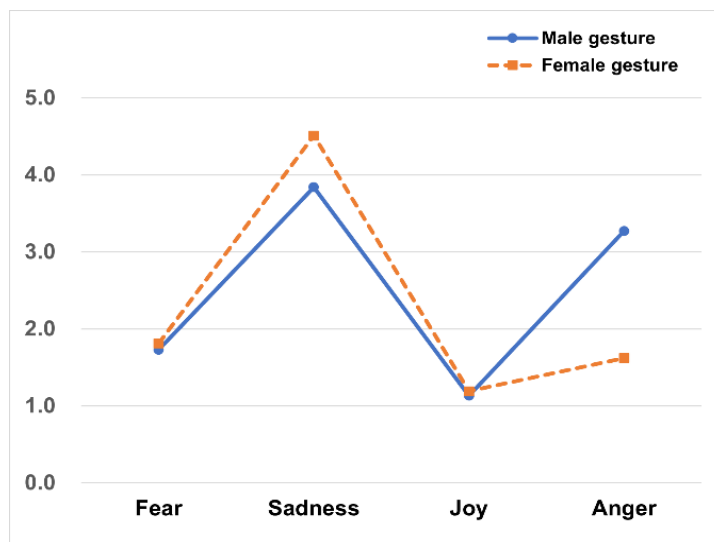


Figure 6. Interaction effect of intended emotion (sadness) and gender-specific gestures on sadness perception

In the perception of the joy gesture, there was a significant interaction effect found ($F_{(3,252)} = 43.46, p = .000$, partial $\eta^2 = 0.34$), and the analysis of the simple main effects revealed two significant differences (see Figure 7). The joy gesture was perceived as joy much more in the female gestures than in the male gestures ($p < .001$), indicating that joy was perceived as stronger in the female gestures than male gestures. The joy gesture was also significantly different from other emotions in both male and female gestures ($p < .001$ in all). There was no difference in joy gestures perceived as fear and sadness by gender-specific gestures ($p > .05$). However, while female joy gestures were perceived low as anger emotions, male joy gestures were perceived significantly high as anger emotions ($p < .001$).

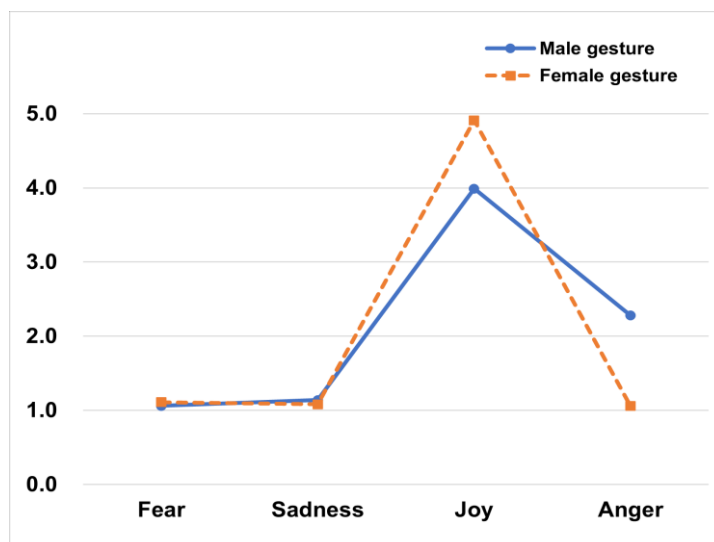


Figure 7. Interaction effect of intended emotion (joy) and gender-specific gestures on joy perception.

Anger gestures showed no interaction ($F_{(3,252)} = 2.59, p = .068$). Based on emotion, the main effect analysis showed that the perception of anger had the highest score, which indicates that the anger gesture was correctly perceived. Unlike the other emotional gestures, anger gestures did not have any gender effect or interaction by gender and emotion. In other words, anger gestures did not have gender specificity.

Discussion

This study's primary goal was to investigate how gender-specific emotional gestures of virtual avatars are perceived differently. Even with the same emotion, gesture expression is different according to gender. So we examined how each emotion was perceived depending on whether it was a male gesture or a female gesture. We developed avatars without facial expressions, expressing emotions (fear, sadness, joy, and anger) only with gender-specific gestures.

Participants rated the degree of emotions they perceived with 5-point scales. The results of this study are twofold. First, the type of emotions affects the degree of perceived emotion differently. In general, participants accurately perceived the avatar's sadness, joy, and anger gestures as intended emotions. However, gestures of fear can be perceived as fear or sadness. Second, the intended emotions were perceived differently depending on the gender of the avatar. An avatar expression of a male joy gesture could be perceived as anger, and a female fear gesture could be perceived as a joy gesture. Interestingly, of the four emotional gestures, there were no gender differences in the perception of the anger gesture. Participants perceived the anger gesture as anger, regardless of the gender of the avatar.

The results of this study show that carefully designing an avatar's gestures is important. This is because, depending on the avatar's gesture, users might misrecognize the intended emotion. In the field of education, pedagogical avatars have been applied for effective learning by inducing learning motivation through interactions with learners and engaging learners in multimedia learning (Adamo et al., 2021). As the educational paradigm shifts from offering student knowledge to emphasizing learning experiences, practical learning support tools for self-learning, such as virtual avatars, are becoming critical issues in current education (Haswgawa & Echizenya, 2021). In particular, the learner's emotions affect the cognitive process, so accurately recognizing a virtual avatar's emotions is a vital learning design factor (Plass et al., 2020). Based on this study's results, the following points should be considered when designing virtual avatars in education.

First, the pedagogical avatar should use gestures appropriate to the intended emotion in the learning situation. Avatar can express emotions with gestures, but learners may misunderstand depending on emotions. As a result of this study, when designing an avatar that expresses fear emotions, it is important to consider that fear gestures may be mistaken for sad emotions. In a virtual reality training simulation with an avatar applied, the avatar's emotional expression is more important. When pedagogical avatars express emotions appropriate to the learning context, emotional interactions with learners are possible, and these emotional interactions can immerse learners in learning (Lawson et al., 2021; Tuyen, Elibol, & Chong, 2020). Gestures used by virtual avatars in a learning environment affect learners' emotions, which is an essential factor that also affects learning outcomes.

Second, it should be taken into account that gestures expressing emotions differ according to gender. Different gestures have been used on avatar to accentuate the difference in the body composition of men and women, the influence of clothing, and so forth (Einstein, Downar, & Kennedy, 2013). The perception of gestures according to gender can be seen as a gender stereotype (Hess et al., 2000). In a study by Yang and Ryu (2020), which confirmed the difference in avatars' facial expressions according to gender in emotion perception, there was a significant difference in perception between male and female avatars in all emotions of fear, sadness, joy, and anger. Further, there were differences in the perception of emotions in facial expressions and gestures according to gender. Einstein et al. (2013) and the findings from this study suggest that it is appropriate to apply a female avatar to strongly express joy or sadness, whereas a male avatar may be more effective in a fear situation. Thus, using a female avatar may be more potent in making learners happy.

Lastly, for the learner to accurately recognize the avatar's emotions, facial expressions and other emotions must be expressed together. In this study, facial expressions and gender were excluded from examining the effects of emotional gestures. However, accurately expressing the intended emotion with only gestures is challenging. Body language is ambiguous and varies depending on many factors, such as culture and environment (Tuyen et al., 2020). To correctly interpret body language as an indicator of emotional state, various parts of the body must be considered simultaneously (Noroozi et al., 2018). Non-verbal expressions for expressing emotions include gestures and postures, eye movements, touches, and personal space use. Considering these various parts, it is possible to accurately recognize the emotional state through body language (Siegman & Feldstein, 2014). Therefore, when designing a virtual avatar in a learning environment, it is necessary to combine various parts to express emotions accurately.

Conclusions and Limitations

Virtual avatars are increasingly being used in network-based interactive environments (e.g., SNS, conferences, games, and learning) that have been increasingly used after COVID-19 (Dawkins & Young, 2020). Significantly, the use of the virtual world called metaverse is expanded all over the world. In the virtual world, users interact with others through avatars as representing themselves. The users want to communicate with others by expressing their emotions and thoughts through avatars in a virtual world. In virtual environments, avatars can convey emotions verbally and non-verbally. Therefore, it is essential to express the avatar's emotions for non-verbal interactions accurately to perceive correctly. So the design of an avatar's emotional gesture is vital for non-verbal interactions.

The results of this study suggest a design method that can accurately recognize the intended emotions of avatars. This study suggests that the gender of the avatar should be considered when designing a virtual avatar. Since the degree of emotion perception is different according to the emotional and gender-specific gesture of the avatar, the gender that expresses the intended emotion properly should be considered. When interacting with avatars, if users know their avatar's emotional status, they can have an emotional interaction with their avatar. It is also helpful for learning if the emotional interaction between the avatar and the learner is strengthened. A persona effect is explained by what labeled that phenomenon avatar in the virtual world affects learning outcomes. Because social presence increases by emotional interaction with learners and avatar teachers, the learners would be more engaged in the learning context. Shortly, interaction with others through avatars in the virtual world will increase, so the emotional expression of the avatars is a crucial thing for virtual world design.

We did not investigate participants' gender because of the previous study by Thaler, Schlögl, and Groth (2020). In that study, there was no gender of participants affect ratings to virtual avatars. However, the avatar's gender influenced their emotional perception. So we hypothesized that the avatar's gender-specific gestures, not participant's, are influenced the degree of emotional perception. Therefore we focused avatar's gender, not the participant's. However, it needs to be focused on the participant's gender to examine an emotional judgment effect.

Emotional perception plays a crucial role in learning. If a learner is in the virtual world and interacts with avatars, it is crucial to facilitate the learner in a good mood. Furthermore, research on virtual learning environments found that emotion has an impact on the presence. We can postulate that the learner's emotions are essential for online learning. Emotions have an undeniable role in the learning process. In e-learning or online environment, it is essential to facilitate learning engagement through avatars' emotional expressions, which defines feeling states with negative or positive affective valence. When a learner is getting to the virtual world, the emotional motions have a substantial role in social interaction and the learning process.

The present study has two limitations to be addressed. First, we could not apply Asian gestures to this study. The gestures used in this study are the basic gender-specific emotional gestures provided by iClone, a 3D avatar authoring tool. The motions used in this study were based on Western culture. However, it is necessary to consider that gestures vary according to culture because subtle differences in gestures allow users to perceive emotions differently. Therefore, future studies should investigate participants' emotional perceptions by assigning avatars to gestures perceived by specific cultures.

Second, we cannot control emotional strengths across the emotions (fear, sadness, joy, and anger). For instance, it could be possible that the strength of expressed joy emotion can be more robust to the fear or anger. If the strength of emotions were different, the perceptions by a user could be different too. Although the motion libraries of iClone are reliable to make a representative emotional expression, it could be different how strongly the feelings are expressed. Future studies should set a quantified index to show the degrees of emotion.

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