

Figure 1: Users tend to express emotion through Memojis, which can augment a communication with a mood but might also lead to misunderstanding, confusion, and, sometimes, clarity

Graphical Abstract

The characteristics of facial emotions expressed in Memojis

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Highlights

The characteristics of facial emotions expressed in Memojis

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- Memojis accurately convey happy, sad, and disgusted faces while failing to express fear, anger, contempt, and surprise.
- Memojis failed to convey these four emotions; people tend to confuse fear and surprise, while anger and contempt are mainly perceived as disgust.
- Among the seven emotions, sadness showed a high accuracy when Memojis were compared with photographs (Session B), so much so that Memojis achieved an impact as powerful as photography.
- We applied the AI-driven prediction to photographs and Memojis and received the prediction results. Except for happiness, Memojis convey emotion less reliably than the photographs.

The characteristics of facial emotions expressed in Memojis

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Abstract

Memoji represents humans in online communications, and their emotional conveyance is attracting much attention. Despite this, there is a lack of studies exploring the emotional conveyance level of Memoji using various methods. In this study, we examined the emotional quality of Memojis and compared them with photography using the 5-Likert questionnaire and an AI-driven method. An online survey was conducted to collect user assessments of emotional expressions in Memojis. Twenty-eight photographs from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE) database depicting seven emotions were employed. Memojis of these photographs were made with an iPhone using iOS 15.2. The emotional content of individual Memojis was evaluated and compared with those of the photographs. We confirmed each emotion with an AI-driven prediction and analyzed it with human assessment. In general, Memojis were less efficient in communicating emotions than photography. Happiness and sadness showed robust results, while fear and contempt were relatively inaccurately perceived. When participants were less confident with a Memoji's facial expression, they tended to prefer photography even more. The tendency was coherent between human judgments and AI-supported predictions. We also discuss the limitations and challenges of the proper use of Memojis for improved figure-based and non-verbal communication.

Keywords: CMC (Computer-mediated communication), AMC (Avatar-mediated communication), Avatar, Memoji, Facial expressions, JACFEE, emotion

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1. Introduction

As human facial expressions are a universal nonverbal communication channel to convey emotions[1, 2, 3], “emojis” or “emoticons” are increasingly being used in daily computer-mediated communication[4, 5]. Most social media platforms have actively adopted them to assist users to enhance emotional communication. These cartoon-like illustrations of human faces showing emotions can protect users’ identity in social media[6], and operating systems now support most of them. Studies have examined how people perceive and change their moods during social media conversations to confirm their effect. For example, Smith found that emoticons were effective in relaxing a hostile atmosphere by weakening tension during conversations [7], and Das reported that emojis influence users’ cognitive behaviors, such as their purchase intentions [8].

Designers and researchers are working on the development of emojis. For example, Cherbonnier designed new emoticons and compared them with photography to examine the quality of recognition of emotions. This result showed that some emotions are better expressed with emoticons than photographs[9]. Their efforts resulted in avatars that represent the facial features and emotions of the users themselves. Among the avatar platforms, “Memojis,” designed by Apple, have shown high-performance replication of facial expressions[10]. Memojis are expected to have higher emotional conveyance than actual photographs. However, few studies have demonstrated whether these Memojis convey emotions, and insignificant evidence is available.

In this study, we aim to analyze the accuracy and reliability of Memoji’s emotional conveyance compared with photographs. First, we investigate whether Memojis fairly or more effectively deliver emotions across emotion categories. We conducted an online survey to collect user assessments to determine the emotional conveyance of Memojis. For the emotional norms of facial expressions, we used photographs from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE)[11] database to generate the Memojis in this study. For the examinations, we used three approaches, including assessments of the Memojis, comparative judgments between photography and the Memojis, and interpretations of emotions by a deep learning-based API solution.

2. Facial expression in virtual

Previously, researchers indicated that virtual and in-person emotional communication are similar, and even computer-mediated communication (CMC) shows more frequent and explicit emotional communication than face to face (F2F)[12]. Dewall states, “Facial expressions serve as rich nonverbal cues that can powerfully communicate important interpersonal intentions and motives”[13]. Based on prior research, facial expressions in virtual figure-based graphics have been designed, such as emoticons, text arranged to be seen as faces, and emojis, an image mapped to a Unicode character[14]. These are fixed graphics that do not move. Since iOS 8, Apple supported emojis in graphical interface format (GIF)[15, 16] which repeats the process of affective transformation[17], and the application of facial illustrations has expanded to avatars, computer-generated characters that represent the self in symbolized forms in interactions[18].

Avatars have been shown to influence a variety of contexts[18], such as group communication[19], non-verbal communication[20, 21], organizational communication[22], and advertising[23][24]. Avatars have especially stunning facial expressions that help people to communicate ideas and emotions in emotional contexts[25, 26, 27, 28]. Additionally, Suda made an avatar and confirmed the effect of mimicking facial expressions in both avatar–avatar and human–avatar environments[10].

Considering this effectiveness, many companies have made their avatars in various forms. Memojis by Apple(<https://support.apple.com/en-us/HT208986>), Facebook Avatar by Facebook (<https://www.facebook.com/help/278747370042382>), LINE Avatar by LINE (<https://linecorp.com/ja/pr/news/ja/2020/3427>), Bitmoji by Snap (<https://www.bitmoji.com/>), MetaHuman by Epic Games (<http://www.makehumancommunity.org/>), Reality (<https://reality.app>), and open-source software MakeHuman (<https://www.live2d.com/>) are a few examples[10].

Therefore, the avatar is a unique communication channel to express the users’ facial expressions, and assessing avatars’ ability to deliver facial expressions is worth exploring.

3. Memoji

Among the avatar platforms, “Memoji” is Apple’s animated avatar and is expected to effectively convey emotions. Indeed, Memojis have demonstrated

high-performance replication of facial expressions[10]. Memoji originated with the “Animoji,” one of Apple’s early object icons mainly generated from animals. Since the launch of iOS 12, a Memoji-making tool has been included as one of the essential services. The tool generates customized figures from one’s own facial images (<https://support.apple.com/en-us/HT208986>).

Features of Memojis widen the communication context into video communication from social media and texting platforms. Memojis can help users in real-time. Studies have examined how Memojis are effective in streaming video. Polen observed that eight-year-olds used Memojis to express their emotions and responses in a Zoom chat room[29]. Additionally, Ogawa found that Memojis improved the content delivery of video-based lectures [30]. Along with the growth in users and contents of Memojis, studies about figure-based messages have pursued better representations. The concerns include accurate resemblance[31], ethnicity issues[14], and graphic style depending on the software[32].

Furthermore, beyond resemblance, Memoji users expect Memojis to reflect their personality and mood state when shared while communicating[33, 34]. Considering this, we conducted an online survey to measure how accurately and effectively Memojis express facial emotions. We compared the performance of the JACFEE norm data set with that of the Memojis.

4. Study Goal

Our study aims to confirm Memoji’s emotional conveyance in aspects of accuracy and reliability by answering the following research questions.

- (Session A) Can humans effectively perceive the intended emotions through Memojis?
- (Session B) Compared to human facial expressions, what is the current level of emotional conveyance with Memojis?
- (Session C) How does artificial intelligence evaluate the emotional conveyance level of a Memoji?

We conducted a session for each research question: Session A, Session B, and Session C.

5. Online survey

5.1. Method

5.1.1. Materials: JACFEE

For the emotional norms of facial expressions, we used photographs from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE)[11] database. It contains photographs of 28 Japanese and 28 Caucasian men and women displaying seven categories of facial emotions: anger, contempt, disgust, fear, happiness, sadness, and surprise. To reduce the duration of the survey, we selected only 28 photographs: seven Japanese men, seven Japanese women, seven Caucasian men, and seven Caucasian women, and each face represented a different emotion category. According to percent judgments of intended emotion for each photograph in the JACFEE, the accuracy ranged between 26.72% (fear) and 100% (happy). Among the seven emotions, happiness achieved the highest accuracy, followed by surprise, sadness, anger, disgust, fear, and contempt. Except for contempt, both US-born Americans and Japanese Americans identified the intended emotion expressed by Caucasian faces more correctly than those expressed by Japanese faces[35]. Hence, we planned to analyze whether this trend appears coherently when the participants evaluate the Memojis generated from the JACFEE photography.


5.1.2. Materials: Memojis from JACFEE

For objectivity, we generated the Memojis from the pictures in the JACFEE data set. Three design researchers first configured the facial features and styles, imitating each JACFEE photo. We followed an iterating process to generate Memojis that resembled the JACFEE photos. Then, we generated the facial expressions of Memojis through the JACFEE photo, which had already confirmed its emotional accuracy. Finally, we prepared materials for the survey: a total of 28 Memojis and 28 pairs of Memoji-photos. All the Memojis were made with iPhone 11 operated with iOS 15.2. Appendix A presents all the images used in the survey.

5.1.3. Participants

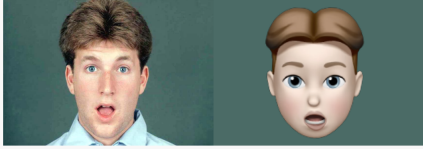
We recruited 82 participants aged between 18 and 26 years old (mean=20.95, standard deviation = 2.49), consisting of 43 men and 39 women. All participants were Korean native university students who use smartphones and have experience with Memojis. They were paid 5 dollars for voluntary participation.

With the following face, which emotions are being strongly expressed?



	strongly disagree	disagree	neutral	agree	strongly agree
angry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
contempt	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
disgust	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
fear	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
happiness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
sadness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
surprise	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Which one conveys the emotion of surprise better?



☐
☐
☐
☐
☐

definitely left
maybe left
same
maybe right
definitely right

Figure 2: Online surveys. (Left) Session A: Judgements of facial expressions of emotion from the Memojis. The emotional intensity was assessed in aspects of seven emotions. (Right) Session B: A comparison between a photograph and its Memoji regarding emotion conveyance.

5.1.4. Questionnaires

The survey began with Session A, followed by Sessions B and C. As shown in Figure 2, in Session A, we presented one out of 14 Memojis asking participants to rate emotional intensity with regard to the seven emotions using a 5-point (1–5) scale, labeled strongly disagree (−2), disagree (−1), neutral (0), agree (+1), and strongly agree (+2). Through these questions, we analyzed the accuracy of the Memoji’s emotional conveyance. Fourteen Memojis paired with their source photographs were displayed in Session B. Participants compared the emotional intensity between two images. In Session B, we analyzed the reliability of Memojis in conveying emotion compared to the photographs. Lastly, in Session C, we examined the deep learning-based emotion prediction interpreted by an API service provided by Microsoft(<https://docs.microsoft.com/ko-kr/xamarin/xamarin-forms/data-cloud/azure-cognitive-services/emotion-recognition>) and confirmed their reliability in AI.

5.2. Procedure

To proceed with the survey while keeping the participants’ attention, we limited the stimuli to 14 of the 28 JACFEE images and matching Memojis. The Memoji materials (Session A) and the photo-Memoji pairs (Session B, Session C) were selected randomly, making 82 evaluations for each. Participants joined the survey remotely, and their responses were collected via a web-based survey platform(moaform.com). The average survey completion

Table 1: Emotional assessments of Memojis (Session A) (N = 82): The averaged assessments are horizontally displayed regarding the seven intended emotions arrayed vertically. The strongest agreement is in underlined bold text.

Intended Emotion	Aspect Emotion						
	anger	contempt	disgust	fear	happiness	sadness	surprise
<i>anger</i>	0.52(1.25)	-1.08(1.00)	<u>1.10(1.07)</u>	-1.30(0.92)	-1.00(0.96)	-1.30(0.94)	-1.50(0.77)
<i>contempt</i>	0.21(1.28)	0.07(1.44)	<u>0.70(1.19)</u>	-1.00(1.04)	-1.00(1.25)	-0.60(1.34)	-1.30(0.90)
<i>disgust</i>	0.04(1.25)	-0.76(1.18)	<u>0.80(1.06)</u>	-0.80(1.12)	-1.00(1.03)	-0.70(1.21)	-1.20(0.94)
<i>fear</i>	-1.11(1.08)	-1.57(0.69)	-1.30(0.97)	<u>0.10(1.25)</u>	-2.00(0.79)	-0.80(1.19)	-0.80(1.25)
<i>happiness</i>	-1.81(0.46)	-0.04(1.17)	-1.50(0.87)	-1.60(0.65)	<u>1.00(0.84)</u>	-1.80(0.54)	-0.90(1.17)
<i>sadness</i>	0.03(1.47)	-1.43(0.85)	-1.20(1.00)	-0.7(1.18)	-2.00(0.71)	<u>1.30(1.09)</u>	-1.50(0.81)
<i>surprise</i>	-1.38(0.92)	-1.53(0.80)	-1.10(1.04)	<u>1.30(0.99)</u>	-1.00(0.91)	-1.30(0.94)	<u>1.30(1.02)</u>

time for the survey was 8 minutes 5 seconds.

6. Results and Analysis

6.1. Session A: Emotional assessments of Memojis

Based on the assessments, we summarized the central tendency across the seven emotions. Each Memoji was according to the seven emotions, and we analyzed whether the intended emotion was generally conveyed. The summarized results shown in Table 1 are the averaged assessments of the four categories: Caucasian men, Caucasian women, Japanese men, and Japanese women. The assessment scores confirmed that happiness, sadness, and disgust were assessed as intended, with agreement scores equal to or greater than 0.8, between -2 (strongly disagree) and $+2$ (strongly agree). Furthermore, the scores for happiness, sadness, and disgust were distinctively higher than those for different emotions. This indicates that Memojis convey happy, sad, and disgusted faces accurately.

However, a different tendency was found regarding the remaining four emotions: surprise, fear, anger, and contempt. In the case of the surprised expression, participants confused fear and surprise, showing that the scores on both emotions were equally 1.30. Also, the score for fear was the highest but merely 0.10 on average, indicating that the Memojis failed to convey fearful expressions. Furthermore, angry and contemptuous faces were mostly seen as disgusted, which clearly shows that Memojis may cause inaccurate delivery of intended emotions. Finally, these results imply that Memojis might inaccurately communicate emotions unless they illustrate happy, sad, or disgusted faces.

Which medium conveys emotion better?

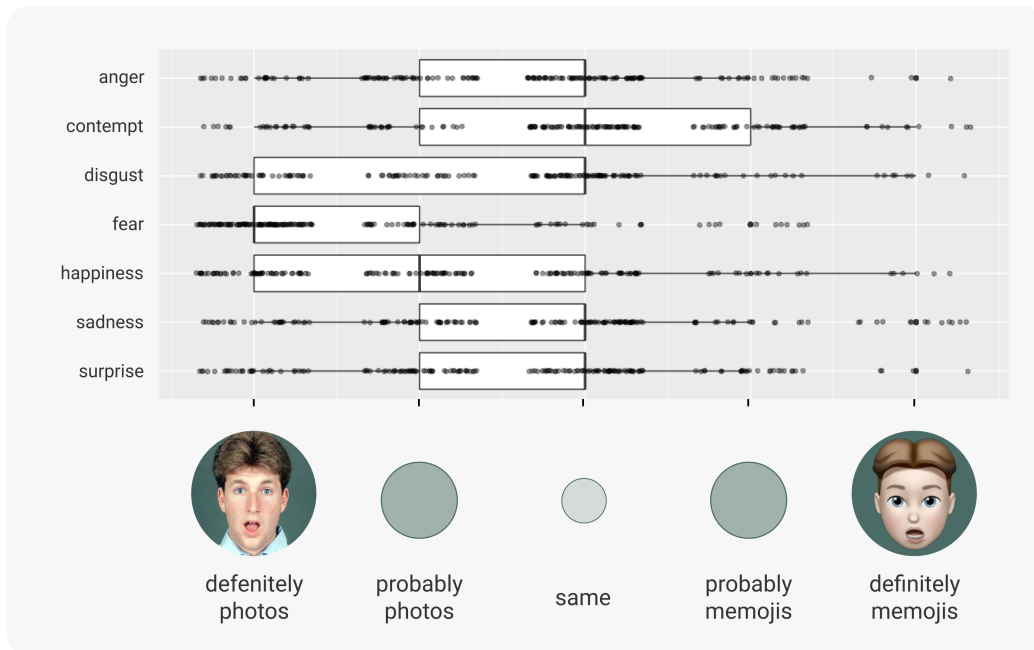


Figure 3: Box plot of Memoji and photograph comparison over the seven intended emotions. For an explanation of the box plot, refer to Table 2 (Session B) (N = 82).

Table 2: The mean and standard deviation of photographs and Memojis emotion conveyance (Session B) (N = 82)

Emotion	Mean	Std. Deviation	Mean difference (Memojis-Photographs)	cohen's d	t
<i>anger</i>	-0.46	1.03	-0.46	-0.47	-5.69*
<i>contempt</i>	-0.35	1.13	-0.35	-0.31	-4.01*
<i>disgust</i>	-0.73	1.13	-0.73	-0.65	-8.25*
<i>fear</i>	-1.37	.92	-1.37	-1.49	-19.07*
<i>happiness</i>	-0.51	1.12	-0.51	-0.46	-5.88*
<i>sadness</i>	-0.05	1.07	-0.05	-0.5	-0.58
<i>surprise</i>	-0.41	0.98	-0.41	-0.42	-5.35*

t scores from a one-sample t-test to statistically examine the mean difference with 0.

* p < 0.05

6.2. Session B: Comparative judgments between photographs and Memojis

To determine the reliability of Memoji’s emotional conveyance, we asked participants to select between -2 and $+2$, corresponding to: “Photography is more reliable to convey each emotion(-2)” and “Memoji is more reliable to convey each emotion($+2$).” “0” was set as the target value indicating that the Memoji was perceived as similar to the photograph. We performed a one-sample t-test to determine if the average assessment was statistically different from 0 for each photo/Memoji pair.(Table 2)

Except for the “sadness” emotion, the result showed that photography conveys emotions more accurately than Memojis. The comparative central tendency of the balance leans more towards photography across the entire emotion set. In particular, except for the “sad” emotion, the differences were statistically different at an alpha level of 0.05.

The photography for fear received the strongest assessment (-1.37) followed by disgust (-0.73), happiness (-0.51), anger (-0.46), surprise(-0.41), and contempt (-0.35). None of the emotions received positive average scores towards Memojis, indicating that photography generally conveys emotional expression more effectively than Memojis. Figure3 displays the judgments of the 82 participants along the seven emotions.

In Session A, sadness was one of the robust emotions accurately expressed in Memojis. The results of Session B support this tendency, showing that the participants found that sadness Memojis are as equally expressive as photography. This indicates that Memojis with a sad emotion will be correctly perceived, and their impact is as powerful as the photography. Also, the Memoji’s poor delivery of the fear emotion is confirmed in Session B. The fearful photography was more effective than its Memoji pair at expressing fearful emotion. The average score reached -1.37 , indicating that participants strongly advocated photography to convey fearful emotion.

Table 3: The mean and standard deviation of comparison data by AI (Session C). The intended emotion is arranged horizontally, while the estimation on each emotion is shown vertically.

	anger		contempt		disgust		fear	
	<i>photo</i>	<i>Memoji</i>	<i>photo</i>	<i>Memoji</i>	<i>photo</i>	<i>Memoji</i>	<i>photo</i>	<i>Memoji</i>
<i>anger</i>	45.35(22.57)	0.55(0.85)	12.03(10.02)	1.55(0.77)	5.90(11.00)	0.03(0.05)	0.15(0.24)	0.00(0)
<i>contempt</i>	0.00(0)	0.00(0)	31.85(11.83)	2.48(3.12)	0.00(0)	0.00(0)	0.00(0)	0.00(0)
<i>disgust</i>	7.83(8.92)	0.13(0.19)	0.18(0.15)	0.03(0.05)	89.92(9.00)	0.03(0.05)	0.00(0)	0.00(0)
<i>fear</i>	0.05(0.06)	0.00(0)	0.18(0.15)	0.55(0.64)	2.18(3.75)	0.03(0.05)	61.43(38.29)	0.05(0.10)
<i>happiness</i>	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)
<i>sadness</i>	0.00(0)	0.00(0)	0.20(0.14)	0.18(0.29)	0.00(0)	0.00(0)	0.00(0)	0.00(0)
<i>surprise</i>	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)
	happiness		sadness		surprises		neutral	
	<i>photo</i>	<i>Memoji</i>	<i>photo</i>	<i>Memoji</i>	<i>photo</i>	<i>Memoji</i>	<i>photo</i>	<i>Memoji</i>
<i>anger</i>	0.00(0)	0.50(0.10)	20.13(21.86)	31.65(35.93)	0.43(0.78)	0.00(0)	15.98(13.68)	66.13(36.67)
<i>contempt</i>	34.25(23.77)	22.78(18.33)	0.08(0.05)	0.05(0.10)	0.00(0)	0.00(0)	33.70(16.25)	74.70(15.88)
<i>disgust</i>	1.38(1.25)	34.90(46.62)	0.25(0.44)	0.00(0)	0.00(0)	0.00(0)	0.68(0.73)	64.95(46.61)
<i>fear</i>	0.00(0)	0.05(0.10)	3.53(3.70)	49.08(46.51)	25.70(29.32)	0.93(1.85)	6.95(8.06)	49.33(46.51)
<i>happiness</i>	100.00(0)	100.00(0.00)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)	0.00(0)
<i>sadness</i>	24.93(49.85)	0.00(0)	47.58(37.83)	46.50(49.09)	0.00(0)	0.03(0.05)	27.38(27.57)	53.28(48.89)
<i>surprise</i>	0.25(0.50)	0.10(0.20)	0.00(0)	0.45(0.83)	97.90(3.56)	21.10(21.02)	1.85(3.70)	78.33(20.84)

In general, the Memojis were less convincing than photography. Memojis with sad faces may be able to replace photography; however, in general, Memojis are still insufficient at delivering the intended emotion using facial expressions compared to photographs.

6.3. Session C: Comparison with the facial emotion prediction by AI

Next, we confirmed the algorithm-based emotion prediction using an open API. We facilitated the Face Analysis app service based on the API offered by Microsoft at [azure.microsoft.com](https://azure.microsoft.com/en-us/services/cognitive/face-api/). This is an open API that predicts emotional quantity based on a facial image. We uploaded photographs and corresponding Memoji images and obtained predicted scores in eight emotion categories, including neutrality. We applied the AI-driven prediction for photography and Memojis and received the prediction results as likelihood ratios across the eight emotions. We performed a t-test on the paired samples to examine whether the AI judges the emotional intensity of the photography and Memojis statistically differently based on the ratio data. All 28 pairs were entered for the paired-samples t-test, and the tests were carried out regarding the eight emotions.

Table 3 displays the results. The average and standard deviation are displayed horizontally, and the seven intended emotions are arranged vertically. This comparison indicates that, except for happiness, Memojis are inadequate at reliably conveying emotion compared to the photographs. In the

case of happiness, the Memoji is also indicated as 100 at happiness emotion. However, because the AI algorithm was trained with human photography[36], the Memojis may have been inadequate for the analysis.

7. General Discussion

The three phases of studies aimed to determine how people predict emotion when viewing Memojis compared with photographs of human faces. Based on the survey assessments and AI-driven prediction, we concluded the following findings. In session A, the participants recognized the intended emotion from the Memojis with **happy, sad, or disgusted emotions**. The remaining four emotions remain challenging. Surprised Memojis were interpreted as both surprise and fear emotions. The fearful Memojis failed to deliver any distinctive emotional accuracy. Also, angry and contemptuous Memojis were perceived as disgusted faces. Results from session B, the analysis elaborates on the comparative performance between Memojis and photography in detail. Although happy, sad, and disgusted emotions were reasonably well perceived in Memojis, participants showed that photography expresses happy and disgusted emotions better. Except for sadness, every emotion category received a preference for photography. Finally, in session C, the results agreed with the participants' subjective judgments, Session A. This lead the conclusion that Memojis can express happy, sad, and disgusted emotions as efficiently as photography. However, we found Memojis vague in conveying surprised, fearful, angry, and contemptuous facial expressions. This can cause a misunderstanding when conveying emotion with computer-mediated communication using Memojis.

Taken together, all of the sessions demonstrate that the Memoji is still unable to convey emotion effectively that inaccurate or vague communication. Perhaps this is caused by Memojis' typical features: cartoonist style and systemic problem. Compare to photographs, Memojis have bigger eyes, flawless skin, or round facial contours. Such graphical characteristics might have hindered, biased, or exaggerated actual human faces, which we are more familiar with. Memojis also do not have necks or shoulders. Part of the emotion is conveyed by the body posters, especially the angle between the chin and shoulder, which is lost in the Memoji[37, 38]. The Memojis might have a friendly appearance but potentially deliver incorrect messages. A possible explanation for the Memoji's systemic problem is that facial detecting system directly mimics facial expressions rather than understanding them. Memoji

by Apple is a high-performance facial expression replicator that precisely maps facial expressions with facial features[10] and avatars with emotional mimicry are known as increasing the communication[39, 40]. Although this can sometimes cause users to exaggerate their facial expressions, our research indicates that exact mapping still has a low level of accuracy. Moreover, the result implies that the user would be burdened with generating exaggerated facial expressions due to the exact mapping. Oh also emphasized that enhancing one’s avatar’s smile can result in more positive outcomes than using a smile that is accurately mapped [41].

These studies have some limitations. The Memoji materials given was consisted with diverse of race and gender, the survey was limited to Korean participants. As Hess asserted, in general, people judge facial expressions more accurately within the same ethnicity[42]. Thus, a future online survey could invite diverse ethnic groups to derive a more robust conclusion. Moreover, because the study used the JACFEE data set for external validity, the Memojis had different styles and facial features with particular style memojis. These differences can sometimes cause a distinction in conveying emotion. Hence for future research, Memojis with the same style and character expressing other emotions with common style of memoji would be needed. The study was tested by a small group of participants, which means a more substantial sample should be required in future research.

Nonetheless, we analyzed the emotional conveyance of the Memoji system and confirmed that they do not reliably express emotion. This analysis leads us to identify a problem with Memojis to prevent misunderstandings between senders and receivers due to the miscommunication of emotions. Through this, we motivate designers to improve the Memoji system and correct the direction of the Memoji design. A thorough study of human facial expressions is necessary to generate the Memoji expressions properly. The empirical evidence of this study can be utilized to advance emotional communication in computer-mediated communication.

8. Conclusion

This study highlights how people understand emotional expression when viewing Memojis in comparison to photographs as well as the quality of Memoji’s ability to convey emotional expression. In particular, we analyzed whether the intended emotions were effectively perceived through Memojis (Session A), how reliable they are in relation to the source photography

(Session B), and whether humans judge differently from the AI algorithm (Session C). We conducted an online survey with two sets of 14 photographs and their Memoji pairs, and the photography was selected from the JACFEE data set. A total of 82 participants assessed one of the survey sets. Their responses were statistically analyzed, resulting in three major findings. First, Memojis convey happy, sad, and disgusted emotions as intended. However, they might inaccurately deliver the emotion of surprise. Also, the fearful emotion is difficult to express using Memojis. Both angry and contemptuous Memojis might be perceived as disgusted. Second, Memojis are still insufficient to convey emotion compared to photography in general. Lastly, the participants' judgments were overall coherent with the AI solution for emotion recognition. We discussed the cause of Memojis' typical problems as cartoonist style and systemic issues. Memojis' graphical characteristics might mislead the intended emotions without body posters. Exact mapping of facial expressions without understanding emotion would burden Avatar users and limit emotional perceptions. In our future study, we plan to explore what essentially affects the Avatar to convey intended emotion and suggest the guideline for better computer-mediated communication.

Appendix A. Every image used in the survey

References

- [1] P. Ekman, Facial expression and emotion, *American psychologist* 48 (4) (1993) 384.
- [2] P. Ekman, Emotions revealed, *Bmj* 328 (Suppl S5) (2004).
- [3] J. A. Russell, Is there universal recognition of emotion from facial expression? a review of the cross-cultural studies., *Psychological bulletin* 115 (1) (1994) 102.
- [4] L. K. Kaye, H. J. Wall, S. A. Malone, “turn that frown upside-down”: A contextual account of emoticon usage on different virtual platforms, *Computers in Human Behavior* 60 (2016) 463–467.
- [5] D. Derks, A. E. Bos, J. Von Grumbkow, Emoticons in computer-mediated communication: Social motives and social context, *Cyberpsychology & Behavior* 11 (1) (2008) 99–101.

























































Materials	Ethnicity	Emotion						
<i>Photograph</i>	Caucasian							
		angry	contempt	disgust	fear	happiness	sadness	surprise
	Japanese							
		angry	contempt	disgust	fear	happiness	sadness	surprise
	Caucasian							
		angry	contempt	disgust	fear	happiness	sadness	surprise
	Japanese							
		angry	contempt	disgust	fear	happiness	sadness	surprise
<i>Memoji</i>	Caucasian							
		angry	contempt	disgust	fear	happiness	sadness	surprise
	Japanese							
		angry	contempt	disgust	fear	happiness	sadness	surprise
	Caucasian							
		angry	contempt	disgust	fear	happiness	sadness	surprise
	Japanese							
		angry	contempt	disgust	fear	happiness	sadness	surprise

Figure A.4: Left to right, images signify anger, contempt, disgust, fear, happiness, sadness, and surprise.

- [6] O. Ayalon, E. Toch, User-centered privacy-by-design: Evaluating the appropriateness of design prototypes, *International Journal of Human-Computer Studies* 154 (2021) 102641.
- [7] K. A. Smith, Assessing the supportiveness of gift emoticons in care scenarios, in: *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, 2015, pp. 151–156.
- [8] G. Das, H. J. Wiener, I. Kareklas, To emoji or not to emoji? examining the influence of emoji on consumer reactions to advertising, *Journal of Business Research* 96 (2019) 147–156.
- [9] A. Cherbonnier, N. Michinov, The recognition of emotions beyond facial expressions: Comparing emoticons specifically designed to convey basic emotions with other modes of expression, *Computers in Human Behavior* 118 (2021) 106689.
- [10] M. Suda, M. Oka, Evaluation of the effect of mimicry on facial expression in avatar-mediated communication, in: *ALIFE 2021: The 2021 Conference on Artificial Life*, MIT Press, 2021.
- [11] D. Matsumoto, Japanese and caucasian facial expressions of emotion (jacfee) and neutral faces (jacneuf), *Intercultural and Emotion Research Laboratory, Department of Psychology* (1988).
- [12] D. Derks, A. H. Fischer, A. E. Bos, The role of emotion in computer-mediated communication: A review, *Computers in Human Behavior* 24 (3) (2008) 766–785.
- [13] C. N. DeWall, J. K. Maner, D. A. Rouby, Social exclusion and early-stage interpersonal perception: Selective attention to signs of acceptance., *Journal of Personality and Social Psychology* 96 (4) (2009) 729.
- [14] P. Kimura-Thollander, N. Kumar, Examining the” global” language of emojis: Designing for cultural representation, in: *Proceedings of the 2019 CHI conference on human factors in computing systems*, 2019, pp. 1–14.
- [15] J. Eppink, A brief history of the gif (so far), *Journal of visual culture* 13 (3) (2014) 298–306.

- [16] K. M. Miltner, T. Highfield, Never gonna gif you up: Analyzing the cultural significance of the animated gif, *Social Media+ Society* 3 (3) (2017) 2056305117725223.
- [17] L. Stark, K. Crawford, The conservatism of emoji: Work, affect, and communication, *Social Media+ Society* 1 (2) (2015) 2056305115604853.
- [18] K. L. Nowak, J. Fox, Avatars and computer-mediated communication: A review of the definitions, uses, and effects of digital representations, *Review of Communication Research* 6 (2018) 30–53.
- [19] S. F. Van Der Land, A. P. Schouten, F. Feldberg, M. Huysman, B. van den Hooff, Does avatar appearance matter? how team visual similarity and member–avatar similarity influence virtual team performance, *Human Communication Research* 41 (1) (2015) 128–153.
- [20] G. Bente, N. C. Krämer, Virtual gestures: Embodiment and nonverbal behavior in computer-mediated communication, *Face-to-face communication over the internet: issues, research, challenges* (2011) 176–209.
- [21] E. Heyselaar, P. Hagoort, K. Segaert, In dialogue with an avatar, language behavior is identical to dialogue with a human partner, *Behavior Research Methods* 49 (1) (2017) 46–60.
- [22] H. Park, H. Lee, Show us you are real: The effect of human-versus-organizational presence on online relationship building through social networking sites, *Cyberpsychology, Behavior, and Social Networking* 16 (4) (2013) 265–271.
- [23] S. J. Ahn, J. N. Bailenson, Self-endorsing versus other-endorsing in virtual environments, *Journal of Advertising* 40 (2) (2011) 93–106.
- [24] S.-A. A. Jin, J. Bolebruch, Avatar-based advertising in second life: The role of presence and attractiveness of virtual spokespersons, *Journal of Interactive Advertising* 10 (1) (2009) 51–60.
- [25] R. M. Martey, J. Stromer-Galley, M. Consalvo, J. Wu, J. Banks, T. Strzalkowski, Communicating age in second life: The contributions of textual and visual factors, *New Media & Society* 17 (1) (2015) 41–61.

- [26] S. Antonijevic, From text to gesture online: A microethnographic analysis of nonverbal communication in the second life virtual environment, *Information, Community and Society* 11 (2) (2008) 221–238.
- [27] T. Koda, T. Ishida, M. Rehm, E. André, Avatar culture: Cross-cultural evaluations of avatar facial expressions, *AI & society* 24 (3) (2009) 237–250.
- [28] N. Yee, J. Bailenson, The proteus effect: The effect of transformed self-representation on behavior, *Human communication research* 33 (3) (2007) 271–290.
- [29] E. Polen, Effect of covid-19 on elementary students’ use of language online (2021).
- [30] M.-B. Ogawa, S. Mosier, K. McDermott, N. Nagatoshi, Building engagement through memoji enhanced asynchronous video lectures, in: *EdMedia+ Innovate Learning*, Association for the Advancement of Computing in Education (AACE), 2020, pp. 1125–1130.
- [31] H. J. Wall, L. K. Kaye, S. A. Malone, An exploration of psychological factors on emoticon usage and implications for judgement accuracy, *Computers in Human Behavior* 62 (2016) 70–78.
- [32] G. W. Tigwell, D. R. Flatla, Oh that’s what you meant! reducing emoji misunderstanding, in: *Proceedings of the 18th international conference on human-computer interaction with mobile devices and services adjunct*, 2016, pp. 859–866.
- [33] D. Zhu, R. Wang, Z. Zhang, D. Wang, X. Meng, W. Liu, Exploring and reflecting on generation z interaction qualities and selfie scenario designs, in: *International Conference on Applied Human Factors and Ergonomics*, Springer, 2021, pp. 352–357.
- [34] S. C. Herring, A. R. Dainas, H. L. Long, Y. Tang, Animoji adoption and use: Gender associations with an emergent technology, *Proceedings of Emoji2020*, CA. AAAI (2020).
- [35] M. Biehl, D. Matsumoto, P. Ekman, V. Hearn, K. Heider, T. Kudoh, V. Ton, Matsumoto and ekman’s japanese and caucasian facial expressions of emotion (jacfee): Reliability data and cross-national differences, *Journal of Nonverbal Behavior* 21 (1) (1997) 3–21.

- [36] W. Zhao, R. Chellappa, P. J. Phillips, A. Rosenfeld, Face recognition: A literature survey, *ACM computing surveys (CSUR)* 35 (4) (2003) 399–458.
- [37] B. Campos, M. N. Shiota, D. Keltner, G. C. Gonzaga, J. L. Goetz, What is shared, what is different? core relational themes and expressive displays of eight positive emotions, *Cognition & emotion* 27 (1) (2013) 37–52.
- [38] J. L. Tracy, R. W. Robins, The prototypical pride expression: development of a nonverbal behavior coding system., *Emotion* 7 (4) (2007) 789.
- [39] R. Hoegen, J. Van Der Schalk, G. Lucas, J. Gratch, The impact of agent facial mimicry on social behavior in a prisoner’s dilemma, in: *Proceedings of the 18th International Conference on Intelligent Virtual Agents*, 2018, pp. 275–280.
- [40] B. S. Hasler, G. Hirschberger, T. Shani-Sherman, D. A. Friedman, Virtual peacemakers: Mimicry increases empathy in simulated contact with virtual outgroup members, *Cyberpsychology, Behavior, and Social Networking* 17 (12) (2014) 766–771.
- [41] S. Y. Oh, J. Bailenson, N. Krämer, B. Li, Let the avatar brighten your smile: Effects of enhancing facial expressions in virtual environments, *PloS one* 11 (9) (2016) e0161794.
- [42] U. Hess, S. Blairy, R. E. Kleck, The influence of facial emotion displays, gender, and ethnicity on judgments of dominance and affiliation, *Journal of Nonverbal Behavior* 24 (4) (2000) 265–283.