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A Comparative Study on the Processing of Emojis and Faces in Human Communication

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In the digital era, emojis have enriched the way people communicate and research on emojis explosively increased in recent years. However, few noticed their functions from the neurocognitive perspective, especially their similarities and differences with facial expressions in traditional face-to-face communication. To fill this gap, we conducted a Meta-analysis with 25 independent effect sizes from previous experimental studies. The present study shows that emojis have slight advantages in processing efficiency, which might be attributed to their simplicity in design, namely the omission of complex facial features, but the difference between emoji and face processing is not significant. In addition, emotional valence and experimental methods do not have significant influences, which suggests that emojis are equally effective as human faces in emotional expression. The current research contributes to the knowledge in digital communication and the crucial role played by emojis therein.

Keywords: emoji processing, face processing, comparison

Introduction

When human beings communicate with each other, they often use facial expressions, gestures and other paralanguage to assist their verbal expressions, showing that human communication involves multiple modalities. As digital technology develops, the internet has changed the traditional way people communicate. To make up for the lack of gestures and facial expressions in online communications, emojis have become a popular way to express emotions in online messages (Paggio & Tse, 2022).

Emojis have evolved from various forms that were not invented only to aid verbal information at the very beginning, such as smileys and emoticons (Bai et al., 2019; Daniel & Camp, 2020). In 1963, the amalgamation of two companies led to the birth of the “smiley” face. Devised by Harvey Ball, a yellow face with a wide grin featuring two dots for eyes was widely distributed on buttons and pins to boost company morale (Stark & Crawford, 2015). Emoticons and smileys almost appeared at the same time. In the 1980s, the first ASCII-based

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emoticon :-), combining a sequence of characters from common punctuation marks on computer keyboards, which appeared like a smiling face, was invented to construct visual representations of facial images in text (Ganster et al., 2012; Walther & D' Addario, 2001; Zhou et al., 2017). With the advancement of technology, emoticons have been increasingly replaced by more colored and vivid smileys that do not require a 90-degree rotation (Ganster et al., 2012). According to Miller et al. (cited from Chairunnisa & A.S., 2017), emojis were first invented in Japan in 1990s and originated from smileys (Bai et al., 2019). They have grown to incorporate a diverse array of pictographs, spanning beyond the original smileys to encompass various images, including animals and different kinds of objects (Paggio & Tse, 2022).

Emojis come in a wide variety of forms, starting from simple yellow icons originally used to convey emotions, and gradually being endowed with richer meanings and connotations. They can play the role of human faces in face-to-face communication in digital environments. Several studies have confirmed the similarities of neural mechanisms that trigger facial and emotional expression recognition, and some researchers also investigated the neural processing of emojis through ERP experiments. According to Landa et al. (2014), event-related potentials (ERPs) are changes in voltage that occur at a particular time in response to specific events or stimuli, which can be seen as a kind of evoked signals measured by electroencephalogram (EEG) recorded by putting electrodes on one's scalp. This measurement technology provides researchers with a window into the in-depth understanding of how the brain processes information. Three types of ERP (P100, N170 and LPP) have been identified as the most sensitive to emotional content and facial processing (Smith et al., 2013). Gantiva et al. (2019) further revealed the way emojis are processed in the brain. Though emojis elicit lower P100 and LPP than faces, the increase in N170 indicates that they are as efficiently processed as faces. Linda et al. (2023) compared in detail N170 elicited by emojis and faces and obtained the same results. Moreover, they found that N170 elicited by faces is usually right-sided while emoji-based N170 is left-sided, which may indicate the differences between the cognitive processing of emojis and faces.

Moreover, there are a range of studies conducted to testify whether emojis themselves are truly emotional as human faces and how the valence of emojis influence the processing of different kind of messages. Gantiva et al. (2019) examined the ERPs in response to different valence of both human and emoji faces. The results showed that the neural activities during the processing of human and emoji faces were similar despite some different amplitude elicited by angry faces. This discovery reveals the potential connection between emoticons and real faces in emotional processing. However, Kaye et al. (2021) summarized through previous studies over emotional processing that words with emotional valence are processed more easily. Thus, he hypothesized that three kinds of stimulus including emojis with emotional valence would have processing advantages than neutral ones of the same kind. However, his results were not in accordance with previous studies, not proving the processing advantage and thus the emotionality of emojis, adding challenges to proving and understanding their emotionality as faces. Weiß et al. (2018) conducted an ERP research in economic context using emojis as stimuli for social emotional feedback. Their results showed that when bargaining, emojis with different valence as stimulus affect variously the neural processing of quoted prices. Then, Weiß et al. (2020) employed emojis as feedback triggers again to evaluate how emojis contribute to decision-making in the ultimatum game this time. They showed emojis twice in an experiment and found that different emojis in two stages have multiple influences on the final decision.

In conclusion, whether emojis are as emotionally rich as human faces and whether the processing of emojis and human faces in the brain is completely similar remains a controversial topic. Given the importance of emojis in digital communication and the inconsistency of existing research results, this study will employ a Meta-analysis to explore the similarities and differences between the processing of emojis and faces.

Methodology

Meta-analysis is a quantitative analysis method that derives more universal conclusions by comprehensively analyzing the statistical data from multiple research results. According to Fang et al. (2021), there are roughly eight steps for the Meta-analysis, namely the topic selection, literature search, quality screening, data coding, data analysis, heterogeneity assessment, publication bias test, and outcome presentation. And for data analysis, commonly used software programs for Meta-analysis include Stata, R language (Foo YZ et al., 2017), SAS, and SPSS. These software programs have varying operating systems and offer a range of functions, providing an important guarantee for the implementation of different types of Meta-analysis, and the choice of which depends on the specific needs of the research.

Meta-analysis has high reliability. Since Meta-analysis promotes more complete investigation of one variable or one question, it provides more objective results and stronger statistical power. It is particularly useful in the field of medicine, and has been widely applied in many areas. Now Meta-analysis has become the most optimal approach that evaluates together results across studies and offers the most rigorous form of evidence (Fang et al., 2021).

Literature Search

This study conducted a literature search for research on emoji processing between 2014 and 2023. During the literature search process, the database Web of Science was utilized, with the keyword ‘emoji process’. Additionally, to broaden the search scope, the study also employed the Google Scholar platform on the internet, conducting similar searches with various combinations of keywords. Given that Google Scholar does not support the use of wildcard characters, the study carefully selected the most frequently used combinations such as “emoji process”, “emoji processing”, “process emoji”, and “emoji processed”, to comprehensively capture all types of research related to emoji processing. In total, the study retrieved 289 relevant studies from these two platforms.

Quality Screening

Given that this study focuses on the cognitive processing mechanisms of emojis in the field of psychology, including their recognition, processing, and understanding, this study conducted an initial screening of the retrieved literature. This step excluded a significant number of studies closely related to computer science or statistical analysis of emoji usage frequency, ultimately selecting 31 studies directly relevant to psychology and the cognitive processing of emojis.

To further ensure the validity of the Meta-analysis, these studies underwent a more rigorous screening process. Firstly, only experimental or quasi-experimental designs were retained, excluding review articles and purely theoretical papers, as these types of studies cannot directly provide the data support required for empirical analysis. Secondly, the selected studies had to provide sufficient datasets, including but not limited to sample sizes, means, and standard deviations. For papers that did not directly provide the required data, they can be estimated from figures and tables or obtained by contacting the authors. Lastly, the studies had to involve comparative analysis between emojis and faces to more comprehensively explore the unique aspects of emoji cognitive processing.

Ultimately, three studies that fully met all criteria were identified, and a total of 25 effect sizes were extracted from these studies for subsequent Meta-analysis.

Literature Coding

The coded variables in the literature include author information, publication year, valence of emojis and faces, and experimental methods. Each independent sample is coded once, and if a single piece of literature contains multiple independent samples, they are coded separately.

The valence of emojis and facial expressions is categorized based on the polarity of emotions, namely positive, neutral, and negative.

Experimental methods are divided into two categories: behavioral experiments and neural experiments. Behavioral experiments document human behavior through various means such as eye-tracking and questionnaires, while neural experiments utilize electroencephalography (EEG) to analyze brain electrical signals, delving deeper into the neural mechanisms of cognitive processing.

Data Analysis

Using the Comprehensive Meta-Analysis (CMA) 3.0 software, this study conducted a Meta-analysis through main effect and moderating effect analyses on the comparison between the cognitive processing of emoji and faces. A total of 25 effect sizes were incorporated into this Meta-analysis.

Heterogeneity Test

The results of the Meta-analysis Q test reveal heterogeneity among the included studies, evidenced by a high Q value of 405.51 and a statistically significant P-value less than 0.001. This level of statistical significance indicates the presence of heterogeneity among the effect sizes incorporated into the Meta-analysis. Furthermore, the I-squared value stands at 94.08%, far exceeding the threshold of 75% set by Huedo-Medina et al. (2006) for high heterogeneity. This suggests that up to 94.08% of the total variation between studies can be attributed to genuine differences in effect sizes across different studies.

Multiple factors may contribute to this high degree of heterogeneity, including but not limited to variations in the selection of study participants, differences in experimental designs, inconsistencies in measurement tools and indicators, and so forth. Given these discrepancies, the present study employs a random-effects model for analysis. Additionally, the significant heterogeneity among effect sizes also hints at the potential existence of moderating variables that could influence the effect size. Therefore, relevant moderating variables will be identified and further analyzed in this study.

Publication Bias Test

The funnel plot (Figure 1) results show that the effect quantities are concentrated in the upper middle part and symmetrically distributed on both sides of the total effect quantity. The Egger's regression test result is not significant, with an intercept of 0.78 ($p = 0.27$). Moreover, the trim and fill evaluation found that the estimated main effect was not significant. The above analysis indicates that there is also no publication bias in this Meta-analysis. Therefore, the research data included in this study are objective and reliable.

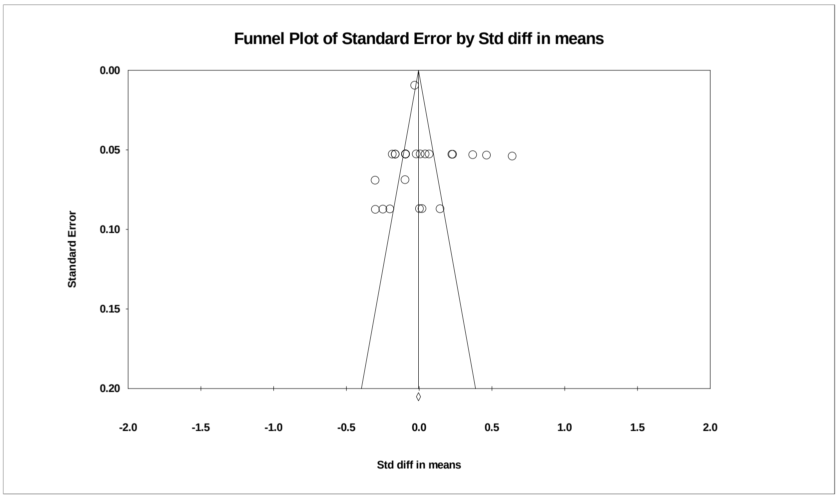

Figure 1. Funnel diagram of the relationship between the processing of emojis and faces.

Results

This study utilizes the Comprehensive Meta-Analysis software to quantify and analyze the effect sizes in Meta-analysis. Once the data is input and the analysis process is initiated, the software automatically generates a detailed report of the results. It not only directly provides the main effect analysis result but also allows users to flexibly present the results of subgroup analysis and moderating effects by adjusting the calculation settings, thereby presenting a comprehensive and in-depth analysis.

The results of main effect test from Table 1 reveal that emojis exhibit a slight edge in processing compared to human faces (d = 0.009), though the disparity between them is not statistically significant (Z = 0.242, p > 0.05). Moreover, the heterogeneity test suggests the presence of potential moderating factors in the Meta-analysis concerning processing disparities between emojis and faces. Consequently, additional subgroup analysis and testing for moderating effects are warranted.

Table 1.
Main Effect test Results between Emojis and Faces

Model	Number studies	Point estimate	95% confidence interval		Z	
			Lower limit	Upper limit		p
Random	25	0.009	-0.067	0.086	0.242	0.809

Considering the impact of valence of emojis and faces on their processing, the findings indicate that among those studies on emotional processing, the processing advantages of emojis over faces does not reach a significant level (d = 0.053, p > 0.1). Furthermore, regardless of the valence of the emoji, the difference in processing between emojis and faces remained insignificant. Although positive emojis (d = 0.118, p > 0.1) demonstrated a slightly greater processing advantage compared to neutral emojis (d = 0.056, p > 0.1), and neutral emojis showed a marginal advantage over negative emojis (d = -0.031, p > 0.1), inter-group tests revealed no significant differences in processing advantages among different valences (Q = 0.734, p > 0.1).

Table 2.
Subgroup Analysis Results of the Moderating Effect of Valence

Valence	Number studies	Point estimate	95% confidence interval		p	Q
			Lower limit	Upper limit		
Negative	5	-0.031	-0.283	0.221	0.811	
Neutral	6	0.056	-0.714	0.286	0.631	
Positive	8	0.118	-0.112	0.348	0.314	
Total between					0.693	0.734
Overall	17	0.053	-0.084	0.189	0.451	

Based on the results presented in Table 3, the choice of experimental method is not found to impact the outcomes. Neither the processing advantage of emojis in behavioral studies nor the processing disadvantage of emojis in neural studies reached a significant level (d = 0.051, p > 0.1; d = -0.093, p > 0.1). Both behavioral and neural studies failed to reveal significant differences between the processing of emojis and faces. Furthermore, according to the between-group comparison, there were no significant differences between the two experimental methods (Q = 2.575, p > 0.1).

Table 3.
Test Results of the Moderating Effect of Experimental Types

Experimental type	Number studies	Point estimate	95% confidence interval		p	Q
			Lower limit	Upper limit		
Behavior	18	0.051	-0.044	0.145	0.292	
Neural	7	-0.093	-0.242	0.055	0.218	
Total between					0.109	2.575

Discussion

The main effect analysis results reveal a slight advantage in the processing of emojis, but this advantage is not significant, indicating that there is no significant difference in the processing between emojis and human faces. Upon further consideration of specific factors, the moderating effect test results are largely consistent with that of main effect analysis, suggesting a high degree of similarity in the processing of emojis and faces. It is worth noting that current research on the processing of emojis with faces as a comparison is relatively scarce, and thus existing data can only support the deeper analysis of two factors: emotional valence and experimental methods.

The subgroup analysis results of the moderating effect of valence in Table 2 show that regardless of the valence, the processing of emojis and faces are similar to each other. Although the processing differences between emojis with different valence did not reach a significant level, negative emojis would increase the processing difficulty. It can be explained by the discovery of Pfeifer et al. (2020) that negative emojis, because of their more significant emotional impact, tend to trigger deeper processing of subsequent information. Similarly, based on the results shown in Table 3, there is no significant difference between the results in behavioral experiments and neural experiments, and emojis are similarly processed to faces in both types of experiments. Specifically, emojis do not show significant processing advantages compared to words in behavioral experiments, nor did they show significant disadvantages in neural experiments. Therefore, based on existing research, this study infers that there are high similarities between the processing of emojis and faces.

Emojis were designed initially to compensate facial expressions existing in face-to-face communications. Then, with the popularity of online communication, the use of emojis becomes very common and even a habit for most people. The results of Meta-analysis show that there is no significant difference between the processing of emojis and faces. Based on that, emojis can be considered as effective substitutes for human faces.

However, though insignificant, emojis are found to have some advantages over faces. And this discovery is basically consistent with previous research. The findings of Gantiva et al. (2019) supported the similarity between the processing of emojis and faces, and they discovered that in attention processing, emojis trigger smaller P100 amplitudes, indicating a greater advantage over facial expressions. Nogare and Proverbio (2023) attributed the processing advantages of emojis over faces to their apparent absence of details and thus less challenges on classification. Based on the findings of previous research and this Meta-analysis results, one inference can be drawn that emojis and faces are processed similarly overall, serving as important nonverbal cues in current online communication. Furthermore, emojis possess their unique processing mechanisms, suggesting their crucial role in future communication modalities.

Conclusion

This study adopted Meta-analysis to investigate the similarities and differences in the processing of emojis and faces, and identified factors influencing these processing mechanisms. The results indicate that, overall, the processing of emojis is similar to that of faces. Neither the valence of emojis nor the experimental methods significantly impacted the outcomes. This Meta-analysis contributes to understanding the processing characteristics of emojis, which is of great significance in enhancing our comprehension of emojis as modern communication tools. However, the study also has limitations. Given that previous literature has paid relatively little attention to the comparison between the processing of emojis and faces, though the number of effect sizes included in this meta-analysis met the requirements, these effect sizes were derived from a limited number of studies. Consequently, the moderating factors analyzed in this meta-analysis were constrained by the narrow range of data sources, potentially containing certain biases. That provides possibilities and calls for further comparative research on cognitive processing between emojis and faces.

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