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RESEARCH ARTICLE

Investigating the effect of emoji position on eye movements and subjective evaluations on Chinese sarcasm comprehension

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ABSTRACT

Evidence indicated that emojis could influence sarcasm comprehension and sentence processing in English. However, the effect of emojis on Chinese sarcasm comprehension remains unclear. Therefore, this study investigated the impact of the smiley emoji position and semantics on eye movements and subjective assessments during Chinese online communication. Our results showed that the presence of a smiley emoji improved participants' interpretation and perception of sarcasm. We also found shorter dwell times on sarcastic words compared to literal words under the comment-final emoji condition. Additionally, we clarified the time course of emojified sentence processing during Chinese reading: the presence of emoji initially decreased first fixation durations compared to the absence of emoji and then the comment-final emoji shortened dwell times on sarcastic words compared to literal words in the critical area of interest. Our findings suggested that the comment-final emoji was the preferable choice for avoiding semantic comprehension bias in China.

PRACTIONERS SUMMARY

We studied how emoji position influenced Chinese semantic processing by combining the indices of eye movements and subjective assessments. Our results revealed that the comment-final smiley emoji was preferable for avoiding sarcasm comprehension bias. The corresponding time course and recommendations for improving Chinese online interpersonal interactions were discussed.

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KEYWORDS
Sarcasm comprehension; emoji position; eye movements; Chinese reading; online communication

1. Introduction

With increasing access to the internet, more people tend to share their opinions on social media. Among these utterances are literal expressions and figurative language, of which sarcasm is the most common and puzzling one (Wen et al. 2022). Garcia et al. (2022) found that the winking face emoji affected sarcasm comprehension in English online communication by promoting the correct interpretation of sarcastic comments and increasing the perception of sarcastic intent. However, the use of emojis and the meanings assigned to them by users in different language communities are different (Lu et al. 2016). Despite China being the largest language community globally (Duanmu 2000) and the widespread use of emojis among young people in recent years (Chen and Siu 2017), little research is available related to the impact of emojis on the processing of Chinese sarcastic texts. Consequently, there is an imminent demand for exploring the role of emojis in sarcasm comprehension in the Chinese context in order to provide users with appropriate guidance in online sarcasm communication.

1.1. The comprehension of sarcastic versus literal meaning

Sarcasm is a common form of irony which involves someone expressing one thing when they actually mean the opposite (Grice 1975) and is used especially in order to insult someone or to show irritation, for example, saying to the last runner, 'You ran really fast!'.

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Sarcasm is used frequently in daily life, with research indicating that approximately 73% of blogs contain some form of verbal irony including sarcasm (Whalen et al. 2013). However, despite the common use of sarcasm in computer-mediated communication, there is a higher risk of miscommunication when using sarcasm in written form (Hancock 2004). During face-to-face conversation, sarcasm is perceived as a multi-layered incongruity among the utterance's context, content, and prosody (Nakamura et al. 2022). This incongruity between the context and content enables the hearer to understand the ironic intent (Ackerman 1983; Colston 2002; Ivanko and Pexman 2003; Katz and Lee 1993; Katz and Pexman 1997; Kreuz and Glucksberg 1989). Conversely, when sarcasm is uttered only in textual data online, due to the absence of communicative cues and the possibility of interpreting the sentence literally, it is challenging to identify sarcasm accurately for a common person (Bharti et al. 2016), which contributes to the high risk of misinterpretation of the use of sarcasm in online communication.

On the other hand, with regard to literal meaning, most views assume that it refers to what entire sentences mean apart from context and enriched pragmatics (Gibbs 2002). Regarding the comparison of sarcastic and literal meanings, it has been confirmed that sarcasm in written communication can be more challenging to process and understand compared to the message with a literal meaning (Filik et al. 2014; Filik and Moxey 2010; Kaakinen et al. 2014; Regel, Gunter, and Friederici 2011; Spotorno et al. 2013). For example, the difficulty of processing sarcasm has been observed in longer reading times for a sarcastic comment than a literal comment (Giora et al. 2007) and in longer response times to sarcastically than literally related probe words (Fein, Yeari, and Giora 2015). However, the observations can be reversed under certain circumstances. For example, readers may expect a character to be less hurt by criticism that is delivered ironically rather than literally, which makes it easier to process an amused response to ironic criticism than to literal criticism (Filik et al. 2017). Besides, participants may form an expectation of sarcasm after encountering several sarcastic utterances during experiments (Olkoniemi, Ranta, and Kaakinen 2016; Olkoniemi, Johander, and Kaakinen 2019). In these cases, sarcasm can be read and processed faster than literal ones.

1.2. Sarcasm-induced miscommunication in Chinese online conversations

In the landscape of Chinese online communication, the emerging social platforms have provided a stage for diverse voices, whereas they could also become hotbeds of misunderstanding and miscommunication. Despite the expanding diverse voices, there is little scholarly exploration into miscommunication in Chinese online communication. Within this context, several factors contribute to miscommunication in Chinese online conversations, such as the polysemy and ambiguity of the language (McCaughren 2009) or the growing distinction between online and offline communication (Wang and Taylor 2019). Notably, one of the significant contributing factors to miscommunication is sarcasm.

Sarcastic statements are not easy to communicate accurately in online conversations, as recently highlighted by Li et al. (2023), who indicated that sarcastic meaning is more difficult to process than literal meaning for Chinese remarks. Firstly, some words initially denoted friendliness that developed a sarcastic sense in Chinese online communication, making it easy to overlook the intended purpose of sarcasm. For example, Wang and Taylor (2019) mentioned that the Chinese onomatopoeic word 'hehe', initially associated with laughter and conventionally regarded as a discourse marker of politeness and friendliness, has gradually acquired a variety of new meanings, including sarcasm. Some individuals may not grasp the sarcastic meaning of 'hehe' until they are reminded of it by others. Secondly, certain words are prone to misinterpretation and misuse in online communication, giving rise to sarcasm and misunderstanding. For instance, Ji and Cai (2021) noted that in China, if an elder uses the respectful form 'nin' (a second-person pronoun in Chinese, e.g. 'you') to address someone younger, it may generate a respect violation like misuse or an ironic intention, leading to confusion. In online conversations, the confusion caused by sarcastic expressions could undermine the intended function of the sarcastic words, occasionally leading to hurtful interactions and making it difficult to keep communication on track.

1.3. The effect of emoji on sarcasm comprehension

Digital faces such as emoticons and emojis emerge as online communication evolves, and more people tend to use them to enhance the meaning of their messages and to express their thoughts and emotions (Derks, Bos, and Von Grumbkow 2008; Thompson and Filik 2016; Weissman and Tanner 2018). As the predecessors of emojis, the effect of emoticons on sarcasm comprehension has been well-researched. Extensive evidence has shown that the winking face emoticon ';)'

can convey sarcastic intent and enhance the comprehension of sarcasm in the English context (Derks, Bos, and Von Grumbkow 2008; Filik et al. 2016; Howman and Filik 2020; Thompson and Filik 2016; Walther and D'Addario 2001), which is possibly due to the positive connotations associated with the smiling portion of the winking face emoticon, while the winking eye suggests that there is an unknown or hidden meaning behind the message (Derks, Bos, and Von Grumbkow 2008). With the advancement of computer-mediated communication, emojis are now more ubiquitous in platforms such as instant messaging, emails, and blogs (Weissman and Tanner 2018). Similar to the winking face emoticon, the winking face emoji '😉' can also introduce ambiguity via the discrepancy between the smiling portion and the winking eye. Weissman and Tanner (2018) revealed that the winking face emoji elicited a P600 effect (a large positive peak in electrical brain activity) comparable to that elicited by word-induced irony. Besides, recently, Garcia et al. (2022) investigated the influence of the winking face emoji on how younger and older adults comprehended literal and sarcastic comments and suggested that the winking face emoji could be an effective tool to aid written sarcasm comprehension in English and therefore reduce the risks of miscommunication online.

Asian countries, especially China, have used emojis extensively for many years (Chen and Siu 2017), which is ripe for research on emoji effects (Ge and Herring 2018). Recently, studies have focused on the meaning of emojis in the Chinese context and revealed that in contrast to the winking face emoji, the emoji regarded as sarcastic in China is the smiley emoji '🙂' (De Seta 2018; Zhou, Hentschel, and Kumar 2017). This smiley emoji is widely used in WeChat, the most frequently used instant messaging software by the Chinese public (Shi et al. 2019), and is deployed by WeChat users as cryptic responses implying detachment, sarcasm, or outright rejection (De Seta 2018). Wu et al. (2022) researched the multiple meanings of emojis in China and found that more than 70% of the participants thought the meaning of the smiley emoji was negative (such as angry, sarcastic, speechless, or awkward). More recently, Cui, Dandan, and Jiang (2023) investigated the effect of sender occupation on emoji-based sarcasm interpretation and used this smiley emoji as a marker of ironic intention in their stimuli for the experiment.

1.4. The effect of emoji on sentence processing

In face-to-face conversation, people use gestures and facial expressions when talking, while in online text-based chats, graphics are delivered as turns, and they land in particular sequential spaces within a string of other turns (Garcia and Baker Jacobs 1999). As a relatively new construct, emojis do not necessarily follow specific grammatical or syntactic rules, therefore, the functions of emoji position in sentences on perceptual and attentional behaviours are largely unknown (Robus et al. 2020).

Research focus in this area has been predominantly placed on establishing where people choose to place emojis in a sentence. Previous studies showed that in the English context, users chose to place emojis at the end of the sentence in approximately half of the cases (Garrison et al. 2011; Tauch and Kanjo 2016). Spina (2019) indicated that the sentence-final placement of the emoji demonstrated its function as a structural marker in linguistic processing, similar to punctuation marks. Recently, studies began to focus on how emoji position affected the parsing and perception of sentences. For example, Holtgraves and Robinson (2020) examined the role of emoji position (before or after the text) in the processing of potentially face-threatening indirect replies and found no significant main effect or interaction on the reaction time or accuracy of interpretation for the different placement of emojis. Besides, Robus et al. (2020) conducted an experiment to investigate how emoji position in neutral narrative sentences influenced eye movements during reading and found significantly longer first-pass and late-stage fixations produced by emojis at the end of the sentences (sentence-final) compared to emojis at the beginning of the sentences (sentence-initial). These processing costs on the sentence-final emojis were comparable to the sentence wrap-up effect, which means that once reading is completed, wider global sentence comprehension requires more complex integrations of accumulated semantic information, consequently incurring the cost in processing speed (Balogh et al. 1998; Hirotani, Frazier, and Rayner 2006; Kuperman et al. 2010; Payne and Stine-Morrow 2012; Warren, White, and Reichle 2009). Robus et al. (2020) also found increased reading times on sentence-initial emojis compared to sentence-final emojis, which might reflect the novelty of the sentence-initial placement and the possibility that sentence-initial emojis made semantic integration more difficult during sentence wrap-up.

Nevertheless, the placement of emojis in sentences is sometimes the other way around in the Chinese context. For example, Ge and Herring (2018) investigated emojis and their relationships with accompanying text in Weibo, a platform of networking and information sharing in China, and found that general users more often placed emojis at the beginning of their posts. In terms of the effect of emoji

position in the Chinese context, Wu, Chen, and Li (2021) utilised the eye-tracking method to investigate the effect of the angry emoji '😡' position on the consumers' perceptions of the sender's anger and indicated that the angry emoji in the middle of a sentence led to higher fixation counts, longer fixation durations, and a stronger perception of anger, compared to the angry emoji at the end of a sentence.

1.5. The current study

With the rapid growth of the usage of computer-mediated communication in modern society, emojis are now more ubiquitous than emoticons in online platforms around the world (Weissman and Tanner 2018). On the side of emoji position, there is evidence showing that emoji position in sentences can influence how the sentences are parsed (Robus et al. 2020) and how the emotion is perceived (Wu, Chen, and Li 2021). However, no research has examined the effect of emoji position on sarcasm comprehension. On the side of semantics, Garcia et al. (2022) investigated the effect of the winking face emoji on the clarification of sarcastic versus literal intent in the English context by the indices of subjective ratings. Although the subjective evaluation methodology has provided useful means of assessing general emotional consequences, it can be limited by randomness, leading to response biases and errors (Barzy et al. 2020). In contrast, the eye-tracking methodology can assess processing in real-time, which can be used to understand how the manipulated variables influence people's reading behaviours. Additionally, in China, the largest language community in the world (Duanmu 2000), despite the extensive use of emojis over the last decades (Chen and Siu 2017) and the existing sarcasm-induced miscommunication in Chinese online conversations, the way that emoji affects sarcasm comprehension and reading behaviours remains unknown.

Therefore, on the basis of the previously discussed literature, we aim to investigate the effect of the smiley emoji '🙂' position and semantics on Chinese online communication by combining the indices of eye movements and subjective ratings and to explore the time course of emojified sentence processing during Chinese reading. The implications of our findings could further clarify the best approach for communicating sarcasm and provide recommendations for successful social interactions, which was beneficial to reducing the risks of miscommunication in Chinese online conversations.

2. Methods

2.1. Participants

Based on a translated version of the Toronto Alexithymia Scale (TAS-20; Bagby, Parker, and Taylor 1994), a total of 30 students (23 females, 7 males) were selected to participate in the present study. The participants were 22.53 (SD = 2.43) years old on average and were all native Chinese speakers with normal or corrected-to-normal vision. Besides, they were not diagnosed with any reading impairments. This study was approved by the university office of research ethics. Each participant confirmed the informed consent and answered a questionnaire on demographic information before beginning the experiment.

The TAS-20 was used to assess participants' ability to recognise emotions, as evidence showed that the ability to recognise emotions impacted eye movements when reading sarcastic sentences (Olkoniemi, Johander, and Kaakinen 2019). The TAS-20 is a self-report scale that includes short claims, such as 'I am often confused about what emotion I am feeling'. Participants responded to each item on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree), with five items being negatively scored. In the current study, we used the Chinese version of the TAS-20, which has been established with acceptable reliability and validity (Yi, Yao, and Zhu 2003). This scale was scored by summing up all responses (the responses of negatively scored items were reverted), and higher summed scores indicated a poorer ability to recognise emotions. According to Taylor, Bagby, and Parker (1997), a score ≥ 61 on the TAS-20 indicates that the participant has alexithymia, which can impair the participant's ability to comprehend sarcasm. In the current study, the scores of all 30 participants on TAS-20 were all less than 61 (range = 29–57, M = 44.90, SD = 7.67).

2.2. Materials and design

Referring to the experimental items of Garcia et al. (2022), the current study created 46 experimental items, please see Figure 1 for an example and Appendix A for the full set of items. Each item described an interaction between two characters, with one of the characters using the pronoun 'you' to bring the conversations closer to reality. As Garcia et al. (2022) suggested, a first-person perspective might be more akin to sarcastic exchanges in reality. Every item consisted of two sentences. The first sentence provided the context, and the second sentence contained the message comment which was

Example experimental item in all the six conditions

(1) Literal semantics with comment-initial emoji

王璐发现你的画不是很好看。她发消息给你：🙄画得太差了

Translation: Wang Lu noticed that your drawing wasn't very good. She messaged you: 🙄Terrible drawing

(2) Literal semantics with comment-final emoji

王璐发现你的画不是很好看。她发消息给你：画得太差了🙄

Translation: Wang Lu noticed that your drawing wasn't very good. She messaged you: Terrible drawing🙄

(3) Literal semantics with no emoji

王璐发现你的画不是很好看。她发消息给你：画得太差了

Translation: Wang Lu noticed that your drawing wasn't very good. She messaged you: Terrible drawing

(4) Sarcastic semantics with comment-initial emoji

王璐发现你的画不是很好看。她发消息给你：🙄画得太好了

Translation: Wang Lu noticed that your drawing wasn't very good. She messaged you: 🙄Great drawing

(5) Sarcastic semantics with comment-final emoji

王璐发现你的画不是很好看。她发消息给你：画得太好了🙄

Translation: Wang Lu noticed that your drawing wasn't very good. She messaged you: Great drawing🙄

(6) Sarcastic semantics with no emoji

王璐发现你的画不是很好看。她发消息给你：画得太好了

Translation: Wang Lu noticed that your drawing wasn't very good. She messaged you: Great drawing

Example filler item

杜安听说你年会抽中了一个小奖。他发消息给你：你真倒霉🐵

Translation: Du An heard that you won a small prize at the annual party. He messaged you: You are unlucky🐵

Figure 1. Example experimental item in all conditions and example filler item.

messaged from one character to 'you'. Depending on the context, the correct interpretation of the textual content in the message comment could be either literal or sarcastic. In addition, the message comment could be without an emoji or contain a smiley emoji, either positioned at the beginning of the comment (comment-initial) or the end of the comment (comment-final). The utilisation of semantically clear sentences (either literal or sarcastic) was intended to examine the impact of the smiley emoji on eye movements and subjective evaluations in different semantic contexts. Thus, the study used a 2 (semantics: literal and sarcastic) × 3 (emoji position: comment-initial, comment-final, and no emoji) mixed design. The factors of semantics and emoji position were within-subjects and within-items.

The 46 experimental items were interspersed with eight filler items, which followed the same structure as the experimental items. However, the filler items contained a mixture of emojis, such as '😌' and '🙊', in order to reduce the likelihood of participants noticing that the current study was investigating the smiley emoji. The filler items were removed ahead of statistical analysis.

The current study used a Latin-square design to counter-balance experimental items and the conditions they represented, which involved a rotation of the *semantics* and *emoji position* combinations for each experimental item. There were six different Stimulus Sets, and each Stimulus Set contained all 46 experimental items, with every experimental item in only one of the *semantics* and *emoji position* combinations.

For example, in Stimulus Set 1 there was Item 1 in the *sarcastic semantics* under the *comment-initial emoji* condition, in Stimulus Set 2 there was Item 1 in the *sarcastic semantics* under the *comment-final emoji* condition, in Stimulus Set 3 there was Item 1 in the *sarcastic semantics* under the *no emoji* condition, and so on. Participants were allocated to different Stimulus Sets, and each was presented with all 46 experimental items plus eight filler items.

In addition, each item was followed by two questions, and each question was followed by a response scale from 1 to 8. According to the message comment in each item (e.g. '🙄 画得太差了', which means '🙄 Terrible drawing'), the first question (*Question 1*) examined participants' interpretation of the message comment, and the second question (*Question 2*) assessed participants' perception of the message comment as sarcastic. See Table 1 for an example.

In order to prevent participants from adopting strategies in their responses, following half of the experimental items, *Question 1* focused on the negative interpretation (e.g. '你会不会认为王璐不喜欢你的画?', which means 'Will you think that Wang Lu did not like your drawing?'). For the other half of the experimental items, *Question 1* focused on the positive interpretation (e.g. '你会不会认为王璐喜欢你的画?', which means 'Will you think that Wang Lu liked your drawing?'). The eight filler items were followed by similarly designed questions.

2.3. Procedure

This study was a laboratory study in which all participants completed a three-trial practice set, 46 experimental and eight filler trials. The trials were randomly presented for each participant to avoid the influence of the experiment sequence. A desktop-mounted SR Research EyeLink 1000 eye tracker was used to record eye movements, which sampled every millisecond. Viewing was binocular, but only the right eye was recorded. A chin rest was used to minimise head movements. Instructions and stimuli were presented on a DELL P1913S monitor (1024×768, 60 Hz) through SR Research Experiment Builder software (version 2.2.1), positioned 92 cm from participants' eyes. One character subtended approximately 1.32° of visual angle.

Before the formal task trials, participants performed a calibration procedure and completed a three-trial practice set to familiarise themselves with the tasks. In each task trial, a drift-correction point was first presented in the left quadrant of the screen to assess calibration quality, which required participants to fixate upon it in order for the stimulus computer to display the item. If the calibration discrepancies were observed, the tracker would then be recalibrated. Participants were instructed to read the items silently at their usual pace. After finishing reading each item, participants pressed a key and were then presented with a screen asking them to have subjective feedback on their interpretation (i.e. *Question 1*) of the item they had just read and their perception of the item as sarcastic (i.e. *Question 2*). Once the eye-tracking experiment was completed, participants were asked to complete the TAS-20. The entire experiment took about 25 minutes to complete, and participants received the payment after the experiment.

Table 1. An example for *Question 1* and *Question 2*.

Question	Example
Question 1	你会不会认为王璐不喜欢你的画? 完全不认为 1 2 3 4 5 6 7 8很有可能 Translation: Will you think that Wang Lu didn't like your drawing? Very Unlikely 1 2 3 4 5 6 7 8 Very Likely
Question 2	你会不会认为王璐是在讽刺? 完全不认为 1 2 3 4 5 6 7 8很有可能 Translation: Will you think that Wang Lu is being sarcastic? Very Unlikely 1 2 3 4 5 6 7 8 Very Likely

2.4. Data preparation

In the current study, each experimental item was separated into two areas of interest (AOI), as illustrated in Figure 2. The critical AOI contained several critical words of the comment, which could be literal or sarcastic (e.g. '太有精神', which means 'so energetic'). The emoji AOI only contained the smiley emoji '🙄', which did not exist under the no emoji condition. Before the two AOIs, there was an explanation of the item context (e.g. '梁萧看到你整个星期都躺在沙发上。她发消息给你: ', which means 'Liang Xiao saw you lying on the sofa all week. She messaged you:').

For each AOI, three measures of reading behaviour were analysed. (1) *First fixation duration*. First fixation duration is the duration of the initial fixation that a reader makes within an AOI. (2) *First-pass reading time*. First-pass reading time is also known as gaze duration if the AOI is a single word, which is the sum of all the fixations a reader makes within an AOI until their point of fixation leaves that AOI, either to the left or the right. (3) *Dwell time*. Dwell time is the sum of all fixations made within an AOI.

The first two measures of reading behaviour, first fixation duration and first-pass reading time capture early processing difficulties and can indicate whether a reader experiences difficulty immediately when encountering

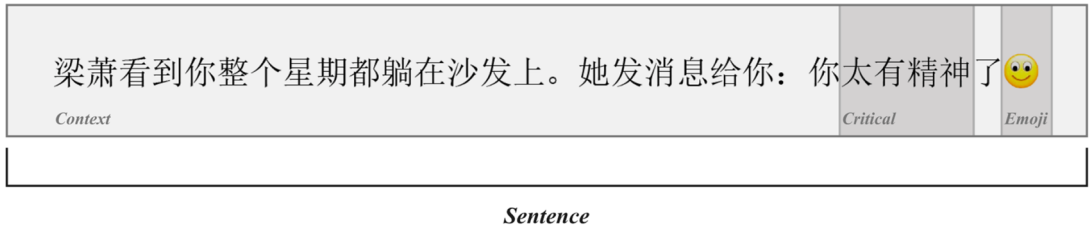

Figure 2. Example of the critical AOI and emoji AOI for a sarcastic item under the comment-final emoji condition.

that portion of text. Meanwhile, dwell time depicts overall processing difficulty. In the experiment, first fixation duration, first-pass reading time and dwell time were all measured in milliseconds and obtained from the EyeLink Data Viewer software (version 4.4.1). The same software was widely used in previous studies, such as Eraslan Boz et al. (2023).

During preliminary data assessment, fixations shorter than 100 ms were merged if within 1.5 characters of another fixation or otherwise removed. The upper cut-off parameter for individual fixation durations was 800 ms. Blinks in each AOI were also removed from the analysis.

2.5. Statistical analysis

Data analysis was performed in R (version 4.1.2; R Core Team 2020) using linear mixed-effects modelling (lme4 package version 1.1–30; Bates et al. 2015). Linear mixed-effects modelling has the advantages of being able to analyse incomplete data sets and being robust against violations of homoscedasticity and sphericity (Quené and Van den Bergh 2004). Besides, the introduction of random intercepts and slopes for subjects and items means that the analysis now accounts for intrinsic differences between participants and items, which are not manipulated experimentally. The same data analysis method was used in previous studies, such as Robus et al. (2020) and Garcia et al. (2022).

The first step was to make the maximal model fitted to the data. The full linear mixed-effects models contained the two independent within-subject variables (*semantics* and *emoji position*) as fixed effects, the interaction term, and the random-effects structure. The next step was to establish the appropriate random-effect structure. If the maximal model failed to converge, the random slope that explained the least amount of variance in the previous non-converging model would be removed at a time to simplify the random-effect structure. For a summary of the random-effect structures, please see Appendix B.

Once the random-effect structure had been established, significance values for fixed effects were generated using likelihood-ratio tests comparing the full model against reduced models that remove either the main effects of semantics, emoji position or the interaction effect. The random-effects structures were maintained the same across the likelihood-ratio tests. After that, the post hoc analysis was performed using the emmeans package (version 1.8.0; Lenth 2022) to obtain Bonferroni-corrected pairwise comparisons, and we reported the estimate (b), standard error (SE), t-values (t), and p-values (p). The level of statistical significance for all of these analyses was set at 0.05.

3. Results

3.1. Eye-tracking data analysis

Descriptive statistics of the eye-tracking data in the critical AOI and emoji AOI are presented in Table 2, and the results of likelihood-ratio tests are presented in Table 3.

3.1.1. Critical AOI

In the critical AOI, in terms of first fixation durations, our results showed a significant main effect of emoji position (χ^2 (2, N = 30) = 15.04, $p < 0.001$). Firstly, there were shorter first fixation durations on critical words under the comment-final emoji condition compared to the no emoji condition (b = −24.90, SE = 6.53, t = −3.813, $p < 0.001$). Secondly, critical words under the comment-initial emoji condition also induced shorter first fixation durations than those without an emoji (b = −16.39, SE = 6.56, t = −2.496, p = 0.038). Thirdly, there was no significant difference in first fixation durations on critical words between the comment-initial and comment-final emoji conditions. Besides, there was no significant main effect of semantics and no significant interaction between semantics and emoji position (semantics-position interaction).

In terms of first-pass reading times, our results demonstrated a significant main effect of semantics (χ^2 (1, N = 30) = 22.69, $p < 0.001$). Specifically, there were longer first-pass reading times on literal words compared to sarcastic

Table 2. Means, standard deviations, and confidence intervals of measures by conditions.

	Literal			Sarcastic		
Measure	Initial	Final	No emoji	Initial	Final	No emoji
Critical AOI						
First fixation duration	266 (101)	262 (102)	276 (113)	265 (104)	249 (90)	286 (125)
First-pass reading time	465 (359)	470 (317)	474 (358)	386 (208)	396 (225)	420 (262)
Dwell time	800 (511)	949 (731)	762 (492)	757 (623)	767 (455)	769 (547)
Emoji AOI						
First fixation duration	253 (109)	279 (112)		246 (97)	276 (119)	
First-pass reading time	297 (168)	323 (152)		269 (118)	312 (165)	
Dwell time	452 (326)	452 (285)		375 (233)	466 (348)	
Subjective Ratings						
Question 1	7.21 (1.28)	7.11 (1.45)	7.04 (1.46)	6.98 (1.53)	6.90 (1.51)	6.62 (1.66)
Question 2	4.33 (2.13)	4.05 (2.11)	3.34 (2.01)	6.78 (1.55)	6.80 (1.54)	6.50 (1.65)
95%CI						
Critical AOI						
First fixation duration	(252, 279)	(249, 276)	(261, 291)	(252, 279)	(238, 261)	(270, 303)
First-pass reading time	(417, 512)	(428, 512)	(427, 521)	(358, 414)	(366, 425)	(385, 454)
Dwell time	(733, 868)	(853, 1046)	(698, 827)	(674, 839)	(708, 827)	(697, 840)
Emoji AOI						
First fixation duration	(234, 272)	(260, 299)		(229, 263)	(255, 296)	
First-pass reading time	(269, 326)	(297, 350)		(248, 290)	(283, 340)	
Dwell time	(397, 507)	(402, 502)		(334, 416)	(406, 527)	
Subjective Ratings						
Question 1	(7.04, 7.38)	(6.92, 7.30)	(6.85, 7.23)	(6.78, 7.18)	(6.70, 7.09)	(6.41, 6.84)
Question 2	(4.05, 4.60)	(3.77, 4.32)	(3.08, 3.60)	(6.58, 6.98)	(6.60, 7.00)	(6.29, 6.71)

Fixation duration measures rounded to the nearest whole number, in milliseconds; subjective ratings rounded to 2DP. Standard deviations of means are presented in parentheses.

Table 3. Results of likelihood-ratio tests. Significant fixed effects are highlighted in bold.

		Likelihood-ratio test	
Measure	Effect	χ^2	P
Critical AOI			
First fixation duration	Semantics	0.03	0.869
	Emoji position	**15.04**	**< 0.001**
	Semantics × Emoji position	3.02	0.221
First-pass reading time	**Semantics**	**22.69**	**< 0.001**
	Emoji position	1.18	0.553
	Semantics × Emoji position	0.63	0.730
Dwell time	**Semantics**	**7.80**	**0.005**
	Emoji position	3.66	0.160
	Semantics × Emoji position	**9.31**	**0.010**
Emoji AOI			
First fixation duration	Semantics	0.47	0.495
	Emoji position	**8.43**	**0.004**
	Semantics × Emoji position	0.02	0.882
First-pass reading time	Semantics	2.63	0.105
	Emoji position	**5.86**	**0.015**
	Semantics × Emoji position	0.27	0.604
Dwell time	Semantics	2.17	0.141
	Emoji position	0.68	0.409
	Semantics × Emoji position	**3.87**	**0.049**
Subjective Ratings			
Question 1	**Semantics**	**7.47**	**0.006**
	Emoji position	**16.76**	**< 0.001**
	Semantics × Emoji position	2.76	0.251
Question 2	**Semantics**	**54.34**	**< 0.001**
	Emoji position	**45.10**	**< 0.001**
	Semantics × Emoji position	**12.83**	**0.002**

P-values rounded to 3DP, χ^2 score rounded to 2DP.

words (b=67.60, SE = 14.10, t=4.786, p<0.001). Besides, there was no significant main effect of emoji position and no significant semantics-position interaction.

In terms of dwell times, there was a significant main effect of semantics (χ^2 (1, N=30) = 7.80, p=0.005). Our results showed longer dwell times on literal words compared to sarcastic words (b=69.90, SE = 25.00, t=2.803, p=0.005). Besides, our results demonstrated a significant semantics-position interaction (χ^2 (2, N=30) = 9.31, p=0.010). Specifically, under the comment-final emoji condition, there were shorter dwell times on sarcastic words compared to literal words (b=−171.70, SE = 43.10, t=−3.983, p<0.001), however, under the comment-initial and no emoji conditions, there was no significant

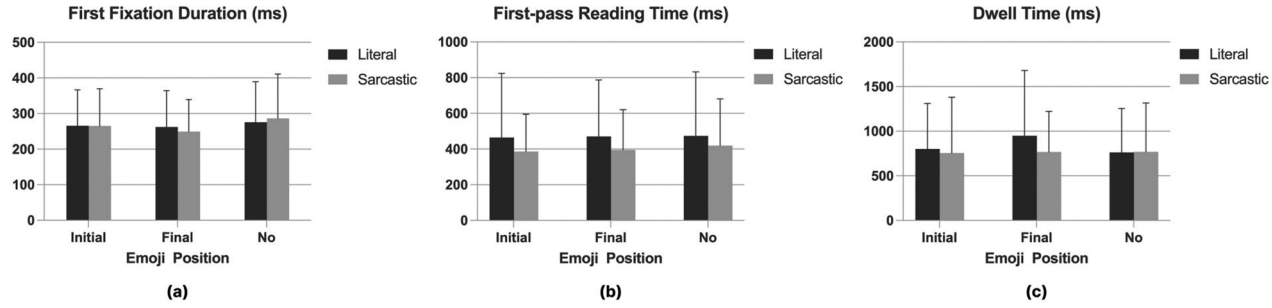

Figure 3. Mean first fixation duration (a), first-pass reading time (b), and dwell time (c) in milliseconds in the critical AOI in literal and sarcastic sentences under the comment-initial, comment-final, and no emoji conditions.

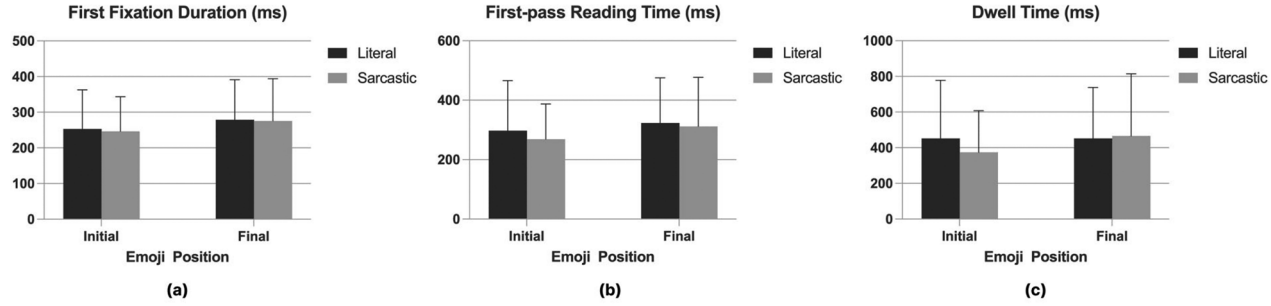

Figure 4. Mean first fixation duration (a), first-pass reading time (b), and dwell time (c) in milliseconds in the emoji AOI in literal and sarcastic sentences under the comment-initial and comment-final emoji conditions.

difference in dwell times on the critical words between sarcastic and literal semantics. Additionally, the main effect of emoji position did not reach significance. For a visual representation of these results in the critical AOI, please see Figure 3.

3.1.2. Emoji AOI

In terms of first fixation durations, our results demonstrated a significant main effect of emoji position (χ^2 (1, N=30) = 8.43, p=0.004). Specifically, there were longer first fixation durations on the comment-final emoji compared to the comment-initial emoji (b=27.40, SE = 9.43, t=2.902, p=0.004). Besides, the main effect of semantics and the semantics-position interaction did not reach significance.

In terms of first-pass reading times, there was a significant main effect of emoji position (χ^2 (1, N=30) = 5.86, p=0.015). Specifically, there were longer first-pass reading times on the comment-final emoji compared to the comment-initial emoji (b=31.2, SE = 12.9, t=2.426, p=0.016). Besides, there was no significant main effect of semantics and no significant semantics-position interaction.

In terms of dwell times, our results demonstrated no significant main effect of semantics or emoji position. However, there was a significant semantics-position interaction (χ^2 (1, N=30) = 3.87, p=0.049). Specifically, under the comment-initial emoji condition, our results showed longer dwell times in the emoji AOI in literal sentences compared to sarcastic sentences (b=84.31, SE = 34.90, t=2.417, p=0.018); while under the comment-final emoji condition, there was no significant difference in dwell times in the emoji AOI between sarcastic and literal semantics. For a visual representation of these results in the emoji AOI, please see Figure 4.

3.2. Subjective evaluation analysis

Subjective evaluation data were derived directly from the 8-point response scales of *Question 1* and *Question 2* following each item. The data for *Question 1* were coded, where a score of 1 corresponded to a wrong interpretation of the comment, and a score of 8 corresponded to a correct interpretation. For *Question 2*, a score of 1 corresponded to the perception of little sense of sarcasm, and a score of 8 corresponded to the perception of a high sense of sarcasm. Descriptive statistics of *Question 1* and *Question 2* are presented in Table 1, and the results of likelihood-ratio tests are presented in Table 2. For a visual representation of these statistics, please see Figure 5.

3.2.1. Question 1: interpretation of the comments

Question 1 examined participants' interpretation of the comments. Our results demonstrated a significant

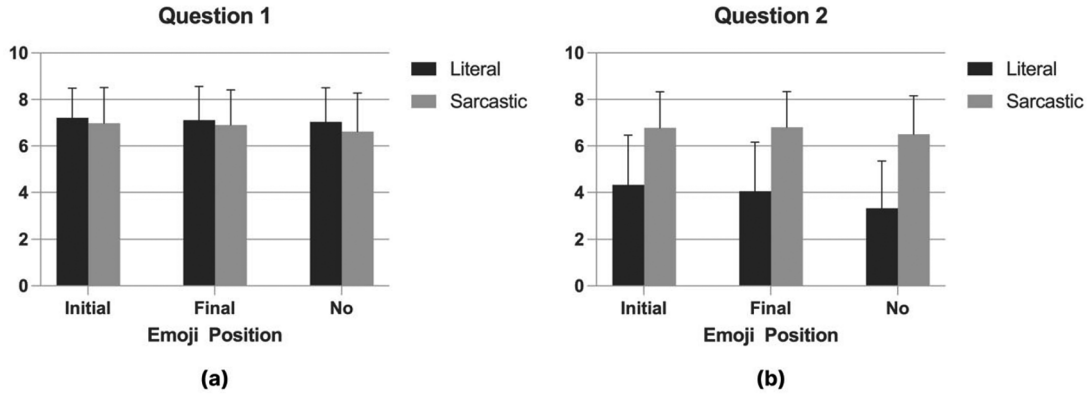

Figure 5. Mean scores of *Question 1* (a) and *Question 2* (b) in literal and sarcastic sentences under the comment-initial, comment-final, and no emoji conditions.

main effect of semantics (χ^2 (1, N = 30) = 7.47, p = 0.006), which showed that literal sentences got higher scores than sarcastic sentences (b = 0.29, SE = 0.10, t = 2.819, p = 0.007), indicating that literal sentences were easier to be understood accurately than sarcastic sentences. Besides, there was a significant main effect of emoji position (χ^2 (2, N = 30) = 16.76, p < 0.001). Firstly, sentences accompanied by a comment-initial emoji (b = 0.27, SE = 0.07, t = 4.076, p < 0.001) or a comment-final emoji (b = 0.16, SE = 0.065, t = 2.459, p = 0.042) got higher scores than sentences without an emoji, indicating that sentences accompanied by an emoji were easier to be understood accurately than those without an emoji. Secondly, the difference in the scores between the comment-initial and comment-final emoji conditions was not reached significance. In addition, there was no significant semantics-position interaction.

3.2.2. Question 2: perception of the sarcastic intent

Question 2 assessed participants' perception of the sarcastic intent of the comments. Our results demonstrated a significant main effect of semantics (χ^2 (1, N = 30) = 54.34, p < 0.001), showing that sarcastic sentences were perceived as more sarcastic than literal sentences (b = 2.79, SE = 0.24, t = 11.735, p < 0.001). Besides, our results showed a significant main effect of emoji position (χ^2 (2, N = 30) = 45.10, p < 0.001). Firstly, sentences accompanied by a comment-initial emoji (b = 0.65, SE = 0.10, t = 6.472, p < 0.001) or a comment-final emoji (b = 0.503, SE = 0.10, t = 5.051, p < 0.001) got higher scores than sentences without an emoji, indicating that sentences accompanied by an emoji were perceived as significantly more sarcastic than those without an emoji. Secondly, there was no significant difference in the scores between the comment-initial and comment-final emoji conditions. Additionally, our results demonstrated a significant semantics-position interaction (χ^2 (2, N = 30) = 12.83, p = 0.002). Specifically, under the literal semantics, sentences accompanied by a comment-initial emoji (b = 1.00, SE = 0.14, t = 7.091, p < 0.001) or a comment-final emoji (b = 0.72, SE = 0.14, t = 5.098, p < 0.001) were perceived as more sarcastic than those without an emoji. However, under the sarcastic semantics, sentences accompanied by a comment-initial emoji (b = 0.29, SE = 0.14, t = 2.061, p = 0.119) or a comment-final emoji (b = 0.29, SE = 0.14, t = 2.045, p = 0.123) were not perceived as significantly more sarcastic than those without an emoji.

4. Discussion

This study investigated whether the smiley emoji position in literal and sarcastic sentences impacted physiological and psychological responses when reading online Chinese text.

4.1. Eye movement

4.1.1. Critical AOI

The critical AOI contained critical words that could be interpreted as literal or sarcastic. In this AOI, we measured first fixation durations, first-pass reading times, and dwell times during participants' reading in order to assess the impact of the smiley emoji position on the processing and comprehension of literal and sarcastic Chinese texts. In terms of first fixation durations, we found no significant main effect of semantics. This result could be partly supported by previous studies that irony is not immediately and directly accessed in the text (Gibbs 1986; Gibbs 2002; Ivanko and Pexman 2003). On the aspect of emoji position, firstly, we found that critical words accompanied by a

comment-final emoji had shorter first fixation durations than those without an emoji. Prada et al. (2018) pointed out that, as nonverbal cues used in text-based computer-mediated communication, emojis and emoticons often represented the same content and might compete for the same communicative function. Thus, our result could be supported by Howman and Filik (2020) finding that participants were able to perceive the presence of a sentence-final emoticon and moved forward more quickly to reach it to help interpret the sentence, resulting in shorter first fixation durations in the critical AOI. Secondly, we found that the critical words accompanied by a comment-initial emoji had shorter first fixation durations than those without an emoji. One reason for this result might be that an emoji could elicit a priming effect on the following critical words (Comesaña et al. 2013), which facilitated participants' reading in the critical AOI. Thirdly, we found no significant difference in first fixation durations on critical words between the comment-initial and comment-final emoji conditions. This result was similar to Robus et al. (2020) that emoji position (sentence-initial and sentence-final) did not affect first-pass processing on critical words.

In terms of first-pass reading times and dwell times, on the aspect of semantics, we found significantly longer first-pass reading times and dwell times on literal words compared to sarcastic ones. One of the reasons for these results might be that after encountering several sarcastic utterances, readers formed an expectation of sarcasm (Olkoniemi, Ranta, and Kaakinen 2016; Olkoniemi, Johander, and Kaakinen 2019), which facilitated their processing of sarcastic sentences. On the aspect of emoji position, there was no significant main effect, which might be caused by the possibility that Chinese readers attempt to adopt a cautious rather than risky reading strategy under certain unusual conditions (Bai et al. 2008), such as when reading emojified sentences, resulting in participants utilising a similar and cautious approach during the first pass and later reading regardless of emoji position.

In addition, there was a significant semantics-position interaction on dwell times. Specifically, we found that under the comment-final emoji condition, sarcastic words induced significantly shorter dwell times compared to literal words. As previous studies showed, shorter dwell times on critical words indicated less processing difficulty (Giora, Givoni, and Fein 2015; Au-Yeung et al. 2015; Filik et al. 2018; Howman and Filik 2020). Thus, our result indicated that the sarcastic words were processed more easily than literal words in the presence of the comment-final smiley emoji, because people often have the preference that when an ironic action is performed, it is followed by an action indicating recognition, such as a laughter token (Glenn 1989; Gibson, Huang, and Yu 2018). Besides, we found no significant difference in dwell times between sarcastic and literal semantics under neither the no emoji condition nor the comment-initial emoji condition. One of the reasons was that the interpretation of emojis substantially depended on the interpretation of the text (Gibson, Huang, and Yu 2018), which might cause difficulty in interpreting the comment-initial emoji, resulting in little effect of the comment-initial emoji in helping with the processing of the sarcastic semantics.

4.1.2. Emoji AOI

The emoji AOI only consisted of the smiley emoji '🙂', which did not exist under the no emoji condition. Thus, we measured first fixation durations, first-pass reading times, and dwell times in the emoji AOI and compared the differences between the comment-initial and comment-final emoji conditions on these parameters. In terms of first fixation durations and first-pass reading times, we found that comment-final emoji drew longer first fixation durations and first-pass reading times compared to the comment-initial emoji. These results were consistent with Robus et al. (2020) that sentence-final emoji had longer first fixation durations and first-pass reading times than sentence-initial emoji due to the wrap-up effect, which further confirmed that the sentence-final emoji incurred an accumulated cost of integrating the emoji into the prior context. Thus, our results indicated that, as with the sentence-final emoji in the English context, the comment-final emoji in Chinese sentences could also incur an accumulated cognitive cost due to the wrap-up effect. Conversely, the comment-initial emoji was not impacted by the incremental cost of sentence processing as it was the first thing the reader perceived in the line (Robus et al. 2020).

In terms of dwell times, our results revealed a significant semantics-position interaction. Specifically, under the comment-initial emoji condition, we found longer dwell times on the emoji in literal sentences compared to sarcastic sentences. Because the increased dwell times are usually taken to indicate increased processing difficulty (Liversedge and Findlay 2000; Rayner 1998), our result indicated that the processing difficulty of the comment-initial emoji decreased in sarcastic sentences. This result might be related to the fact that participants already formed an expectation of sarcasm after encountering several sarcastic sentences (Olkoniemi, Ranta, and Kaakinen 2016; Olkoniemi,

Johander, and Kaakinen 2019), which facilitated the processing of the comment-initial smiley emoji in sarcastic sentences. On the contrary, under the comment-final emoji condition, we found no significant difference in dwell times between sarcastic and literal semantics. As the previous study showed that the interpretation of emoji substantially depended on the interpretation of the text (Gibson, Huang, and Yu 2018), our result might be caused by the fact that participants had already formed a preliminary judgement on the semantics of the critical words before they encountered the comment-final emoji which possessed multiple meanings including both sarcasm and literal criticism (Wu et al. 2022), resulting in no significant difference between sarcastic and literal semantics. Therefore, our result confirmed that the comment-final placement could enable the parsing of the emoji regardless of the semantics, which was also in line with the finding of Robus et al. (2020) that the sentence-final emoji served a function in cognition that enabled readers to decode the meaning of emojis more effectively during higher-order processing of the sentence.

4.2. Subjective evaluation

4.2.1. Interpretation of comments

Question 1 examined participants' interpretation of the comments. On the aspect of semantics, we found that participants were more likely to correctly interpret the meaning of the sentence in literal semantics compared to sarcastic semantics. This result could be supported by the view that there is a higher risk of miscommunication when using sarcasm (Hancock 2004), which might make sarcastic sentences more difficult to understand than literal sentences. On the aspect of emoji position, our results showed that participants were more likely to accurately interpret the comments when there was a smiley emoji, regardless of emoji position. These results were similar to the findings of Garcia et al. (2022) that participants interpreted both the literal and sarcastic comments that were accompanied by a winking face emoji as more sarcastic than those without an emoji, which suggested the winking face emoji was a helpful tool to aid sarcasm comprehension in the English context. In the Chinese context, our results could be supported by De Seta (2018) that instead of being a cheerful smile, the smiley emoji is deployed by Chinese users as cryptic responses implying detachment, sarcasm, or outright rejection. Thus, we supposed that the smiley emoji could improve the interpretation of sarcasm in the Chinese context. Additionally, we found no significant difference in the interpretation of the sentences between the comment-initial and comment-final emoji conditions. This result was similar to Holtgraves and Robinson (2020) that, whether the emoji was presented before or after the text, interpretation was facilitated when the reply contained both the text and an emoji.

4.2.2. Perception of sarcastic intent

Question 2 assessed participants' perception of the sarcastic intent of the comments. We found a significant main effect of emoji position, indicating that participants' perception of sarcasm was significantly increased when the comment was accompanied by a smiley emoji compared to no emoji condition, which suggested that, unlike the winking face emoji that could indicate sarcasm in the English context (Garcia et al. 2022), in the Chinese context, it was this smiley emoji that indicated sarcasm and thus increased the perception of sarcastic intent in online communication. Moreover, our results revealed a significant semantics-position interaction. Specifically, under the literal semantics, sentences accompanied by a smiley emoji were perceived as more sarcastic than those without an emoji, suggesting that the smiley emoji could effectively increase the perception of sarcasm in literal text; however, under the sarcastic semantics, sentences accompanied by a smiley emoji were not perceived as significantly more sarcastic than those without an emoji, indicating that the smiley emoji was not effective in enhancing sarcasm perception in sarcastic text.

5. Conclusion

In this study, we conducted an experiment to evaluate the influence of emoji position on reading online Chinese sarcastic and literal sentences by combining the indices of eye movements and subjective ratings. The following main conclusions were made:

- Our experimental parameters could be effectively used to determine the differences among emoji positions in subjective and objective assessments. On the side of subjective assessment, we found that sentences accompanied by a smiley emoji were rated as more sarcastic and easier to be interpreted accurately than those without an emoji, confirming that the smiley emoji could signal sarcasm in China. On the side of objective assessment, in the critical AOI, we found that there were shorter dwell times on sarcastic words compared to literal words under the comment-final emoji condition, suggesting that the comment-final

smiley emoji could serve the function of facilitating sarcasm comprehension and sentence integration in Chinese online communication.

- Our findings clarified the time course of emojified sentence processing during Chinese reading: the presence of emoji decreased first fixation durations compared to the absence of emoji at the initial stage, and the comment-final emoji shortened dwell times on sarcastic words compared to literal words at the later stage in the critical AOI.

This is the first study that focuses on the effect of emoji position on online semantic comprehension. Our study extends the previous findings in terms of the impact of the smiley emoji on eye movements and subjective assessments during Chinese online communication. These discoveries may have important considerations for providing a scientific basis for guiding the appropriate usage of the smiley emoji, which can be beneficial in avoiding the risk of misunderstanding sarcasm online in China.

The implications of our findings could extend to practical applications. The results obtained from eye movement measures confirmed that the smiley emoji could facilitate sarcasm comprehension and sentence integration when placed at the end of a sentence. Considering the positive impact of incorporating emojis into advertisements (Das, Wiener, and Kareklas 2019), marketers can strategically utilise and position the smiley emoji to convey a subtle sense of irony, playfulness or humour in promotional content, creating a memorable and engaging brand interaction.

There are limitations to our research that should be addressed. The present study only examined the role of the smiley emoji '🙄' in Chinese sarcastic comprehension in WeChat. However, researchers pointed out that the Weibo version of the smiley emoji also carried a passive attitude and could be used to express sarcasm (He 2022; Li et al. 2020). Thus, further study is needed to extend the scope to a broader range of messaging applications and a wider variety of emojis to examine the effect of emojis in more detail. In addition, our study focused on the impact of the emoji in semantically clear contexts (either literal or sarcastic semantics), and future research could explore the effects of emojis in various contexts, such as semantically ambiguous scenarios, for a more comprehensive understanding of emoji usage in Chinese online communication.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

Ackerman, B. P. 1983. "Form and Function in Children's Understanding of Ironic Utterances." *Journal of Experimental Child Psychology 35* (3): 487–508. doi:10.1016/0022-0965(83)90023-1.

Au-Yeung, S. K., J. K. Kaakinen, S. P. Liversedge, and V. Benson. 2015. "Processing of Written Irony in Autism Spectrum Disorder: An Eye-Movement Study." *Autism Research: official Journal of the International Society for Autism Research 8* (6): 749–760. doi:10.1002/aur.1490.

Bagby, R. M., J. D. Parker, and G. J. Taylor. 1994. "The Twenty-Item Toronto Alexithymia Scale—I. Item Selection and Cross-Validation of the Factor Structure." *Journal of Psychosomatic Research 38* (1): 23–32. doi:10.1016/0022-3999(94)90005-1.

Bai, X., G. Yan, S. P. Liversedge, C. Zang, and K. Rayner. 2008. "Reading Spaced and Unspaced Chinese Text: evidence from Eye Movements." *Journal of Experimental Psychology: Human Perception and Performance 34* (5): 1277. doi:10.1037/0096-1523.34.5.1277.

Balogh, J., E. Zurif, P. Prather, D. Swinney, and L. Finkel. 1998. "Gap-Filling and End-of-Sentence Effects in Real-Time Language Processing: Implications for Modeling Sentence Comprehension in Aphasia." *Brain and Language 61* (2): 169–182. doi:10.1006/brln.1997.1917.

Barzy, M., R. Filik, D. Williams, and H. J. Ferguson. 2020. "Emotional Processing of Ironic versus Literal Criticism in Autistic and Nonautistic Adults: Evidence from Eye-Tracking." *Autism Research: official Journal of the International Society for Autism Research 13* (4): 563–578. doi:10.1002/aur.2272.

Bates, D., M. Mächler, B. Bolker, and S. Walker. 2015. "Fitting Linear Mixed-Effects Models Using lme4." *Journal of Statistical Software 67* (1): 1–48. doi:10.48550/arXiv.1406.5823.

Bharti, S. K., B. Vachha, R. K. Pradhan, K. S. Babu, and S. K. Jena. 2016. "Sarcastic Sentiment Detection in Tweets Streamed in Real Time: A Big Data Approach." *Digital Communications and Networks 2* (3): 108–121. doi:10.1016/j.dcan.2016.06.002.

Chen, X., and K. W. M. Siu. 2017. "Exploring User Behaviour of Emoticon Use among Chinese Youth." *Behaviour & Information Technology 36* (6): 637–649. doi:10.1080/0144929X.2016.1269199.

Colston, C. 2002. "Challenges to Information Retrieval–a Global Solution?" *International Journal of Law and Information Technology 10* (3): 294–326. doi:10.1093/ijlit/10.3.294.

Comesaña, M., A. P. Soares, M. Perea, A. P. Piñeiro, I. Fraga, and A. Pinheiro. 2013. "ERP Correlates of Masked Affective Priming with Emoticons." *Computers in Human Behavior 29* (3): 588–595. doi:10.1016/j.chb.2012.10.020.

Cui, J., Y. R. Dandan, and G. Jiang. 2023. "Judging Emoji by Occupation: A Case of Emoji-Based Sarcasm Interpretation."

Acta Psychologica 234: 103870. doi:10.1016/j.actpsy.2023.103870.

Das, G., H. J. Wiener, and I. Kareklas. 2019. "To Emoji or Not to Emoji? Examining the Influence of Emoji on Consumer Reactions to Advertising." *Journal of Business Research* 96: 147–156. doi:10.1016/j.jbusres.2018.11.007.

Derks, D., A. E. Bos, and J. Von Grumbkow. 2008. "Emoticons and Online Message Interpretation." *Social Science Computer Review 26* (3): 379–388. doi:10.1177/0894439307311611.

De Seta, G. 2018. "Biaoqing: The Circulation of Emoticons, Emoji, Stickers, and Custom Images on Chinese Digital Media Platforms." First Monday 23 (9). doi:10.5210/fm.v23i9.9391.

Duanmu, S. 2000. *The Phonology of Standard Chinese*. Oxford: Oxford University Press.

Eraslan Boz, H., K. Koçoğlu, M. Akkoyun, I. Y. Tüfekci, M. Ekin, and G. Akdal. 2023. "Eye Movement Patterns during Viewing Face Images with Neutral Expressions in Patients with Early-Stage Alzheimer's Disease and Amnestic Mild Cognitive Impairment." *Brain and Behavior* 13 (11): e3232. doi:10.1002/brb3.3232.

Fein, O., M. Yeari, and R. Giora. 2015. "On the Priority of Salience-Based Interpretations: The Case of Sarcastic Irony." *Intercultural Pragmatics 12* (1): 1–32. doi:10.1515/ip-2015-0001.

Filik, R., E. Brightman, C. Gathercole, and H. Leuthold. 2017. "The Emotional Impact of Verbal Irony: Eye-Tracking Evidence for a Two-Stage Process." *Journal of Memory and Language 93*: 193–202. doi:10.1016/j.jml.2016.09.006.

Filik, R., H. Howman, C. Ralph-Nearman, and R. Giora. 2018. "The Role of Defaultness and Personality Factors in Sarcasm Interpretation: Evidence from Eye-Tracking during Reading." *Metaphor and Symbol 33* (3): 148–162. doi:10.1080/10926488.2018.1481258.

Filik, R., H. Leuthold, K. Wallington, and J. Page. 2014. "Testing Theories of Irony Processing Using Eye-Tracking and ERPs." *Journal of Experimental Psychology. Learning, Memory, and Cognition 40* (3): 811–828. doi:10.1037/a0035658.

Filik, R., and L. M. Moxey. 2010. "The on-Line Processing of Written Irony." *Cognition 116* (3): 421–436. doi:10.1016/j.cognition.2010.06.005.

Filik, R., A. Ţurcan, D. Thompson, N. Harvey, H. Davies, and A. Turner. 2016. "Sarcasm and Emoticons: Comprehension and Emotional Impact." *Quarterly Journal of Experimental Psychology (2006) 69* (11): 2130–2146. doi:10.1080/17470218.2015.1106566.

Garcia, A. C., and J. Baker Jacobs. 1999. "The Eyes of the Beholder: Understanding the Turn-Taking System in Quasi-Synchronous Computer-Mediated Communication." *Research on Language and Social Interaction 32* (4): 337–367. doi:10.1207/S15327973rls3204_2.

Garcia, C., A. Ţurcan, H. Howman, and R. Filik. 2022. "Emoji as a Tool to Aid the Comprehension of Written Sarcasm: Evidence from Younger and Older Adults." *Computers in Human Behavior 126*: 106971. doi:10.1016/j.chb.2021.106971.

Garrison, A., D. Remley, P. Thomas, and E. Wierszewski. 2011. "Conventional Faces: Emoticons in Instant Messaging Discourse." *Computers and Composition 28* (2): 112–125. doi:10.1016/j.compcom.2011.04.001.

Ge, J., and S. C. Herring. 2018. "Communicative Functions of Emoji Sequences on Sina Weibo." First Monday *23* (11). doi:10.5210/fm.v23i11.9413.

Gibbs, R. W. 1986. "On the Psycholinguistics of Sarcasm." *Journal of Experimental Psychology: General 115* (1): 3–15. doi:10.1037/0096-3445.115.1.3.

Gibbs, R. WJr, 2002. "A New Look at Literal Meaning in Understanding What is Said and Implicated." *Journal of Pragmatics 34* (4): 457–486. doi:10.1016/S0378-2166(01)00046-7.

Gibson, W., P. Huang, and Q. Yu. 2018. "Emoji and Communicative Action: The Semiotics, Sequence and Gestural Actions of 'Face Covering Hand." *Discourse, Context and Media 26*: 91–99. doi:10.1016/j.dcm.2018.05.005.

Giora, Rachel, Ofer Fein, Dafna Laadan, Joe Wolfson, Michal Zeituny, Ran Kidron, Ronie Kaufman, and Ronit Shaham. 2007. "Expecting Irony: Context versus Salience-Based Effects." *Metaphor and Symbol 22* (2): 119–146. doi:10.1080/10926480701235346.

Giora, R., S. Givoni, and O. Fein. 2015. "Defaultness Reigns: The Case of Sarcasm." *Metaphor and Symbol 30* (4): 290–313. doi:10.1080/10926488.2015.1074804.

Glenn, P. J. 1989. "Initiating Shared Laughter in Multi-Party Conversations." *Western Journal of Speech Communication 53* (2): 127–149. doi:10.1080/10570318909374296.

Grice, H. P. 1975. "Logic and Conversation." In *Speech Acts*, 41–58. Brill. doi:10.1163/9789004368811_003.

Hancock, J. T. 2004. "Verbal Irony Use in Face-to-Face and Computer-Mediated Conversations." *Journal of Language and Social Psychology* 23 (4): 447–463. doi:10.1177/0261927X04269587.

He, J. 2022. "Sharing Emotions or/and Making Allies: emoji's Interpersonal Function in Chinese Social Media News Comments." *Social Semiotics* 33 (5): 1131–1146. doi:10.1080/10350330.2021.2025355.

Hirotani, M., L. Frazier, and K. Rayner. 2006. "Punctuation and Intonation Effects on Clause and Sentence Wrap-up: Evidence from Eye Movements." *Journal of Memory and Language 54* (3): 425–443. doi:10.1016/j.jml.2005.12.001.

Holtgraves, T., and C. Robinson. 2020. "Emoji Can Facilitate Recognition of Conveyed Indirect Meaning." *PloS One 15* (4): e0232361. doi:10.1371/journal.pone.0232361.

Howman, H. E., and R. Filik. 2020. "The Role of Emoticons in Sarcasm Comprehension in Younger and Older Adults: Evidence from an Eye-Tracking Experiment." *Quarterly Journal of Experimental Psychology (2006) 73* (11): 1729–1744. doi:10.1177/1747021820922804.

Ivanko, S. L., and P. M. Pexman. 2003. "Context Incongruity and Irony Processing." *Discourse Processes 35* (3): 241–279. doi:10.1207/S15326950DP3503_2.

Ji, L., and L. Cai. 2021. "The Interplay between Respectfulness and Lexical-Semantic in Reading Chinese: evidence from ERPs." *Cognitive Neurodynamics* 16 (1): 101–115. doi:10.1007/s11571-021-09700-2.

Kaakinen, J. K., H. Olkoniemi, T. Kinnari, and J. Hyönä. 2014. "Processing of Written Irony: An Eye Movement Study." *Discourse Processes 51* (4): 287–311. doi:10.1080/0163853X.2013.870024.

Katz, A. N., and C. J. Lee. 1993. "The Role of Authorial Intent in Determining Verbal Irony and Metaphor." *Metaphor and Symbolic Activity 8* (4): 257–279. doi:10.1207/s15327868ms0804_1.

Katz, A. N., and P. M. Pexman. 1997. "Interpreting Figurative Statements: Speaker Occupation Can Change Metaphor to Irony." *Metaphor and Symbol 12* (1): 19–41. doi:10.1207/s15327868ms1201_3.

Kreuz, R. J., and S. Glucksberg. 1989. "How to Be Sarcastic: The Echoic Reminder Theory of Verbal Irony." *Journal of*

Experimental Psychology: General 118 (4): 374–386. doi:10.1037/0096-3445.118.4.374.

Kuperman, V., M. Dambacher, A. Nuthmann, and R. Kliegl. 2010. "The Effect of Word Position on Eye-Movements in Sentence and Paragraph Reading." *Quarterly Journal of Experimental Psychology (2006) 63* (9): 1838–1857. doi:10.1080/17470211003602412.

Lenth, R. 2022. emmeans: Estimated Marginal Means, aka Least-Squares Means. R package version 1.8.0. https://CRAN.R-project.org/package=emmeans

Li, D., R. Rzepka, M. Ptaszynski, and K. Araki. 2020. "HEMOS: A Novel Deep Learning-Based Fine-Grained Humor Detecting Method for Sentiment Analysis of Social Media." *Information Processing & Management 57* (6): 102290. doi:10.1016/j.ipm.2020.102290.

Li, Y., H. Shi, S. Li, L. Gao, and X. Gao. 2023. "The Adjustment of Complexity on Sarcasm Processing in Chinese: Evidence from Reading Time Indicators." *Brain Sciences* 13 (2): 207. doi:10.3390/brainsci13020207.

Liversedge, S. P., and J. M. Findlay. 2000. "Saccadic Eye Movements and Cognition." *Trends in Cognitive Sciences 4* (1): 6–14. doi:10.1016/S1364-6613(99)01418-7.

Lu, X., W. Ai, X. Liu, Q. Li, N. Wang, G. Huang, and Q. Mei. 2016. "Learning from the Ubiquitous Language: An Empirical Analysis of Emoji Usage of Smartphone Users." *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, Heidelberg, Germany, 770–780. doi:10.1145/2971648.2971724.

McCaughren, A. 2009. "Polysemy and Homonymy and Their Importance for the Study of Word Meaning." *The ITB Journal* 10 (1): 7.

Nakamura, T., T. Matsui, A. Utsumi, M. Sumiya, E. Nakagawa, and N. Sadato. 2022. "Context-Prosody Interaction in Sarcasm Comprehension: A Functional Magnetic Resonance Imaging Study." *Neuropsychologia 170*: 108213. doi:10.1016/j.neuropsychologia.2022.108213.

Olkoniemi, H., E. Johander, and J. K. Kaakinen. 2019. "The Role of Look-Backs in the Processing of Written Sarcasm." *Memory & Cognition 47* (1): 87–105. doi:10.3758/s13421-018-0852-2.

Olkoniemi, H., H. Ranta, and J. K. Kaakinen. 2016. "Individual Differences in the Processing of Written Sarcasm and Metaphor: Evidence from Eye Movements." *Journal of Experimental Psychology. Learning, Memory, and Cognition 42* (3): 433–450. doi:10.1037/xlm0000176.

Payne, B. R., and E. A. Stine-Morrow. 2012. "Aging, Parafoveal Preview, and Semantic Integration in Sentence Processing: testing the Cognitive Workload of Wrap-up." *Psychology and Aging 27* (3): 638–649. doi:10.1037/a0026540.

Prada, M., D. L. Rodrigues, M. V. Garrido, D. Lopes, B. Cavalheiro, and R. Gaspar. 2018. "Motives, Frequency and Attitudes toward Emoji and Emoticon Use." *Telematics and Informatics 35* (7): 1925–1934. doi:10.1016/j.tele.2018.06.005.

Quené, H., and H. Van den Bergh. 2004. "On Multi-Level Modeling of Data from Repeated Measures Designs: A Tutorial." *Speech Communication 43* (1-2): 103–121. doi:10.1016/j.specom.2004.02.004.

R Core Team 2020. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

Rayner, K. 1998. "Eye Movements in Reading and Information Processing: 20 Years of Research." *Psychological Bulletin 124* (3): 372–422. doi:10.1037/0033-2909.124.3.372.

Regel, S., T. C. Gunter, and A. D. Friederici. 2011. "Isn't It Ironic? An Electrophysiological Exploration of Figurative Language Processing." *Journal of Cognitive Neuroscience 23* (2): 277–293. doi:10.1162/jocn.2010.21411.

Robus, C. M., C. J. Hand, R. Filik, and M. Pitchford. 2020. "Investigating Effects of Emoji on Neutral Narrative Text: Evidence from Eye Movements and Perceived Emotional Valence." *Computers in Human Behavior 109*: 106361. doi:10.1016/j.chb.2020.106361.

Shi, H., X. Liu, K. Li, and J. Xie. 2019. "Emoji Usage and Interpersonal Relationship in Computer-Mediated Cmmunication." *2019 International Joint Conference on Information, Media and Engineering (IJCIME)*, Osaka, Japan, 262–266. doi:10.1109/IJCIME49369.2019.00059.

Spina, S. 2019. "Role of Emoticons as Structural Markers in Twitter Interactions." *Discourse Processes 56* (4): 345–362. doi:10.1080/0163853X.2018.1510654.

Spotorno, N., A. Cheylus, J. B. Van Der Henst, and I. A. Noveck. 2013. "What's behind a P600? Integration Operations during Irony Processing." *PLoS One*. *8* (6): e66839. doi:10.1371/journal.pone.0066839.

Tauch, C., and E. Kanjo. 2016. "The Roles of Emojis in Mobile Phone Notifications." *Proceedings of the 2016 Acm International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct*, Heidelberg, Germany, 1560–1565. doi:10.1145/2968219.2968549.

Taylor, G. J., R. M. Bagby, and J. D. Parker. 1997. *Disorders of Affect Regulation: Alexithymia in Medical and Psychiatric Illness*. Cambridge University Press.

Thompson, D., and R. Filik. 2016. "Sarcasm in Written Communication: Emoticons Are Efficient Markers of Intention." *Journal of Computer-Mediated Communication 21* (2): 105–120. doi:10.1111/jcc4.12156.

Walther, J. B., and K. P. D'Addario. 2001. "The Impacts of Emoticons on Message Interpretation in Computer-Mediated Communication." *Social Science Computer Review 19* (3): 324–347. doi:10.1177/089443930101900307.

Wang, J., and C. Taylor. 2019. "The Conventionalisation of Mock Politeness in Chinese and British Online Forums." *Journal of Pragmatics* 142: 270–280. doi:10.1016/j.pragma.2018.10.019.

Warren, T., S. J. White, and E. D. Reichle. 2009. "Investigating the Causes of Wrap-up Effects: Evidence from Eye Movements and E–Z Reader." *Cognition 111* (1): 132–137. doi:10.1016/j.cognition.2008.12.011.

Weissman, B., and D. Tanner. 2018. "A Strong Wink between Verbal and Emoji-Based Irony: How the Brain Processes Ironic Emojis during Language Comprehension." *PloS One 13* (8): e0201727. doi:10.1371/journal.pone.0201727.

Wen, Z., L. Gui, Q. Wang, M. Guo, X. Yu, J. Du, and R. Xu. 2022. "Sememe Knowledge and Auxiliary Information Enhanced Approach for Sarcasm Detection." *Information Processing & Management 59* (3): 102883. doi:10.1016/j.ipm.2022.102883.

Whalen, J. M., P. M. Pexman, A. J. Gill, and S. Nowson. 2013. "Verbal Irony Use in Personal Blogs." *Behaviour & Information Technology 32* (6): 560–569. doi:10.1080/0144929X.2011.630418.

Wu, R., J. Chen, and Y. Li. 2021. "The Effect of the Angry Emoji Position on Consumers' Perception of the Sender's Anger." *Acta Psychologica Sinica 53* (10): 1133–1145. doi:10.3724/SP.J.1041.2021.01133.

Wu, R., J. Chen, C. L. Wang, and L. Zhou. 2022. "The Influence of Emoji Meaning Multipleness on Perceived Online Review Helpfulness: The Mediating Role of Processing

Fluency." *Journal of Business Research 141*: 299–307. doi:10.1016/j.jbusres.2021.12.037.

Yi, J., S. Yao, and X. Zhu. 2003. "The Chinese Version of the TAS-20: Reliability and Validity." *Chinese Mental Health Journal 17*(11): 763–767.

Zhou, R., J. Hentschel, and N. Kumar. 2017. "Goodbye Text, Hello Emoji: Mobile Communication on WeChat in China." *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, Denver Colorado, USA, 748–759. doi:10.1145/3025453.3025800.