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■ RESEARCH ARTICLE

Differences in Emoji Interpretation Between Cerebral Palsy Patients and Neurotypical Individuals

Yudi Fu

The Northwest School, 1415 Summit Avenue, Seattle, Washington, 98122, USA ; fuyudi023@gmail.com

ABSTRACT: Nowadays, emojis have become a popular and useful means of communication over the internet. This study aims to investigate the difference between cerebral palsy (CP) patients' and neurotypical individuals' understanding of 33 most used emojis from the iOS system. Participants were 11 children and adults with CP who were diagnosed with mild cerebral palsy and 11 neurotypical peers who were age and gender matched as controls. The CP patients filled out a printed version of a questionnaire, and the neurotypical peers filled out an online version of it in which participants were asked to independently rate the valence of 33 emojis on a scale from 0 to 10. Overall, the interpretations of emojis between CP and neurotypical peers were mostly consistent. However, independent two-sample t-test analysis showed that the difference of the two groups' ratings was significant (p's < 0.05) for five emojis. This study demonstrated that despite previous research suggested that CP patients had worse emotion interpretation, they could interpret most emojis similarly to their neurotypical peers with some exceptions. Possible explanations were also discussed in the paper. Because of this similarity, emojis can potentially be a powerful tool to assist CP patients to communicate more efficiently.

KEYWORDS: Behavioral and social science; Cognitive psychology; Emojis; Cerebral palsy; Emotion interpretation.

■ Introduction

Cerebral palsy (CP) is one of the most common motor disorders in children, with approximately 2.11 cases per 1000 live births.[1] It is defined as a group of disorders caused by damage to developing brains, typically in the prenatal setting. CP affects patients' muscle tone and posture, and in turn, influences patients' motor abilities.[2] While prior research focuses mainly on the motor development of CP patients,[3-6] their psychological capabilities and emotional well-being are less frequently studied. This paper aims to investigate the communication skills of CP patients, particularly their interpretations of a set of commonly used symbols in text communication —emojis.

Communication is the transfer of information from one person to another one. To achieve this, communicators should be able to send and receive messages, and have similar, if not the exact same, understanding of message interpretations as their conversation partners. However, patients with CP may have difficulties sending and/or receiving messages.[7] Moreover, they frequently have delayed timelines in expressing and understanding language.[8] This language impairment may limit their interactions with others and cause various problems in their day-to-day lives. Further research has demonstrated that a significant proportion of CP children aged 8 to 12 years have social impairments.[9] In social relationships, adolescents and young adults with CP were found to be less active than their peers.[10] While the expression of language is often impaired in patients with CP due to motor disabilities and dysarthria, facial expressions can be used as an alternative way to communicate their thoughts. In fact, half of the children in Himmelmann, Lindh, & Hidecker's 2013 study[7] used facial expressions, in addition to eye gaze, gestures, and pointing, as a way to communicate thoughts, compensating for their delayed language expression. Another study that explored CP patients' use of online social networks (OSNs) has shown that OSNs have helped children with CP communicate with others and enhance their communication skill[11] The use of OSNs may thus help CP patients with their day-to-day social interactions, possibly resulting in improved quality of life.

An important aspect of communication is the communication of affect: the transfer of information regarding underlying experiences of feeling, emotion, or mood. The same message carrying different affects can have drastically different meanings. For instance, the sentence "I had pizza today" with a positive affect could express excitement, whereas the same sentence with a negative affect could express disappointment and dissatisfaction. During face-to-face conversations, vocal tone, facial expression, and gestures can serve as cues to the speaker's affect, and these cues are as important as the words being said.[12,13] Nowadays, communication modalities are no longer limited to face-to-face interactions due to a wealth of communication technologies. Online social media and chat apps are among the most common tools for people to communicate with families and friends. During the COVID-19 pandemic, people have relied more heavily on social media, which has become an indispensable part of daily communication for many. However, through social media, vocal tone, facial expression, and gestures are no longer available to communicators. As these cues are limited or removed, the communication of affect becomes more prone to misinterpretation.[14]

In OSNs, non-verbal cues for affect are not entirely absent. Instead, communicators can adapt by making these cues explicit. For example, people can express their agreement or appreciation via outright statements.[15] For example, "I loveeating pizza." In addition to such expressions, capitalization can be considered

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a substitute for shouting, multiple exclamation points for excitement, and emoticons/emojis for facial expressions.[16] Emojis cover a wide range of meanings, ranging from facial expressions like smiling or crying, body gestures like thumbs-up or thumbs down, to representations of objects, animals, food, places, or events.[17] Emojis are powerful tools for communication with the potential to shape how messages are understood.[18] In recent years, emojis have become a common means of expressing one's feelings and affect in online communication. This rise is intertwined with the popularity of OSN in which people interact with friends, describe their daily routines, and post opinions, experiences, and queries about various topics.[19,20] This rise also calls for research investigating people's understanding of emojis and how they interpret messages accompanied by different emojis.

In recent years, researchers have studied how the typical adult population understands emojis extensively. Overall, people tend to have consistent interpretations for most emojis, even when they were presented across various operating systems such as Android and iOS.[21] It has also been found that emojis are generally placed at the end of sentences.[22,23] and that the interpretations of emojis tended to be positive.[24,26] When emojis accompanied a positive message, the message was likely to be perceived as more positive. On the other hand, when emojis accompanied a negative message, the message was likely to be perceived as less negative. Furthermore, the number of emojis was found to influence the intensity of its moderating effects on message affect interpretation[16,26]; but see counter arguments in Riordan & Trichtinger, 2017[14] and Riordan & Kreuz , 2010.[27] Emojis were also found to express intimacy through a showing of informality or playfulness.[24]

While we have a relatively solid understanding of how typical adult populations interpret emojis, there is a lack of data regarding how these symbols are interpreted by less typical populations. Emojis can potentially help CP patients better communicate with others in the online environment and help with their interpersonal communication and relationships. if CP populations interpret the emojis similarly to neurotypical individuals, this is the indication that emojis may be a tool to assist CP patients' communication, which implies that they already utilize facial expression to compensate for their linguistic communication impairments. On the other hand, if CP individuals perceive particular emojis differently from neurotypical persons, changes should be made to make communication easier for CP patients. Moreover, emojis may be used as a potential means for intervention in addition to assisting with communication. Therefore, how CP patients interpret emojis and whether they have the same understanding of facial expression as their neurotypical peers must be investigated. This study aims to create a comprehensive profile of CP patients' understanding of 33 commonly used emojis, and to compare their affect ratings with their neurotypical peers. For the purpose of this study, we tested the difference of affect ratings of emojis from the iOS system between cerebral palsy patients and their neurotypical peers. We hypothesized that there is an overall difference of affect ratings between CP patients and neurotypical individuals. Due to the fact that there is limited knowledge of CP patients' interpretation on emojis, this study is exploratory in its nature. We do not have a specific hypothesis of how and where the differences of affect ratings are.

Methods

Participants:

After contacting a total of four charity houses through personal connections in Shanxi and Beijing, we visited the charity houses and recruited the participants who resided there. As a result, seventeen children and adults with CP participated in the study (aged 3 to 28 years old), and eleven completed the study (aged 5 to 28 years old). In our final sample, all of those who finished were diagnosed with mild cerebral palsy and did not have severe communication or motor impairment at the time of the study. They were able to have a comprehensive understanding of the instructions and procedures in the study. Another eleven neurotypical peers participated in the study as controls (age and gender matched). All twenty-two participants spoke Mandarin Chinese as their native language and resided in major cities in China. The CP patients had lived in a charity house for an average of 9.95 years (range: 1.5 to 20 years) at the time of the study.

All participants filled out a questionnaire regarding their understanding of emojis independently. The CP patients filled out the questionnaire on printed papers, as many CP participants did not own their personal mobile phone or electronic devices, and many felt more comfortable when writing by hand. Their typically developing peers completed the same questionnaire online through their own laptops or PCs, because, in order to match the age and gender of CP participants, neurotypical participants were far away from each other and located in eight different cities in China. To this end, distributing the questionnaire online was more productive and effective. The questionnaire was written in simplified Chinese. From recruiting participants to finishing collecting the answers in questionnaires, the process lasted for 25 days.

At the beginning of the questionnaire, participants were asked basic demographic questions and CP patients were additionally asked about their experience with the disorder and their time living in the charity house. The rest of the questionnaire consisted of standardized questions asking participants' impressions of individual emojis. The emojis used in this questionnaire were identical to the ones used in Jaeger, Roigard, Jin, Vidal, and Ares's 2019 study,[29] comprising the 33 facial emojis that were most frequently used in online social media. Table 1 shows the 33 emojis and their semantic meanings reported by participants in Jaeger *et al.*'s study.

For each of the 33 emojis, participants were asked to rate their sentiments regarding the emojis using a 11-point scale. The instruction was as follows: "As you answer the following questions, please note that 0 means you think the emoji expresses a very negative emotion, 5 means neutral (neither positive nor negative), and 10 means a very positive emotion, and choose a number from 0 to 10 to express how you feel when you see each emoji." The order of the emojis was

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randomized for each participant. Ratings were then averaged for each emoji across participants. Ratings from the CP patients and those from their typically developing peers were compared using two sample t-tests.

Results and Discussion

To better understand the data, ratings were arbitrarily grouped as follows: 0 to 3 were considered negative affect, 4 to 6 were neutral, and ratings from 7 to 10 were considered positive affect. Table 1 shows the distribution of affect ratings among cerebral palsy (CP) participants and neurotypical participants for the 33 emojis. The mean and standard deviation of ratings for each emoji are also shown in Table 1.

Table 1: The rating distributions for each of the 33 emojis from CP and neurotypical participants are shown. The mean ratings and standard deviations are calculated for each emoji across CP and neurotypical participants. The results of t-tests performed are also shown. The emoji meanings and arousal scores (range 1-9) are from Jaeger *et al.*'s 2019 study.

		Negative (0-3)		Neutral (4-6)		Positive (7-10)		Average					
Emoji #	Emoji	CP	neurotypical	CP	neurotypical	CP	neurotypical	CP (SD)	neurotypical(SD)	t score	p-value	Emoji Meaning	Arousal
1	😠	45.50%	81.80%	27.30%	18.20%	27.30%	0	4.64(3.64)	2.27(1.90)	1.91	0.071†	angry,grumpy, mad	6.1
2	😖	81.80%	54.50%	18.20%	36.40%	0	9.10%	1.55(1.44)	3.27(2.15)	-2.21	0.039*	confounded, angry	5.8
3	😎	18.20%	0	0	9.10%	81.80%	90.90%	7.55(3.39)	8.27(1.62)	0.64	0.528	cool, relaxed	5.0
4	😣	27.30%	45.50%	54.50%	45.50%	18.20%	9.10%	4.45(2.34)	3.64(2.29)	0.83	0.417	sad, bad	4.2
5	😕	36.40%	45.50%	27.30%	54.50%	36.40%	0	4.91(3.11)	3.45(1.51)	1.39	0.178	confused, puzzled	3.5
6	😘	9.10%	0	18.20%	18.20%	63.60%	81.80%	6.36(3.61)	8.36(1.80)	-1.64	0.116	loving,blowing a kiss	6.5
7	😟	27.30%	81.80%	54.50%	18.20%	18.20%	0	4.45(2.58)	2.27(1.49)	2.43	0.025*	helpless, confused	4.8
8	😄	27.30%	0	9.10%	36.40%	63.60%	63.60%	7.09(3.33)	7.55(1.97)	-0.39	0.701	smiling, happy	6.7
9	😬	27.30%	27.30%	45.50%	54.50%	27.30%	18.20%	5.09(2.55)	4.64(2.06)	0.46	0.651	awkward, grimace	5.8
10	😜	27.30%	9.10%	27.30%	36.40%	45.50%	54.50%	5.64(2.46)	7.18(2.44)	-1.48	0.155	crazy,silly, flirtation	6.7
11	😅	18.20%	0	45.50%	54.50%	27.30%	45.50%	5.18(2.86)	6.73(2.10)	-1.45	0.164	smiling,happy, awkward	5.9
12	😏	27.30%	9.10%	9.10%	27.30%	54.50%	63.60%	5.55(2.62)	6.64(1.75)	-1.48	0.264	smirk, smug, sly	4.7
13	😫	54.50%	81.80%	27.30%	18.20%	18.20%	0	3.27(3.00)	2.36(1.50)	0.90	0.380	exhausted, tired	5.6
14	😌	18.20%	0	0	63.40%	81.80%	36.40%	7.73(2.57)	6.36(2.11)	1.36	0.190	content, relief	3.5
15	😂	45.50%	0	36.40%	54.50%	18.20%	45.50%	4.55(2.77)	6.73(2.37)	-1.98	0.061†	laughing, happy tears	6.8
16	😓	45.50%	54.50%	45.50%	36.40%	9.10%	9.10%	3.45(2.02)	3.18(2.09)	0.31	0.759	stressed, nervous	4.1
17	😱	90.90%	36.40%	0	45.50%	9.10%	18.20%	1.82(2.36)	3.18(3.02)	-1.73	0.099†	scared, scream, surprised	3.2
18	😞	45.50%	90.90%	45.50%	9.10%	9.10%	0	3.55(2.11)	1.91(1.45)	2.12	0.047*	disappointed, sad, unhappy	3.2
19	😒	27.30%	63.60%	63.60%	36.40%	9.10%	0	4.36(1.86)	2.64(1.75)	2.25	0.036*	dissatisfied, annoyed	3.7
20	😐	36.40%	9.10%	45.50%	90.90%	18.20%	0	5.45(2.30)	4.36(1.57)	1.30	0.208	neutral, straight face	3.9
21	😴	18.20%	0	27.30%	100.00%	54.50%	0	6.45(2.81)	5(0.63)	1.68	0.109	sleeping, sleepy	2.3
22	😉	0	0	27.30%	45.50%	72.70%	54.50%	7.64(2.16)	7.18(1.40)	0.59	0.564	flirtation,joke, humor	5.4
23	😑	18.20%	9.10%	36.40%	90.90%	45.50%	0	5.09(2.66)	4.64(0.81)	0.54	0.594	indifferent, unconcerned	3.8
24	😭	63.60%	45.50%	36.40%	36.40%	0	18.20%	2.45(2.62)	4.18(3.37)	-1.34	0.195	crying,sad, sobbing	5.6

Note. The image, affect rates, t-score, p-value, emoji meaning, and arousal level of each of the 33 emoji are shown.

CP and neurotypical participants overall have consistent affect ratings for most of the emojis. The five emojis that induced the most different ratings from the two groups were: angry face 😠 (M_{CP}= 4.64, SD_{CP}= 3.64; $M_{neurotypical}$= 2.27, $SD_{neurotypical}$= 1.90), face throwing kiss 😘 (M_{CP}= 6.36, SD_{CP} = 3.61; $M_{neurotypical}$= 8.36, $SD_{neurotypical}$= 1.80), persevering face (M_{CP} = 4.45, SD_{CP}= 2.58; $M_{neurotypical}$= 2.27, $SD_{neurotypical}$= 1.49), face with tears of joy 😂 (M_{CP}= 4.45, SD_{CP} = 2.77; $M_{neurotypical}$= 6.73, $SD_{neurotypical}$= 2.37), and face with stuck out tongue and tightly closed eyes 😝 (M_{CP}= 4.91, SD_{CP} = 2.07; $M_{neurotypical}$= 7.27, $SD_{neurotypical}$= 2.49). Upon closer examination of these five emojis, *CP* patients tended to interpret them more neutrally whereas neurotypical participants had more leaned opinions (either more positive or more negative pairs) and 3000 pairs of different people (negative pairs).

Then, an independent two-sample t-test was performed to compare CP patients' and neurotypical patients' ratings for each of the 33 emojis. The results of the t-tests are summarized in Table 1. There was a significant difference between CP patients' ratings and neurotypical participants' ratings for five emojis. CP patients found the emoji of confounded face 😖 to entail a more negative affect than their neurotypical peers (M_{CP}= 1.55, SD_{CP}= 1.44; $M_{neurotypical}$= 3.27, $SD_{neurotypical}$= 2.15; $t(20)$= -2.21, p= .039). CP patients also had a more neutral affect for the emojis of persevering face 😣 (M_{CP}= 4.45, SD_{CP}= 2.58; $M_{neurotypical}$= 2.72, $SD_{neurotypical}$= 1.49; $t(20)$ = 2.43, p= .025), disappointed face 😞 (M_{CP}= 3.55, SD_{CP} = 2.11; $M_{neurotypical}$= 2.72, $S_{neurotypical}$ = 1.49; $t(20)$ = 2.12, p = .047), and unamused face 😒 (M_{CP}= 4.36, SD_{CP} = 1.86; $M_{neurotypical}$= 2.64, $SD_{neurotypical}$= 1.75; $t(20)$= 2.25, p= .036), while their neurotypical peers had more negative ratings. On the other hand, CP patients interpreted the emoji of the face with stuck-out tongue and tightly closed eyes 😝 as more neutral compared to the positive ratings from their neurotypical peers (M_{CP}= 4.91, SD_{CP}= 2.07; $M_{neurotypical}$= 7.27, $SD_{neurotypical}$= 2.49; $t(20)$= -2.42, p= .025).

Furthermore, several trending relationships were found: CP patients found both the face with tears of joy 😂 ($t(20)$= -1.98, p= .061) and face screaming in fear 😱 ($t(20)$=-1.73, p=0.099) more negatively than did their neurotypical peers, and found the angry face 😠 ($t(20)$= 1.91, p= .071) more positively. No significant differences were found between CP patients' ratings and neurotypical participants' ratings for the remaining 25 emojis.

Discussion

Overall, CP patients and neurotypical patients had similar and consistent affect understandings for most of the tested emojis. While recent findings indicate that CP patients generally have worse emotional understanding than their neurotypical peers,[30] in this study, they understood the effects of emojis similarly to their neurotypical peers. CP patients only interpreted five emojis' affects significantly differently from the neurotypical group. Further experiments can investigate how CP patients' emotional understanding is related to their interpretations of emoji affect.

It is worthy to note that, out of the five emojis, four entailed negative emotions (see Table 1 for the reported meanings of these emojis in Jaeger *et al.*'s 2019 study). Since the interpretation of emojis tends to be positive,[24,26] CP patients may have a harder time interpreting those entailing negative feelings as they defy normal expectations. Furthermore, with the exception of the confounded face 😖, the other four emojis were rated more neutrally by CP patients compared to their neurotypical peers. It could be that they may encounter these emojis less frequently in their day-to-day life, resulting in a less thorough understanding of these emojis. Some emojis received ratings from both extremes (score of 0 and 10), which may

indicate a lack of understanding. Similarly, it was shown that the face with stuck-out tongue and tightly closed eyes 😝 (the only positively affected emoji with a significant difference in ratings between CP and neurotypical participants) was hard to interpret even for typically developing participants. In Jaeger *et al.*'s 2019 study,[29] participants had reported both "naughty/playful" and "dislike/disgust" for this emoji. Future studies should be performed to explore CP patients' understanding of facial emojis using interviews or free-response questions. This can provide a more comprehensive profile of how CP patients assign meaning to these emojis.

The more neutral ratings for the four emojis were in line with findings from a recent brain-imaging study. In their 2019 study, Belmonte, Montoya, Gonzalez-Roldan, and Riquelme found that children with CP rated affected pictures (either pleasant or unpleasant) as less arousing, and demonstrated decreased amplitudes of evoked potentials in early brain processing latencies.[31] The lower arousal level in CP patients when viewing affected pictures may explain why CP patients in our studies gave some emojis significantly more neutral ratings compared to their neurotypical peers.

It is also worthwhile to mention that, in Jaeger *et al.*'s 2019 study, the mean arousal scores for these five emojis are relatively neutral (ranging from 3.2 to 6.4 on a scale from 1 to 9). The two emojis for which CP patients had significantly lower affect ratings than their neurotypical peers (i.e., the face with stuck-out tongue and tightly closed eyes 😝 and confounded face 😖) had arousal scores of 5.8 and 6.4. The other three emojis for which CP patients had significantly higher ratings, had arousal scores of 3.2, 3.7, and 4.8. It seems that among these five emojis, higher arousal scores were associated with lower affect ratings in CP patients and lower arousal scores with higher affect ratings. The arousal scores of emojis may be related to CP participants' understanding of affect and could potentially explain the discrepancies in CP and neurotypical participants' understandings. Future studies could further explore this association.

While CP patients' communication skills lay along a broad spectrum, it is important to note that all participants in this study were relatively high functioning, and the sample size was relatively small. It is thus unclear as to whether the findings of this experiment can be generalized to the entire CP population. Another limitation of this study is that a different survey was sent to CP and neurotypical participants: CP participants used printed questionnaires while neurotypical people filled them out online. Since emojis are typically used on the internet and in social media, the ratings of emojis on paper might be different from those on a phone or laptop.

This study concluded that CP patients understand emojis similarly to neurotypical participants, so it is indicated that emojis may be a tool to help them communicate since they already use facial expression to compensate for their reduced language expression.[7] Conversely, when CP patients understand certain emojis differently from neurotypical people, such as the five special emojis discovered in this study, necessary adjustments are needed to facilitate CP patients' communication. In addition to helping with communication, emojis may also serve as a potential intervention method. Currently, OSNs are a useful tool for patients with severe CP who have communication impairments. Emojis would be an effective complimentary tool for use on chat boards for those who have severe cerebral palsy and reduced language capacities. Since emojis might be a powerful tool to assist CP patients or even people who have communication impairments more generally, it is worthwhile to dedicate more effort to exploring how these populations understand emojis.

Conclusion

This study shows that, overall, CP patients interpret emojis from the iOS system similarly to neurotypical people despite their motor and communication impairments. However, a significant ratings difference exists among five emojis. These significant differences can be interpreted by CP patients' harder time in life, relatively high arousal level, and CP patients' and neurotypical people's lack of clear understanding of certain emojis. Further studies can explore how exactly CP patients interpret emojis and how CP patients' emotional understanding is associated with their interpretations of emoji affect. Still, if CP patients and neurotypical peers interpret the effects of emojis consistently, it may be helpful for CP patients to use emojis to communicate in the future, demonstrating their facial expressions. On the other hand, if CP populations understand emojis differently, emojis may be adjusted or altered for them to better assist their communication abilities. Thus, It is valuable to devote more into understanding how CP patients and even people with other communication impairments interpret emojis.

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Author

Yudi Fu is a rising senior at the Northwest School in Seattle, Washington, class of 2022. She is interested in psychology and special education and aims to study psychology and education in college. She has been devoting herself into her charity career concerning people with disability for ten years. Her research projects focus mainly on mental health issues and people with disabilities.