Exploring Designs to Improve Miscommunications in Emoji-Based Communication

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Abstract

Project SORA is a collaborative initiative among the researchers at Georgia Tech's Sonification Lab. Part of the project is creating a UI/UX mockup that studies using *sentiment analysis, emoji dictionary, and rich text formatting* to reduce CMC (Computer-Mediated Communication) miscommunication. We used remote usability studies to collect feedback on our proposed solutions, identified the solutions' benefits and shortcomings, and finally, discussed their potential for growth and research beyond our work.

Introduction

As mobile communication becomes more prevalent and advanced, means other than text have been adopted to convey users' emotions. First created in Japan in 1999 (Pardes, 2018), emojis have gained in popularity and expanded to nearly every modern-day communication platform. Emojis are now maintained by Unicode, which defines them as pictographs (pictorial symbols) that are typically presented in a colorful form and used in inline text (Unicode, 2019a). Emojis have become a go-to means for people to express emotions, feelings, ideas, activities, and more. It has gained so much influence that in 2015, Oxford Dictionary chose the Face with Tears of Joy emoji (😂) as its official word of the year (Steinmetz, 2015), and the emoji's popularity has remained as recent as Unicode v. 12.0, published in 2019 (*Figure 1*). As of February 2021, there are a total of 3304 emojis registered in the Unicode Emoji data files (Unicode, 2021) to represent different emotions, activities, objects, and more on multiple communication platforms.

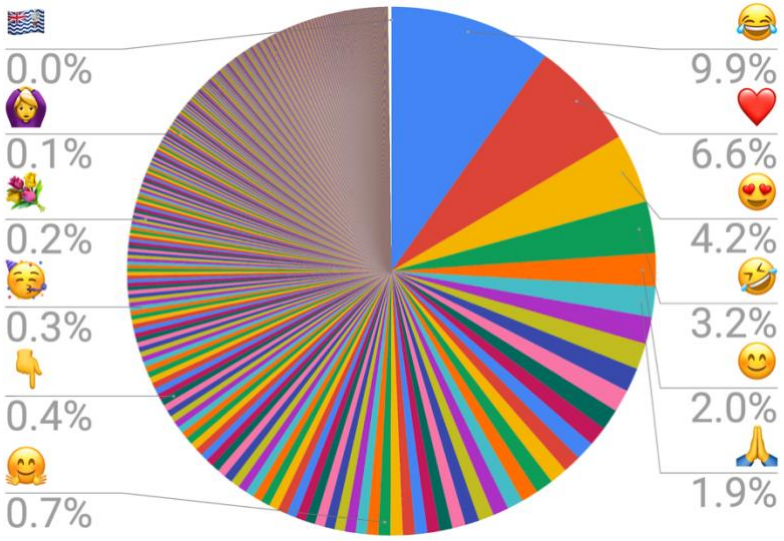


Figure 1. Most Frequently Used Emojis in Unicode v12.0 (Unicode, 2019b)

Adopted to aid users' communication, Emojis are widely researched within the HCI (Human-Computer Interaction) community. Research investigating how people use, appropriate, and communicate with emojis typically falls under the field of CMC (Computer-Mediated Communications), and many researchers have sought to determine if emojis are effective at improving communication in CMC systems. Emojis have been studied for their usage across culture, gender, and geography, and it is commonly observed that emoji usage is influenced by a plethora of human factors. Sentiment analysis is also commonly performed with Emojis to

interpret their emotional meanings, so machine learning models can be created to help predict and understand the underlying meanings of text messages.

To investigate the values and potential of emojis, we propose the following research questions:

1) What are some ways emojis can be more effectively used to improve communication?

2) How can emojis contribute to a reduction of problems and barriers introduced by CMC platforms?

We will attempt to answer these questions by developing a proof-of-concept messaging application and include various features designed to improve communication. The application will then be presented to the public for assessment through a remote usability study to collect and evaluate their opinions.

This work will contribute to the greater effort of reducing the existing difficulties faced by CMC mediums. Furthermore, we believe that the communication features presented through our mockup, if popularized, can make it easier for people to communicate and understand each other on online platforms.

Literature Review

Known Observations in CMC

Research in CMC began long before Emojis were introduced. Various studies were previously done when emoticons (facial expression represented by keyboard characters, i.e., :-)) and e-mails were being used as popular means of communication. Studies have been performed to show the difference between CMC and FTF (Face-to-Face) communications.

In comparing the ways FTF groups and CMC groups communicated, Kiesler et al. have found that CMC groups, when making decisions, **1)** took longer to reach consensus, **2)** had significantly more choice shift (individuals changing decisions during group discussions), and **3)** displayed more uninhibited verbal behaviors such as swearing and insults (Kiesler, Siegel, & McGuire, 1984). This can be explained by how CMC often lacks ways for people to observe and respond to social and non-verbal cues. However, other studies have also reported that CMC groups report higher participation, as there are no social barriers to communication (users can just type). CMC groups also have shown more capabilities in idea generation tasks as members have more time to think (Bordia, 1997).

Another observation of CMC is more focused on individuals rather than groups. *Private self-awareness* is defined as an individual's evaluation of covert aspects of self, in contrast, *public self-awareness* is defined as an individual's evaluation of overt aspects of self from the perspective of others. CMC users reportedly display significantly higher levels of acute private self-awareness and marginally lower levels of public self-awareness (Matheson & Zanna, 1988). To put it in another perspective, people are more self-conscious when engaging in CMC. A study that focuses more specifically on social media reported that social media exposure affects a person's self-esteem and self-evaluations. Users with more chronic exposure to Facebook tend to have lower trait self-esteem. Likewise, viewing social media profiles with upward comparison (e.g., better at fitness, networking, etc.) is associated with poorer self-esteem and self-evaluations (Vogel, Rose, Roberts, & Eckles, 2014). This suggests that people's change in self-esteem may be caused by an increase in private self-awareness from using CMC.

Emoji Miscommunication

Unicode aimed to establish a standard for emojis to have an identification code common across all platforms so that common emojis can all be rendered for users communicating cross-platforms. For example, U+1F600 represents the emoji, 😀, no matter the platform (Emojipedia, 2021). However, platforms still have the freedom to create different renderings of emojis. Many studies have identified that differences in rendering and people's varying interpretations have created miscommunication. While emojis have assisted people in conveying their emotions, many existing shortcomings for this medium result in miscommunication between users.

Unicode	Apple	Google	Microsoft
U+1F600	😀	😀	😀

Figure 2. Different platforms' renderings of U+1F600

It is worth noting that oftentimes emojis are often used along with text. In most cases, emojis follow a string of text to clarify the meaning behind the text. In other words, text and emojis are often used in conjunction to convey clearer meanings and intentions. However, findings have shown that unless under extreme circumstances where the emoji itself has high ambiguity, the text has very little effect on people's interpretations of the emoji (Miller, Kluver, Thebault-Spieker, Terveen, & Hecht, 2017).

Emoji interpretation can affect how people understand the sentiment under which the emoji is being used. A study has shown that even when communicating through the same

platform (i.e., between Apple iMessage), people would not agree on the sentiment (positive, negative neutral) in 25% of the cases. From the same study, when emojis are interpreted across platforms, 41% of the emojis have a sentiment interpretation of significant difference (>1 sentiment unit) (Miller et al., 2016). This suggests that while the sender may intend for a specific meaning, the receiver may interpret the meaning differently as it is based on their own understanding. With respect to our proposed research question, emoji miscommunication observations also demonstrate that there is a need where additional mediums can be used to mitigate the problems currently present in emoji-based communication.

Emoji Usage Trends

Emojis have been established as a popular means of communication, and this means that they are being used across various cultures and societal groups. Due to this widespread usage, many trends can be observed. In this section, we point out some of the trends that have been noted by the literature and categorize them into 3 separate groups.

Communication Purpose

In communication, emojis are being used beyond pictorially representing one's emotion. As reported by a study from the University of Bath (Tigwell & Flatla, 2016), emojis can be used for relational maintenance. Participants of the study have pointed out that there have been instances where they respond to each other with only emojis to continue a conversation. Another use for emojis in conversations is their ability to create meanings. Participants have reported they apply personal meanings to emojis so that using an emoji is playful and intimate in the context of a relationship. In such cases, emojis can be seen as a tool for relationship bonding and helps people connect. It may be suggested here that emojis' capacity for different interpretations has created opportunities for personal meanings to be associated with them.

Gender

According to a study on the different usage patterns of emojis across genders, male and female users have been shown to exhibit different behaviors when using emojis. Some of the common observed differences include **1)** females uses emojis more frequently than males, **2)** females tend to only use one emoji, while males often use multiple emojis consecutively (to reinforce their sentiment) in the same sentence and, **3)** females and males use different categories of emojis even when describing the same subject (Chen et al., 2017).

Culture

Users' culture groups also play a critical role in how emojis are being used. It has been shown that users of similar cultural groups tend to use emojis in behaviors unique to that cultural group (e.g., Spanish-speaking countries using emojis in a particular fashion). More importantly, different emoji usage patterns by these groups are linked to different sentiments behind them. To illustrate, users from countries that focus more on individualism (e.g., France) tend to express positive emotions through emojis (Lu et al., 2016). Different cultural groups' usage of emojis signal the potential for miscommunications to occur between cross-culture emoji communications.

All the category-specific observations discussed above make it possible that emojis can be suggested or recommended based on specific user parameters. The parameters represent a set of behaviors unique to the user's demographics, and a model can be trained to adapt to different use cases.

Proposed Methods to Improve Emoji-Based Communication

As we have discussed, many scholars have acknowledged the present shortcomings of emoji-based communication, motivating many to propose potential improvements.

To our knowledge, present keyboards offer fixed emoji layouts, with dedicated pages that remember the most recently used emojis. However, studies have suggested that these layouts can be redesigned to reduce miscommunication. An improved layout will encourage users to select emojis that align more with common interpretations and are more suited to their conversations. One possible design is to create context-aware layouts (Lu et al., 2016) based on the user's text, location, etc. In this design, emojis will be suggested/organized according to the common usage pattern of a user's country and culture. Another possible design is to optimize the layout based on semantic model interpretations (Pohl, Domin, & Rohs, 2017). In this model, emojis with similar semantic values will be organized together.

Other than changing emoji keyboard layouts, improvements can also be made upon users' interpretations of emojis. Tigwell et al. suggest creating a system where users build a one-time model of their unique emoji interpretations (Tigwell & Flatla, 2016). When a user sends an emoji, they also send along an emoji intent. A similar model on the receiver's end will then translate the emoji into one that is most proximal to to the sender's intent. The proposed system

will be independent of platform renderings but associates closer with a user's emotional interpretations.

Methodology

Given knowledge of the prior works, we recognize that other methods can contribute to reducing emoji miscommunication. We propose Project SORA, a text messaging platform with features designed to aid user communication. The platform and its features are presented as a high-fidelity UI/UX mockup. We sought to assess the effectiveness of three features: Emoji Dictionary, Sentiment Analysis, and Text Manipulation. While a thorough functioning application is our end goal, this paper seeks to answer our research questions by studying how the features can be effectively designed into the UI of a mobile text-messaging application.

We designed a generic interface mockup of the application and presented it to participants. We asked 11 participants to evaluate different features in our mockup through a moderated remote usability investigation. Participants were gathered from the Georgia Tech student body through SONA, School of Psychology's online registration system. The participants' demographics consisted mostly of undergraduate students between the age of 18 to 23 and they were compensated with psychology course assignment credits upon completion.

In addition, a demographics survey is conducted at the end of each study session to help us better understand our participant sample.

Moderated Remote Usability Investigation

Given the circumstances of the COVID-19 pandemic, all usability sessions were conducted via a remote video conference call. In each call, users were asked to share their screens as they interacted with the design. A research facilitator helped navigate the users to different feature prototypes and asked them to explore the design. As they explored, we asked them to verbalize their experience while interacting with the interface. To help us obtain a more detailed knowledge, we also asked a series of questions as they explored the design (see appendix). Their immediate responses are recorded and analyzed to help us gauge our proposed features' effectiveness. Questions were designed to be open-ended to obtain participants' feedbacks. A generic question may be "Describe what you see here?" or "What functionality do you think is available here?" For more specific cases, we asked questions such as "What do you think [a feature] means" or "How may [a feature] affect your experience?" We also provided

participants with more context after they answered to reduce confusion and provide more clarity. The study took approximately 30 minutes to 1 hour to complete for each participant. Video and audio were recorded, and the research facilitated collected written notes during each usability session. These data were analyzed in ATLAS.ti via Thematic Analysis using a deductive, open-coding process.

Design Specifications

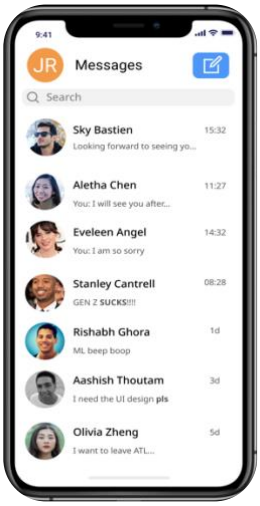


Figure 3. Generic design

The generic design was modeled after Apple iMessage and Facebook Messenger, two popular messaging platforms. Moreover, many of the design choices were made after being inspired by how each application implemented its features. As for specific features, we have designed a possible variation of emoji dictionary, sentiment analysis, and text manipulation. The designs were made through Figma, an online collaborative UI/UX design platform. We chose Figma for its capabilities, features, and affordability to students. In addition, Figma enabled us to add contemporary animations with our features, which provided a more immersive user experience when participants interacted with the mockup.

Emoji Dictionary

Figure 4. Emoji Dictionary. Each definition (from top) has its summary, detailed definition, example usage, similar emojis, and scores

Miller et al. have pointed out the minuscule effect of accompanying text in clarifying the intention behind emojis' usage. People often used emojis in support of their intentions, but it is commonly observed that emojis' meaning depends on the perceiving user's demographics and cultural background. We seek to create a platform where users can provide custom emoji definitions (using the plus button on the top right corner). On the platform, users can write an emoji's summary, detailed definition, example usage, and other quantitative metrics. For each definition, we present an example of how the emoji can be used with that definition. We also display other emojis that can contain a similar

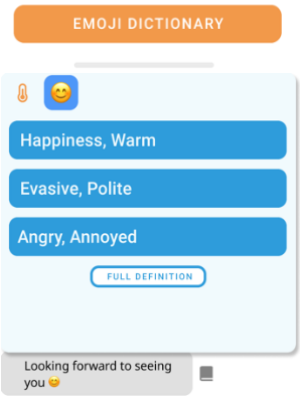


Figure 5. Accessing the emoji dictionary through a dedicated button (top) or in-text pop up (bottom)

definition. Each definition also contains three scores on its excitement, pleasantness, and popularity. Excitement means a definition's ability to elicit emotions. Pleasantness means the positive sentiment behind a definition. Popularity is how often an emoji is used with a definition. We acknowledge that the scores can be confusing, so in our study, we asked participants how they understood those scores' meanings. The order in which definitions are presented can be based on each definition's popularity and the user's profile demographics. Our mockup provides two ways to access the emoji dictionary: **1)** through a dedicated emoji dictionary button in the user's profile, or **2)** through a pop-up menu next to each message in their conversations.

It is interesting to point out that Urban Dictionary, a contribution-based online dictionary provides similar features. However, the dictionary primarily focuses on common text vernaculars and terms, while our dictionary focuses only on emojis currently published in the official Unicode standard.

Sentiment Analysis

Figure 6. Each message is colored to indicate its sentiment

Emojis were adopted more frequently in response to recognizing how text is limited in communicating the sender's intentions. If a user can have a better understanding of another's sentiment in a text-based communication, miscommunication can be reduced. Nowadays, it has become possible to estimate a sender's intention using machine learning and NLP (Natural Language Processing) model. A text messaging application that adopts such concepts can provide users with a suggested emotion behind the messages sent and received on its platform. In our design, each text message has a colored vertical bar attached next to it that's used to indicate whether the text message sounds positive (green) or negative (red). Additionally, in the text's pop-up information panel (accessed by the book icon next to each message), users can observe the text's positivity score based only on its texts, only on its emojis, or the overall text message. The positivity score can be understood as how positive the message sounds.

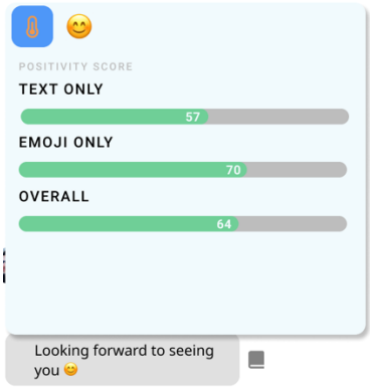


Figure 7. Each text is analyzed for its positivity score on only text, only emoji, or overall message

In our study, we wanted to assess if sentiment analysis is a novel concept to users when applied to text messages, and we wanted to see if our sentiment analysis feature's design can be easily understood by users who use it. We also questioned if providing sentiment analysis on the user's sent texts is helpful, hence why we created a variation where colored bars also exist on the messages sent by the user. We then asked our participants to compare the two approach and share how the latter may affect them in their text messaging experience.

Text Manipulation

Miller et al. have pointed out the minuscule effect of accompanying text in clarifying the intention behind emojis' usage. We suspect that a potential reason behind this phenomenon is the lack of ability for users to manipulate text. It is common in modern literature for the author to manipulate the text (i.e., bold or italicize) to emphasize its intention and meaning. We think text manipulation can be useful in reducing miscommunication. In our mockup, users can highlight specific words in their text and have the option to applies rich text formatting (bold, italicize, and underline). By applying text formatting, a sender can provide more cues for the receiver to understand their intention. In our study, we asked participants questions that gauged the effectiveness of rich text formatting in text messaging.

Figure 8. Rich text formatting applied to messages and the user is seen bolding "discuss"

Results

Our results describe various categories of responses and the number of times a response is given to each question we asked. The number for each response is out of 11 as that was the total number of participants. To our surprise, responses were not as unified as we believed, suggesting implications that we explore in the discussion section. We report the results according to each mockup feature next.

Emoji Dictionary

To access the emoji dictionary, participants can press a dedicated "emoji dictionary" button located in the mockup's profile page. Upon pressing the button, participants were presented with a grid of emojis. Ideally, the grid contains every emoji included in the Unicode standard. When asked what they observe, most participants (8/11) identified the page as an "emoji bank." A few of the participants assumed that the page is associated with an app-specific feature, such as "insert emoji in text" (3/11); "app specific emojis," "react message with emoji," and "user status update" (1/11, each).

When the participants select an emoji, they will be taken to the emoji's specific definition page. Again, when asked for their observations, most of the participants recognized that the page presented a "detailed emoji definition" (10/11). When questioned more specifically on the design, we received various feedbacks. Many participants specifically pointed out that they "liked emoji example" (6/11) and "liked similar emojis" (7/11). Participants provided positive feedback on the page's overall design (5/11). More negative feedback, such as "more explanation on excitement, pleasantness, and popularity" (1/11) and "more specific, readable definitions" (2/11) were also identified.

To observe how participants understood the meanings of *excitement, pleasantness, and popularity,* we asked the participants to share how they perceive the terms. Popularity is well understood, with many of the participants (8/11) reflecting that it means an "emoji definition's usage popularity." Pleasantness had various meanings such as "perceived pleasantness by the receiver" (2/11), "emoji appreciation" (3/11), "emoji positivity score" (1/11), and "friendliness" (1/11). Excitement had more different meanings with respect to what we intended. Participants believed excitement meant "eagerness to use the definition" (2/11), "excitement level when using the definition" (3/11), "perceived excitement by the receiver" (2/11), and "unsure" (1/11).

The emoji dictionary platform allows its users to contribute their own definitions using the plus button on the top right on each emoji's specific definition page. We asked participants about the expected functionality of the plus button. Some participants said the button "adds emoji definition" (4/11), and several different feedbacks were recorded. Other expected functionalities included "bookmark emoji" (2/11), "insert emoji in text" (3/11), "more information" (4/11), and "new conversation" (1/11).

Sentiment Analysis

Sky Bastien's chat mockup was designed to assess performing sentiment analysis in CMC. We appended color bands that color either green or red to indicate whether the message sounds positive or negative, respectively. Without explaining the color bands' usage, we asked the participants for their initial thoughts on them. There were various scattered responses. The top response we received was that the color bands serve to indicate a "message's sentiment", or as an "aesthetic user interface addition" to the chat's messages (3/11). The next group of responses (2/11) included that the color bands indicate "different users," "message read/unread status," "user online status," and "unclear usage." The remaining responses (1/11) thought that the color bands were "not noticeable, showed "device type," "message delivered status," or "receiver agrees with the message." Note that each participant often suggested multiple purposes of the color bands, hence why the number of responses does not sum to 11. In a separate chat mockup, we added color bands to both the sender's and the receiver's messages. To evaluate, we asked the participants how having the color bands when they send messages affects their text messaging experience. Responses were generally positive, as many said this feature "assists with intention clarity" (6/11), "assists message interpretation" (3/11), and "improves communication intention" (2/11). A few of the concerns raised included that the color bands "can contradict sender's intention" (2/11), and that "binary representation of a message's emotion is limiting" (2/11).

Next, we asked participants how they perceived the book icon next to each message. Pressing the book icon is meant to bring up additional information on each message. The information included sentiment analysis on the message and emojis' definitions in the message. Most of the participants perceived the icon as a "book" (8/11), and many were able to interpret that the book accesses the "emoji dictionary" (6/11). However, a few participants thought the book is meant to "change color band color" (1/11) or "indicate message is read" (2/11).

Sentiment analysis is displayed as a set of bars and numbers that indicated the message's positivity metrics. When asked what the metrics meant, most of the participants identified them as "positive sentiment of the message" (9/11). Emoji pop-up definitions display a summarized version of what the full dictionary conveys. We asked participants how they perceived the summarized definitions, many pointed out that the page conveyed "emoji definition summary" (6/11) and that it showed "emoji definition's usage popularity" (8/11). Interestingly, a few participants also took note that they could "access full definition" from the pop-up. Otherwise, A few commented that the summarized definition "assists with message interpretation" (3/11).

Rich Text Formatting

Providing rich text formatting is another way to improve CMC, as many commercial products (e.g., Slack) already provide this capability. In Aletha Chen's chat mockup, we designed a way to provide rich text formatting while texting. Many of our participants understood what feature was provided in the chat mockup, as a majority pointed out that there was "rich text formatting" (10/11). Moreover, many said that the ability to apply rich text formatting "assist word emphasis" (5/11), "assist intention clarity" (6/11), is "better than capitalization" (2/11). However, some also said that "formatting can be optional" (2/11) and that the feature is "time consuming" (3/11).

Discussion

As previously noted, the participants' responses were not unified. They presented different assessments on the features. We believe that a cause of this phenomenon is due to the nature of usability investigation: participants were not provided explanations. Most of the features we piloted are novel to the regular texting experience, so when left to openly interpret, participants are likely to respond based on their background and experiences. This suggests that detailed explanations and intuitive design are necessary when introducing a novel feature. Other findings specific to each feature will be discussed next.

Emoji Dictionary

Our results suggest the novelty of an emoji dictionary concept. Many participants were surprised by the concept of assigning custom definitions to emojis. Starting with the "all emojis" page, a few of the participants believed the page is used in conjunction with texting. Tapping on an emoji meant inserting it into a text, which confirms emojis' roles in enriching conversations.

Participants provided mostly positive feedbacks regarding the detailed emoji definition page. Two features, namely the emoji example usage, and the similar emojis, received support from more than half of our participants. Examples are often great tools for assisting understanding. Having a relatable medium is important in understanding emojis' meanings, which reduces the possibility of misinterpretations. Likewise, similar emojis indicate the shared meanings across emojis. On some occasions, using another emoji of similar meaning may be a better method of communicating a user's intentions. The features' popularity suggests that they are valuable and should be included in an emoji dictionary designed to reduce CMC miscommunication.

As introduced previously, we scored each definition based on its *excitement, pleasantness, and popularity*. However, as suggested by our results, these terms appeared ambiguous to the general users. Besides *popularity*, participants provided very different interpretations for these terms. If an emoji dictionary is to be adopted by the public, methods on how to rank each definition and assess their metrics (such as the one linking to emotions) should be thoroughly investigated. Appropriately designed metrics can improve the clarity of the dictionary, and possibly even offer another layer of interesting interactions. Another conclusion we can draw is that using academic terms should be avoided in general consumer applications. The terms are vulnerable to confusion, so designs should use more colloquial descriptions.

Many participants did not expect that the emojis' definitions can be community driven. From the results, less than half thought the plus button on emoji's specific definition page allowed for contributions. A community where people create definitions to help each other understand emojis is a novel concept. The creation and maintenance of such a community can help reduce CMC miscommunications as more people can agree on emojis' interpretations. Separately, from the other responses, more studies can be done on what capabilities and use cases can extend from an emoji's detailed definition.

Sentiment Analysis

One method we designed to integrate sentiment analysis into our text messaging application is to color user's messages based on their perceived tone. From our results, it is evident that to the public, sentiment analysis is an unprecedented feature. Participants offered various possibilities to what the color bands' purposes. Only a few were accurate. Most of our

participants expressed that having context to the sentiment behind a CMC conversation is helpful in both interpreting others' messages and writing the messages themselves. However, participants also expressed concerns in two main categories. We designed the color to be binary; red meant negative text, while green meant positive. The binary color representation of sentiment, according to some, is limiting. More color should be used to convey the emotion behind a message. The second concern is oriented around a sentiment analysis algorithm's accuracy. It is troublesome if an algorithm's interpretation contradicts a user's intention behind a message. In one of our studies, the participant offered a potential workaround:

> *Researcher: If a message wasn't actually the tone you want to convey it in. What would you do to correct the tone, or reinform the algorithm?*
>
> *Participant: Maybe if there's an option that you can click on color to indicate "this wasn't what I meant," then, you can manually put in what you meant. That way, the algorithm gets to learn more in general, but also specifically on your texting style.*

Other participants have also offered similar solutions such as the option to turn sentiment analysis off. From the above responses, we think more work can be done to study how sentiment analysis can be incorporated into modern-day texting. Another possible area worth investigating is how to train an algorithm to better understand human intentions when texting.

We also designed the emoji definition with respect to sentiment analysis. Each message has its own information panel. In the panel, users could view the message's positivity score and the summarized definitions of the message's emojis. When we reached this point in our study, many of our participants got accustomed to our design, as shown from how many identified the purposes behind the information panel. We think that if an emoji dictionary is well integrated into text messaging, it can become recognizable and a part of the normal CMC routine. Sentiment analysis in texting is useful for reducing CMC miscommunication, and it has the potential of being further researched on an application basis.

Rich Text Formatting

Rich text formatting is well recognized and used commonly, as shown by the number of participants that recognized the feature. Additionally, applying rich text formatting is easily

learnable. We think that this feature is an easy-to-implement approach in reducing CMC miscommunication. As pointed out by one of our participants:

"I think [rich text formatting] would make it a lot easier to text other people or understand, just because you can emphasize the words you want. Some of those get lost when you are messaging versus talking in person."

Currently, emphasis during texting is conveyed through capitalizing words or phrases. In an in-person conversation, adding emphasis during a conversation is an important verbal cue of intentions in addition to what is being spoken. By providing users the ability to emphasize, CMC can see reduced miscommunication and improved effectiveness.

However, rich text formatting does come with shortcomings. A few participants pointed out that it is time-consuming and optional. As mentioned above, capitalization, while simple, is already being used to emphasize. Methods can be researched on more effortless methods to apply rich text formatting to words or phrases while texting.

Future

Limitations

The results of this paper were limited by the following factors: the COVID-19 pandemic that continued at the paper's completion, and the demographics of our participant pool. The COVID-19 pandemic forced many researchers to seek socially distanced alternatives of their methodologies, including ours. Without the pandemic, communication between our teams would have been more efficient, and we possibly would have been able to accomplish more tasks in the same timeframe. Data collection could have been easier if we were able to conduct live interviews and allow our participants to interact with our mockup in a more controlled environment.

As discussed previously, our participant pool consisted of Georgia Tech's undergraduate student body aged from 18 to 23. However, as many other works have pointed out, age is a factor that affects CMC and individuals' emoji usage patterns. If the study's participant pool can be scaled up, we can obtain results that suggest improvements for a more diverse age group. The participant pool also is limited to individuals in the United States. CMC miscommunication is an issue that exists globally on text messaging platforms. As Lu et al. have pointed out, CMC

behaviors are unique to different cultures. More findings and understanding are possible if the study can be extended to people of other cultures.

Prototype Messenger Application

Our mockup is limited to the scenarios we designed, but each person can use our proposed features differently. To create a proof of concept that showcases functioning versions of our proposed solutions, we developed a standalone PWA (Progressive Web Application) named GT Messenger that is usable on different platforms. The messenger adopts a real-world machine learning NLP model to perform sentiment analysis on each message and contains an emoji dictionary built from data collected in other studies. Registered users can communicate on the platform and use the features discussed in this paper. Much work is yet to be completed with the PWA. We intend for the messaging application to be assessed by more participants and other academic faculty members. The application also only serves as a proof of concept on what is possible in features that reduce miscommunication. It takes wide adoption and commercial implementations to see significant improvements.

Conclusion

In this thesis we presented the concept of adopting *sentiment analysis, emoji dictionary, and rich text formatting* into CMC. We created a UI/UX mockup to test our proposed solutions and answer the proposed questions at the start of this paper. Sentiment analysis can be a suitable tool to support and clarify intentions in CMC. Emojis exist already as a meaningful method to add context during CMC, but if offered methods to define and expand their meanings, they can be more effectively used. Rich text formatting is an appropriate method to add emphasis in text messaging, but it would be more popular if it can be easily applied. In all, much work can still be done to thoroughly investigate these ideas.

We hope that the concept can be acknowledged by the CMC community and possibly be one day integrated into the world's commercial messaging platforms. For instance, online dating is a platform that can benefit from our solutions. Individuals can connect better if there exist solutions that assist them in interpreting others' intentions and sentiments when communicating. It is even possible that people can learn to improve their communication skills. In a society that is growing to become more reliant on its online presence, our solution can bring forth many benefits in CMC.

Appendix

Study Questions

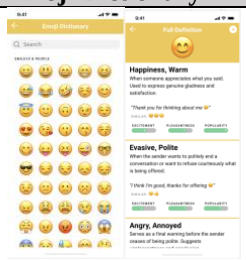
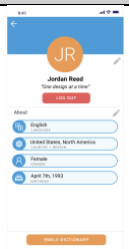
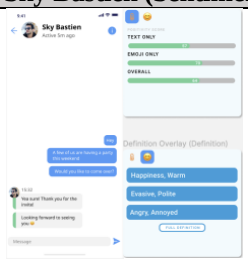
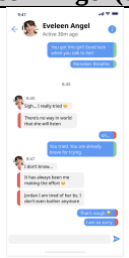
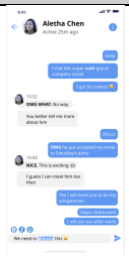
1. Emoji Dictionary	
	**Q1.1** Describe what you see on this screen? What do you think is going on here? (All emojis page) **Q1.2** What do you think is going on here? (Specific definition page) **Q1.3** What are your thoughts about how the definitions are presented? **Q1.4** What does excitement, pleasantness, and popularity mean to you? **Q1.5** What do you expect to see? (Plus button on the top right corner)
Profile	
	What are your thoughts on this? (Profile demographics). We excluded this question from discussion as there were limitations around the concept.
2. Sky Bastien (Sentiment Analysis, Text Message Context)	
	**Q2.1** Describe what you see on this screen. **Q2.2** What do you think about the color bands on each message? **Q2.3** What does the icon mean to you? (Message pop up icon that looks like a book) **Q2.4** What do these metrics mean to you? (Positivity score) **Q2.5** What do you see? What do they mean to you? (Emoji definition summary)
2. Eveleen Angel (Sentiment Analysis)	
	**Q2.6** How do you think this affects your text messaging experience? (Colored bands on sender)
3. Aletha Chen	
	**Q3.1** Describe what you see on this screen? What functionality do you think is available here? **Q3.2** How may rich text formatting affect your text messaging experience?

Table 1. List of questions asked by the researcher for each feature design

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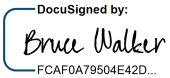
Bruce Walker bruce.walker@psych.gatech.edu Security Level: Email, Account Authentication (Optional)	DocuSigned by:  FCAF0A79504E42D... Signature Adoption: Pre-selected Style Using IP Address: 45.17.73.91 Signed using mobile	Sent: 7/31/2021 3:39:18 PM Viewed: 7/31/2021 4:22:59 PM Signed: 7/31/2021 4:23:21 PM
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Notary Events	Signature	Timestamp

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