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# RPPR Final Report

## as of 03-Jan-2024

Agency Code: 21XD

Proposal Number: 71881HCYIP

Agreement Number: W911NF-19-1-0368

### INVESTIGATOR(S):

**Name:** Jeff Huang  
**Email:** Jeff\_Huang@brown.edu  
**Phone Number:** 4018635808  
**Principal:** Y

Organization: **Brown University**

Address: Brown University, Providence, RI 029129002

Country: USA

DUNS Number: 001785542

EIN: 050258809

**Report Date:** 31-Oct-2023

Date Received: 25-Nov-2023

**Final Report** for Period Beginning 01-Aug-2019 and Ending 31-Jul-2023

**Title:** Sochiatrist: Automatically Predicting Emotion from Social Messaging Data

**Begin Performance Period:** 01-Aug-2019

**End Performance Period:** 31-Jul-2023

**Report Term:** 0-Other

Submitted By: Jeff Huang

Email: Jeff\_Huang@brown.edu

Phone: (401) 863-5808

**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

**STEM Degrees:** 5

**STEM Participants:** 9

**Major Goals:** The proposed research addresses the following research questions: 1) How accurately can emotion measured through self-report or through biomarkers be predicted purely from social messaging data? In what conditions can specific emotions or biological responses be more predictable, especially as an indicator of social support? 2) Which aspects of social messaging are predictors of emotion, and in what way do different social features about the frequency, content, timing, and recipients of messages influence affect? 3) Are predictions better or worse for different populations, particularly those who have been admitted for mental health concerns? Inversely, if we know a mental health condition of a person, does that change how we may predict their emotional states? However, the contributions of this work go beyond answering these research questions. The proposed work goes through the full cycle of developing a prediction model, reporting the results from multiple study populations, and releasing the software for social scientists. We will publish lessons from developing the prediction model, including both the statistical factors of the social messaging features, and the comparison between different prediction algorithms for emotional states. Perhaps most useful for the social science community, the PI's research group will release the Sochiatrist software that performs automated extraction of social messaging data for social scientists in multiple research groups across the country, who then use that data to make inferences about their participants. The software will be offered along with documentation and support for those social scientists to use without needing additional support from our team. Social messaging data can be sampled cost-effectively from a large number of participants. The Sochiatrist software can then be used for predicting emotional state from social messaging data to build on our research or replicate our studies, or even for other studies that incorporate social messaging data. We are also particularly interested in the effectiveness of non-text social messaging, based on emojis and reactions, in answering these questions. To assess the effectiveness of interpersonal social support based on emojis, an additional study based on a newly developed app, Chime, will examine how different populations interpret the emojis as a mechanism for messaging.

**Accomplishments:** Prior methods for understanding social connectivity focused on studying public discourse online. By developing and maintaining a tool for extracting private messages, this research has been able to deeply investigate online conversations in non-public conversations. While we aimed to predict sentiment, we found that the platform, topic, and personal subjectivity were mediators of understanding the intricacies of emotion. This work occurred during the COVID-19 pandemic, which we found transformed how people communicated online, particularly younger users such as undergraduate students. But the transformation was itself an opportunity, as the research was able to capitalize on those environmental changes to identify the shift from public posting to private (group) messaging. We discovered how the basic units of communication—text and emojis—related to social support and empathy; especially as we found that private platforms held the strongest ties to perceived social support. Fundamental units of communication, like a single character sent in real-time to the other person, led to a

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## as of 03-Jan-2024

richer communication medium that was less frustrating and cognitively demanding, while emojis conveyed stories that could be understood across multiple demographics. We have revealed that as younger people shift from public posting to everyday communication via direct and group messaging, their use of these platforms for empathizing and socially supporting one another has become more prominent.

As private online spaces are increasingly used for essential social support, this leaves a key utility of communication outside the study of most social analytical research. Especially among younger users, private messaging continues to outpace public posting both in size and depth. In fact, public posting by regular users and traditional social medium is a declining medium, with private messaging (especially among groups) serving as the place where peoples' true thoughts are revealed.

Our research shows that public posting does not reveal a positive effect on perceived social support and loneliness. And overall, the proposed work goes through the full cycle of developing and maintaining the tooling, studying individual units of communication in the form of emojis and character-by-character typing, investigating computational and expert-based prediction models for emotion, and examining empathy in populations that seek it most. With our work, private social messaging data can be sampled cost-effectively from a large number of participants, and we pose key questions to the research community to continue studying the meaning behind messaging and its metadata.

Overall the work was well-received by the community of researchers. It produced 3 publications at top-tier venues, and two additional papers which have been reviewed and deemed "Revise and Resubmit" which may then lead to publications in January 2024. Finally, software components built during the work have been released, and both software projects have been used by people for their intended purposes.

**Training Opportunities:** Trained Ph.D. students, a Masters student, and 5 undergraduate students in skills of: mobile app development, systems development, designing and conducting user studies, and academic paper writing. Technical skills included mobile app data extraction, which is an uncommon skill that contributes to cybersecurity capabilities, and data anonymization and analytics, which is a critical computational skill. Partly based on skills gained during this research, the Masters student graduated and went to work at IBM, and the undergraduates who graduated have gone to work at technical companies Google, Apple, and Goldman Sachs. The work led to an undergraduate honors thesis, major components of 2 Ph.D. dissertation proposals, and 2 IRB-approved and ARL Human Research Protections approvals.

**Results Dissemination:** Published:

"Together but not together": Evaluating Typing Indicators for Interaction Rich Communication. Zainab Iftikhar, Yumeng Ma, Jeff Huang. CHI 2023, Article 724.

Bridging the Social Distance: Offline to Online Social Support during the COVID-19 Pandemic. Gabriela Hoefler, Talie Massachi, Neil Xu, Nicole Nugent, Jeff Huang. CSCW 2022, Article 429.

Sochiatrist: Signals of Affect in Messaging Data. Talie Massachi, Grant Fong, Varun Mathur, Sachin Pendse, Gabriela Hoefler, Jessica Fu, Chong Wang, Nikita Ramoji, Nicole Nugent, Megan Ranney, Daniel Dickstein, Michael Arme, Ellie Pavlick, Jeff Huang. CSCW 2020, Article 111.

Under review, Revise & Resubmit (passed first round):

Chime: The Impact of Private Online Self-Disclosure on Perceived Social Support. CSCW 2024. Talie Massachi, John Roy, Lauren Choi, Gabriela Hoefler, Shaun Wallace, Jeff Huang.

Understanding Empathy in Online Peer Support: A Cognitive Behavioral Approach. CHI 2024. Sara Syed, Zainab Iftikhar, Amy Wei Xiao, Jeff Huang.

Software systems developed and released:

Sochiatrist: a social data extractor used to predict signals of mental health from social messaging data.

Chime: a social mood-tracking app that encourages social support through emoji-only communication.

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**Honors and Awards:** Nothing to Report

**Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

**PARTICIPANTS:**

**Participant Type:** PD/PI

**Participant:** Jeff Huang

**Person Months Worked:** 4.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Participant Type:** Graduate Student (research assistant)

**Participant:** Zainab Iftikhar

**Person Months Worked:** 3.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Participant Type:** Graduate Student (research assistant)

**Participant:** Talie Massachi

**Person Months Worked:** 6.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Participant Type:** Graduate Student (research assistant)

**Participant:** Yumeng Ma

**Person Months Worked:** 1.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Participant Type:** Undergraduate Student

**Participant:** Neil Xu

**Person Months Worked:** 1.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Participant Type:** Undergraduate Student

**Participant:** John Roy

**Person Months Worked:** 2.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Participant Type:** Undergraduate Student

**RPPR Final Report**  
as of 03-Jan-2024

**Participant:** Lauren Choi

**Person Months Worked:** 2.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Participant Type:** Graduate Student (research assistant)

**Participant:** Shaun Wallace

**Person Months Worked:** 1.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Participant Type:** Undergraduate Student

**Participant:** Sara Syed

**Person Months Worked:** 2.00

Project Contribution:

National Academy Member: N

**Funding Support:**

**Participant Type:** Undergraduate Student

**Participant:** Reet Agarwal

**Person Months Worked:** 1.00

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**Journal:** Proceedings of the ACM on Human-Computer Interaction  
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**Volume:** 6      **Issue:**      **First Page #:** 1  
**Date Submitted:** 11/24/23 12:00AM      **Date Published:** 11/1/22 4:00AM  
**Publication Location:**

**Article Title:** Bridging the Social Distance: Offline to Online Social Support during the COVID-19 Pandemic

**Authors:** Gabriela Hoefler, Talie Massachi, Neil G. Xu, Nicole Nugent, Jeff Huang

**Keywords:** covid-19 pandemic, college students, mental health, social support, social media, loneliness

**Abstract:** The severe impact of COVID-19 in the United States has forced many students to replace in-person socialization with online digital contact. In this study, we investigate the mental health impacts associated with this shift by examining properties of online interactions that may affect loneliness and perceived social support. Students were surveyed (N = 827) across 97 universities across the US during their first full semester impacted by the COVID-19 pandemic (Fall 2020). Private online interactions (messaging, phone call, video call) were found to have a comparable correlation to social support as face-to-face interactions, but public online interactions (social media) were associated with more negative outcomes. Among private platforms, messaging had the strongest correlation with social support; and daily self-disclosure over messaging yielded social support levels that were 1.21x higher than rarely or never disclosing over this platform. We speculate that factors such as the level

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**Acknowledged Federal Support:** Y

### CONFERENCE PAPERS:

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**Date Received:** 24-Aug-2021      **Conference Date:** 17-Oct-2020      **Date Published:** 17-Oct-2020  
**Conference Location:** virtual  
**Paper Title:** Sochiatrist: Signals of Affect in Messaging Data  
**Authors:** Talie Massachi, Grant Fong, Varun Mathur, Sachin Pendse, Gabriela Hoefler, Jessica Fu, Chong Wang,  
**Acknowledged Federal Support:** Y

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**Date Received:** 24-Nov-2023      **Conference Date:** 25-Apr-2023      **Date Published:** 23-Apr-2023  
**Conference Location:** Hamburg Germany  
**Paper Title:** "Together but not together": Evaluating Typing Indicators for Interaction-Rich Communication  
**Authors:** Zainab Iftikhar, Yumeng Ma, Jeff Huang  
**Acknowledged Federal Support:** Y

### WEBSITES:

**URL:** <https://sochiatrist.cs.brown.edu>  
**Date Received:** 24-Nov-2023  
**Title:** Sochiatrist  
**Description:** a social data extractor used to predict signals of mental health from social messaging data

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**URL:** <https://chime.cs.brown.edu/>

**Date Received:** 24-Nov-2023

**Title:** Chime, social mood-tracking, made simple!

**Description:** a social mood-tracking app that encourages social support through emoji-only communication

## Partners

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I certify that the information in the report is complete and accurate:

Signature: Jeff Huang

Signature Date: 11/25/23 7:45PM

*By Jeff Huang*

## Abstract

Prior methods for understanding social connectivity focused on studying public discourse online. By developing and maintaining a tool for extracting private messages, this research has been able to deeply investigate online conversations in non-public conversations. While we aimed to predict sentiment, we found that the platform, topic, and personal subjectivity were mediators of understanding the intricacies of emotion. This work occurred during the COVID-19 pandemic, which we found transformed how people communicated online, particularly younger users such as undergraduate students. But the transformation was itself an opportunity, as the research was able to capitalize on those environmental changes to identify the shift from public posting to private (group) messaging. We discovered how the basic units of communication—text and emojis—related to social support and empathy; especially as we found that private platforms held the strongest ties to perceived social support. Fundamental units of communication, like a single character sent in real-time to the other person, led to a richer communication medium that was less frustrating and cognitively demanding, while emojis conveyed stories that could be understood across multiple demographics. Overall, we have revealed that as younger people shift from public posting to everyday communication via direct and group messaging, their use of these platforms for empathizing and socially supporting one another has become more prominent.

## Objectives and Findings

There were three original objectives, which have been studied and expanded upon as follows.

### **1) How accurately can emotion measured through self-report or through biomarkers be predicted purely from social messaging data?**

With the Sochiatrist software, we developed and iterated on procedures for clinical research assistants to deploy and use the tool, for extracting private messaging data from devices and web services [7]. About a dozen clinical research assistants were trained on the software, in preparation for the long-term goal of releasing Sochiatrist to the broader social science community. A version of the software that could be used remotely by users was also developed, and procedures were written for the clinical research assistants so they could use it without in-person interaction, suitable for using during the pandemic, but also for future cases with remote populations. Ours is the only non-commercial tool that we are aware of that can extract and allow for analysis of private social messages, as the continued maintenance of this tool is challenging due to its dependency on data export and connections with social media platforms and changing operating system permissions. Most recently, the Sochiatrist tool is now also being used to study social rhythmicity and its association with sleep and suicidality [1].

Through many trials and IRB+ARL human subjects approved studies, we've found that the messages can be automatically rated on sentiment, but even humans don't do it that well and the circumstances and relationship of the communication partner play major roles. Humans judge messages based more on the meaning and timing, while sentiment analysis techniques like LIWC and VADER use word choices as the primary signal, leading to different predictions between the two [2]. It is difficult to consistently

interpret a user's emotion from self-report or expert judges. These discrepancies can be quantified, but it is a challenge to identify a true "ground truth" of a person's mood. Our finding after studying both automated computational approaches and expert evaluators, is that each approach has its own biases if trying to predict PANAS scores that were originally self-reported. Aside from logistical conversations, messaging is also used for a personal need—for online social support as a growing mode of communication. We have been noticing this, and opted to focus on this after investigating this objective.

## **2) Which aspects of social messaging are predictors of emotion and empathy?**

We examined 4 types of metadata: time of affect recording, message frequency, message length, and message platform, with modifiers regarding whether messages were sent or received, to identify the correlations between them and the predictions. Timing was a factor we tried to compensate for by addressing the misprediction regarding message weight based on temporal distance to affect recording, applied on a message by message basis [2]. A more optimal method would combine insights from: sentence tone, used primarily in sentiment analysis; insights from situational context, noted by human expert reviewers; and also more obscure data outside of message content.

Additional factors were investigated by applying the prediction model to individuals based on their history, rather than based on the whole subpopulation. We added a second population using anonymous data collected by collaborators on adolescents before this grant, to be able to answer the question without having to do in-person studies which have been difficult logistically and inherently biased due to the covid-19 pandemic. However, despite the barrier of the pandemic happening in the middle of the proposed work, we took it as an opportunity, using the extra year offered in a no-cost extension to refocus on the undergraduate student population as veterans were a population that was inaccessible during the pandemic, and to investigate how social support moved online during the pandemic. We found that the nature of how students send messages to each other changed.

We find self-disclosure across private platforms held the strongest ties to perceived social support, specifically on messaging platforms as opposed to phone and video calls, perhaps due to the privacy and flexibility messaging provides. We also examined group dynamics online, revealing one-on-one communication to have much stronger ties with social support than group communication. As online interactions were not found to mediate loneliness as much, interventions are needed for physically isolated individuals so that all students can feel connected and effectively bridge the social distance [3]. Overall, we see clear ties between online communication and feelings of social support, and suggest further study into private platforms and self-disclosure specifically.

In a second study, we've found that real-time messaging conveys empathy in a more expressive way. We examine this feeling in richer forms of typing indicators in messaging interfaces, such as showing text as it is typed. By assessing users' subjective workload and interpreting these findings in the context of users' experiences, we found that more expressive typing indicators were perceived as "rich in communication", as they helped people communicate more allowing for closer connections [4]. Richer texting platforms are less frustrating and cognitively demanding, can be validating encouraging active listening. These indicators also increased users' perceived co-presence. However, they can limit selective self-presentation. Users' apprehensiveness towards richer text in their interpersonal communication implied that even though most participants preferred the "richness of the medium", they felt uncomfortable with the same platform in a different setting (their personal lives). In addition, our

research suggested that there may be benefits of designing customized typing indicators for relationship maintenance and task-based communication.

### **3) Are predictions better or worse for different populations?**

Moving beyond student populations, we explore the presence and expression of empathy in iCBT-based peer support conversations [5]. Online peer support platforms provide space for individuals to connect with others and seek support. We explore measures of empathy that can be automatically calculated and identify where they're flawed. There has been a lack of research regarding understanding how digital empathy scores relate to the experience of a person seeking support in online conversations. And there is no standardized approach to measuring digital empathy. However, while empathy is critical for effective mental support, recent studies have found that highly empathetic support in these platforms can be rare.

Using data from online peer support sessions, we conducted a mixed-methods analysis to study the role that Cognitive Behavioral Therapy (CBT)-based empathetic techniques play in peer support. We applied an existing three-measure framework called EPITOME to quantify empathy [9], alongside qualitative content analysis to understand the impact of therapeutic training on fostering empathetic conversations. Our findings provide insight into interpreting empathy measurements in relation to support seekers' experiences and demonstrate that sessions that follow CBT techniques have high levels of quantified empathy. Whereas in sessions that had low perceived empathy, several contributing factors were identified, including a rigid adherence to CBT structure, misalignment of concerns, and lack of emotional validation. Our investigation considered text from both users, the model better encapsulating the CBT-based definition of empathy of whether the supporter "can go into a clients' world" by including the context of the information the person seeking help has shared.

As the nature of online communications is dynamic, the fundamental unit of communication is also changing, especially among younger users. As social media continues to grow as a space for emotional self-disclosure, it is important to understand whether self-disclosure acts as a causal factor impacting positive outcomes for users. We developed Chime, an anonymous social media platform designed to explore the underlying effects of disclosure within private online spaces [8]. Users in Chime are prompted to self-disclose moods and emotions using emojis. Emoji-based communication allows us to investigate highly-quantifiable measures of affect. Through a between-subjects study among a cohort of users on Chime, we evaluate the effect of self-disclosure within private online spaces on social support. A lot of emotion is conveyed through emojis, and we find that interpretation of emojis is consistent regardless of the population; that is, our original belief that emojis may be demographic-specific is unfounded.

While Chime use does not significantly increase feelings of social support, results suggest that self-disclosure in Chime may provide more social support than typical social media use or simple mood tracking over a two-week period [6]. Chime usage shows that even in cases of low-bandwidth communication methods, self-disclosure may cause increased feelings of social support. Our findings highlight the impact of communication in private online spaces on perceived social support.

### **Implications of the Work**

As private online spaces are increasingly used for essential social support, this leaves a key utility of communication outside the study of most social analytical research. Especially among younger users,

private messaging continues to outpace public posting both in size and depth. In fact, public posting by regular users and traditional social medium is a declining medium, with private messaging (especially among groups) serving as the place where peoples' true thoughts are revealed [10].

Our research shows that public posting does not reveal a positive effect on perceived social support and loneliness. And overall, the proposed work goes through the full cycle of developing and maintaining the tooling, studying individual units of communication in the form of emojis and character-by-character typing, investigating computational and expert-based prediction models for emotion, and examining empathy in populations that seek it most. With our work, private social messaging data can be sampled cost-effectively from a large number of participants, and we pose key questions to the research community to continue studying the meaning behind messaging and its metadata.

Overall the work was well-received by the community of researchers. It produced 3 publications at top-tier venues [2, 3, 4], and two additional papers which have been reviewed and deemed "Revise and Resubmit" which may then lead to publications in January 2024 [5, 6]. Finally, software components built during the work have been released [7, 8], and both software projects have been used by people for their intended purposes.

*Grants:*

[1] Social Media Use, Sleep, and Suicidality in Adolescents, NIH National Institute of Mental Health RFA-MH-23-115. September 7, 2023 to July 31, 2028. PI Nicole Nugent, Co-I Jeff Huang, Brown University.

*Published papers:*

[2] Sochiatrist: Signals of Affect in Messaging Data. Talie Massachi, Grant Fong, Varun Mathur, Sachin Pendse, Gabriela Hoefler, Jessica Fu, Chong Wang, Nikita Ramoji, Nicole Nugent, Megan Ranney, Daniel Dickstein, Michael Armey, Ellie Pavlick, Jeff Huang. CSCW 2020, Article 111.

[3] Bridging the Social Distance: Offline to Online Social Support during the COVID-19 Pandemic. Gabriela Hoefler, Talie Massachi, Neil Xu, Nicole Nugent, Jeff Huang. CSCW 2022, Article 429.

[4] "Together but not together": Evaluating Typing Indicators for Interaction Rich Communication. Zainab Iftikhar, Yumeng Ma, Jeff Huang. CHI 2023, Article 724.

*Under review, Revise & Resubmit (submitting to second round):*

[5] Understanding Empathy in Online Peer Support: A Cognitive Behavioral Approach. CHI 2024, revise and resubmit. Sara Syed, Zainab Iftikhar, Amy Wei Xiao, Jeff Huang.

[6] Chime: The Impact of Private Online Self-Disclosure on Perceived Social Support. CSCW 2024, revise and resubmit. Talie Massachi, John Roy, Lauren Choi, Gabriela Hoefler, Shaun Wallace, Jeff Huang.

*Software systems developed and released:*

[7] Sochiatrist: a social data extractor used to predict signals of mental health from social messaging data. Brown University HCI lab.

[8] Chime: a social mood-tracking app that encourages social support through emoji-only communication. Brown University HCI lab.

*External references:*

[9] A Computational Approach to Understanding Empathy Expressed in Text-Based Mental Health Support. Ashish Sharma, Adam S Miner, David C Atkins, Tim Althoff, 2020, EMNLP.

[10] Group-Chat Culture Is Out of Control: The most social social media these days is ... texting. And it's gotten overwhelming. Faith Hill, The Atlantic. September 28, 2023.

<https://www.theatlantic.com/family/archive/2023/09/group-chat-whatsapp-social-media-replacement/675473/>