

Loneliness on Twitter during pandemic: A tale from two sides

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Abstract

During the pandemic, people all around the world are striving for connection through social media as the only means available left for them to alleviate their loneliness. In this work, we are interested in the feeling of loneliness at its core level, and we attempt to investigate how people perceive and express loneliness on social media. Whereas most works focused on either analysis using mined data from social media or using survey/questionnaire, we want to utilize both of them to carry out the best results possible. We mined data related to loneliness from Twitter and combined it with the results we got from the survey on Vietnamese people. We found that people generally talk about loneliness in regard to themselves and how to alleviate that feeling. Our survey showed that there is no aspect of one person that makes him or her significantly more lonely than others. Besides, we found that tweets about loneliness are mostly personal and emotionally complex, encompassing mainly sadness, happiness, anger, and fear. We hypothesized some types of loneliness from the sentiment correlation. We also analyzed how and why people use hashtags and retweet functions when it comes to sharing about loneliness. Overall, our findings are important to develop a better understanding of loneliness and how people perceive and display it on social media in the context of the pandemic.

Keywords: loneliness, twitter, LDA, sentiment, survey, pandemic

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1 Introduction

‘Before you can be with others, first learn to be alone,’ that is what we are taught since our very first day to experience a strange feeling that makes us feel depressing- something

called “Loneliness”. Loneliness becomes prevalent to everyone across human history. It is not static but rather dynamically evolves [1]. Loneliness has been integrated into our genes, became our social fabric, the drive that binds individuals into a community. Yet, it presents to us as a negative feeling to avoid at all costs. First, loneliness is subjective and can be different to individuals, even to the same individual at different points of his or her life. Discussing loneliness requires one to be concerned about the context that it is situated in, including gender, age, science, religion, ethnicity, environment, and even economics. Secondly, loneliness is a conscious experience, arising from the deficiency in one’s social networks. Thirdly, loneliness can be momentary or chronic but generally is distressing and unpleasant.

The pandemic outbreak has worsened our “loneliness epidemic”, which has already been terrible by itself, by the stay-at-home policy. People crave social connections from social media, which came with the promise of a more connected society yet now receives pessimistic views from the general public. Without regard to one’s pessimism, social media becomes an inevitable part of human life, and therefore significantly shapes their life, including the social network.

By getting into the messy relationship between Loneliness and social media in the context of the pandemic, this study wants to generate more insight into human loneliness through their expression of loneliness and people themselves. Therefore, this study conducts an original research on people’s attitudes on loneliness and what they talk about in relation to it. We conducted two independent studies to investigate the feeling of loneliness on social media, lonely people, and the relationship between them. The first half of the research will closely look at what people share and post on Twitter, using LDA (Latent Dirichlet Allocation) and orange sentiment analysis. The second half will examine people’s loneliness and its relationship to their demographics and perception, specifically on the population of Vietnam. By doing so, we want to find the answer to our research questions:

1) How do one’s demographics make him or her lonelier than the average, and why, especially in the context of the pandemic and digital age?

2) Why do people talk or do not talk about loneliness, especially on social media - the only means available left for communication during the pandemic?

3) Which tone do people choose to talk about loneliness and which stories do they tell encompassing their loneliness?

4) Is there anything special about the way people talk about loneliness? If yes, what functions does it play in the communication about loneliness?

2 Literature Review

Loneliness exists in the modern world as a part of the social fabric. It is often used as a shorthand for a sense of disconnect, for the depressing feeling and alienation, or the absence of usual happiness [1]. Therefore, it sometimes becomes a convenient way to imply several discontents. The situation can become more terrible as loneliness comes to bind with a disability, vulnerability, or mental health problem. However, loneliness is much more complicated. It is a protean concept layered with meanings, which can be physical, emotional, symbolic, attitudinal, and sensorial [1]. Loneliness is contagious and deliberately distressing so that one may fear and try to avoid it at all costs. Loneliness can be a choice of life - a companion, rather than a shadow. Sometimes, it is sought after, and indeed, beneficial. It can help one to think, grow and learn more about the self and others, which possibly increases social integration because as human beings, we are an indispensable part of a greater force than ourselves.

2.1 "Modern" Loneliness

In the modern-day, there is no consensual definition of loneliness when it comes to either academic jargon or common language, and the lonely experience is unique for every individual, at different points of their lives too [27]. Different definitions of loneliness have been proposed in attempts to understand this emotional state. Without regard to those differences, the experience of loneliness must comprise four major elements including interpersonal isolation, self-alienation, agony, and distressing reaction [39]. Besides, the concept of "loneliness" is underlined by three assumptions regarding its origin, nature, and effect. Loneliness arises from the shortage of perceived social interaction either qualitatively or quantitatively, which is subjective to individuals, yet is commonly unpleasant and distressing [10, 29, 49]. Sometimes, loneliness is considered pervasive either at a personal or interpersonal level [27]. Loneliness can be momentary or chronic. To some people, the experience of loneliness is nothing different from stepping into the ponds on a rainy day-easily getting out and may encounter others at different stages of life. To some, loneliness feels like a boundless ocean.

Many researchers have found loneliness in a positive correlation with social skills [9], introversion [29], depression and anxiety [14], internet use [8], while some have given the opposite findings. Without regard to empirical evidence of loneliness's negative impacts on human life, loneliness is generally viewed negatively and the strategy to combat it is sought after by many countries. The UK even appointed a

"minister of loneliness" to tackle the social and health issues that arose from loneliness in 2018.

2.2 The complexity of loneliness

An enormous amount of research has been devoted to understanding loneliness since the eighteenth century when loneliness became a serious problem as a hazard of modern society. However, many researchers have overlooked the complexity of loneliness.

First, different countries view loneliness differently, and indeed some do not have a common language for loneliness such as Middle Eastern countries. In the meantime, some studies while trying to understand the biological inevitability of loneliness have ignored the fact that loneliness is also a product of one's culture and circumstances. Sometimes, the stigma of loneliness also influences the results such as the assumption about the inevitable loneliness of old people, which in turn magnifies the distressing feeling of old age and the feeling of loneliness [44].

In many studies, loneliness is pathologized, framed as a condition similar to depression anxiety, which therefore drives neuroscientists to develop a 'loneliness pill'. 'If there are medications for social pains like depression and anxiety, why not loneliness?' asked Laura Entlis in The Guardian. Yet, the way the media took up and ran with the story misled general understanding from the public. The 'loneliness pill' indeed targets the distressing emotional symptoms of loneliness rather than the feeling of loneliness itself.

However, it is also undeniable that the alleviation of distress feeling can help lonely people integrate into society better, which in turn reduces the feeling of loneliness. Therefore, loneliness should be regarded as a reflection of many bigger social concerns including gender, religion, ethnicity, age, science, environment, and even economics [1].

Hence, this study aims to come back to the very core of the problem and try to define "what is loneliness?" in the context of social media during COVID-19.

2.3 Social media and Loneliness

Social media has become an indispensable part of human everyday activities in the 21st century. It has fundamentally reshaped how people communicate, and brings about a 'relationship revolution' as a result, opening opportunities for people to communicate, interact and share information that used to be inaccessible [25]. The effects may vary as to some, relationships mediated through social media may help them feel more connected while to others, they may feel more distant [25].

Virtually every aspect of social media usage is now assumed to be accompanied by certain potential threats to users' well-being [13]. Despite the undeniable benefits of social media, its popularity is moderately shadowed both by sensible and irrational claims about its adverse impacts

including mental health issues, dysfunction, and notably loneliness [13].

Those claims frequently have been made with the oversimplification of the relationship between social media and its negative impacts. For instance, from the correlation between screen time and loneliness, one can hastily argue that it is because of social media that makes people feel more lonely without taking into consideration the context of the society that finding placed in [30].

A recent finding disproved that myth by delineating that internet usage can be a distraction to cope with loneliness [34]. In short, the relationship between loneliness and social media usage is complicated [28]. Contrary to the conventional view, a new turn in research has debunked those myths and pointed out that social networking sites can be a mechanism to cope with loneliness [6, 42], alleviate loneliness [12, 37], and can help people build social relationships online [33].

Notably, the outbreak of the coronavirus pandemic has made virtual communication through social networking sites become the only means left open for social connection. It brings to researchers both questions and opportunities to investigate the relationship between social media usage and users' loneliness in such conditions. Understanding people's loneliness accompanied by social media requires identifying who experiences it. Traditionally, the understanding is made through surveys [21, 35, 36], but many researchers have provided an alternative method through social media itself [18, 23, 28]. As social context and communication boundaries have been blurred on social media, people increasingly use social media as a means to inform others about their daily life and mental states [17, 19]. Therefore, it has been pointed out that social media is a potentially relevant tool to passively investigate people's mental states and behaviors [18, 26, 28]. Interestingly, research has shown that lonely people found social media to be a useful tool for social connection and self-disclosure [24].

Hence, this study aims to be one of the very first studies to investigate loneliness through what people post on social media. Besides, this study is the first one to integrate surveys to understand what people share about their loneliness, what they really feel, and most importantly, what is the relationship between the two dimensions.

3 Methods

To investigate loneliness through what people post on social media, their perception of loneliness, and the relationship between two dimensions, this study includes two tasks:

- Analyzing tweets expressing loneliness from Twitter
- Analyzing the loneliness survey on social media users.

3.1 Twitter Data

Twitter was chosen as one of the most popular social media sites that allow users to mine data for research purposes.

From the code we have written, which can be found in Supplemental Documents, we have mined approximately 150,000 tweets containing at least one keyword related to loneliness, which we mentioned in Supplemental Documents, on January 3rd, 2022 (ICT). The keyword we set as a criterion to mine tweets must include the two most prevalent aspects of loneliness: being alone and having a negative feeling. [11, 15]. In the meantime, those tweets were also analyzed using LDA [7] and visualized using LDavis [43].

3.2 Survey Participation

A survey was developed by integration of UCLA loneliness scale [40] - the first loneliness scale to achieve widespread acceptance among scientists, and the personal questions formulated by us. The survey used in this research can be found in Supplemental Documents. The survey was released on Facebook from December 26, 2021, to January 1, 2022, for Vietnamese social media users only under the form of a Google Form. 202 valid responses have been collected and analyzed using Python. Among our respondents, 132 were female, 65 were male, 4 were non-binary, and 1 identified with others. The dominant age group was 14-20, which made up 85.1% of total responders, followed by the 21-31 age group with 13.4% and the 31-65 age group with 1.5%. Other demographic information regarding respondents can be found in Supplemental Documents.

4 Results

4.1 Sentiment Analysis

From the sentiment analysis and correlations, we find a high correlation between happiness and sadness (0.727). This suggests that Sadness and Happiness often go together in the tweets, which can be interpreted as people usually accompanying sharing about loneliness with positive emotions online. Besides, the experiences of sadness correlate with expressions of anger (0.725) and disgust (0.642). Anger and disgust also correlate with one another (0.709) while having a moderate correlation with happiness (respectively 0.499 and 0.452). On the other hand, fear and surprise also have a positive correlation with sadness, anger, disgust, and happiness (respectively 0.360, 0.448, 0.176, 0.363 and 0.269, 0.406, 0.452, 0.196) while having a 0.480 correlation with one another. Besides, sentiment had a negative correlation with most emotions, including anger (-0.306), fear (-0.253), disgust (-0.224), and trivial correlation with others (correlation coefficient falls between -0.1 and 0.1).

Posts about loneliness tend to be personal in terms of topics and tone. The data showed that four sentiments: happiness (0.861), sadness (0.640), fear (0.815), and anger (0.332) were highly rich in tweets related to loneliness posted on Twitter. Otherwise, surprise, disgust, and sentiment had a mean value of approximately zero.

4.2 LDA analysis

Among the mined tweets, only 8.5% of them included hashtag(s), and 40% of them are retweeted tweets. LDA analysis of the text of every mined tweet showed that most of the topics are related to loneliness experienced at a personal level while some of them are related to other things, such as an Indian film (Topic 6) and Political Issues (Topic 10). There was no significant difference between topics extracted from the retweeted text and every tweet text. However, all LDA topics were shown to be personal when the LDA analysis was applied to the full text, which did not have any hashtag. Text without hashtags tend to include topics concerning personal sentiments and related to mental health (top-down): desires, healing, relationship, resentment, in daily life, during covid. Meanwhile, LDA topics analysis of text with hashtags mostly comprised political subjects and arts and media-related subjects. Tweets with hashtags are often less personal, have a much more 'public' tone, and allocate to a public audience: self-reflection, Kpop, film, social activism for the minority, social topics like arts, film, and music. The LDA analysis of hashtags again confirmed the findings that hashtags were mostly related to music, media, and arts or political problems including war and conflicts. Among the posts that contain hashtags, the topic on arts, music, and artists constitute the highest proportion. Following after is animal activism (Orca the lonely whale), human and political affairs (Myanmar, Ethiopia). Those are much more social topics than the topics about healing, relationship - personal matters, and require sharing to spread awareness.

4.3 Survey Analysis

Among 202 responses, the survey showed that when talking about loneliness on social media, the most topics people talk about is about Self-Development (71) then followed by Educations/Science (65) and News/Social Event (41). Other topics to talk about regarding loneliness is Covid 19/Pandemic (31), Social media/ Technology (30), Consequences/Causes (27), Finance/Economics (12), and Others (2). Notedly, 78 respondents claimed that they never talk about loneliness on social media. On average, respondents had 2 topics to talk about in regards to loneliness. Among reasons to talk about social media (if possible), 64 respondents chose to Perceive connectedness, 62 aimed for Social support, 56 wanted Self-Expression, 40 for Education/ Social Awareness, 23 for Purely Entertainment, and 1 for others. Interestingly, we received 70 responses saying that they only talk about loneliness via private chat while 49 said they saw no reason to talk about loneliness on social media.

The results from the survey found that the mean of loneliness score of male highest (45.46), followed by non-binary (44.75), then female (44.84). The finding is in agreement with the paper on the revised UCLA scale [41], which was conducted in 1980 when there was no coronavirus pandemic and

the usage of social media. Besides, the score is also higher than the finding from the research conducted before covid but after the birth of social media. [2]. Without regard to hours using social media, the loneliness score of females fell between 45.43 and 46.39, with the peak at the group using social media 4-6 hours per day. However, females who used social media 1-2 hours per day have significantly low scores of loneliness (42.78). The group of males using social media less than 1 hour per day also experienced considerable loneliness (50.5) compared to other males (44.7- 46.2). On the other hand, the results of our survey showed that age did not affect much on one's loneliness as people from groups of 14-20, 21-30, 31-65 had the loneliness score of 45.02, 45.37, 44.7, respectively.

It is interesting to note that respondents who used social media, which is not popular in Vietnam, experienced a slightly higher score of loneliness compared to respondents who did not use, respectively including Twitter (45.59 and 44.89), Reddit (45.08 and 45.06), Tiktok (46.00 and 45.04), Snapchat (45.46 and 45.01). Meanwhile, the loneliness score correlates to the time using social media in an upside-down bell shape with the highest score belonging to the group using social media under 1 hour per day (47.27) and who used social media more than 6 hours per day (46.15) while the group using social media

2-4 hour experience least loneliness (43.59). The frequency of using social media also significantly affected one's loneliness in a generally increasing trend. People who used social media every time possible experienced less loneliness (42.73) while the one who used it once per several weeks experienced the most (50.8). The volunteers were also asked questions specific to Twitter. Without regard to the reasons to use Twitter, respondents using twitter score similarly on the loneliness scale (Data can be found in Supplemental Documents).

When collecting the results about the frequency of sharing loneliness on social media, and in-person (scale from 1 to 4, with 1 is the lowest), the data showed that people had a low tendency to share about loneliness on social media and in-person with the score of 1.78 and 2.17, respectively. A trend having an upside-down bell shape had been found. Regarding sharing loneliness on social media, those who chose 1 and 4 had the highest loneliness score, respectively were 45 and 48.8. Without regard to respondents' frequency of sharing about loneliness in person, there was no significant difference in loneliness score.

In the questions about topics to talk about loneliness, the difference in respondents' choice and the number of topics one can talk about did not make the difference in their loneliness score. However, people who talked about Covid 19/ Pandemic in regards to loneliness (42.32) experienced lower loneliness compared to those who did not talk about it (45.56). Regarding questions about reasons to talk/share about loneliness on social media, those who did for the sake of perceived connectedness and purely entertainment were

more lonely compared to those who did not (46.05 and 44.6, 46.65 and 44.86, respectively). Besides, those who talk regarding Education/ Social events or only talk in private chat experienced less loneliness (43.45 and 45.47, 43.61 and 45.84, respectively). Different respondents' reasons to talk/share about loneliness on social media and the number did not significantly correlate with their loneliness score (Data can be found in Supplemental Documents).

In the question about people's truthfulness about their disclosure of being lonely, the loneliness score increased from 44.83 (the least honest) to 45.94 (moderately honest), but significantly decreased to 43.24 (the most honest).

Regarding impacts on the pandemic on one's loneliness, those who were more isolated had more free time and had loneliness heightened experienced more loneliness than those who did not get this effect (46.01 and 44.51, 45.37 and 44.94, 46.86 and 43.52, respectively). Interestingly, those who were are of their mental health were affected (44.48) experienced less loneliness than those who were not (45.25)

5 Discussions

5.1 Demographics versus Loneliness

The results of the survey about the motivations and topics to talk about regarding loneliness showed that people mostly talk regarding themselves. They wanted to talk about certain topics because they want to talk about their development, well-being, and knowing such distressing feelings. They talked about loneliness because they want to feel connected, to search for social support, to express themselves, and to educate others. Interestingly, people tend to avoid talking about their loneliness on social media, especially to the public. It is believed that the social stigma of feeling lonely is being weak and annoyed. [31]. Despite respondents' high loneliness score, the majority of them do not want to talk about it, especially through social media - the one means left to communicate during the pandemic, which therefore can explain the high loneliness score.

The findings from the survey one again confirmed that demographics regarding gender and age) do not make one significantly more or less lonely compared to people from the other group. Besides, regarding most of our categories, people's differences do not significantly affect their loneliness. However, there are still certain differences. There is a clear pattern that people who use social media too often or too infrequently are the most lonely. However, it is interesting to note that if a person used one more social media compared to his or her peers, he or she will likely be more lonely. Yet, we are aware that we should not readily view this relationship as one way because loneliness is also a motivation for people to seek more meaningful relationships through social media as has been shown elsewhere.

In the meantime, the two loneliest groups are the group sharing least and the group sharing most about loneliness

on social media. It is reasonable because loneliness is a conscious feeling as people may not be aware of it, and therefore not feel lonely. However, it seems to not be the case here. In our questions regarding different impacts of social media and covid on respondents' life, there is a general trend that respondents who were aware of how terrible the situation was less lonely compared to their counterparts. In the meantime, it may lead one to hypothesize that we can better deal with loneliness by being aware of how terrible the situation is. It is in agreement with other research, where "high private self-conscious adolescents' greater willingness to self-disclose to peers resulted in their feeling less lonely". Therefore, we propose a new insight into loneliness coping mechanisms and confirm that social media and pandemics did affect people's loneliness, yet not necessarily negatively. Besides, this research also showed that people's loneliness is still increasing, compared to preliminary research indicating that the public health problem regarding loneliness is growing and so should our concern. In the meantime, from the little difference in loneliness caused by different factors, we hypothesized that there are no certain traits that can significantly make one lonelier than others. In other words, the most predictive factor we can use to predict one's loneliness is the time they live, the later on human history, the more lonely they are, which may be linked with the development of individualism and industrialism. [1]

5.2 Loneliness experiences depicted on Twitter

Because the feeling of loneliness already encompasses sadness, the high correlation between happiness and sadness in sentiment analysis indicates that the dominant amount of posts about loneliness is written in a positive tone. The posts tend to be happy, and will also be reflexive and recollective of experience - where the sadness comes from. This happiness is supposed to come from getting through the trauma of these lonely experiences. On the other hand, the correlation data showed anger, disgust, and sadness were strongly correlated to one another. However, anger and disgust have a moderate correlation with happiness. Therefore, there must be at least three typical types of tweets about loneliness on social media: the one accompanied with happiness - the supposedly reflective one, the one associated with anger and disgust - tweets expressing resentment, and the tweets encompassing all four mentioned emotions.

On the other hand, happiness is not encompassed by the definition of loneliness, by most papers to date, but was presented to be the most dominant emotion in tweets about loneliness. Besides, our survey results showed that people's willingness to share about loneliness on social media authentically is low. Hence it is understood here that most of those posts are not about the feeling of loneliness itself but a way of using the feeling called "loneliness" to express the triumph of getting through it or the loneliness accompanied with the path to happiness, which once again confirmed through

many among most LDA common topics, such as healing or describing the experience. Besides, fear was the second dominant emotion, which is in line with preliminary research. Loneliness is accompanied by FOMO [20], hopelessness [48], war [45], old age [4], uncertain relationships [1], and disability [16], all of which are associated with fear. Anger is presented in LDA as a topic, while happiness and fear are the nature of the topic. Yet, anger is not prevalent in the sentiment score. We hypothesized that it is because loneliness is associated with the passive and vulnerable status where people are in the state of needing someone. Meanwhile, the feeling of anger is a strong feeling that requires one to be active. Hence, it is reasonable here that people may feel resentment towards others or things that make them lonely, but they can do little about it, and therefore not much anger is presented here. However, in general, it is shown from the results that most of the tweets encompass many emotions, beyond the distress and sadness of loneliness. Therefore, it suggests that our modern view of loneliness has been shifted to more emotionally complex.

5.3 How loneliness is expressed

Our mined tweets showed that only 8.5% of them include hashtags. Besides, all of the hashtags were political or entertained to some extent. According to Andreas Bernard, the hashtag is no longer a functional sign but has been a promising social symbol, which stands for the generation and accumulation of public attention [5]. It has been a signature of many political matters, including Ferguson, BlackLives-Matter, and MeToo. The hashtag has enabled the ignored or overlooked group of people to collectively speak up for the attention of the public sphere. In the meantime, the hashtag can “allows the writer to comment on his emotional state, to sarcastically undercut his tweet, to create an extra layer of irony” [46]. According to Twitter, the support page in 2018 has explained for users to “index keywords or topics” of their content and to easily find the topics they are interested in. [38]. In addition, a hashtag can promote a topic, and for posting reach purpose [47] or to identify the posts of their interest. [22]. It also received a wide adoption by many other popular social media platforms, such as Facebook, Instagram, LinkedIn, and WeChat. [38]

In this research, the data showed that none of the personal issues were raised through the hashtag, which therefore indicates the disregard of loneliness as a personal problem requiring public attention. However, people may express their loneliness through metaphors such as music, Orca- the loneliest whale, which makes their feeling of loneliness not stand as an urgent public health issue but rather a poetic image. On the other hand, people did express their loneliness but in the context of war, which had the main focus on the war itself. Therefore, the data suggested that loneliness is not regarded as a public health issue as stated in many papers, but only regarded in concern of war or conflict. Otherwise,

loneliness was regarded as a personal problem and people were positive about it. On the other hand, the LDA analysis of tweets without hashtags yielded the 10 most common topics only about personal issues. Therefore, it is worth noting that people are generally concerned about loneliness only at the personal level. They did not require any attention for their loneliness other than from their social network.

Besides, it is also interesting that up to 40% of the mined tweets were retweeted. One researcher recently found people retweets because they want 1) Show support to the tweeter, 2) To argue against a tweet, 3) to gain attention, and 4) to entertain. [32]. Due to the nature of loneliness, reasons 4 can be reasonably excluded as loneliness is generally negative. It is clear among the LDA topics, some fall into categories of three remaining reasons. Topic 10 is about politics, which therefore may relate to arguing. Topic 6, which presumably falls into reason 1, is about a female character in an Indian film named Bigg Boss, who had received a public concern for their mental health. Reason number 3 presumably can apply to all remaining topics as literature papers [3] have shown that people tend to disclose about themselves on social media to get public attention. However, it is undeniable that some topics can fit into more than one category. Besides, the high number of retweets also indicates two things: 1) the social need of the users of the original tweets had been responded to and 2) people sometimes share information about loneliness, as an alternative method to speak for themselves. The result is in line with our findings from our survey, which together showed that people did not want to share about their loneliness, therefore they tended to share their other thoughts which spoke for them.

6 Limitations and Future Work

The study used Twitter and surveys to understand more about human loneliness, yet both of the tools have their imperfections. First, the data is obtained from Twitter by using keywords in English, which may not capture slang, abbreviation, and other languages, which therefore may be biased towards formal English writing tweets. Besides, Twitter users can not be representative of the general population. For instance, in the US, 40% of Twitter users are between the ages of 18 and 29. Besides, the data we mined and surveyed was around New Year - the festive time, which may change behavior, location, and level of loneliness from the users or respondents. The survey also gave a small gift for respondents of the survey, hence the results could have reflected the bias of respondents. In addition, we have not taken into consideration the economical context, cultural difference, and the difference between their social need and the social need available to them, which in turn results in their loneliness. In future work, we aim to work again on the questionnaire to produce a more robust survey, which can capture users' information better. Besides, we aim to

broaden the scope of our project by mining data from many social media network sites besides Twitter using many more languages. In short, we acknowledge that this research is far from perfect but is really replicable, can be utilized to investigate more aspects of humans in different contexts, and provide a great insight into different perspectives of human's loneliness at the intersection of the digital age and the coronavirus pandemic.

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References

- [1] Fay Bound Alberti. 2019. *A biography of loneliness: The history of an emotion*. Oxford University Press, USA.
- [2] Sofia Esmeralda Auné, Facundo Juan Pablo Abal, and Horacio Félix Attorresi. 2020. Modeling of the UCLA loneliness scale according to the multidimensional item response theory. *Current Psychology* (2020), 1–8.
- [3] Natalya N Bazarova and Yoon Hyung Choi. 2014. Self-disclosure in social media: Extending the functional approach to disclosure motivations and characteristics on social network sites. *Journal of Communication* 64, 4 (2014), 635–657.
- [4] M Berg-Weger and John E Morley. 2020. Loneliness in old age: an unaddressed health problem. , 243–245 pages.
- [5] Andreas Bernard. 2019. *Theory of the Hashtag*. John Wiley & Sons.
- [6] Helena Blažun, Kaija Saranto, and Sari Rissanen. 2012. Impact of computer training courses on reduction of loneliness of older people in Finland and Slovenia. *Computers in Human Behavior* 28, 4 (2012), 1202–1212.
- [7] David M Blei, Andrew Y Ng, and Michael I Jordan. 2003. Latent dirichlet allocation. *the Journal of machine Learning research* 3 (2003), 993–1022.
- [8] Scott E Caplan. 2002. Problematic Internet use and psychosocial well-being: development of a theory-based cognitive-behavioral measurement instrument. *Computers in human behavior* 18, 5 (2002), 553–575.
- [9] Scott E Caplan. 2005. A social skill account of problematic Internet use. *Journal of communication* 55, 4 (2005), 721–736.
- [10] Martha Carr and Cynthia Schellenbach. 1993. Reflective monitoring in lonely adolescents. *Adolescence* 28, 111 (1993), 737–748.
- [11] Janez Demšar, Tomaž Curk, Aleš Erjavec, Črt Gorup, Tomaž Hočevar, Mitar Milutinović, Martin Možina, Matija Polajnar, Marko Toplak, Anže Starič, et al. 2013. Orange: data mining toolbox in Python. *the Journal of machine Learning research* 14, 1 (2013), 2349–2353.
- [12] Tineke Fokkema and Kees Knipscheer. 2007. Escape loneliness by going digital: A quantitative and qualitative evaluation of a Dutch experiment in using ECT to overcome loneliness among older adults.
- [13] Bianca Fox. 2019. An Introduction to Emotions and Loneliness in a Networked Society. In *Emotions and Loneliness in a Networked Society*. Springer, 1–9.
- [14] Martha J Foxall, Cecilia R Barron, Kathleen Von Dollen, Kelly A Shull, and Patricia A Jones. 1994. Low-vision elders: living arrangements, loneliness, and social support. , 6–9 pages.
- [15] David Freedman, Robert Pisani, Roger Purves, and Ani Adhikari. 2007. Statistics.
- [16] Linda Gilmore and Monica Cuskelly. 2014. Vulnerability to loneliness in people with intellectual disability: An explanatory model. *Journal of Policy and Practice in Intellectual Disabilities* 11, 3 (2014), 192–199.
- [17] Sharath Chandra Guntuku, Anneke Buffone, Kokil Jaidka, Johannes C Eichstaedt, and Lyle H Ungar. 2019. Understanding and measuring psychological stress using social media. In *Proceedings of the International AAAI Conference on Web and Social Media*, Vol. 13. 214–225.
- [18] Sharath Chandra Guntuku, Rachele Schneider, Arthur Pelullo, Jami Young, Vivien Wong, Lyle Ungar, Daniel Polsky, Kevin G Volpp, and Raina Merchant. 2019. Studying expressions of loneliness in individuals using twitter: an observational study. *BMJ open* 9, 11 (2019), e030355.
- [19] Sharath Chandra Guntuku, David B Yaden, Margaret L Kern, Lyle H Ungar, and Johannes C Eichstaedt. 2017. Detecting depression and mental illness on social media: an integrative review. *Current Opinion in Behavioral Sciences* 18 (2017), 43–49.
- [20] Melissa G Hunt, Rachel Marx, Courtney Lipson, and Jordyn Young. 2018. No more FOMO: Limiting social media decreases loneliness and depression. *Journal of Social and Clinical Psychology* 37, 10 (2018), 751–768.
- [21] Yoosun Hwang. 2014. Antecedents of interpersonal communication motives on twitter: Loneliness and life satisfaction. *International Journal of Cyber Society and Education* 7, 1 (2014), 49–70.
- [22] Sarah J Jackson and Brooke Foucault Welles. 2015. Hijacking#myNYPD: Social media dissent and networked counterpublics. *Journal of communication* 65, 6 (2015), 932–952.
- [23] Kokil Jaidka, Sharath Guntuku, and Lyle Ungar. 2018. Facebook versus Twitter: Differences in self-disclosure and trait prediction. In *Proceedings of the International AAAI Conference on Web and Social Media*, Vol. 12.
- [24] Borae Jin. 2013. How lonely people use and perceive Facebook. *Computers in Human Behavior* 29, 6 (2013), 2463–2470.
- [25] Rodney Jones and Christoph Hafner. 2012. *Understanding digital literacies: A practical introduction*. Routledge.
- [26] Sep Kamvar and Jonathan Harris. 2009. *We feel fine: An almanac of human emotion*. Simon and Schuster.
- [27] Colin Killeen. 1998. Loneliness: an epidemic in modern society. *Journal of advanced nursing* 28, 4 (1998), 762–770.
- [28] Funda Kivran-Swaine, Jeremy Ting, Jed Brubaker, Rannie Teodoro, and Mor Naaman. 2014. Understanding loneliness in social awareness streams: Expressions and responses. In *Proceedings of the International AAAI Conference on Web and Social Media*, Vol. 8.
- [29] Linda A Kraus, Mark H Davis, Doris Bazzini, Mary Church, and Clare M Kirchman. 1993. Personal and social influences on loneliness: The mediating effect of social provisions. *Social Psychology Quarterly* (1993), 37–53.
- [30] Daria J Kuss and Mark D Griffiths. 2011. Excessive online social networking: Can adolescents become addicted to Facebook? *Education and Health* 29, 4 (2011), 63–66.
- [31] Sing Lau and Gerald E Gruen. 1992. The social stigma of loneliness: Effect of target person's and perceiver's sex. *Personality and Social Psychology Bulletin* 18, 2 (1992), 182–189.
- [32] Anuja Majmundar, Jon-Patrick Allem, Tess Boley Cruz, and Jennifer Beth Unger. 2018. The why we retweet scale. *PloS one* 13, 10 (2018), e0206076.
- [33] Janet Morahan-Martin and Phyllis Schumacher. 2000. Incidence and correlates of pathological Internet use among college students. *Computers in human behavior* 16, 1 (2000), 13–29.
- [34] Jayashree Panicker and Ritika Sachdev. 2014. Relations among loneliness, depression, anxiety, stress and problematic internet use. *International Journal of Research in Applied, Natural and Social Sciences* 2, 9 (2014), 1–10.
- [35] Nicola Petrocchi, Anu Asnaani, Alejandra Piquer Martinez, Ashwini Nadkarni, and Stefan G Hofmann. 2015. Differences between people who use only Facebook and those who use Facebook plus Twitter. *International Journal of Human-Computer Interaction* 31, 2 (2015), 157–165.

- [36] Matthew Pittman. 2015. Creating, consuming, and connecting: Examining the relationship between social media engagement and loneliness. *The Journal of Social Media in Society* 4, 1 (2015).
- [37] Matthew Pittman and Brandon Reich. 2016. Social media and loneliness: Why an Instagram picture may be worth more than a thousand Twitter words. *Computers in Human Behavior* 62 (2016), 155–167.
- [38] Philipp A Rauschnabel, Pavica Sheldon, and Erna Herzfeldt. 2019. What motivates users to hashtag on social media? *Psychology & Marketing* 36, 5 (2019), 473–488.
- [39] Ami Rokach. 1988. The experience of loneliness: A tri-level model. *The Journal of Psychology* 122, 6 (1988), 531–544.
- [40] Dan Russell, Letitia A Peplau, and Carolyn E Cutrona. 1980. The revised UCLA Loneliness Scale: concurrent and discriminant validity evidence. *Journal of personality and social psychology* 39, 3 (1980), 472.
- [41] James A Russell. 1980. A circumplex model of affect. *Journal of personality and social psychology* 39, 6 (1980), 1161.
- [42] Ali Haydar Şar, Gamze Yeşim Göktürk, Gülşah Tura, and Nalan Kazaz. 2012. Is the Internet use an effective method to cope with elderly loneliness and decrease loneliness symptom? *Procedia-Social and Behavioral Sciences* 55 (2012), 1053–1059.
- [43] Carson Sievert and Kenneth Shirley. 2014. LDAvis: A method for visualizing and interpreting topics. In *Proceedings of the workshop on interactive language learning, visualization, and interfaces*. 63–70.
- [44] Marcel Smeets. 2021. PREJUDICE: OLD PEOPLE ARE NOT LONELY PER SE, BUT MAY FEEL SO PERSONALLY. *TABOOS AND PREJUDICES IN LONG-TERM CARE* (2021), 40.
- [45] Zahava Solomon, Mario Mikulincer, and Stevan E Hobfoll. 1986. Effects of social support and battle intensity on loneliness and breakdown during combat. *Journal of personality and social psychology* 51, 6 (1986), 1269.
- [46] Julia Turner. 2012. InPraiseOfTheHashtag. *The New York Times* 2 (2012).
- [47] Rong Wang, Wenlin Liu, and Shuyang Gao. 2016. Hashtags and information virality in networked social movement: Examining hashtag co-occurrence patterns. *Online Information Review* (2016).
- [48] Adela Yarcheski, Noreen E Mahon, and Thomas J Yarcheski. 2011. Stress, hope, and loneliness in young adolescents. *Psychological Reports* 108, 3 (2011), 919–922.
- [49] Janet B Younger. 1995. The alienation of the sufferer. *Advances in Nursing Science* 17, 4 (1995), 53–72.

A Supplemental Documents

You can find the summary of our survey and tweets analysis results and our code [here](#).