User Dynamics in Mental Health Forums – A Sentiment Analysis Perspective

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Abstract. Individuals around the world in need of mental healthcare do not find adequate treatment because of lacking resources. Since the necessary support can often not be provided directly, many turn to the Internet for assistance, whereby mental health forums have evolved into an important medium for millions of users to share experiences. Information Systems research lacks empirical evidence to analyze how health forums influence users' moods. This paper addresses the research gap by conducting sentiment analysis on a large dataset of user posts from three leading English-language forums. The goal of this study is to shed light on the mood effects of mental health forum participation, as well as to better understand user roles. The results of our exploratory study show that sentiment scores develop either positively or negatively depending on the condition. We additionally investigate and report on user forum roles.

Keywords: Mental Health, Sentiment Analysis, Big Data, Forums, Natural Language Processing

1 Introduction

Mental disorders are defined as "a combination of abnormal thoughts, perceptions, emotions, behavior and relationships with others" [1]. The term comprises depression, bipolar disorder, schizophrenia, dementia, and developmental disorders such as autism. An estimated 300 million people are affected by depression alone (worldwide) and 15% of people aged 60 and over suffer from one or more disorders [2]. What is more, the world population is aging rapidly. Between 2015 and 2050, the proportion over 60 years will nearly double, from 12% to 22% [2]. Health systems have not yet adequately answered the growing burden. Between 35% and 85% of affected individuals receive no official treatment [3]. In many countries, less than one psychiatrist per 100,000 people is available [4]. Moreover, the fear of stigma discourages people from seeking assistance [5]. Even if willing, those affected often cannot afford the medical treatment [6], since professional help involves expensive clinical procedures [7]. The medical cost of mental health exceeds $200 billion in the U.S., making it the costliest medical condition in the country [8].

The digitalization of health information has created opportunities for individuals to seek self-help and connect directly to other affected individuals [9]. Online information

is free, anonymous, and time- and location-independent [11]. 80% of the U.S. population with Internet access gather information from mental health discussions, and 34% of those read others' personal stories [12]. Mental health forums are particularly appealing to those individuals who are afraid that coming out of the cloak of anonymity may expose them to stigma [33]. Online information is by no means limited only to the younger generation, as the usage of social media by adults aged 60 and over nearly doubles on a yearly basis [13]. Furthermore, studies show that users are more honest and more likely to share personal stories online than in-person [14]. The chance to share experiences, connect with others with similar conditions as well as gain insights from their stories, creates a rewarding experience for the users of these forums [12].

This paper looks into online tools for mental health by longitudinally analyzing sentiment development of user posts in online mental health forums. We investigate (1) the sentiment progression in forums over time, and (2) the user role dynamics, as well as (3) the relation between user role and sentiment. We apply sentiment analysis on a dataset of 500,754 individual posts across 8 mental health conditions collected from 3 leading English-language forums. We show that the longitudinal development of user sentiment differs across conditions and types of engagement. We compare user roles and their correlation to sentiment.

This study contributes to existing research by exploring how engagement in virtual healthcare communities affects users, and the potential to empower patients to self-management. We especially address the application of behavioral analytics for mental health, which has been more widely adopted for commercial purposes [16], by illustrating how text mining can help practitioners and policy-makers in understanding the value and risks of using user-led online tools [17].

2 Conceptual Background

2.1 Online Mental Health Forums

Previous IS research has focused on trust formation in online health communities, triaging of symptoms, user roles in forums [18, 20], but not on forum influence on well-being. We address this research gap by looking into conversation dynamics and their influence on user sentiment. Prior research shows that users recognize risks of posting personal medical information online, they nevertheless share as potential rewards outweigh risks [19]. User roles have been researched in terms of superusers (frequent posters), however not in terms of sentiment and its correlation to user roles.

Prior research has found online communities to be not only helpful for mitigating various mental conditions but also dangerous, as users can be influenced to commit potentially life-threatening actions, as in pro-suicide or pro-anorexia groups [21]. Many of these studies have applied manual analysis, such as user surveys or discourse analysis based on a small sample of posts. Johnsen, Rosenvinge and Gammon [22] used human readers to classify interactions in mental health forums as helpful or unhelpful based on only 102 posts. By manual assessment, Spijkerman, Pots and Bohlmeijer [23] investigated advantages of online mindfulness and meditation practice for depression and anxiety. In a comparable paper, Mitchell et. al. [24] used human coders to analyze

401 posts from 55 forum threads and found that 25% of users with ADD reported positive effects of self-medicated cannabis on their illness. Although human readers provide reliable analysis, the amount of processed posts is very limited. In this study, we analyze 500,754 forum user posts. Such a vast dataset, to the best of our knowledge, has not been analyzed yet in this context, thus allowing us to explore the shared stories and experiences of tens of thousands of individuals.

2.2   Sentiment Analysis

Recently, natural language processing (NLP) techniques such as sentiment analysis (SA), emotion classification, and stigma measurements have been increasingly applied in research on various data sources such as Twitter, Facebook, and online forums [41]. SA can determine sentiment polarity in written text [25], using a classifier such as Naive Bayes to train with a pre-annotated dataset of sentences, and then apply to new data. Sentiment in psychological literature is referred to as mood or affect. There is a long-standing position in psychological research that a well-adjusted mood is crucial for good mental health [26, 27]. A person in good mental health would express about "three times more positive than negative affect" [28]. Diehl et. al. formally showed that the absence or presence of positivity or negativity can be used to distinguish an individual's mental health status (waning vs. healthy). Therefore, while sentiment is not a tell-all signal of mental well-being, it is a fundamental indicator of the progression of a mental state.

Only few papers use SA in the context of online mental health forums. Nguyen et. al. [29] conducted a fundamental effort by comparing the sentiment expressed on depression forums with sentiment in non-depression forums, demonstrating that individuals without depression express themselves more positively. The study directly backs the application of SA as an appropriate method to analyze data from mental health forums. SA has also been applied to pharmacovigilance in social media (Twitter) – the identification of adverse drug effects – by detecting posts with negative sentiment towards specific medications [30], allowing researchers to explore drug effects across a large and diverse population. The study presents an important example in using text mining to identify potentially negative effects of treatments that might have been otherwise considered safe. Twitter alone has been used in a dozen studies where healthcare issues in general have been explored using sentiment analysis [43]. Furthermore, Cobb, Mays and Graham [31] demonstrated by using SA that talking positively about quitting smoking influences social media users to quit in real life. Via SA, the study shows that user-to-user communication can affect life choices. Aspect-based sentiment analysis has also been applied in order to examine how forum users express themselves on specific concepts such as family or therapy [42]. Finally, Wang et. al. [32] applied SA to classify a user's condition. These ways of using SA have had great success and will be even more useful in the future, considering the development of automated online diagnostic tools [6]. What has not been addressed is the effect of participating in mental health forum conversations, and if and how this depends on the way a user engages with the forum and the role they assume.

3   Research Propositions

Many studies have provided evidence that exchanging support and talking to peers can improve well-being [34]. In fact, even if people seek treatment from professionals, they often still participate in online discussions [33]. Participants also enhance their psychological well-being by providing support [35]. As a result, they feel "better informed, confident with the physician, treatment and social environment, improved acceptance of the illness, increased optimism and control, enhanced self-esteem" [34]. Disadvantageous posts may also occur due to the lack of control of quality of information, potentially destructive content that reinforces negative emotions [10, 22]. Some evidence of the possible benefits from participation exists specifically for mental health forums, although findings are mixed mainly due inconclusive studies and a lack of quantitative research [15].

Owing to the exploratory nature of the study, we use propositions to frame our central premises. In our study we look explicitly at forum users who post, therefore in this context users (or participants) are those who post on the forums, whether to ask a question, to share an experience, to provide answers or comment. By applying sentiment analysis, we test if through participation in forum conversations the affect of a participant is improved. Since threads in mental help forums are started with the purpose to solve or at least mitigate the problem of the original poster [15, 34], the sentiment is expected to improve throughout the thread if the conversation is to be proven as helpful.

P1a: The sentiment score of posts within a thread in mental health forums increases throughout the thread with each subsequent post.

Moreover, we expect that after receiving advice and support, the original poster (OP) will improve their mood, e.g. with regards to confidence, optimism, or ability to cope with their mental condition [15, 34, 36].

P1b: The sentiment score of posts by the original poster within a thread in mental health forums increases throughout the thread with each subsequent post.

Second, we investigate whether the proposed positive sentiment progression is true outside of single threads, i.e. throughout a user's general forum participation. Studies [36] found that "helping others" was one of the empowering processes that occurred the least frequently in social support groups, since users have to actively post to assist others. High-frequency posters were found to provide more advice than asking for help [36]. Therefore, if a user is commenting on threads by other users, they will improve sentiment and keep the solution-oriented perspective.

P2: The sentiment score of user posts in mental health forums increases throughout the general participation in the forum with each subsequent post.

Third, we look into the roles that users assume in mental health forums, and the relation between roles and sentiment. Initially, users participate by passively reading [37]. In urgent cases, they will post their problem fast and receive encouragement or advice. However, users also increase their psychological well-being by commenting on and engaging with issues posted by others [35], and providing help to others will indirectly assist in coping with their initial problem. Therefore, we propose that users of mental health forums normally fall into one of two roles, either original posters or

commenters. The interaction between these two user groups is what drives and defines mental health forum dynamics [38]. Proposition P3 is sentiment-independent and helps establish the dynamics of a user's forum lifetime. The analysis procedure for P3 is to look at the timeline and type of user comments - specifically original poster versus commenter.

P3: Users start their forum participation as original posters, then go on to participate and reply to threads opened by other users.
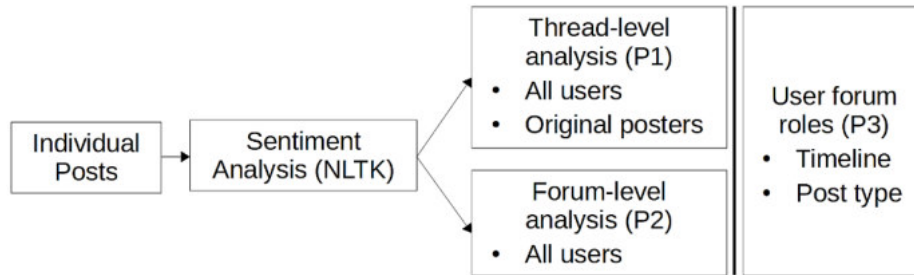

Figure 1. Research Process and Propositions

4   Methodology

To test our propositions, we apply sentiment analysis on peer-to-peer mental health forum posts. Three of the leading English-language mental health forums were scraped to create a combined set of 49,113 threads containing 500,754 individual posts from about 75,000 users across 8 conditions (i.e., depression, bipolar disorder (BD), anxiety and panic attacks, attention deficit hyperactivity disorder (ADHD), Borderline personality disorder (BPD), obsessive-compulsive disorder (OCD), post-traumatic stress disorder (PTSD)). After removing outlying users who have posted more than 30 times, each user posted on average 6,7 posts throughout a forum. The data were extracted in August 2017 and encompass all publicly available posts on the respective websites. For each post, the dataset contains information on forum username, date posted, thread name, and post content. The forums have moderators whose task is to make sure conversations do not go off-topic; thus, we can be sure that in our research we are considering discussions relevant to each condition. Additionally, moderators remove offensive or damaging material (e.g. posts that encourage self-abusive behavior). However, they do not provide advice, as the forum is a place of discussion among the users, i.e. a forum is not meant or seen as a tool to replace established practices such as therapy.

The sentiment score of a post is scored between -1 (negative) and +1 (positive). We use the Python Natural Language Toolkit (NLTK) sentiment analysis implementation with a lexicon-based classifier. Each forum post is given a score. In order to trace the sentiment progression of user posts throughout forums and threads, we map the average sentiment score of individual users' posts based on the post order within threads (P1)

and forums (P2); for proposition P1b we look exclusively at posts made by the original poster within the threads the OP started.

The sentiment is calculated using the Valence-Aware Dictionary for Sentiment Reasoning (Vader) (Gilbert & Hutto, 2014), which offers several unique advantages to other models. The sentiment of a post equals the sentiment valence (or score) of each word recognized by the lexicon. If a word is part of a negation structure (e.g. neither…nor), it's valence will be reversed. If a word is used in combination with a booster word (e.g. "amazingly", "awfully"), its valence will be intensified. The Vader lexicon was built on social media data, namely Twitter tweets, New York Time (NYT) articles, and online movie and product reviews. The sources capture a variety of aspects of social media writing, as well as more analytical texts, thus generalizing well to mental health forum data as it captures features from informal online discussions, e.g. conventional use of punctuation ("good" vs. "good!!!"), capitalization, emoticons, degree modifiers ("good" vs. "very good"), as well as common slang and abbreviations ("this sux", "lol") to signal sentiment intensification. Since its creation in 2014, Vader has been iteratively empirically validated by human judges.

In order to determine the extent of improvement resulting from a prolonged forum posting, we test sentiment score trends by applying regression analysis. For P3, we test the association between user roles and conditions by applying chi-square analysis.

5   Results

Using linear regression, we analyze the sentiment score of a sequence of posts made over a period of time, either within threads or on a per-user basis. Equation (1) models the forum-wide sentiment of depression.

$$y = 0.0011 * x + 0.09 \tag{1}$$

Table 1 presents the regression results and significance for degree of improvement for sentiment trends from three points of view: (1) thread sentiment progression for OP posts only, (2) thread sentiment progression for all thread participants, and (3) sentiment progression per user throughout a forum. Table 1 shows a mild improvement in affect as users keep posting for some conditions, and deterioration in other conditions. The posts of original posters show the highest improvement. The pace of change in sentiment on forums (whether positive or negative) is slightly slower compared to patient improvement observed in therapy. For comparison, a moderate therapy treatment would last 3-4 months and would include 15-20 sessions for 50% of patients to report significant symptom improvement (Leichsenring et. al., 2004). According to our analysis, anxiety, bipolar, and depression forum users must post 100 posts in order to improve their expressed sentiment by 15%. For example, if a depression forum user posts as an OP in threads, the average sentiment improvement per post is 0,003, thus adding +0,3 to positive sentiment after 100 posts. The low R2 values point to high variability in individual user post sentiments. This is consistent with observations from previous studies with a psychological or sociological aspect, as

individuals are relatively meandering in their responses [40]. Testing for weekday effects on sentiment change did not prove to be significant.

Table 1. Regression Results and P-Values for Analyzed Mental Conditions

	OP Thread Posts		All Thread Posts		All Forum Posts	
	Coeff.	**R²**	**Coeff.**	**R²**	**Coeff.**	**R²**
ADHD	0.007	0.2	0.0001	0.2	0	0.2
Anxiety	0.003*	0.3	0.001*	0.4	0.001*	0.3
Autism	0.002*	0.3	-0.006**	0.3	0.002	0.3
Bipolar	0.003**	0.4	0.001	0.2	0.001**	0.2
Borderline	0.001*	0.4	0.0001	0.2	0.0001	0.2
Depression	0.003**	0.8	0.001*	0.4	0.001**	0.4
OCD	0.0001*	0.2	-0.001*	0.2	-0.001	0.1
PTSD	0.0001	0.4	0.003**	0.5	0.001**	0.4
Note: N = 500,754; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$;, Coeff = Coefficient						

5.1 Thread Sentiment Progression of Posts by all Users

Overall, 5 out of 8 tested conditions (i.e., depression, anxiety, autism, PTSD, OCD) show statistically significant sentiment trend. For depression, anxiety, and PTSD, as the conversation thread progresses, post sentiment improves marginally for every subsequent post. PTSD threads have the steepest improvement per post. On the other hand, autism and OCD mark a downward trend, with autism sentiment deteriorating the fastest per post.

Also, OCD and autism threads show significantly more fluctuation within thread posts, whereas conversations in depression, autism, and PTSD have relatively stable trend progressions.
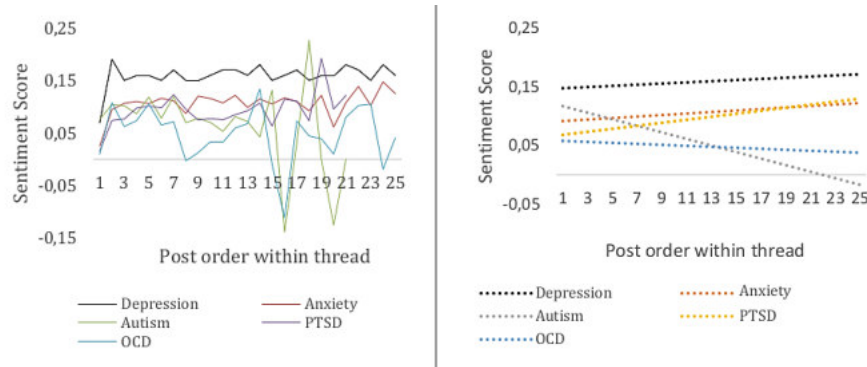
Figure 2. Average Post Sentiment Score Progression within Threads

Based on these findings, Proposition P1a can be confirmed only for depression, anxiety, and PTSD. Thus, mental health forums for these three conditions increase the expressed sentiment in threads that originally started with a lower sentiment score.

5.2 Sentiment Progression of Posts by Original Posters

Across all conditions, OP posts within threads have a positive sentiment score development for every subsequent OP post made (see Fig. 3). However, only 5 out of 8 conditions show significant trends (depression, anxiety, borderline, autism, bipolar). Autism, anxiety, and depression sentiment improve the fastest, whereas depression and borderline forum sentiment improves still, however at a slower pace.

For the most part, the depresson posts by OPs have the highest average score per post order. The anxiety forum exhibits the highest sentiment fluctuation per OP post; interestingly, if an OP opens a thread about anxiety and then immediately follows their own opening post by a second post (usually to provide more detail to their situation), the second post normally has a much lower sentiment score. Thus, those anxiety forum users may be feeling particularly negative when opening a thread, making the subsequent sentiment improvement within their own thread posts that much more substantial.

Based on these results, proposition P1b is supported for 5 out of the 8 conditions tested, showing that, as OPs or advice seekers become more engaged with the thread conversations they start, their expressed sentiment increases.

In terms of improvement per OP post, in all statistically significant conditions, autism forums show the fastest positive sentiment development. This is starkly opposed to general autism posts in a thread, where autism had the worst performance. It is important to note that OCD forums exhibit the same pattern, but without as drastic a change as in the case of autism.
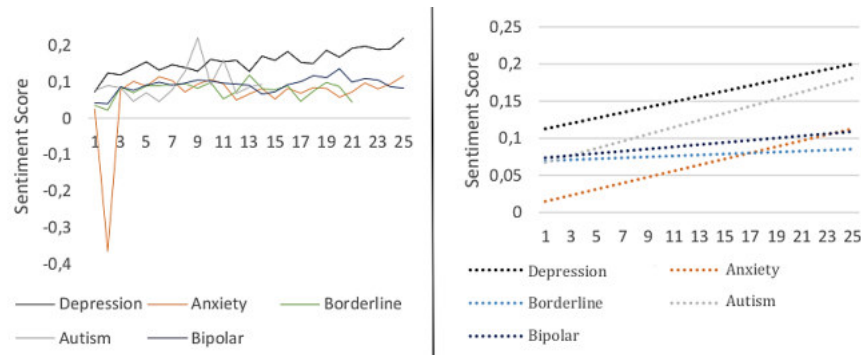
Figure 3. Average Sentiment of OP Post within Threads

Compared to OP-only thread posts, overall thread posts still do improve sentiment score with each subsequent post, however at a slower pace. The coefficients suggest that a forum participant benefits much more from OP posts. Therefore, the forum platforms could encourage users to open their own posts as a way to accelerate and strengthen the increased positivity that results from this interaction.

Additionally, many OPs (50% across all conditions) post only once within the threads they open. However, analysis results indicate that a prolonged participation in the thread which an OP starts actually improves the sentiment within OP posts. Therefore, assuming that the personality of forum members does not play a confounding role, our results suggest that users should be incentivized or encouraged to remain active posters in the threads they create, to draw maximum benefit from their participation.

5.3 Sentiment Progression of Forum-wide Posts by all Users

The 4 out of 8 tested conditions with statistically significant trends are depression, anxiety, PTSD and bipolar disorder, where all show a positive change in sentiment score as a user writes more posts. PTSD marks the highest improvement rates per comment. Of all conditions, only OCD forum users show a negative sentiment score trend with subsequent posts, however the trend is statistically insignificant.

With regards to depression forums, those users with 10 or more posts express a consistently positive sentiment score. Furthermore, the sentiment improves continuously as users post more frequently (regardless of whether as OP or commenter). In the anxiety forum, those users with 42 or more posts express a consistently positive sentiment score. The results point that depression users on average achieve consistently more positive sentiment much faster than anxiety users. PTSD and OCD forum posts show much more variability and fluctuation between positive/negative sentiment. When discussing OP posts vs. thread posts vs. Forum posts (OP and commenter) – the forum-wide posts for the 4 conditions above, even though in general showing positive trend development, mark much more fluctuation in sentiment than the other two post types.
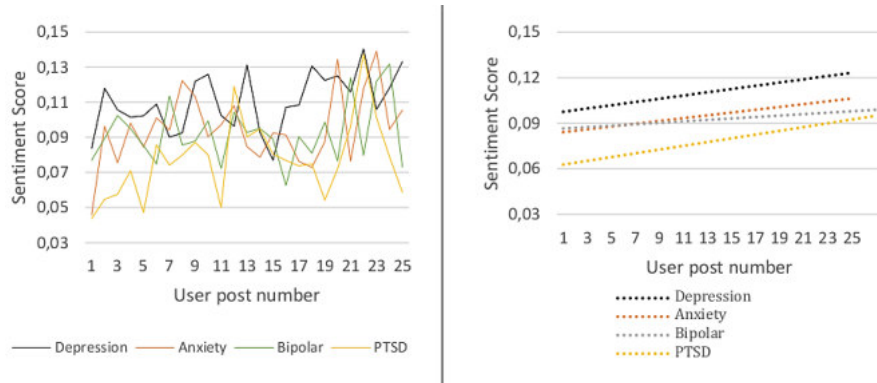
965

Figure 4. Average Post Sentiment Score per User Post Order within Forums

Based on the results presented, proposition P2 is supported for depression, anxiety, PTSD and bipolar forums, where exposure to mental health forums is shown to be beneficial in terms of improving a user's post sentiment per each subsequent post. For propositions P1 and P2, we can rule out familiarity as a reason for increased sentiment, as the sentiment does not appear to increase or decrease significantly faster depending on how long a user has used a forum.

5.4 User Roles Within Forums

Figure 5 shows the partition of users according to roles for each of the eight conditions examined (chi-square test significance < 0.01). We recognize three user roles: users who exclusively use forums as original posters (OP), users who exclusively act as commenters, and users who take on both roles. A very low percentage of users (15%) take on both roles, which suggests that a transition from OP to commenter or vice versa does not happen for most forum users. PTSD forums have the highest percentage of users who only post as OP (39%), as opposed to bipolar forums, where only 20% of all users are only OP.

Overall, around half of participants across forums use the forums only in a capacity of commenters, with bipolar forums having the highest percentage (64%) of users in that category. The results are concurrent with the reader-to-leader framework [39] in that only few individuals make the transfer from one group to another. Looking into the connection between user roles and sentiment scores, the average OP post sentiment across conditions is always lower than the average sentiment for commenters (see Table 2).
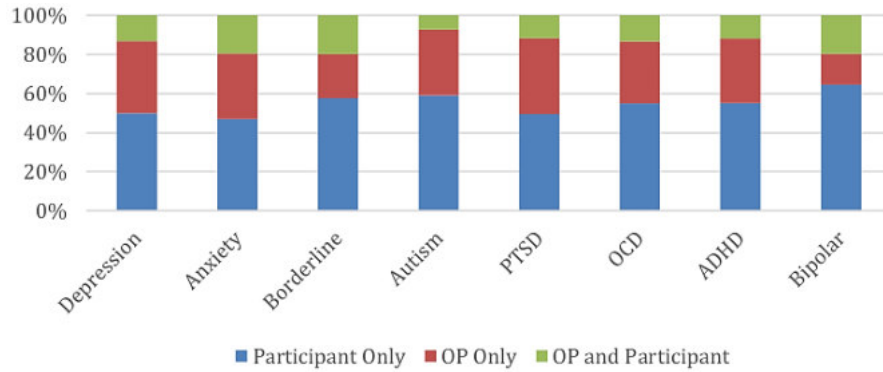
Figure 5. Distribution of User Roles across Conditions

According to the analysis results, there is a correlation between user role and sentiment score. Psychological literature supports the fact that commenters gain benefits by helping other users [36], which is also supported by our analysis. Therefore, forums may be able to further help users in best utilizing forum resources by encouraging participation into the questions and concerns posed by other users.

Table 2. Average Sentiment per User Role across Conditions

	Depres-sion	*Anxie-ty*	*Border-line*	*Autism*	*PTSD*	*OCD*	*ADHD*	*Bipolar*
OP	0.13	0.07	0.07	0.08	0.04	0.03	0.06	0.08
Com-menter	0.16	0.11	0.08	0.10	0.10	0.08	0.09	0.10

6 Discussion and Contributions

Based on our results, in their current form, mental health forums are most beneficial for depression and anxiety sufferers for all roles examined: original poster, commenter, and general forum participant. Some, yet limited benefit was observed for bipolar, borderline, PTSD, OCD, and autism forums, and no benefit for ADHD forums. Borderline forum users benefit only by posting as OP, as opposed to OCD users who only significantly benefit from general thread participation. OCD and autism forum users are the only ones to mark a worsening when participating in threads, specifically in the role of posters (not OP). Research into the content and discourse of the threads and a comparison with contents of other forums can uncover potential conversational and topical differences which might be the reason for opposing sentiment trends. Autism forum users only mark sentiment increase from OP threads. Consequently, autism forum users may benefit from having more options to share their personal stories. These differences in results are important to understand how current forum formats and specific features affect help seekers, and what new features may be

beneficial to introduce in order to facilitate forum usage and maximize benefit for all users. The observations made in this study point to a need to provide more customized options for forum participation based on a user's condition – not every type of participation is equally beneficial for all types of conditions and such customizations could optimize a user's forum experience.

In this exploratory study, we apply automated text mining techniques (sentiment analysis) to provide evidence of the benefit of mental health forums. Specifically, we expand the practical application of text mining to mental health behaviors online, thus showing the potential of this technique to not only describe the behavior of thousands of users online, but also to shed light on the environment in which specific users benefit from forums the most. We show that not all users benefit the same, i.e. that mental health conditions as well as user roles are factors related to expressed sentiment. So far, mental health forums have not in any way been optimized or open to customization and personalization, and this paper shows that the individual users stand to gain from such a thing.

We contribute to research by exploring how engagement in virtual user-driven healthcare communities affects users who suffer from mental health conditions, and the potential to empower patients to self-management. Forum creators and administrators can learn from forum content with behavioral analytics in order to adjust forum mechanisms so that they register positive effects across all conditions, and not just a few. At the example of three of the leading English-language mental health forums, we show which forums are beneficial for specific conditions, so that forum creators can guide the future development of these platforms accordingly. We contribute to healthcare analytics research by demonstrating that machine learning and text analytics can uncover new information on user behavior to be used by practitioners and policy-makers in order to advance forum design. We specifically show that forums can in fact have a negative effect on user sentiment for conditions such as autism or OCD, with a further important observation that a change in user roles (e.g. from commenter to original poster) can play a significant role in sentiment development over time.

7   Limitations and Directions for Future Research

The conducted study presents an initial investigation and, thus, needs to be understood with respect to limitations. These limitations simultaneously represent opportunities for future research.

Our study does not control for all factors internal and external to mental health forums, e.g. moderation and feature effects. Also, we did not control whether users received therapy during participation in the forums, which may have affected forum sentiment. Furthermore, using different measures can help form a more detailed picture of forum effects across conditions. Given the difference in positive vs. negative sentiment development in different conditions and for different user roles, future studies can look into the specific forum mood drivers and mechanisms on a per-condition basis. Each of the investigated illnesses are independently unique, with nuances that cannot be fully captured by sentiment analysis alone; the application of various measures and

an inquiry specifically regarding forum design and moderation may help to provide more detailed answers to this question. Adopting a user perspective, future studies can also address sentiment as a function of user forum life. Finally, this study presents an application of sentiment analysis on a large dataset with sensitive personal data. This raises privacy concerns which require a detailed separate study.

The digitization of health information has created opportunities for individuals to take control of their health, highlighting the evolving socio-technical change that occurs within healthcare [9]. Although our findings highlight the potential applicability of machine learning within mental healthcare practice and research, our analyses are still an initial endeavor in form of an exploratory approach. Further investigation is needed to understand how and why sentiment develop the way they do, and might be a helpful undertaking to comprehend why health forums are visited so often for advice.

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