

Comparing Automatically Extracted Topics from Online Mental Health Disorder Forums

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Abstract—Mental health disorders may share similar symptoms which make differentiating between them for the purposes of diagnosis a difficult task. Bipolar Disorder and Borderline Personality Disorder have been shown to fall into this category. Based on the language used by Reddit.com users in forums dedicated to each of these disorders, as well as forums dedicated to the loved ones of individuals with these disorders, we identify differences that may increase accuracy of diagnosis. We use natural language processing techniques to automatically identify informal topics and patterns in the language extracted from these forums that can be analyzed in a comparative way. We find that there are significant differences in the language used in these different forums that could be applicable to diagnostic protocols.

Index Terms—topic modeling, association rules, word embedding

I. INTRODUCTION

Bipolar disorder (BD) and borderline personality disorder (BPD) are mental health disorders that share similar characteristics. BD affects more than 1% of people globally and is one of the main causes of functional and cognitive impairment in young people. BD is a condition in which an individual experiences episodes of mania, usually in combination with depressive episodes. The high prevalence of suicide among those affected severely increases the need for correct diagnoses, but this is a difficult task. Longitudinal clinical assessment is currently the best known way to differentiate this disorder from other similar conditions [1]. Similarly, diagnosis of BPD is reliant on behavioral patterns that must be present over time and in a number of contexts, and people with this disorder have a high rate of suicide. While BPD affects a similar number of individuals as BD, BPD individuals comprise 9-40% of high utilizers of psychiatric treatment. Individuals with this disorder will exhibit impulsive, self-destructive behavior and volatile interpersonal relationships [2].

It is frequent that an individual with BPD will be wrongly diagnosed as suffering from BD at some point in their life. As previously stated, both of these disorders are difficult

to diagnose, and the similarities in mood related symptoms between the two presents a further challenge in accurate diagnosis. For example, instability in mood, a symptom of BPD, may be mistaken for frequent cycling between manic and depressive states that is characteristic of BD. The major difference between these two disorders is that BPD is a personality disorder while BD is a mood disorder, but even this conclusion is not wholly agreed upon. A misdiagnosis of this type is severe as medications used to treat BD have not been shown to be effective in managing BPD [3]. Greater understanding of each of these two disorders, as well as their differences, may lead to improved diagnostic accuracy.

Social networks provide individuals the opportunity to publicly share on a massive scale. Reddit.com is a popular social media platform for young adults, one study finding that it is used by 42% of U.S. internet users age 18-24. This website features discussion forums called subreddits for essentially any topic. Reddit is highly interactive as users can vote on posts, respond to posts, and partake in private messaging.

It is not surprising that social networks are a popular apparatus for the discussion of mental health issues as they can negate issues such as geographic proximity that previously presented people with certain disorders, especially those like BD and BPD with low prevalence, from interacting with other sufferers. Reddit has been shown to be a particularly useful tool for online mental health discussions, partially due to the anonymity provided by “throw away” accounts, a response to the social stigma around mental health disorders [4].

In previous work, we extracted informal latent recurring topics from online mental health forums, particularly those focused on suicide, depression, and PTSD. Our prior analysis of such latent topics suggests that users in these forums express ideas that are complementary to the risk factors defined by experts, but differ in their scope and language [5]. We also later showed that analysis of these topics over time could be used for trend detection and characterization of topics in

suicidal ideation [6].

In this work, we automatically detect latent topics within four subreddits: *r/BipolarDisorder*, *r/BPD*, *r/BipolarSOs*, *r/BPDlovedones*. We analyze the topics automatically detected within these four forums and compare the relative usage of latent topics between them, as well as analyze associations between different topics. We leverage forums discussing two similar disorders as well as forums for significant others affected by both disorders to meaningfully analyze the differences in the language of those affected by BD and BPD.

Our rigorous evaluation of the language in subreddits discussing BD, BPD, and their respective significant others shows that distinctive language characteristics exist between those with BD and BPD, as well as their loved ones, which can aid in the development of an archetype for each mental health disorder. By providing the colloquial language archetypes of these disorders we can better understand their commonalities and differences. The analysis of these differences can provide means for more accurate and distinctive methods of diagnosis.

The structure of this paper proceeds as follows. In II we describe previous work that has been done pertaining to this topic. In III, we detail the process taken to obtain topic distributions and association rules for the language in each subreddit chosen. In IV, we discuss the subreddits chosen for analysis of BD, BPD, and their respective loved ones. In V, we present experimental findings in the characterization of the language in each of these subreddits using both topic usage distributions and association rules. In VI, we discuss potential limitations of our work. In VII, we discuss potential future applications of the work that is presented in this paper.

II. RELATED WORK

According to a study done by [7], BD affects 2.7% of American adults. Additionally, upon ranking each case as either mild moderate or serious, [7] found that 82.9% of cases were deemed a serious mental health disorder. According to the National Alliance on Mental Illness (NAMI), an estimated 1.6% of American adults are diagnosed with borderline personality disorder (BPD) [8]. Recently, many studies have been published concerning issues with current methods for diagnosing patients with BD or BPD [9], [10]. One study from Oxford analyzed the psychiatrist's interactions with the DSM-IV-TR criteria, a widely accepted standard for clinical diagnosis of mental health disorders [11]. The study found that while psychiatrists demonstrated comprehensive understanding of the criteria, they often felt it unhelpful in aiding in diagnosing and differentiating the mental health disorders of BD and BPD [9]. Another study found that patients with BPD were often at increased risk of misdiagnosis of BD [10].

Significant others of those with mental health disorders commonly display unique characteristics as a result of their relationship with those with a mental health disorder [12], [13]. For example, in [12], a study found that mothers of those with autistic related disorders commonly screened positive for significant psychological distress. In [13], it was found

that marriages between couples with a BD disorder saw high divorce rates and significant volatility in their relationships.

Natural language processing (NLP) makes it possible to do analysis on text scraped from social media websites. While these sources of data may appear more noisy than traditional edited texts, past studies have found that it is possible to clean the text sufficiently with NLP techniques so that the grammaticality of social media text is only slightly worse than traditional text [14]. Once text has been cleaned, typical NLP analysis can be done to learn both semantic and syntactic meaning with models such as Word2Vec.

Work has been previously done on NLP in social media pertaining to mental health. [5], [6], [15], [16]. In one publication, user embeddings based on past social media posts were used to identify mental health conditions of users [16]. In another, the Linguistic Inquiries in Word Count (LIWC) lexicon was used to create a metric representing the degree to which social media users contribute to mental health topics in a one year period [15]. In other publications, word embedding and k-means clustering was used to discern and study trends in relative topic distributions in the language of people with suicidal tendencies [5], [6].

Association rules are a data analysis tool used to find relationships within sets of data. Rules are generated by finding items that occur frequently together and determining the strength of their correlation in order to determine if the occurrence of one item increases the probability of another [17]. There are a variety of algorithms that are used for association rules. This includes the frequent pattern growth algorithm, which mines items that occur together frequently using an efficient tree-based system [18].

Our work differs from these efforts in the following ways. First, we analyze subreddits on BPD and BD and their significant others to get data on the authentic perspectives of those directly afflicted with these diseases and their loved ones. Next, we use k means clustering and matrix algebra to determine relative topic distributions for each subreddit, helping to characterize the language of each subreddit. Finally, we mine association rules to analyze deeper connections in topics for all subreddits. In performing this analysis, we provide characterization of BPD and BD from the colloquial perspective of those directly afflicted with the disease and their loved ones. This in turn could pave the way for better diagnosis and understanding of these diseases in the future.

III. METHODOLOGY

In this section, we detail the methodology used to extract information on topic usage and topic associations to allow for convenient comparison of language distinctions across BD, BPD, and their respective significant others. First, we perform word embedding to allow for topic clustering. We then perform matrix multiplication and association rule mining to produce cluster usage vectors and association rules that can be conveniently compared between subreddits for analysis. The process for these steps is detailed below.

A. Word Embeddings

Word embedding is a technique commonly employed in the field of natural language processing to represent words in the form of a vector in n-dimensional space. These vectors closely orient words together that are similar in semantic and syntactic meaning. By performing word embedding, we can then group words by similar semantic meaning.

A number of widely accepted and used word embedding algorithms exist today [19]–[22]. We chose to use Word2Vec, for its simplicity and efficiency in implementation alongside its ability to accurately extract semantic and syntactic meaning in n-dimensional space. Word2Vec relies on a shallow neural network to produce word vectors. Word2Vec can be implemented as either a continuous bag of words (CBOW), or Skip-gram model. In this paper we implement the Skip-gram model, as per the recommendation of [19], [20]. The Skip-gram model trains the neural network by inputting words and outputting the surrounding context words. Any errors in the context words result in the adjustment of a small sample of neurons; this small sample adjustment is called negative sampling.

B. Topic clustering

After using Word2Vec to embed words, we can now cluster words to extract latent topics from our dataset. We chose to perform k-means clustering, due to its simplicity in implementation, and its ability to make localized clusters of relatively uniform spatial extent.

Each cluster in this representation can be thought of as a topic, containing words of similar semantic meaning. For example, a cluster containing the topic on diagnosing a patient might contain words such as “diagnose”, “diagnosis”, “diagnosed”, “suspect”, “medicated”, and “prescribed”.

Following topic clustering, we can now determine the usage of each cluster with simple matrix multiplication and normalization. When originally scraped, the data for each subreddit was sorted into posts and the words used in each post, which can be represented as a Posts by Words matrix (PW). Each subreddit has a unique PW matrix, and as such the following steps were done for each subreddit.

$$M \text{ Posts} \begin{bmatrix} & N \text{ Words} \\ a_{11} & a_{12} & \cdots & a_{1N} \\ a_{21} & a_{22} & \cdots & a_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ a_{M1} & a_{M2} & \cdots & a_{MN} \end{bmatrix}$$

Figure 1. Posts by Words Matrix (PW)

The PW matrix is a sparse frequency matrix, with each cell representing the number of times a word appears in a given post. After performing k means clustering on our overall model containing all four subreddits, we can represent our created clusters in the form of a Words by Clusters matrix (WC), as seen in figure 2.

The WC matrix is a sparse binary matrix, with each cell representing whether a word is included in a given cluster. A

$$N \text{ Words} \begin{bmatrix} & K \text{ Clusters} \\ c_{11} & c_{12} & \cdots & c_{1K} \\ c_{21} & c_{22} & \cdots & c_{2K} \\ \vdots & \vdots & \ddots & \vdots \\ c_{N1} & c_{N2} & \cdots & c_{NK} \end{bmatrix}$$

Figure 2. Words By Clusters Matrix (WC)

value of 1 indicates that the word is present in the cluster, while a value of 0 indicates the word is absent. By simple matrix multiplication, we can generate a Posts by Clusters matrix (PC), as can be seen in figure 3.

$$M \text{ Posts} \begin{bmatrix} & N \text{ Words} \\ & & & \\ & & & \\ & & & \end{bmatrix} \times N \text{ Words} \begin{bmatrix} & L \text{ Clusters} \\ & & & \\ & & & \\ & & & \end{bmatrix} = M \text{ Posts} \begin{bmatrix} & L \text{ Clusters} \\ & & & \\ & & & \\ & & & \end{bmatrix}$$

Figure 3. Posts By Clusters matrix (PC) produced through matrix multiplication

Each cell in the PC matrix represents the number of times a words from a cluster appeared in a given post. After performing matrix multiplication and obtaining the PC matrix, we now have a representation of the relative usage of each cluster for each post in a subreddit. In order to compare the relative cluster usage of the subreddit as a whole, we sum all of the posts in the PC matrix, creating a vector describing the relative usage of each cluster for a given subreddit (SC).

$$SC = \sum_{i=1}^m \hat{P}C_{ij} \quad (1)$$

Prior to this summation, we normalize the rows of the PC matrix. Normalization of the rows is done in order to ensure that no post is given more weight than another in the scope of the subreddit when summing all of the posts in the subreddit. If this normalization was not performed, one post in the subreddit containing unusually high usage of a certain cluster would skew the subreddit cluster usage towards that cluster, when in reality only one post in the subreddit as a whole used the cluster often.

Normalization is also performed after obtaining the SC vector. This normalization is done to allow for meaningful comparison of the SC vectors for multiple subreddits. If this normalization were not done, disparities in the magnitude of each SC vector would make comparisons meaningless. For example, if the subreddit for BD significant others were significantly smaller than the subreddit for BD, then the usage ratings for clusters in the BD significant others SC would be lower than the BD SC simply because a smaller dataset was analyzed. This process results in a normalized cluster usage vector for each subreddit, as can be seen in figure 4. L1 normalization was used for both cases of normalization.

$$\text{Subreddit} \begin{bmatrix} \hat{d}_{11} & \hat{d}_{12} & \hat{d}_{13} & \cdots & \hat{d}_{1L} \end{bmatrix}$$

Figure 4. Normalized Subreddit by Cluster matrix ($\hat{S}C$)

C. Association Rules

Association rules were first developed for use in market basket analysis to offer increased efficiency in consumer shopping, and offer suggestions based off of common transaction patterns. For example, consumers that buy eggs are likely to also buy milk. These concepts of association rules can be utilized in the realm of online mental health forum. In our case, the post is a transaction, while the topics discussed in the post are the items. For example, when a person with BD talks about their medication, they may be likely to talk about side effects of their medication as well.

Association rules have three values of principle importance in analysis when mined: support, confidence, and lift. For the purposes of defining what these values mean, consider an association rule relating topic A to topic B in a post. Support is the relative co-occurrence of topic A and topic B in posts as compared to the total number of posts in a subreddit. Confidence is the conditional probability that you will see the topic B in a post given that topic A is already there. Lift is the fold increase in probability for topic B to be present in a post when topic A is already present compared to the unconditional probability of topic B to present.

In this paper, we utilize the frequent pattern growth algorithm [23], [24] for the mining of frequent itemsets on which to create association rules. Association rule mining on our dataset was done in a series of steps. First, itemsets are mined based on a support threshold on all four subreddits. Lower support values allow for more rules as the clusters within the rules don't have to occur together as frequently. Itemsets are limited to a one to one relationship, as we are most interested in determining motifs relating only two topics, and relating more than two topics could result in overfitting of our dataset. Association rules were then created on these itemsets with based on a chosen confidence threshold. Once rules were found, rule sets were recorded and itemsets and rules were manually created for all four subreddits using the union of the four rule sets. This allows for convenient analysis of association motifs in all forums, as all forums now contain the same rule sets. The concept of association motifs is further detailed in section V-C.

IV. ONLINE MENTAL HEALTH FORUMS

Reddit is a unique social media modality due to its division of posts by topic, or "subreddit", and the incredible diversity and breadth in topics covered. The subreddits we use in this study are "r/BipolarReddit" and "r/BPD", forums for people with BD and BPD, respectively, as well as "r/BipolarSOs" and "r/BPDlovedones", for the significant others and loved ones of people with the aforementioned disorders. The specifics of the

purpose and make up of each subreddit are detailed following this section.

All were chosen due to their longevity and substantial number of members, resulting in a large collection of text based posts for language analysis. Additionally, we can be confident that the data collected is related to the topic at hand as moderators, users who volunteer to manage a subreddit, actively delete unrelated posts when they occur, which is infrequently due to the sensitive nature of mental health safeguarding the forums from users who have the intention to purposely misuse the website. These subreddits were scraped for post beginning in 2012 and going through 2018. Both r/BipolarSOs and r/BPDlovedones were not created until some time in 2014, but the quantity of posts are great enough that this difference would not negatively affect results. A total of 149,798 text posts were used in the analysis.

V. EXPERIMENTAL RESULTS

A. Experimental Details

The generation of our Word2Vec model, our k-means clustering, and our association rules required a number of experimental parameters. Based on suggested values from the developer of Word2vec, we chose a window size of five and a word vector size of 300 dimensions for training our model [20]. The window size indicates the number of context words surrounding an input word that the model will predict in training. The dimensionality size and window size chosen offer semantic accuracy while remaining efficient.

To choose our number of clusters generated by k-means clustering, we tested k at values between 10 and 400 and graphed the sum of squared errors of the generated clusters against k . We found 100 to be at the knee of the graph. We found this value captured a diverse group of specific topics within a reasonable runtime.

Itemsets, or groupings of clusters that appear together, were mined at a support level of 15 percent in order to gather as many itemsets as possible within a reasonable run-time. We set a threshold confidence level of 50 percent for the association rules generated from these itemsets in order to maintain meaningful data.

B. Relative Cluster Frequency

We consider clusters that have very high relative frequencies in all or some subreddits and present interesting results with possible interpretations using the top ten words and phrases that characterize each cluster.

1) r/Bipolar:

Among the 4 subreddits there are 5 clusters that appear significantly more frequently in r/BipolarReddit. 2 of those clusters talk about food and dieting, 1 focuses on work and career, while the remaining 2 look at school life and classes. This observation that eating habits as well as career and school life are mentioned far less often in forums for people with BPD than in those for people with BD, shows that the latter seems to encompass more diverse aspects of life.

2) *r/BPD*:

Compared to the three other subreddits, *r/BPD* has the highest relative frequency of 3 clusters with top 10 words and phrases relating to feelings and moods. This indicates that people are more likely to talk about, and be descriptive of, their emotions in *r/BPD* than in all three other subreddits. This observation also demonstrates the difficulty to correctly distinguish patients with BD and BPD: although BD is generally considered as a mood disorder while BPD a personality disorder, people active in *r/BPD* seem to more talk about changes in moods in forums than those active in *r/BipolarReddit*.

3) *Comparing Forums about Bipolar Disorder and Forums about Borderline Personality Disorder*:

Three clusters all occur most frequently in *r/BipolarReddit*. Among them, 2 clusters are also frequently seen in *r/BipolarSOs*. The top 10 words in the cluster not as frequently seen in *r/BipolarSOs* revolve around suicidal ideations and hospitalization, while one of the other clusters talks about medications, and the third cluster looks at the financial factors. It seems that people active in *r/BipolarReddit* post more often about hospitalization, drugs, paying for medications, and insurance.

4) *Summary*:

The analysis presented above demonstrates the noticeable distinctions in the languages used in the four forums discussed. Differences in the relative frequency of cluster topics were observed between forums meant for people with BD or BPD, and those meant for people around BD or BPD patients. Some findings agree with the symptoms as well as the diagnostic differences between BD and BPD, others elicit new insights into the characteristics of these disorders.

C. Association Rules

We mined association rules with the intent to generate the largest collection of rules possible while still ensuring that confidence levels were high enough to garner meaningful results. Therefore, we implemented a confidence level of 50% and a support level of 15% as thresholds. The set of association rules was first reviewed manually as a way to determine that results were valid. We expected certain clusters to appear frequently in association rules based on our data. For example, a specific cluster language like “please” and “thanks” is likely to be in most scraped posts considering the purpose of these subreddits is to create a community of support. We found this cluster appeared in 4.9% of our mined association rules.

As our expectations were confirmed, we proceeded to do an analysis on the motifs present in our association rules. Motifs were used as a way to identify important topics in one or more association rules that show a difference between BD and BPD. To establish which association rules could show a difference, a set was extracted of only the rules that had a lift higher than the median of all the lifts for either *r/BipolarReddit* or *r/BPD* and lower than the median of the other. This set of rules showed differences between the two subreddits’ language, but not all rules were relevant to the purpose of our research, namely in trying to identify differences in the language used by

individuals with BP or BPD that may be useful for diagnoses. Therefore, it is necessary when mining motifs to establish the topics that are relevant to particular research and use the association rules encompassed by these topics.

1) *Motif 1: Dating*:

The association rules in this motif are related to the experiences of romantic relationships and both have lifts higher than the median of *r/BipolarReddit* and lower than *r/BPD*. The first rule relates cluster A, which has language surrounding unhealthy relationships, to cluster H which indicates that the relationships being discussed are between two people romantically dating. The second rule in this motif relates cluster B, containing language about positive every day life, also to cluster H. The relative significance of these association rules for the *r/BipolarReddit* community shows that members of this subreddit are likely to talk about dating in the context of their daily life that generally has a positive sentiment, but also in the context of concerning, unhealthy behaviors. This shows there is range of romantic relationships with significant discussion on *r/BipolarReddit* that does not occur in the same way on *r/BPD*. Considering a major sign of BPD to be volatile relationships, this motif is clearly related to a possible differentiation between the experiences of people with these disorders. To assist with diagnostic accuracy, it may be useful to consider if a patient uses language surrounding dating within the range expressed on *r/BipolarReddit* or seems to be involved in more chaotic relationships.

2) *Motif 3: Work*:

Cluster D contains words all related to working and jobs with a generally negative sentiment. It is related to clusters J, words about medications, and cluster K, words about diagnoses. All three of the association rules for this motif are found to be significant in *r/BPD* and not in *r/BipolarReddit*. All three rules are also higher than the median lift of *r/BPDlovedones*, but only the rule between clusters D and K is lower than the median lift of *r/BipolarSOs*. The rule between clusters D and J shows that the use of medication is relevant to the discussion of work by the *r/BPD* community, possibly in the context of the medications prescribed to these individuals affecting their work performance or ability to hold a job. Similarly, the rule between clusters D and K could indicate that individuals with BPD feel that their diagnoses has a greater impact on their work life than individuals with BD. Therefore, it may be a useful point to make for diagnoses to see if the individual speaks with a similar sentiment, or if their loved ones do, considering that this rule is also significant in a comparison between *r/BPDlovedones* and *r/BipolarSOs*.

3) *Motif 4: Treatment*:

This motif is significant in *r/BPD* and is also higher than the median lift of *r/BPDlovedones*. The association rule that generates this motif relates cluster E to cluster J. While both have the words specifying that medication is being discussed, cluster E also contains words showing the effects of medications or possibly other treatments expressing a general sentiment that things are difficult but getting better. This association rule could show that the medications prescribed

to individuals with BPD generally are discussed at making a positive impact. Therefore, if an individual diagnosed with BPD is not using this type of language about the medications they have been prescribed, it might need to be considered whether a misdiagnosis has occurred.

VI. LIMITATIONS

The limitations of our work mainly arise from the nature of the topic. Our analysis is subject due to the lack of ground truth. We are also unable to determine the best algorithms to generate association rules and topic clusters for a similar reason. Based on the choices made in this paper, however, we are still able to present valuable results and provide foundations for future work on similar topics.

VII. FUTURE WORK

While this study looked at the differences between BD and BPD for the purposes of diagnosis, future work could consider other mental illnesses with similar symptoms that might be misdiagnosed, such as the various classes of BD or schizophrenia. It could also consider differences in terms of treatments or methods of coping rather than symptoms differences to ensure the support given to individuals with these disorders is most effective to their particular disorder. Future work could also look to identify the language of someone who is misdiagnosed by looking at posts in one subreddit that are more similar to the average post of another subreddit for a different disorder.

VIII. CONCLUSION

In this paper, we presented informal topics automatically extracted from online forums for bipolar disorder patients, borderline personality disorder patients, as well as forums for significant others of these people. We first analyzed the differences of relative frequency of these informal topic among the four forums. In general, we found that language surrounding the symptoms of the disorders occurred more frequently in forums for people with disorders. Some of our findings agree with the key difference between the two disorders mentioned in the introduction, while also demonstrating the difficulties in distinguishing between BD and BPD, as many topics were similarly frequent in all four forums. We also analyzed association rules. The motifs found through this analysis indicate differences in discussions by individuals with BPD and BD that could be useful in improving diagnostic accuracy.

REFERENCES

- [1] R. Belmaker, "Bipolar disorder," *New England Journal of Medicine*, vol. 351, no. 5, pp. 476–486, 2004.
- [2] J. Sayrs and U. Whiteside, "Borderline personality disorder," in *Practitioner's Guide to Evidence-Based Psychotherapy*. Springer, 2006, pp. 151–160.
- [3] J. Paris, "Clinical features of borderline personality disorder," *Handbook of Personality Disorders: Theory, Research, and Treatment*, vol. 2, p. 419, 2018.
- [4] M. De Choudhury, E. Kiciman, M. Dredze, G. Coppersmith, and M. Kumar, "Discovering shifts to suicidal ideation from mental health content in social media," in *Proceedings of the 2016 CHI conference on human factors in computing systems*. ACM, 2016, pp. 2098–2110.
- [5] R. N. Grant, D. Kucher, A. M. León, J. F. Gemmell, D. S. Raicu, and S. J. Fodeh, "Automatic extraction of informal topics from online suicidal ideation," *BMC bioinformatics*, vol. 19, no. 8, p. 211, 2018.
- [6] D. Chakravorti, K. Law, J. Gemmell, and D. Raicu, "Detecting and characterizing trends in online mental health discussions," in *2018 IEEE International Conference on Data Mining Workshops (ICDMW)*. IEEE, 2018, pp. 697–706.
- [7] R. C. Kessler, W. T. Chiu, O. Demler, and E. E. Walters, "Prevalence, severity, and comorbidity of 12-month dsm-iv disorders in the national comorbidity survey replication," *Archives of general psychiatry*, vol. 62, no. 6, pp. 617–627, 2005.
- [8] "Borderline personality disorder," Dec 2017. [Online]. Available: <https://www.nami.org/learn-more/mental-health-conditions/borderline-personality-disorder>
- [9] K. Saunders, A. Bilderbeck, J. Price, and G. Goodwin, "Distinguishing bipolar disorder from borderline personality disorder: A study of current clinical practice," *European Psychiatry*, vol. 30, no. 8, pp. 965–974, 2015.
- [10] C. J. Ruggero, M. Zimmerman, I. Chelminski, and D. Young, "Borderline personality disorder and the misdiagnosis of bipolar disorder," *Journal of psychiatric research*, vol. 44, no. 6, pp. 405–408, 2010.
- [11] M. B. First, A. France, and H. A. Pincus, *DSM-IV-TR guidebook*. American Psychiatric Publishing, Inc., 2004.
- [12] J. Bromley, D. J. Hare, K. Davison, and E. Emerson, "Mothers supporting children with autistic spectrum disorders: Social support, mental health status and satisfaction with services," *Autism*, vol. 8, no. 4, pp. 409–423, 2004.
- [13] L. Granek, D. Danan, Y. Bersudsky, and Y. Osher, "Living with bipolar disorder: the impact on patients, spouses, and their marital relationship," *Bipolar disorders*, vol. 18, no. 2, pp. 192–199, 2016.
- [14] T. Baldwin, P. Cook, M. Lui, A. MacKinlay, and L. Wang, "How noisy social media text, how different social media sources?" in *Proceedings of the Sixth International Joint Conference on Natural Language Processing*, 2013, pp. 356–364.
- [15] Y. Li, R. Mihalcea, and S. R. Wilson, "Text-based detection and understanding of changes in mental health," in *International Conference on Social Informatics*. Springer, 2018, pp. 176–188.
- [16] S. Amir, G. Coppersmith, P. Carvalho, M. J. Silva, and B. C. Wallace, "Quantifying mental health from social media with neural user embeddings," *arXiv preprint arXiv:1705.00335*, 2017.
- [17] R. Agrawal, T. Imieliński, and A. Swami, "Mining association rules between sets of items in large databases," in *Acm sigmod record*, vol. 22, no. 2. ACM, 1993, pp. 207–216.
- [18] W. Zhang, H. Liao, and N. Zhao, "Research on the fp growth algorithm about association rule mining," in *2008 International Seminar on Business and Information Management*, vol. 1. IEEE, 2008, pp. 315–318.
- [19] T. Mikolov, K. Chen, G. Corrado, and J. Dean, "Efficient estimation of word representations in vector space," *arXiv preprint arXiv:1301.3781*, 2013.
- [20] T. Mikolov, I. Sutskever, K. Chen, G. S. Corrado, and J. Dean, "Distributed representations of words and phrases and their compositionality," in *Advances in neural information processing systems*, 2013, pp. 3111–3119.
- [21] R. Lebrecht and R. Collobert, "Word Emddeddings through Hellinger PCA," *arXiv e-prints*, Dec. 2013.
- [22] J. Pennington, R. Socher, and C. Manning, "Glove: Global vectors for word representation," in *Proceedings of the 2014 conference on empirical methods in natural language processing (EMNLP)*, 2014, pp. 1532–1543.
- [23] J. Han, J. Pei, and Y. Yin, "Mining frequent patterns without candidate generation," in *ACM sigmod record*, vol. 29, no. 2. ACM, 2000, pp. 1–12.
- [24] J. Han and J. Pei, "Mining frequent patterns by pattern-growth: methodology and implications," *SIGKDD Explorations*, vol. 2, no. 2, pp. 14–20, 2000.