

SOCIAL MOOD MATRIX

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Abstract

In this paper, we address the issue of automatic prediction of readers' mood from newspaper articles and comments. As online newspapers are becoming more and more similar to social media platforms, users can provide *affective* feedback, such as mood and emotion. We have exploited the self-reported annotation of mood categories obtained from the metadata of the Italian online newspaper *corriere.it* to design and evaluate a system for predicting five different mood categories from news articles and comments: indignation, disappointment, worry, satisfaction, and amusement. The outcome of four experiments shows that overall, bag-of-words-ngrams perform better compared to all other feature sets; however, stylometric features perform better for the mood score prediction of articles. Our study shows that self-reported annotations can be used to design automatic mood prediction systems.

1 Introduction and Background

Participating in social media has become a mainstream part of our daily lives – we read articles, comments, other people's statuses and provide feedback in terms of emotion through written content. Currently, newspapers are also being designed as social media platforms to facilitate users to provide their opinion along with emotional feedback. Since currently our social participation is mostly done through social media platforms, the online content, including social media and newspapers' content, is growing very rapidly. In (Turner et al., 2014) the authors estimate that by 2020 online content might reach 44 trillion gigabytes, including news articles and user generated content such as likes, dislikes, emotions, tastes, identities, and data collected by sensors (Liu, 2007).

Such increasing amount of digital data creates a unprecedented opportunities for businesses and individuals, as well as it poses new challenges to process and generate concrete summaries out of it. For example, every day journalists need to deal with

large quantity of information whenever they need to prepare a historical/follow-up report or a summary from a large collection of documents. They might want to know how particular topics of news are associated with users' mood. The importance of such studies and their use cases have also been reported in (Riccardi et al., 2015). The challenges include automatic processing of semi-structured or unstructured data in different dimensions such as linguistic style, interaction, sentiment, mood and other social signals. Finding the collective information of such signals requires automatic processing, which will be useful for various professionals, specifically psychologists and social and behavioral scientists. Among other affected dimensions, mood and sentiment are particularly important for the analysis the consumer behavior towards brands and products (Pang and Lee, 2008; Stieglitz and Dang-Xuan, 2013).

In the past few decades, the affective dimension of text has been mainly analyzed in terms of positive and negative polarity (Pak

and Paroubek, 2010a; Kouloumpis et al., 2011; Cambria et al., 2016a), although more detailed dimensions are proven to be very useful. In particular, moods such as tension, depression, anger, vigor, fatigue, and confusion in tweets have been found to be good predictors of stock market exchanges (Bollen et al., 2011). It has also been demonstrated that it is possible to predict anger, sadness, and joy from LiveJournal blogs with performances up to 78% accuracy (Nguyen et al., 2010). Moreover, it is also possible to distinguish Twitter users who are likely to share content generating joy or amusement from the ones who are likely to share content generating sadness, anger or disappointment with an accuracy of around 61% (Celli et al., 2016). An increasing number of studies focuses on analyzing sentiment in terms of positive and negative polarity from short text (microblog) (Akkaya et al., 2009; Paltoglou and Thelwall, 2010). From the automatic classification perspective, a research application SentiStrength utilizes a different source of information to assign sentiment scores to short text (Thelwall et al., 2011; Stieglitz and Dang-Xuan, 2013). Such information includes word-list of sentiment, idioms, emoticons, negating words, linguistic rules and sentiment polarity classification algorithms.

To design automatic detection and classification systems a typical approach to generating reference annotation is to use either sentiment lexicon or automatic system (such as SentiStrength) (Bollen et al., 2011; Stieglitz and Dang-Xuan, 2013; Ferrara and Yang, 2015; Kim and Salehan, 2015), manual expert annotation or self-reported user annotation (Nguyen et al., 2014; Mishne and others, 2005). In (Cambria, 2016), the authors present a hybrid framework for sentiment analysis that includes a knowledge-based system and a machine learning module. Recent advances in knowledge-based NLP for sentiment analysis can be found in (Cambria et al., 2016b).

Self-reported mood annotation by the users of the blog

has been previously addressed in (Goet et al., 2009; Pak and Paroubek, 2010b; Pak and Paroubek, 2010b). In (Davidov et al., 2010), the authors use Twitter hashtags as labels for designing an automatic classification system. A similar study has also been reported in (Kunneman et al., 2014). There are still many challenges in designing an automatic system using self-reported annotation because the annotations are not done in a consistent manner. Users annotate them based on their *self-perception*, and social media platforms are not designed following any psychological instruments or instructions. The obvious advantages of such annotations are that (1) they are cost-effective, and (2) they provide users' natural affective expressions.

In this work, our goal is to investigate whether such annotations can be useful for designing an automatic system. We investigate two different approaches to predict mood from articles and user comments: (1) regression to assign a score for each mood category, and (2) binary classification into a positive and negative mood. We comparatively evaluate the predictive power of different feature sets such as character, word, and part-of-speech ngrams, stylometric, and psycholinguistic features. Our study is in-line with the study presented in (Nguyen et al., 2014), where the authors investigate a different set of features along with different machine learning algorithms for feature selection and classification. However, our focus is on the prediction of mood on a continuous [0..1] scale and the utilization of different sets of features. Moreover, we extract the feature from both articles and comments. Because text may contain a blend of emotional manifestations in separate parts, our goal is to obtain a fine-grained view on of a comment or an article in the form of 'emotional sphere'. Since mood can be expressed through certain idiosyncratic vocabulary and writing style, we make use of stylometric and psycholinguistic features.

The structure of the paper is as follows. In Section 2 we present the details of the data we use throughout experiments. Then, in Section 3

we report the experimental methodology, and in Section 3.2 the results of the experiments. Finally, discussions and conclusions appear in Sections 4 and 5, respectively.

2 Corpus

The data was collected from the most popular Italian daily newspapers – *Corriere della Sera*. The newspaper’s web site is structured as a social media platform (Boyd et al.,

2010). In particular, the platform of the *Corriere* (1) provides a semi-public profile¹ for each registered user, (2) articulates a list of users connected by an ‘interest’ relationship, (3) allows to view user’s connection to other registered users, and (4) includes mood meta data reported by the readers as their ‘self-perception’.

The annotations for moods are available at the article and author levels. Therefore, the mood scores for

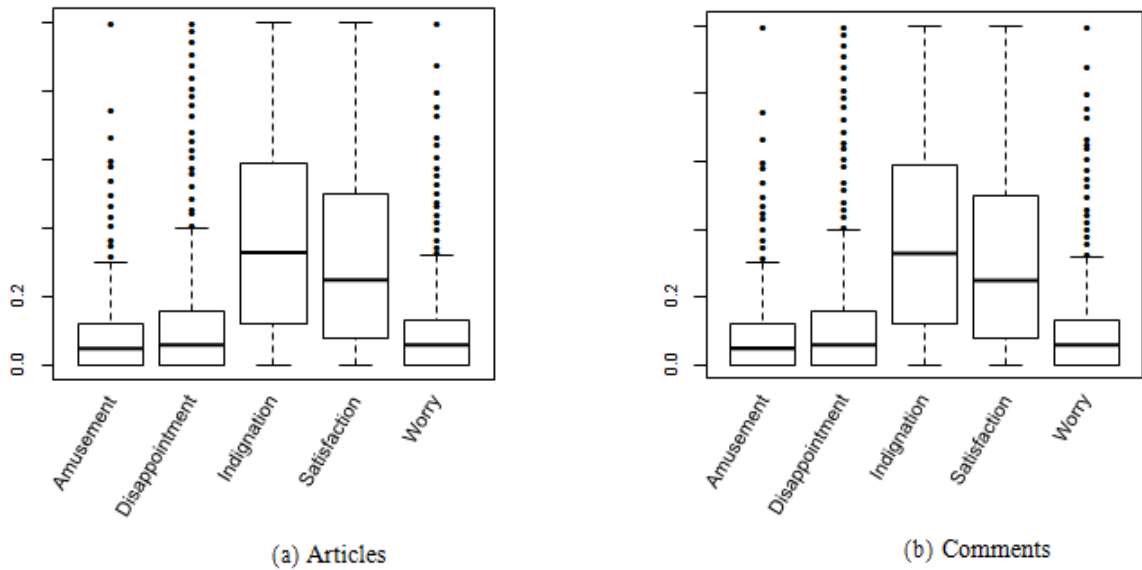


Figure 1: Box-plots for the reference mood scores of each mood category.

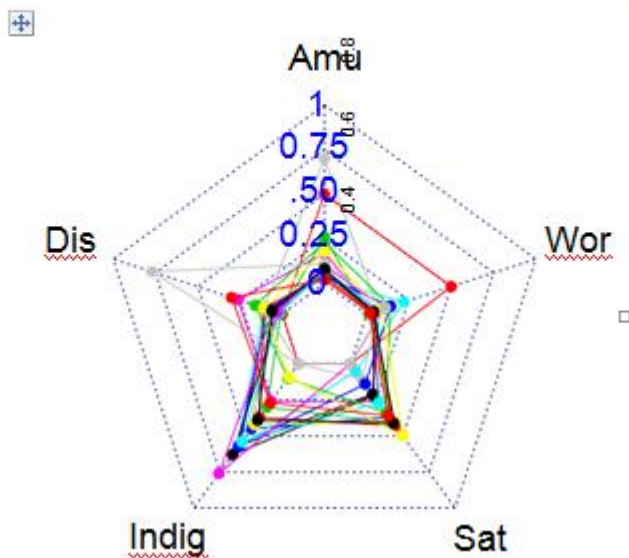


Figure 2: Spider plot of the reference mood scores from the selected comments. Amusement (Amu), Disappointment (Dis), Indignation (Indig), Satisfaction (Sat), Worry (Wor).

each article are directly obtained from the metadata as an average of the reported users' mood score for that article. Whereas the mood scores for comments are obtained from the mood scores of the posting user. Mood scores for users are part of users' personal profiles and describe all the moods they have declared after reading the articles.

A portion of the corpus has also been used in (Celli et al., 2014; Celli et al., 2016) to study mood and the relation between mood, personality traits and interaction styles.

For this study, we have collected 2200 articles and 300K comments to them. The data was pre-processed to remove outliers for each mood category in both articles and comments. Outliers are defined as the mood scores that appear independently in each category. In Figure 1, for instance, for some articles we can observe outliers scores for amused, disappointed and worried.

For comments, on the other hand, the outliers are for the satisfied category.

Outliers for comments in the amused category have a score above 0.4, which are the scores above the upper outer fence in the boxplot.

In Figure 1, we present box-plots of the mood score distribution for the articles and comments, respectively. From the figures, we observe that the distribution of the mood categories for both articles and comments are similar. For example, for *indignation* and *satisfaction*, the scores of the data points vary between 0.1 to 0.6. From the data, we also observe that in many cases users tend to annotate articles when the content of an article represents the emotions of *indignation* or *satisfaction*.

A lexical analysis has been performed on articles and comments to understand the complexity of the task. We observe that for articles the average number of tokens is 550, with maximum 3,188 and minimum 44 tokens. Whereas for comments, the average is 44 with a maximum of 285 and a minimum

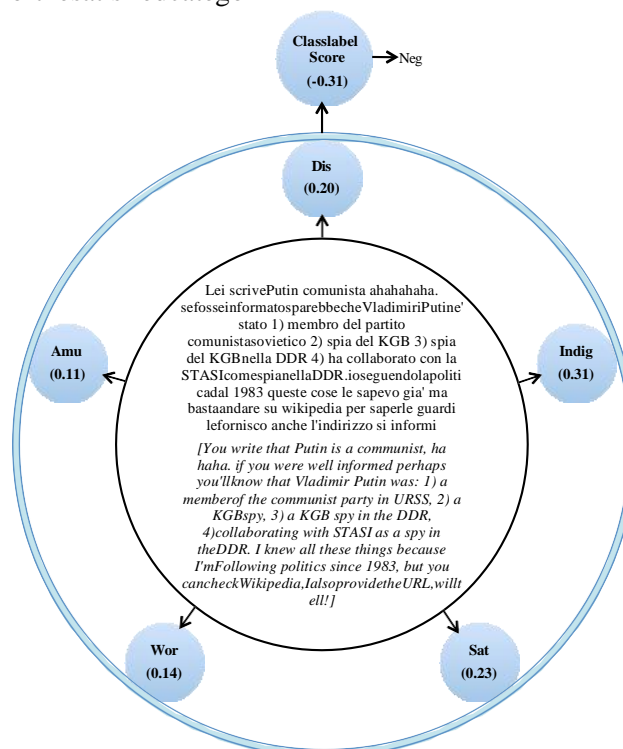


Figure 3: An example of self-reported annotation of a comment with mood scores and category (negative for this example). English translation is provided in italics.

of 1 token. A closer look at the comments with a high number of tokens reveals that people usually talk

about national issues such as economy, taxes, and environmental causes. There is a difference between an article and comments in terms of language style. Naturally, the written style of the articles is more formal, whereas the text in comments is more noisy and informal as it contains repetitions, emoticons, jargon, abbreviations, non-standard grammar, and URLs. The noisy structure is very common in any social media conversation as also reported in (Nguyen et al., 2014; Alam et al., 2013).

In Figure 2, we present a spider plot with reference mood scores from these selected comments, which range from 0 to 1. As can be seen in the figure, the mood scores for indignation and satisfaction are higher than for other categories.

For a better understanding of labels such as mood scores and category for comments and articles, in Figure 3 we provide an example of an annotated user comment. In the figure, the comment is labeled with five mood scores for five mood categories as reported by the user. These mood scores are then turned into a class label (see Section 3.2.2) as positive or negative.

The data is split into training, development, and test sets as 60%, 20%, and 20% respectively. The data partitioning will be made available together with the URL links to the articles on GitHub².

3 Methodology

For prediction of mood score and designing the classification system using both articles and comments, we experiment with different sets of features. The feature sets include bag-of-words, bag-of-character-ngrams, part-of-speech ngrams, psycholinguistic, and stylometric features. In addition to studying predictive power of individual feature sets, we have also experimented with their feature level fusion. However, due to low performances, they are not reported.

For the mood score prediction task we use the Random Forests, whereas for the classification task we use Support Vector Machines (SVMs). The choice of algorithms for each task is motivated by our prior

research on the topic, e.g. in (Celliet al., 2016). Random Forests outperform SVMs for the prediction task.

Features

Bag-of-word-ngram We investigated the bag-of-word-ngrams, with $3 \leq n \leq 1$, and their logarithmic term frequencies (tf) multiplied with inverse document frequencies (idf) – tf-idf. Although the bag-of-words model has many drawbacks such as data sparsity and high dimensionality, it is the simplest and known to work well for most text-based classification tasks. As bag-of-ngrams representation yields a large dictionary which increases computational cost, we have selected 5K most frequent ngrams.

Bag-of-character-ngram Similar to the bag-of-word-ngrams, we also extracted and evaluated bag-of-character-ngrams, with $6 \leq n \leq 2$ and tf-idf transformation. The motivation for experimenting with this feature set is its success in sentiment classification task (Abbasi et al., 2008).

Part-of-Speech features (POS): To extract POS features we used TextPro (Pianta et al., 2008) and designed the feature vector using bag-of-ngram representation, with $3 \leq n \leq 1$ and tf-idf transformation.

Stylometric Features The use of stylometric features has its root in the domain of authorship identification (Yule, 1939; Abbasi and Chen, 2008; Bergsma et al., 2012; Cristani et al., 2012). Its use has also been reported for text categorization and discourse classification problems (Koppel et al., 2002; Celliet al.,). In authorship identification task, stylometric features are defined in different groups such as lexical, syntactic, structural, content specific, idiosyncratic and complexity-based (Koppel et al., 2002; Abbasi and Chen, 2008; Cristani et al., 2012). In this work, we use the term *stylometric* to refer to the complexity-based³ features reported in (Tanaka-Ishii and Aihara, 2015; Tweedie and Baayen, 1998). The used stylometric feature groups are listed in Table 1.

In addition to the features listed in Table 1, we also

extract word and character based low-level features and projected them onto statistical functionals. These include counts of word-ngrams (2 to 3-grams) and character ngram (2 to 4-grams). The statistical functions include mean, median and standard deviation. The total number of the features in the set is 97.

Psycholinguistic Features To extract the psycholinguistic features from the articles and comments we utilized the Linguistic Inquiry Word Count (LIWC) (Pennebaker et al., 2001), which is a knowledge-based system developed over the past few decades. The utility of these features has been studied in different research fields such as psychology and sociology, and they are frequently used to study relations between usage of word and attributes such as gender, age, personality, honesty, dominance, deception, and health (Mairesse et al., 2007; Tausczik and Pennebaker, 2010).

The utility of these features has also been reported in (Nguyen et al., 2014; Alam and Riccardi, 2014; Danieli et al., 2015).

The types of LIWC features include the following:

- *General*: word count, average number of words per sentence, a percentage of words found in the dictionary and percentage of words longer than six letters and numerals.
- *Linguistic*: pronouns and articles.
- *Psychological*: affect, cognition, and biological phenomena.
- *Paralinguistic*: accents, fillers, and disfluencies.
- *Personal concerns*: work (e.g., job and majors), achievement (e.g., earn, hero, and win) and home (e.g., family).
- *Punctuation marks and spoken categories* such as assent (e.g., agree, OK and yes) nonfluencies (e.g., Er, hmandumm).

Since LIWC is a knowledge based system, it is packaged with dictionaries for different languages including Italian. In this paper, we use the Italian version of the dictionary (Alparone et al., 2004), which

Table 1: Stylometric features

General
<ul style="list-style-type: none"> • word count = N • dictionary size = V
Length-based features:
<ul style="list-style-type: none"> • Average word length • Short word ratio (length = 1-3) to N
Frequency-based Ratios
<ul style="list-style-type: none"> • Ratio of Hapax Legomena to N • Ratio of Hapac Dislegomena to N
Lexical Richness using transformations of N and V:
<ul style="list-style-type: none"> • Mean Word Frequency = N/V • Type-Token Ratio = V/N • Guiraud's $R = V/\sqrt{N}$ • Herdan's $C = \log(V)/\log(N)$ • Rubet's $K = \log(V)/\log(\log(N))$ • Maas $A = (\log(N) - \log(V))/\log^2(N) = a^2$ • Dugast's $U = \log^2(N)/(\log(N) - \log(V))$ • Lukjanenkov and Neistoj's $LN = (1 - V^2)/(V^2 * \log(N))$ • Brunet's $W = N^{(V^{-a})}$, $a = 0.172$
Lexical Richness using Frequency Spectrum:
<ul style="list-style-type: none"> • Honore's $H = b(\log(N)/a(V(1, N)/V))$, $b = 100, a = 1$

- Sichel's $S = V(2, N) / V$
 - Michea's $M = V / V(2, N)$
 - Herdan's $V = \sqrt{\sum(V(i, N) * (V(i, N) / N)^2) - 1 / V}$
 - Yule's $K = \alpha(-1 / N + \sum(V(i, N) * (V(i, N) / N)^2))$, $\alpha = 1$
 - Simpson's $D = \sum(V(i, N) (V(i, N) / N) (V(i, N) - 1) / (N - 2))$
 - Entropy = $V(i, N) (-\log((V(i, N) / N)^s * (V(i, N) / N)^t), s = t = 1$
-
- Length ratios 30 features

contains 85 word categories. In addition, we have also extracted 5 general descriptors and 12 punctuation categories to yield a total of 102 features. The LIWC feature processing differs with respect to the type, which includes counts and relative frequencies (see (Tausczik and Pennebaker, 2010)).

Experiments

In this section, we report experiments on mood score prediction and mood classification. The development set is used for the preliminary experiments and final models are trained by joining training and development sets.

Mood Score Prediction Experiments and Results

For the mood score prediction experiments, we utilized Random Forests as a learning algorithm (Breiman, 2001). It is a decision tree based algorithm where instances and features are randomly sampled to generate several trees (forest). Then the score of the forest is computed by averaging the scores from the trees.

For this experiment, the number of trees is set to 100. We did not optimize the number of trees for the task and plan to address this in the future.

We measure the performance of the mood score prediction system as Root Mean Square Error (RMSE). The performances of models are compared to the baseline that is produced by randomly generating the scores using Gaussian distribution with respect to the prior mean and standard deviation, as presented in Table 2.

In Table 2, we present the performances of different feature sets. The best results for the mood of

Table 2: Performance of the different feature sets on the test set as RMSE (lower is better). Baseline performances are produced by randomly selecting from the Gaussian distribution with respect to prior mean and standard deviation. Base: Baseline, W-ng: word ngram, C-ng: character ngram. Amusement (Amu), Disappointment (Dis), Indignation (Indig), Satisfaction (Sat), Worry (Wor).

Class	Article						Comments					
	Base	W-ng	C-ng	POS	Style	LIWC	Base	W-ng	C-ng	POS	Style	LIWC
Amu	0.130	0.100	0.100	0.102	0.120	0.102	0.170	0.118	0.118	0.119	0.119	0.120
Dis	0.150	0.108	0.112	0.116	0.128	0.120	0.180	0.126	0.127	0.127	0.128	0.128
Indig	0.380	0.266	0.274	0.280	0.247	0.278	0.350	0.245	0.244	0.246	0.246	0.247
Sat	0.370	0.267	0.276	0.271	0.166	0.275	0.230	0.165	0.164	0.165	0.165	0.166
Wor	0.130	0.095	0.096	0.099	0.118	0.099	0.170	0.118	0.117	0.118	0.118	0.118
Avg	0.230	0.167	0.172	0.174	0.156	0.175	0.220	0.154	0.154	0.155	0.155	0.156

the articles are obtained using stylometric features, and the second best results are obtained using word-ngrams. For the comments, on the other hand, the best results are obtained with the word-and-character-ngrams. Moreover, for comments, all the feature sets produce closer results. The reason for this might be the noisy nature of comment content, and part-of-speech tags, stylometric and LIWC features might not be able to capture significant information. Yet another reason might be high variation in comment length, thus high feature sparseness. In terms of the performance and the number of features, we speculate that stylometric features might be useful for cross-language/domain experiments. Nevertheless, compared to other random baseline performances are statistically significant with paired t-test $p < 0.05$ for both articles and comments.

Mood Classification Experiments and Results

For the classification task, we first transformed the mood scores into binary classes such as positive and negative. This is done by first computing an overall mood *class label score* by subtracting the sum of “Disappointment”, “Worry” and “Indignation” scores from the sum of “Amusement” and “Satisfaction” scores (see Equation 1). Then, the score is mapped into either of the two classes – positive and negative – with respect to Equation 2. The instances with the overall score of zero are ignored. As a result, 63% of articles are assigned to a negative category and 37% to positive. The distribution of comments into negative and positive categories, on the other hand, is more balanced: 53% (negative) vs 47% (positive).

$$class_label_score = (amusement + satisfaction) - (disappointment + worry + indignation) \quad (1)$$

$$class_label_instance(i) = \begin{cases} pos & \text{if } score > 0 \\ neg & \text{if } score < 0 \end{cases} \quad (2)$$

For the task of classification, we train a Support Vector Machines (SVM) (Platt, 1998) model with a linear kernel. The performance is measured in terms of macro-averaged precision, recall, F1-measure, and accuracy. Baseline results are computed by randomly generating the class labels, such as positive or negative, based on the prior class distribution of the training set (i.e. chance baseline) as shown in Table 3.

In Table 3, we present the classification results for the articles and comments. For the articles, we obtain the best results using word-ngrams and the second best result using character-ngrams. For the comments, on the other hand, we observe similar results with both word and character ngrams, however, character-ngram model is slightly better. The performances of POS, LIWC, and stylometric features sets are lower. Compared to the chance baseline, the results are statistically significant with McNemar's test and $p < 0.05$.

4 Discussion

For the score prediction task, the overall results for comments are better than for articles; whereas, for the classification task, the results are better for articles than for comments. We observe that bag-of-word-ngrams perform well on both tasks.

Table 3: Classification results on the test set using different feature sets as precision (P), recall (R), F1 measure (F1), and accuracy (Acc).

Exp	Articles				Comments			
	P	R	F1	Acc	P	R	F1	Acc
Baseline	47.89	47.93	47.90	53.51	49.93	49.92	49.93	50.04
Word-ngram	62.20	61.70	61.89	58.73	54.44	54.27	54.06	54.71
Char-ngram	55.95	56.22	55.76	56.69	55.33	55.16	55.03	55.71
POS	53.97	53.96	53.96	56.24	52.29	52.12	51.59	52.96
Style	54.43	52.76	50.56	59.64	52.37	52.26	51.96	52.93
LIWC	54.30	54.05	54.02	57.37	52.43	52.31	51.98	53.01

From the article score prediction experiment, we obtain the best results using stylometric features, which are language independent. Thus, we plan to exploit them for cross-domain and cross-language study.

Regarding the use of self-reported mood annotation, our experiment suggests that for a better understanding of their reliability, it is necessary to evaluate them through observer/expert annotation. One important issue is that in this self-reported annotations, users have not followed any instructions or have had any psychological instruments while expressing their affective opinions.

5 Conclusion

In this paper, we have presented the work on the prediction and classification of mood from news articles and comments. These self-reported mood annotations were used as a reference signal, and we have experimented with different feature sets. For the mood score prediction task, the best results were obtained using bag-of-word-ngrams and stylometric features for both articles and comments. For the classification task, on the other hand, the best results were obtained with bag-of-word-ngrams. The prediction and

classification task on comments are difficult due to the noisy nature of the data. Since these self-reported data is increasing over time, further expert annotation of the user-reported scores is required for designing better automatic systems. Another interesting question that we plan to address in the future is how well the mood models generalize across different domains.

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