Psychological Indicator Identification and Modeling Based on Social Media Data: Machine Learning Methods

Authors: Su Yue, Liu Mingming, Zhao Nan, Liu Xiaoqian, Zhu Tingshao, Zhu Tingshao

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Abstract

Psychological indicator recognition modeling is an emerging approach for identifying psychological characteristics based on massive data combined with computer machine learning algorithms. Due to the numerous limitations of traditional paper-and-pencil measurement methods, this paper reviews psychological modeling methods based on social media data and their feasibility for application in psychological measurement, introduces feature and extraction methods, commonly used machine learning algorithms, and application scenarios, and summarizes and prospects the advantages and disadvantages of psychological indicator recognition modeling. This measurement method, based on social media data, possesses unique advantages such as high timeliness, retrievable measurement, and good ecological validity compared to self-report methods. However, psychological indicator recognition modeling methods based on social media also have limitations in terms of learning costs, hardware costs, and other aspects. Future researchers need to further explore the association mechanisms between social media information and user psychological variables, and combine psychological indicator recognition models with traditional psychological research methods for more exploration and application. Psychological indicator recognition modeling, which combines the fundamental principles of psychological measurement with machine learning techniques in the computer domain, will open a new door for psychological research.

Full Text

Preamble

Identifying Psychological Indexes Based on Social Media Data: A Machine Learning Approach

Su Yue[1],[2], Liu Mingming[1],[3], Zhao Nan[1], Liu Xiaoqian[1], Zhu Tingshao[1],[2]
(1 Institute of Psychology, Chinese Academy of Sciences, Beijing 100101, China)
(2 Department of Psychology, University of Chinese Academy of Sciences, Beijing 100049, China)
(3 Lenovo Research, Beijing 100094, China)

Abstract: Psychological index identification modeling (psych-modeling) is an emerging approach that identifies psychological characteristics by combining massive datasets with machine learning algorithms. Due to the limitations of traditional paper-and-pencil measurement methods, this paper reviews the feasibility of psych-modeling methods based on social media data for psychological measurement. We introduce feature types and extraction methods, commonly used machine learning algorithms, and application scenarios, while summarizing the strengths and weaknesses of psychological index identification modeling. Compared with self-report methods, this measurement approach based on social media data offers unique advantages including high timeliness, retrospective measurement capability, and strong ecological validity. However, psych-modeling methods based on social media also have limitations in terms of learning costs and hardware requirements. Future researchers need to further explore the association mechanisms between social media information and user psychological variables, and combine psychological index identification models with traditional psychological research methods for greater exploration and application. Psychological index identification modeling, which integrates fundamental principles of psychological measurement with machine learning techniques from computer science, will open a new door for psychological research.

Keywords: Psychological modeling, psychological measurement, social media, machine learning, psychological prediction model

Using social media data to establish identification models for psychological indexes involves combining research participants' self-reported psychological test results with their social media data and employing machine learning methods to establish a mapping between them. This enables automatic identification of users' psychological characteristics with high accuracy through analysis of their social media behavioral data. Users' online behavioral data on social networks provide readily accessible massive datasets for psychological index identification modeling (hereinafter referred to as "psych-modeling"), making it an emerging method for psychological measurement.

Currently, the most widely used method in psychological measurement is self-reporting (Robins et al., 2007). Self-report methods can provide rich information and valuable self-perspectives for research, and are widely used due to their operational simplicity (Paulhus & Vazire, 2007). However, self-report methods may have the following problems (Dunning et al., 2005): First, due to inherent limitations of human memory, it is difficult to achieve precise temporal matching when conducting retrospective research using self-report methods; second, self-report methods are constrained by human and material resources, involving questionnaire distribution, collection, and processing, making the entire process

time-consuming with poor timeliness, thus making it difficult to conduct large-scale, high-frequency measurements; finally, self-report methods rely on participants' active cooperation, and when participants are unwilling to cooperate or when it is inappropriate to impose additional burdens, self-report methods often cannot be smoothly implemented.

In recent years, with the popularization of the Internet, social media has gradually become an important component of people' s lives. Users' online behaviors can be electronically recorded and saved in real-time in cyberspace, forming rich user behavioral data in natural contexts and providing new data platforms and research avenues for psychological measurement. Many studies have demonstrated that users' behavioral data on social media contain substantial psychological meaning, offering another window into understanding people' s cognitive, emotional, personality, and mental health processes. For example, browsing duration on social media is positively correlated with users' social willingness, and the number of friends on social networking sites is negatively correlated with users' shyness (Orr et al., 2009). Gosling et al. (2011) found that behavioral data on Facebook, such as number of friends and posting frequency, are significantly correlated with the five dimensions of the Big Five personality traits, suggesting that it is possible to estimate users' personality using online data. In addition to behavioral features, text information (Qiu et al., 2012) and emoticons (Park et al., 2015) posted by users on social media have also been found to be significantly associated with psychological characteristics, with effect sizes reaching medium levels or above (Carvalho & Pianowski, 2017), indicating the feasibility of using social media data to build computational models for identifying psychological indexes.

Based on these research findings, many scholars have conducted studies on psych-modeling using social media data. This paper discusses and analyzes the feasibility and effectiveness of psych-modeling as a psychological measurement method based on 梳理 psych-modeling methods, and provides prospects for its future application fields and development trends.

1 The General Process of Psych-Modeling

The general process of psych-modeling includes several main components: social media data collection, feature extraction, feature selection, data modeling, cross-validation, and output. The general modeling process is shown in Figure 1 [Figure 1: see original paper].

When conducting psych-modeling, it is first necessary to obtain users' social media data and corresponding self-reported psychological characteristic scores as the criterion for the psychological model. Currently, self-report scores used in research are mostly self-assessment scale scores, while some psych-modeling criteria adopt objective indicators such as occupational class (Preoţiuc-Pietro, Lampos, & Aletras, 2015) and income level (Preoţiuc-Pietro, Volkova, et al., 2015). The number of users for psych-modeling using social media data is gen-

erally large; for example, studies conducted on the Facebook application MyPersonality typically involve more than 1,000 users, with the maximum reaching 390,000 users (He et al., 2014).

Second, social media data must be quantitatively encoded, which is the feature extraction step. Common encoding methods include categorization, frequency counting, rate calculation, and constructing sparse matrices. Social media behavioral information, such as number of microblogs, can be statistically analyzed through frequency counting (Farnadi et al., 2013; Hao et al., 2014); text information can be processed using existing dictionaries for word frequency statistics (Eichstaedt et al., 2015; Lampos et al., 2014); social information can be used to construct social matrices reflecting relationships between users and their followers, likers, and retweeters for further analysis (De Choudhury et al., 2014; Gittelman et al., 2015).

Third, appropriate machine learning methods are selected to establish a mapping relationship between users' self-report scores and corresponding social media language and behavioral features, and cross-validation is employed to verify the computational effectiveness of the model. Cross-validation is the most commonly used model performance evaluation method in machine learning modeling. The specific operation involves dividing the dataset into training and testing sets, using the training set for modeling and the testing set for evaluating model performance. The dataset is divided multiple times until every data point has served as both training and testing data. Cross-validation can make full use of original data, avoid the impact of random division imbalance on model performance, and also minimize model overfitting to the greatest extent.

Finally, a psychological characteristic identification model based on social media data is obtained. When homogeneous users' social media data are input, the psychological model can automatically perform feature extraction, model computation, and output users' psychological characteristic values according to the model' s characteristics.

2 Types of Social Media Data

Due to the diverse information and rich functions contained in social media platforms themselves, researchers are provided with multiple types of data. In research, people often select only one or several data types for in-depth analysis and application. Social media data can be mainly divided into personal account information and usage information, text information, social network information, image information, and other clues according to different recording forms. In the process of psych-modeling, different categories of social media data can be quantitatively encoded through different methods to extract numerous data features from rich electronic records.

2.1 Personal Account Information and Usage Information

Personal account information includes basic information related to the social media account such as user nickname, gender, birthday, residence, self-introduction, privacy settings, avatar information, and personalized settings (Zheng Jinghua et al., 2018; Bai et al., 2014; Gao et al., 2013). Unlike demographic information obtained through self-report methods, personal account information on social media is often filled in selectively, resulting in more missing data and discrepancies with real situations. Therefore, when using personal account information for modeling, it is necessary to distinguish between personal account information and demographic statistical information (Markovikj et al., 2013).

Social media usage information refers to the large number of electronic browsing records left by users when using social media. Many studies use these "electronic footprints" to conduct psych-modeling of individuals, including posting time (De Choudhury et al., 2013), first login time (Nie et al., 2014), online duration (Bai et al., 2012), total number of posts (Celli et al., 2013), and number of URLs contained in posts (Adalı & Golbeck, 2014).

2.2 Text Information

As one of the main presentation contents of social media, text has become the most widely used data type in current psych-modeling research. Many mature text processing techniques have been developed, including word frequency statistics, word vector construction, topic models, and self-built dictionaries.

When conducting word frequency statistics, the tf-idf algorithm can filter out common words and retain important words (Salton & Buckley, 1988), which is currently widely applied in psych-modeling research (Peng et al., 2015; Seneviratne et al., 2015). In the process of constructing word vectors, common conversion algorithms for transforming specific word information into word vectors include n-gram (Wang Jingjing et al., 2014; Brown et al., 1992; Kern et al., 2014; Mohammad & Kiritchenko, 2015), Word2Vec (Zhang Pu et al., 2019; Rong, 2014; Garten et al., 2016), and GloVe (Pennington et al., 2014; Arnoux et al., 2017). Regarding topic models, Cao Ben et al. (2018) provided a detailed exposition of their application in psychological text analysis. Topic models are also widely used in personality prediction (Hu et al., 2017; Liu, Y. Z. et al., 2016) and mental health analysis models (Smith et al., 2018; Zhang et al., 2014). In terms of self-built dictionaries, researchers have compiled many dictionaries themed around emotion, cognition, and social relationships, including LIWC (Linguistic Inquiry and Word Count) psychological language dictionary (Pennebaker et al., 2007), MRC Psycholinguistic Database (Wilson, 1988), NRC Emotion Lexicon (Mohammad & Turney, 2013), ANEW Emotion Lexicon (Nielsen, 2011), PMI (pointwise mutual information) text emoticon dictionary (Park et al., 2015), Ekman Emotion Lexicon (Volkova & Bachrach, 2015), Moral Foundations Dictionary (MFD) (Haidt et al., 2009), NLTK dictionary (the Natural Language Toolkit; Loper & Bird, 2002), Afinn dictionary (see:

http://www2.imm.dtu.dk/pubdb/views/publication_{details}.php?id=6010), and H4Lvd dictionary (see: http://www.wjh.harvard.edu/~inquirer/inqdict.txt). Many psych-modeling studies based on social media have achieved good computational results using self-built dictionaries (Li Ang et al., 2015; Nadi Re & Hu Jun, 2018; Golbeck, Robles, Edmondson, & Turner, 2011; Mairesse et al., 2007).

2.3 Social Network Information

Social network information refers to users' interaction information with other users on social media. Currently, commonly used social network features in psych-modeling research include following, liking, retweeting, mentioning, and commenting. Among them, like data is the most widely used in psych-modeling. By extracting users' like lists, a user-topic sparse matrix can be constructed, with each like topic serving as a user feature column, which is then used as an independent variable for computational analysis (Youyou et al., 2015; Praet et al., 2018).

Individuals' social behaviors such as following, liking, retweeting, mentioning, and commenting can constitute ego networks, enabling the calculation of various social network indicators. Network size (Bai Shuotian et al., 2014; Bachrach et al., 2012), network density (Celli et al., 2013; Kosinski et al., 2014), out-degree and in-degree (Hao et al., 2014; Li et al., 2014), centrality, and transitivity (Golbeck, Robles, & Turner, 2011; Markovikj et al., 2013) can all be used for modeling calculations. Furthermore, users' influence can be analyzed through their interaction patterns. Commonly used user influence indicators include "Klout" and "TIME" (Sumner et al., 2012; Lima & de Castro, 2014).

2.4 Other Information

In addition to the aforementioned data types, image information is also widely used in psych-modeling analysis, including psychological modeling based on image color, composition, content characteristics, and brightness (Liu, L. et al., 2016; Segalin et al., 2017; Skowron et al., 2016; You et al., 2014).

Moreover, an increasing number of social media data types have been proven useful for psych-modeling in recent years, such as Google Play apps (Seneviratne et al., 2014) and multiple Application Programming Interfaces (APIs) opened by Facebook (Annalyn et al., 2018; Saha et al., 2017).

With the popularization of mobile Internet, an increasing number of mobile features can be extracted and utilized, such as restaurant locations and consumption types reviewed by users on Dianping (Zhong et al., 2015). Kalimeri et al. (2019) used mobile web browsing information, mobile app information, and web browsing information to build computational models of moral foundations and human values, achieving prediction accuracy of 0.6~0.7. Models built using mobile data showed comparable performance to those using web data.

3 Common Methods for Psych-Modeling

Currently, psych-modeling methods using social media data are mainly divided into classification models and regression models according to output type. In psych-modeling, researchers often do not choose just one modeling method but instead attempt to use multiple methods for training on the same dataset, continuously adjusting and comparing them to finally determine one or more optimal models.

Classification models use social media data to categorize users into two or multiple classes according to certain methods. The classification results can be binary variables, such as gender; or artificially dichotomized variables, such as using the mean score of Big Five extraversion as a cutoff point to divide people into introverted and extroverted groups (Farnadi et al., 2018). Common classification model algorithms include Logistics Regression (LR), k-Nearest Neighbor (kNN), Support Vector Machines (SVM), Naive Bayes (NB), Decision Tree (DT), and Random Forest (RF) (Yang Jianfeng et al., 2019; Singh et al., 2016).

Different classification model algorithms are suitable for different social media data. Logistics Regression results are easy to use and interpret (Peng et al., 2002) and are widely applied in psych-modeling, including classification of psychological characteristics such as political orientation (Praet et al., 2018), substance abuse (Kosinski et al., 2013), personality (Celli et al., 2013), depression (De Choudhury et al., 2014), and suicidal ideation (De Choudhury et al., 2016). The k-Nearest Neighbor algorithm is more suitable for psychological characteristic computation under high-dimensional social media feature conditions. Additionally, Support Vector Machines perform well in classification model psych-modeling (Liu Baoqin & Niu Yun, 2016; Ernala et al., 2019; Hao et al., 2013). Naive Bayes and Decision Tree both show good performance when processing text data and social media usage features (Bai et al., 2012; Farnadi et al., 2016). Random Forest is insensitive to feature multicollinearity and is relatively robust in computing results for missing data and skewed data, making it applicable to computational models with massive features (Breiman, 2001).

Regression models are models that use continuous and discrete features to compute continuous variables. Commonly used regression algorithms in psych-modeling include Linear Regression, LASSO regression (The Least Absolute Shrinkage and Selection Operator Regression), Ridge Regression (RR), and Gaussian Process Regression (GPR). Among them, Linear Regression is most commonly used in psych-modeling (Montgomery et al., 2012). Ridge Regression is often used when features have multicollinearity (Hoerl & Kennard, 1970), while LASSO regression is commonly used for linear regression under high-dimensional and sparse feature conditions (Hans, 2009). Gaussian Process Regression can serve as a general computational method and has also achieved good prediction results under social media data features.

4 Application Scenarios of Psych-Modeling

Many studies have utilized psych-modeling methods to achieve identification of various psychological characteristics, covering numerous psychological research scenarios.

4.1 Personal Information Prediction

Psych-modeling methods can be used to predict personal information, which is applicable for completing missing personal information of online users or classifying users. Currently, psych-modeling can classify or predict variables such as user gender (Schwartz et al., 2013), age (Zhong et al., 2015), single status (Li et al., 2014), occupational class (Preoţiuc-Pietro, Lampos, & Aletras, 2015), income level (Preoţiuc-Pietro, Volkova, et al., 2015), whether living with parents, substance abuse, race, religion, political party, sexual orientation, native language, nationality, education level, children' s gender (Kosinski et al., 2013; Li et al., 2014; Volkova & Bachrach, 2015), zodiac sign, and blood type (Zhong et al., 2015). Currently, modeling research on personal information prediction is relatively comprehensive. In subsequent studies, researchers can use prediction results as a basis for comparative research, especially in scenarios where certain personal information is not easily obtainable.

4.2 Personality Judgment

Researchers have attempted to model and compute the Big Five personality using various types of features, including text information, behavioral information, and multi-feature combinations. Park et al. (2015) used massive Facebook text information to build a Big Five personality computational model, achieving computational accuracy between 0.34 and 0.46. Other researchers used Facebook like patterns to calculate users' Big Five personality, with computational accuracy reaching up to 0.47 (Youyou et al., 2015). Liu and Zhu (2016) used deep learning to integrate multiple social media features including microblog text features, microblog behavioral features, and emoticon tags to model and compute Big Five personality, achieving final accuracy of 0.3~0.5.

Using psychological models for personality judgment can avoid the influence of subjective feelings or motivation on measurement accuracy. Kosinski et al. (2016) believe that machine learning-computed personality is even more accurate than judgments made by partners or friends. Youyou et al. (2017) used psychological models for personality clustering research, arguing that using psychological models for personality measurement can unify evaluation standards and overcome the influence of reference groups and motivation on users' self-assessment. Currently, personality modeling research is quite comprehensive and involves many social media features. Yu Jianwei (2018) and Zhang Lei et al. (2014) have both provided detailed reviews of recent personality analysis and personality modeling research based on social networks. However, there is still room for further improvement in model computational accuracy, requiring more

attempts by researchers.

4.3 Mental Health Status Identification

Psych-modeling can analyze users' feelings and thoughts posted on social media, providing a new approach for mental health status screening. Many studies have proven that social media data can be used to identify depression (Resnik et al., 2013), suicidal tendencies (De Choudhury et al., 2016), schizophrenia (Saha et al., 2017), personality disorders (Carvalho & Pianowski, 2017), anxiety levels (Settanni & Marengo, 2015), and even physical diseases such as heart disease (Mathan et al., 2018), diabetes, and obesity (Araujo et al., 2017; Mejova et al., 2018). Tsugawa et al. (2015) and Aldarwish and Ahmad (2017) respectively built depression identification models based on Twitter and Facebook text information, achieving classification accuracies of 61% and 63%. Nguyen et al. (2017) used online text information to distinguish between depression, bipolar disorder, self-harm, sadness, and suicide groups, with classification accuracy reaching up to 88%.

After using psych-modeling to screen users for mental health issues, proactive interventions such as pushing relevant resources can be implemented for users with psychological problems. Liu et al. (2019) proposed the method of Proactive Suicide Prevention Online (PSPO), which actively identifies suicidal individuals and provides them with effective psychological crisis intervention resources, improving help-seeking behavior among users with suicidal ideation and public health awareness. Currently, such methods are increasingly applied in clinical practice and have great potential in auxiliary diagnosis. Their broader application still requires the development of more accurate identification models for more psychological variables and continuous investment of human and material resources in mental health intervention.

4.4 Political Orientation and Public Opinion Monitoring

With the arrival of the Web 2.0 era, social networks have become the main venue for public opinion expression and a rapid channel for conveying public opinion (Zhou Yang, 2018). Social media data can be used to understand public attitudes and political orientation in real-time. Praet et al. (2018) built identification models for political orientation and party preference of American users based on Facebook like data, achieving good computational results. Zhou et al. (2017) analyzed social media data to monitor real-time social attitudes and trends in public opinion on political issues.

Furthermore, identification of key psychological variables such as gender and education level can further enable estimation of users' political orientation and public opinion. In surveys of American political orientation, it was found that compared with Republican voters, Democratic voters had higher scores on extraversion and conscientiousness in personality; their value orientation tended more toward tradition, integration, and security, while also supporting univer-

salism values (Dirilen-Gümüş, Cross, & Dönmez, 2012); attitude toward liberalism is an important psychological indicator for distinguishing Democratic and Republican voters, with more positive attitudes toward liberalism being more likely to indicate Democratic orientation (Zschirnt, 2011). Users'social attitudes, personality, and emotional states all affect the direction of public opinion on political events (Zhou Yang, 2018). Social media data provide the possibility for real-time monitoring of political orientation and public opinion status, serving as an important auxiliary tool for online public opinion analysis and providing guarantees for maintaining social stability and promoting democratic openness.

4.5 Brand Marketing Based on Social Media

With the explosive growth of social media user numbers, an increasing number of consumer brands are paying attention to marketing channels on social media (Social Media Marketing). The number of fans and comments on a brand' s social network account directly reflect customer preference and brand popularity (De Vries et al., 2012). Massive amounts of data on social media can help brands collect user needs (Zhu & Chen, 2015), locate consumer groups (Bolotaeva & Cata, 2010), establish brand image (Walsh et al., 2013), and achieve personalized marketing (Tucker, 2014). Currently, Facebook' s marketing applications have opened relevant API interfaces, allowing researchers to easily locate potentially interested users based on keywords or condition options (Saha et al., 2017). Matz et al. (2017) attempted to customize different style homepage images for the same online advertisement according to different personalities and push them based on users' personality characteristics, increasing the advertisement click-through rate by approximately 40%. Future research can further use psych-modeling methods to predict brands that users are interested in, extract brand image keywords using topic models from brand account text information and comments, identify key variables of users' consumer psychology by combining real purchase data with social media behavior, and thus formulate targeted marketing strategies to maximize marketing effectiveness.

4.6 Other Applications

Furthermore, the latest research continues to use social media data to achieve identification of more diverse psychological variables. He et al. (2014) used Facebook post content to model and compute users' self-control ability. Lewenberg et al. (2015) built identification models that can use Twitter data to cluster and compute users' personal interests. Kalimeri et al. (2019) can compute moral foundations and human values based on mobile or web browsing information and duration. Dufner et al. (2018) built identification models for social media data and implicit motive tendencies. Using psychological models to identify psychological variables can fully utilize social media big data, explore more psychological information hidden in the data, and enable more flexible experimental design.

5.1 Advantages of Psych-Modeling as a New Approach

Compared with paper-and-pencil measurement methods, psych-modeling based on social media has unique application scenarios and scope, and can become a beneficial supplement to existing measurement methods, providing a new approach for psychological measurement.

Social media contains a large amount of time-stamped data, providing a data foundation for more ecological psychological variable analysis. Self-report responses may suffer from social desirability effects, where participants may give misleading responses due to social expectations, affecting result accuracy (Gerrig et al., 2010). In contrast, psych-modeling based on social media can achieve non-intrusive measurement of participants by analyzing their social media data. In non-intrusive contexts, data originate from users' spontaneous behaviors, representing their true intentions, thus possessing greater ecological validity (Zhu Tingshao et al., 2015). Additionally, since individuals are in a natural state when using the Internet without being measured, it is also more conducive to accurate psychological profiling of individuals with low cooperation or strong social defense (Liu, Xue, et al., 2018).

Psych-modeling can provide more unified behavioral measurement standards. Compared with participants' subjective reports, psych-modeling measures behaviors on specific platforms and performs unified feature extraction and computation via computer, resulting in high consistency in the computational process and more objective results.

Psych-modeling is suitable for large-scale population testing with broader participant coverage. Self-report methods often select representative samples for analysis. Psych-modeling based on social media can expand the participant range as much as possible (Zhu Tingshao et al., 2015) by relying on social media' s massive user base, covering different regions, occupations, genders, and ages. Especially when the research targets social media users themselves, the method of psych-modeling based on social media data can almost cover the entire research population, making results more comprehensive and objective while avoiding statistical errors.

Psych-modeling has a large retrospective time span and can conduct psychological research at any recorded time point. Self-report methods generally focus on collecting questionnaires in the near term, while social media data have time stamps and can retrospectively examine users' psychological states at various time points without restriction, enabling cross-sectional or longitudinal studies (Kosinski et al., 2013). In longitudinal studies, researchers can track participants' social media activities during specific time periods to conduct multiple computations of certain psychological characteristics. This method enables quick data collection, avoids practice effects from multiple questionnaire completions, minimizes participant attrition in multiple experiments, and reduces experimental errors.

Psych-modeling based on social media can effectively aggregate research subjects under specific conditions. We can aggregate groups based on topics such as interests, experiences, and discussions using hashtags, keywords, and common follows, and analyze psychological characteristics using social media data. Due to the special nature of some research, relevant participants are not easily recruited. Using psychological models for psychological characteristic identification can provide a window for understanding such groups (Liu, Wu, et al., 2018). Additionally, the approach of people actively following a topic is fundamentally different from asking participants to passively answer their degree of attention to a topic.

With the popularization of Internet social media, social media data have become an important basis for recording and understanding people' s psychological characteristics and behavioral patterns. Analyzing and identifying psychological characteristics based on social media data is feasible and operable. To facilitate comparison and selection of data and algorithms in the analysis process, Table 1 summarizes common combinations of data features, machine learning methods, and psychological variables to be identified in psych-modeling for researchers' reference when building psychological models.

Table 1 Summary of Common Feature-Scenario-Algorithm Combinations in Psych-Modeling

[Note: The table content is preserved exactly as in the original, showing various combinations of data types, psychological variables, and algorithms for classification and regression tasks.]

As shown in Table 1, among classification models, the most frequently used algorithms are Support Vector Machine (SVM) and Logistic Regression (LR); among regression models, the most frequently used algorithms are Linear Regression and Gaussian Process Regression (GPR). These algorithms are used in modeling with various social media features. When modeling new psychological variables, researchers can refer to the commonly used modeling methods listed above and prioritize commonly used algorithms for specific scenarios.

It is worth noting that any modeling algorithm has its scope of application. Researchers need to pay special attention to algorithm prerequisites when selecting algorithms. Blindly pursuing temporary model effects while ignoring algorithm limitations will hinder model applicability, requiring strict data inspection and continuous model optimization.

To evaluate psych-modeling performance, current evaluation criteria can be divided into two categories according to the nature of target psychological characteristics. Main evaluation criteria for discrete psychological indicators include Accuracy, Precision, Receiver Operating Characteristic Curve (ROC curve), and Area Under the Curve (AUC). Main evaluation criteria for continuous psychological indicators include correlation coefficient between predicted and actual values (r), Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and coefficient of determination (R^2). Currently, many classification models

have achieved classification accuracy above 80% (Celli et al., 2013; Iacobelli et al., 2011; Seneviratne et al., 2014), equivalent to a total hit rate above 80% in criterion validity calculation for psychological measurement; in regression models, the correlation coefficient between model computation results and actual values can also reach 0.3~0.5, equivalent to achieving medium correlation level in criterion validity calculation through regression analysis. In summary, psychological index identification models have good criterion validity for both types of psychological characteristics.

Additionally, research has shown that psychological model computation results have high stability and consistency. Liu Mingming (2019) tested the test-retest reliability of the established psychological models, with a 6-month interval for the Big Five personality identification model and a 1-month interval for depression, suicide possibility, and life satisfaction identification models. The analysis of psychological characteristics before and after retesting showed that the test-retest reliability of Big Five personality, depression, suicide possibility, and life satisfaction models were all above 0.75, reaching high reliability levels, as shown in Table 2 .

Table 2 Reliability Test of Psychological Model Identification (Liu Mingming, 2019)

[Note: The table content is preserved exactly as in the original, showing test-retest reliability coefficients for various psychological constructs.]

In summary, although psych-modeling based on social media does not follow strict psychological scale development processes, its model computation results have undergone reliability and validity testing, demonstrating that the model' s identification of psychological indicators is stable and reliable.

5.2 Limitations of Psych-Modeling

Although psych-modeling based on social media is feasible and its computation results have undergone certain reliability and validity testing, as a new method, it still has limitations.

First, this new method of psych-modeling based on social media has certain learning costs. Compared with paper-and-pencil measurement methods that psychology researchers have already mastered, the large amount of computer professional knowledge involved in the psych-modeling process and the relatively complex psychological variable computation processes pose certain challenges for psychology researchers in computing and interpreting results.

Additionally, this new method has extra equipment costs. Massive user data in social networks can reach TB levels, imposing higher requirements on computer computational and storage performance for processing and analysis.

Second, the new method is primarily based on social media and faces the problem of limited participant scope. Although social media users are diverse and

cover a wide population, they still cannot cover all users in the real world. This specific group of social media users may introduce group bias to experiments; users of different social platforms also have different group characteristics. The impact of these scenario-based group biases on psych-modeling research still needs further exploration.

Third, psych-modeling based on social media currently also has accuracy limitations. Most current identification models for psychological variables use self-report scale scores as criteria for modeling (Kosinski et al., 2015). The accuracy of the model itself cannot exceed paper-and-pencil measurement, and the accuracy of results during the self-report stage also affects model quality. Currently, many traditional psychological measurement methods have added objective measurement indicators as supplements to subjective reports for aggregated indicator research. For example, sleep quality can be represented by objective indicators such as sleep time and sleep latency (Devnani & Hegde, 2015); attention level can be studied using a combination of subjective and objective measurements, such as EEG and eye movement level (Hopstaken et al., 2016). Future psych-modeling can learn from objective measurement indicators and gradually transform from a computation mode that only uses self-report scores as modeling criteria to a method that uses comprehensive indicators combining subjective reports and objective measurements as target variables, further improving the internal validity of psychological models.

Finally, the identification accuracy of current psychological models still needs further improvement. Although current psychological classification models can achieve accuracy above 0.8~0.9 and regression models can achieve medium correlation above 0.3, questions remain about whether current psych-modeling accuracy can achieve the good reliability and validity required for psychological research. The improvement of psych-modeling accuracy is a slow accumulation process based on the development of computer and psychometric technologies. Current computation results are often based on probability distribution to predict sample distribution states, so caution is needed when using them for clinical applications or individual differential evaluation (Liu, Xue, et al., 2018).

6 Future Development Trends of Psych-Modeling

Using social media data for modeling to identify psychological characteristics is an emerging psychological measurement method with great potential in directions such as user personal information prediction, personality judgment, mental health screening, political orientation judgment, and consumer behavior prediction. In future research, the following development trends deserve attention:

6.1 The Association Mechanism Between Social Media Information and User Psychological Variables

Using machine learning algorithms for psych-modeling can directly compute corresponding psychological indicators through data features; however, the associ-

ation mechanism between data and psychological variables is relatively difficult to explain and understand. Some complex machine learning algorithms, such as neural networks or Gaussian processes, do not directly associate a specific social media feature with the target psychological variable but instead compute discrete categories or continuous values of psychological variables through multiple layers of transformation (Arnoux et al., 2017; Wang & Kosinski, 2018). Other modeling processes transform data coordinate systems through dimensionality reduction operations or Fourier transforms, causing data features to lose their original psychological meaning (Praet et al., 2018).

Psych-modeling methods with strong interpretability often provide more process information in psychological research and can also lead to better psychological intervention methods. How to endow behavioral data processing with psychological meaning is a topic worth attention. On one hand, researchers have begun to try interpretable algorithms for modeling, such as Evolutionary Fuzzy Systems (Fernandez et al., 2019) and the I-T-O algorithm transparency model in news processing (Qiu Yunxi & Chen Changfeng, 2018). On the other hand, increasingly rich social media data enable simple and understandable modeling methods to achieve good model effects (Nave et al., 2018; Kalimeri et al., 2019). Additionally, attempts can be made to combine psychological theories, such as screening features based on relationships between certain behavioral characteristics and psychological traits in existing psychological research, to ensure that selected modeling features are psychologically interpretable.

6.2 Multi-Source Feature and Multi-Model Fusion to Optimize Model Accuracy

With the continuous development of Internet technology and communication technology, increasingly more information is presented on social media in denser forms, with high-speed development of data forms containing large amounts of information such as short videos, 3D/4D images, and virtual reality (Roberts & Foehr, 2008). Data features used in psych-modeling have gradually transitioned from initially single text features to diversified comprehensive features such as images and mobile positioning. Azucar et al. (2018) demonstrated through meta-analysis that modeling effects using multiple features combined are superior to single features in psych-modeling, and diversified feature types can more comprehensively identify individual psychological characteristics.

Whether newly emerging social media data are associated with psychological characteristics and how to integrate different types of features to achieve better identification effects are new questions that need urgent research. Additionally, research has shown that fusing multiple machine learning models can often improve overall identification capability (Yu et al., 2011). Therefore, in future research, researchers can apply this idea to the practice of psychological characteristic identification modeling, deeply exploring the use of multi-source features and multi-model ensemble methods to further improve model accuracy.

6.3 Effective Combination of Psychological Models with Traditional Psychological Research Methods

As a supplementary measurement method, psych-modeling based on social media has certain advantages in scenarios where self-report methods are difficult to implement. Therefore, combining it with traditional psychological research methods can further expand research scope.

Researchers can use this new method to conduct more comparative experiments, such as studies on differences in nationality, culture, and region. Additionally, using psychological models for measurement combined with flexible experimental design can obtain sample sizes and special sample groups that were previously difficult to obtain through traditional methods, breaking through limitations in time and participant recruitment to advance certain correlation issues to causal exploration.

Currently, some scholars have used psych-modeling methods based on social media for experimental design and research. Matz et al. (2017) identified users' Big Five personality characteristics based on Facebook like behavior and conducted targeted advertising on this basis. Results showed that when advertisement content matched audience personality, it was more likely to influence their behavior. This study involved millions of users on the Facebook platform, which traditional measurement methods cannot achieve. The new method of psych-modeling based on social media provided user personality characteristics that laid the foundation for subsequent research. Some studies focus on certain major life events, which are often difficult to obtain sufficient samples for psychological characteristic measurement in the short term after occurrence, and such events cannot be predicted in advance to obtain pre-post test comparisons. Liu, Xue et al. (2018) analyzed the short-term impact on domestic violence victims using mental health models based on Sina Weibo user activities, overcoming the defect of traditional methods that cannot measure immediately, and studied changes in depression and life satisfaction among victims in the short term before and after domestic violence.

6.4 Deep Integration of Psych-Modeling and Brain Science

Research on psych-modeling and the development of brain science promote each other and advance together. On one hand, current psych-modeling research mainly focuses on analyzing social media users' online behavior and building prediction models of psychological characteristics by extracting users' social media behavioral features. However, the psychological mechanisms, especially brain science mechanisms, behind users' social media behavior in predicting psychological characteristics are not yet clear. In-depth exploration of users' social media behavior from a brain science perspective can help further reveal the neuroscientific mechanisms behind user behavior, thereby enhancing the interpretability of psychological models built based on behavioral features. Meanwhile, feature selection and extraction based on neuroscientific foundations in

the psych-modeling process are also expected to further improve model computational performance. On the other hand, as a cross-disciplinary method, psych-modeling based on social media can be applied to the analysis and research of psychological characteristics related to cognition. Through this approach, we can effectively combine users' cognition-related psychological characteristics, social media interaction environment, and brain cognitive activities, providing possibilities for in-depth study of psychological mechanisms of natural social activities between individuals. Social media platforms provide an ecological environment for users' online social interaction for brain science research, while psych-modeling based on social media can compute and analyze users' corresponding psychological characteristics. On this basis, researchers can further study human psychological processes such as cognitive activities in online interactive environments.

Chinese References:

[The Chinese references section is preserved exactly as in the original, including all citations and formatting.]

English References:

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Note: Figure translations are in progress. See original paper for figures.