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Analyzing Textual Data in Behavioral Science with Natural Language Processing

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ABSTRACT: Natural Language Processing (NLP) has emerged as a breakthrough technique in behavioral science, enabling researchers to examine large-scale textual data to acquire insights into human cognition, emotions, and social interactions. Traditional behavioral research methods frequently rely on manual analysis, which is time-consuming and prone to biases. NLP improves the precision and scalability of behavioral research by automating this process through sentiment analysis, topic modeling, and deep learning techniques. Its applications extend to mental health monitoring, education, social media analysis, and healthcare, with studies demonstrating its effectiveness in detecting depression, analyzing public discourse, and improving clinical decision-making. However, challenges remain such as data bias, ethical concerns, privacy issues, and the interpretability of NLP models. Future research should focus on developing interpretable AI models, integrating multimodal data sources, and improving privacy-preserving techniques to ensure responsible and ethical application of NLP in behavioral science. Addressing these challenges will allow NLP to bridge the gap between qualitative and quantitative research, and revolutionize the way human behavior is studied and understood.

KEYWORDS: Natural Language Processing (NLP), Behavioral Science, Textual Data Analysis, Sentiment Analysis, Machine Learning , Psychological and Social Behavior, Ethical and Privacy Concerns in AI

1.INTRODUCTION

An unprecedented amount of textual data has been generated by the increasing digitization of human interactions, creating new possibilities for natural language processing (NLP) to analyze human emotions, social behaviors, and cognition (Abdullah et al., 2021). NLP facilitates behavioral science research by providing computational techniques to extract important insights from a variety of textual sources, including social media, medical records, and educational discourse (Ibrahim & Abdulazeez, 2021). In behavioral research, traditional qualitative methods often rely on subjective interpretation and hand coding, which can limit scalability and introduce biases. On the other hand, NLP allows researchers to more accurately and efficiently identify psychological markers such as stress levels, personality traits, and mental health issues by automating the processes of sentiment analysis, topic modeling, and linguistic pattern recognition (W. M. Eido & Ibrahim, 2025). NLP has become a crucial tool in behavioral research due to the rapid development of deep learning models, especially transformer-based architectures such as BERT and GPT, which have improved their ability to understand linguistic context and nuances (Ismael et al., 2021).

Mental health monitoring is one of the most important uses of natural language processing (NLP) in behavioral research. By examining linguistic cues in online interactions, electronic health records, and personal writings, researchers have effectively used NLP approaches to identify early indicators of depression, anxiety, and suicidal ideation (Tato & Yasin, 2025). NLP models can predict mental illness and emotional distress by analyzing textual clues including sentiment shifts, language complexity, and recurring themes. This can assist clinicians in early intervention and individualized treatment plans (Saleh & Zebari, 2025). NLP has great potential, but issues remain regarding its ethical implications in mental health research, particularly regarding privacy, bias, and the potential for misinterpretation (Saleh & Zebari, 2025). To overcome these obstacles, continued progress is needed in model interpretability, data pre-processing, and ethical standards to ensure the responsible use of AI in behavioral research (Gading Abdullah et al., 2024).

Beyond mental health, NLP has proven to be of great value in understanding human behavior in a variety of fields, such as political debate, marketing, and education. NLP-based systems in education improve student engagement and personalized learning by enabling AI-assisted tutoring, adaptive learning platforms, and automated article grading (W. M. Eido & Ibrahim, 2025). In the corporate and marketing sectors, NLP enables sentiment analysis to gauge customer preferences, improve digital marketing strategies, and predict consumer behavior based on text interactions (Saleh & Zebari, 2025). Similarly, in political science, NLP has been applied to track ideological shifts, detect misinformation, and assess public opinion patterns in large-

scale social media datasets (Ismael et al., 2021). These interdisciplinary uses demonstrate how NLP can revolutionize the extraction of behavioral insights from text interactions in a variety of fields.

Even with these advances, NLP still faces several hurdles in behavioral science applications. The complexities of human language, cultural differences in communication patterns, and the inherent uncertainty in text interpretation hinder the generalization of NLP models (Ibrahim & Abdulazeez, 2021). Furthermore, issues related to data security, the ethical use of AI, and biased training datasets continue to prevent NLP from being widely used in sensitive areas such as social behavior analysis and mental health diagnosis (Gading Abdullah et al., 2024). The accuracy and relevance of NLP in behavioral science will be greatly improved as research progresses by combining it with advanced techniques such as multimodal AI and reinforcement learning (Tato & Yasin, 2025). Future research should focus on improving NLP models to ensure ethical compliance in practical applications while balancing interpretability, fairness, and computational efficiency (W. M. Eido & Ibrahim, 2025).

2.RESEARCH METHODOLOGY

This section outlines the methodology followed in conducting the literature review and analysis presented in this paper. The research follows a structured approach to selecting, reviewing, and synthesizing existing literature on the impact of web technology, cloud computing, digital marketing, and machine learning in transforming enterprise systems.

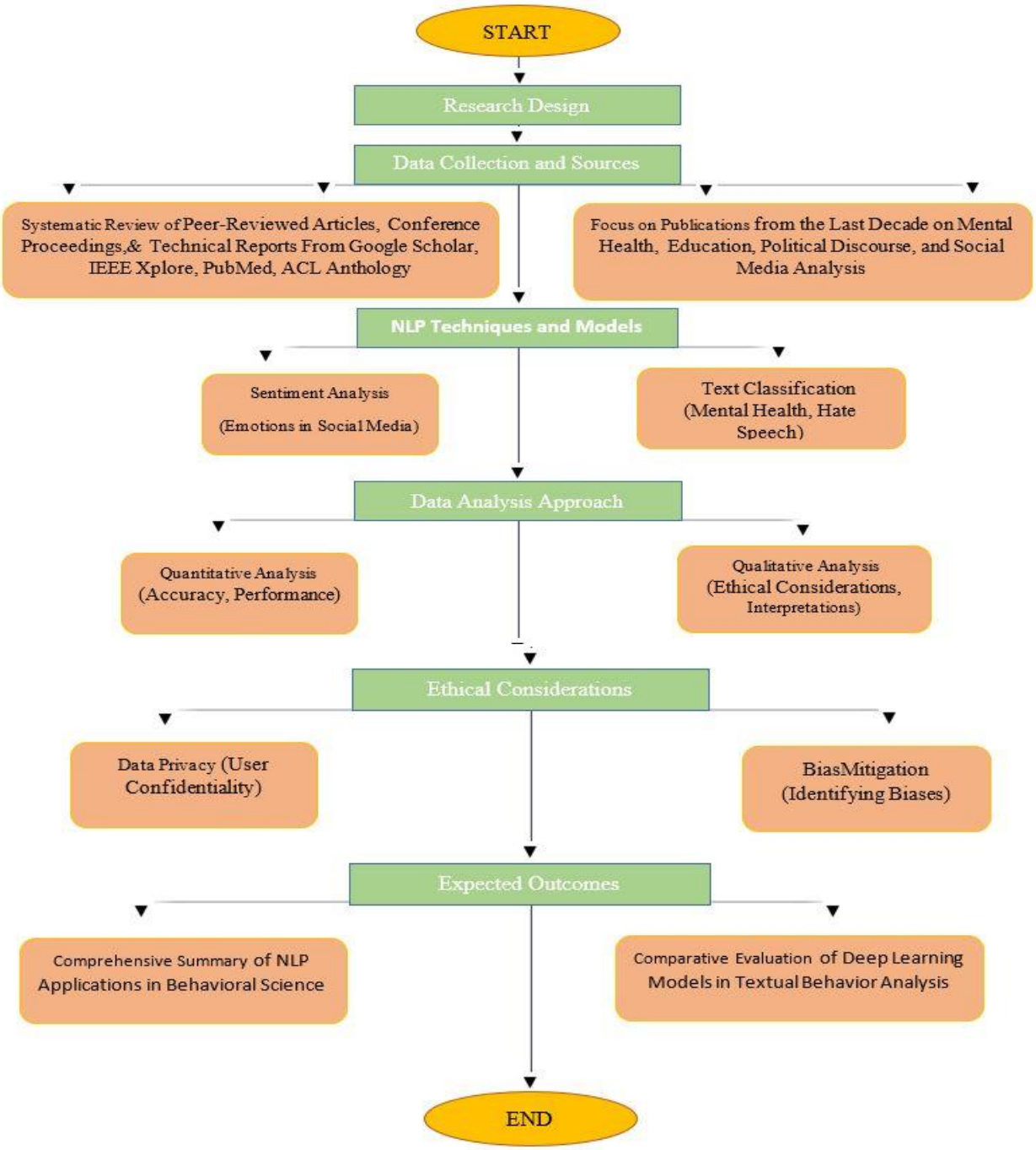

Figure1: General Flowchart of the Methodology.

2.1. Research Design

This study examines the applications of natural language processing in the behavioral sciences using a systematic review and comparative analysis approach. The methodology involves examining previous research studies that apply natural language processing techniques to behavioral data, such as text from social media, electronic health records, and psychological tests, in order to identify trends, benefits, drawbacks, and ethical issues associated with the applications of natural language processing in the behavioral sciences.

2.2. Data Collection and Sources

In this work, publications in peer-reviewed journals, conference proceedings, and technical reports from reputable NLP and behavioral science databases are systematically reviewed. Studies from Google Scholar, IEEE Xplore, PubMed, and the ACL Anthology are among the data sources; to ensure relevance, publications from the past 10 years are prioritized. Articles that discuss NLP approaches used in the analysis of social media, education, mental health, and political discourse are prioritized according to the selection criteria.

2.3. NLP Techniques and Models Used

This study categorizes NLP techniques based on their application areas in behavioral science:

- **Sentiment Analysis** – Used to evaluate emotions in social media texts and patient narratives.
- **Topic Modeling** – Applied to cluster and identify themes in large textual datasets.
- **Text Classification** – Implemented for detecting mental health conditions, hate speech, and extremist content.
- **Deep Learning Approaches** – Models such as **BERT, LSTMs, CNNs, and GPT** are analyzed for their effectiveness in behavioral analysis.
- **Privacy-Preserving NLP** – Investigates secure NLP frameworks, including federated learning and differential privacy.

2.4. Data Analysis Approach

The analysis follows a **quantitative and qualitative approach**:

- **Quantitative Analysis** – Extracting accuracy rates, model performance metrics, and statistical comparisons from previous studies.
- **Qualitative Analysis** – Reviewing interpretations, ethical considerations, and the implications of NLP applications in behavioral research.

2.5. Ethical Considerations

Given the sensitivity of behavioral science data, this study follows ethical guidelines related to:

- **Data Privacy** – Ensuring NLP models do not compromise user confidentiality.
- **Bias Mitigation** – Identifying biases in training datasets and proposing methods to minimize them.
- **Fair AI Use** – Advocating for transparency and accountability in AI-driven behavioral analysis.

2.6. Expected Outcomes

The study aims to provide:

- A **comprehensive summary** of NLP applications in behavioral science.
- A **comparative evaluation** of deep learning models in textual behavior analysis.
- **Recommendations** for ethical AI development in psychology, education, and mental health NLP applications.

3.THEORETICAL FRAMEWORK

3.1. Natural Language Processing (NLP) in Behavioral Science

Researchers can now examine human communication patterns, emotional expressions, and cognitive activities using text-based data thanks to natural language processing (NLP), a powerful tool in behavioral science (Gading Abdullah et al., 2024). In a variety of fields, including psychology, education, and social sciences, NLP encompasses a wide range of computational methods that support text classification, sentiment analysis, and linguistic pattern identification (Ibrahim & Abdulazeez, 2021). The accuracy and interpretability of NLP applications have been greatly improved by combining machine learning and deep learning models, particularly transformer-based architectures such as BERT and GPT (W. M. Eido & Ibrahim, 2025). These developments have facilitated the extraction of important behavioral insights from large-scale text databases, advancing our knowledge of human social interactions and cognitive processes (Saleh & Zebari, 2025).

3.2. Textual Data Analysis and Sentiment Detection

Because it provides access to people's thoughts, feelings, and psychological states through written language, textual data analysis is essential for understanding human behavior (Younis et al., 2023). Researchers can assess psychological well-being and public opinion trends using sentiment analysis, one of the most widely used NLP techniques, to categorize text as positive, negative, or neutral (Orellana & Bisgin, 2023). Sentiment analysis is used in behavioral science to identify stress levels, emotional states, and early indicators of mental health issues in digital chats and social media (Tato & Yasin, 2025). Despite the effectiveness of sentiment analysis, there are still problems in detecting sarcasm, context-specific emotional changes, and cultural differences in language use (Sousa & Kern, 2023).

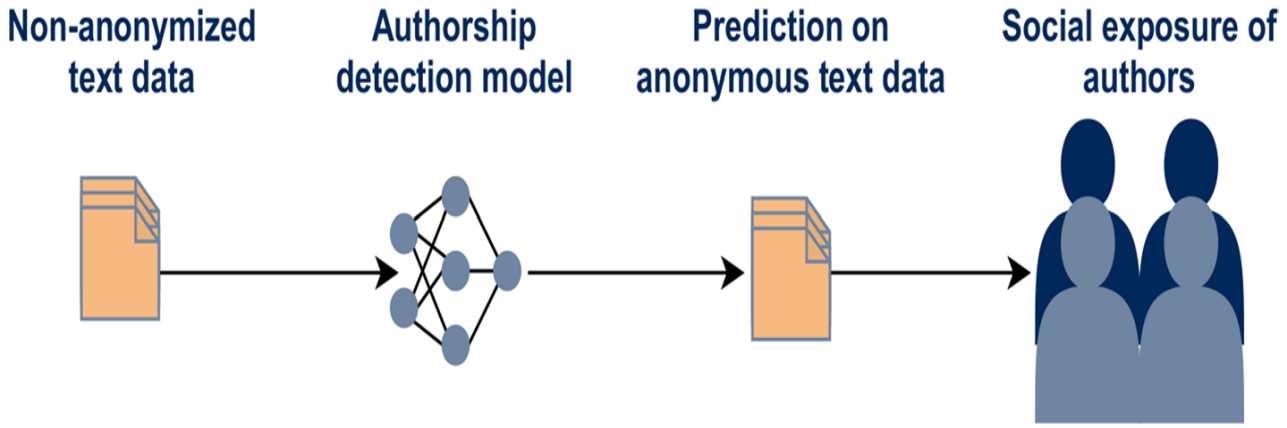

Figure2: Re-identification of previously anonymous texts. The author disclosure model in this context may compromise the identity of the authors of the text data by making it public.

3.3. Machine Learning Approaches in NLP for Behavioral Science

By facilitating automated text classification, entity recognition, and predictive modeling, machine learning in natural language processing has revolutionized behavioral research (Ismael et al., 2021). While deep learning models such as long short-term memory (LSTM) and bidirectional encoder representations from transformers (BERT) have greatly enhanced context-based text interpretation, supervised learning techniques such as support vector machines (SVMs) and random forests have been used for text classification (Abdullah et al., 2021). According to (Hariri, 2023) these models are essential for identifying linguistic patterns indicative of psychological disorders such as anxiety, depression, and post-traumatic stress disorder (PTSD). Applications of natural language processing in behavioral sciences are still limited by the requirements of large labeled datasets and powerful computers (Saleh & Zebari, 2025).

3.4. Psychological and Social Behavior Analysis Using NLP

Natural language processing techniques have been widely used in social sciences and psychology to analyze texts and analyze individual and group behaviors (W. M. Eido & Ibrahim, 2025). Researchers use natural language processing to assess linguistic diversity, emotional intelligence, and personality traits in different social contexts by analyzing survey responses, interview transcripts, and online discussions (Ismael et al., 2021). Natural language processing has been applied in political psychology to identify extremist rhetoric, track ideological trends, and detect propaganda in large-scale text datasets (Orellana & Bisgin, 2023). Workforce analytics based on natural language processing also help assess workplace culture and employee sentiment in corporate behavior (Tato & Yasin, 2025).

3.5. Ethical and Privacy Concerns in AI-driven Text Analysis

The increasing use of natural language processing (NLP) in behavioral research has raised serious ethical questions about algorithmic fairness, data bias, and privacy (Sousa & Kern, 2023). User privacy is at risk when personal text data is collected and processed, especially in sensitive areas such as criminal investigations and mental health diagnoses (Zheng et al., n.d.). Imbalanced training datasets are often a source of bias in NLP models, which can lead to misinterpretations and feed social biases (Gading Abdullah et al., 2024). Future research should focus on putting ethical AI ideas into practice, improving model transparency, and creating frameworks for behavioral science applications of responsible NLP (Saleh & Zebari, 2025).

3.6. NLP in Mental Health and Psychological Well-being

The study of linguistic patterns associated with psychological distress, sadness, and anxiety has been made possible by natural language processing (NLP), which has transformed mental health research (Arowosegbe & Oyelade, 2023). Researchers have examined social media posts, therapy texts, and online forum discussions to assess mental health issues using sentiment analysis, topic modeling, and sentiment detection techniques (T. Zhang et al., 2022). Research has shown that machine learning algorithms trained on large-scale datasets can reliably identify early indicators of post-traumatic stress disorder, stress, and suicidal ideation based on linguistic cues (Hariri, 2023). However, the use of NLP in mental health raises issues of data privacy, permission, and the potential for incorrect diagnoses based on textual analysis alone, despite its potential (Sousa & Kern, 2023).

3.7. NLP in Educational Research and Learning Analytics

Automated feedback systems, adaptive learning platforms, and AI-powered tutors that improve student engagement and learning experiences are made possible by integrating Natural Language Processing (NLP) into education (Bauer et al., 2023). To assess student responses, identify understanding gaps, and personalize learning materials based on language proficiency, NLP-driven systems have been used (Younis et al., 2023). In order to find important learning patterns, text mining techniques have also been used to examine academic writing, online learning environments, and classroom debates

(Saleh & Yasin, 2025). Although NLP has greatly increased the effectiveness of educational assessments, issues related to cultural bias in language models and the ethical application of AI in student assessment remain important factors to consider (Gading Abdullah et al., 2024).

3.8. NLP in Social Media and Public Opinion Analysis

Social media platforms generate massive amounts of textual data, which provide insights into political attitudes, consumer behavior, and public opinion (Orellana & Bisgin, 2023). Natural language processing techniques including sentiment analysis, named entity recognition, and trend detection have been widely used to examine social conversation and predict new patterns in online discussions (Tato & Yasin, 2025). Researchers have used natural language processing to track ideological trends in political discourse, identify false information, and evaluate extremist rhetoric (W. M. Eido & Ibrahim, 2025). However, issues such as algorithmic bias, bot-generated content, and data manipulation seriously compromise the accuracy of NLP-based social media analysis (Ismael et al., 2021).

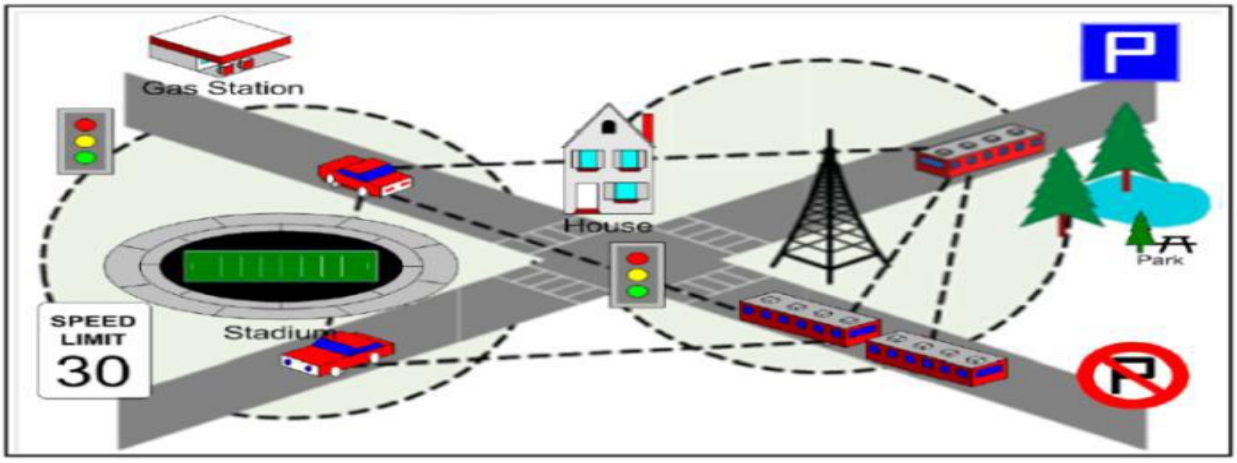

Figure3: Hybrid architecture

3.9. NLP in Healthcare and Clinical Decision Support

Natural language processing has been widely applied in the medical field for automated diagnosis, clinical record keeping, and patient sentiment analysis (Zheng et al., n.d.). Medical NLP applications include predicting disease progression by analyzing text data, evaluating doctor-patient discussions, and extracting relevant information from electronic health records (EHRs) (Zhou et al., 2024). AI-driven virtual assistants and chatbots have also been created to facilitate patient interactions and provide mental health treatment (Hariri, 2023). Despite these advances, issues including model interpretability, regulatory compliance, and potential biases in clinical datasets must be resolved for NLP to be widely used in healthcare (Saleh & Zebari, 2025).

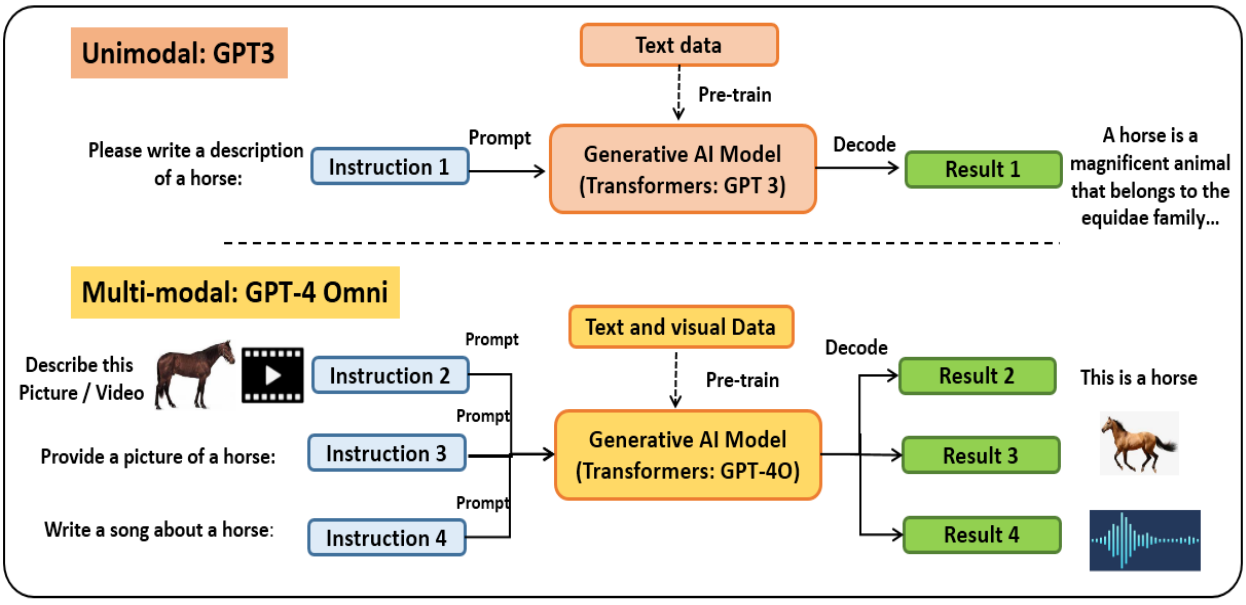

Figure 4: Generative AI models: unimodal and multi-modal examples.

3.10. NLP in Cybersecurity and Fraud Detection

The use of NLP in cybersecurity has become increasingly important as a means of detecting fraudulent activities, discovering online threats, and stopping phishing scams (Sousa & Kern, 2023). Text-based anomaly detection methods have been created to examine malicious intent in online interactions, fake news, and suspicious conversations (Gading Abdullah et al., 2024). NLP-based deception detection has also been used in corporate fraud detection and forensic investigations, helping companies mitigate cybercrime risks (Saleh & Yasin, 2025). However, there are still many hurdles to overcome, including adversarial attacks on NLP models and ethical dilemmas with widespread surveillance and privacy violations (Ibrahim & Abdulazeez, 2021).

3.11. Future Trends and Challenges in NLP for Behavioral Science

As NLP continues to evolve, future research aims to improve contextual understanding, model interpretability, and ethical AI practices in behavioral science (W. merza Eido & Yasin, 2025). The development of multimodal NLP, which integrates text with voice, facial expressions, and physiological cues, presents new opportunities for more comprehensive behavioral analysis (Zheng et al., n.d.). Additionally, enhancing the fairness and transparency of NLP models through bias mitigation techniques and responsible AI frameworks remains a key priority for researchers and policymakers (Saleh & Yasin, 2025). Addressing these challenges will be critical to ensuring that NLP continues to provide valuable insights while maintaining ethical integrity in behavioral research (Tato & Yasin, 2025).

4.LITERATURE REVIEW

(Arowosegbe & Oyelade, 2023) This study explores the role of natural language processing in detecting and preventing suicidal ideation, emphasizing the importance of integrating structured and unstructured data to better predict risk. The study reviews various machine learning techniques used to analyze suicide-related texts from electronic medical records and social media platforms. It highlights the advantages of natural language processing in providing cost-effective alternatives to traditional mental health assessment methods. The results suggest that continuous passive monitoring of individuals with mental health conditions could aid in early intervention and suicide prevention. Finally, the study calls for the expansion of AI-based tools to enhance mental health support systems.

(Bauer et al., 2023) explains how NLP can be used to improve peer-feedback procedures in online learning settings and offers a multidisciplinary framework for incorporating AI into the classroom. The work highlights how large language models, such as ChatGPT and GPT-4, can revolutionize feedback mechanism automation. In order to offer adaptive support, it presents a peer-feedback paradigm that methodically examines students' textual interactions. The study also emphasizes the difficulties in applying NLP in the classroom, such as data accuracy and ethical issues. All things considered, the study offers a methodical way to use NLP to enhance online education and student involvement.

(Boyd & Schwartz, 2021) explores how natural language analysis in psychology has changed over time, from early qualitative interpretations to contemporary computational techniques. Key developments in text analysis are highlighted in the paper, including the move from conventional word frequency counts to more complex NLP techniques. It draws attention to how interdisciplinary cooperation helps to improve language analysis models for psychological studies. The results highlight how computational methods are becoming increasingly important for identifying subtle psychological patterns in text. In order to improve psychological evaluations, the study concludes by urging additional NLP integration in the social sciences.

(Chung et al., 2023) Identifying important research directions and technology gaps by comparing the use of Natural Language Processing (NLP) in computer science and construction. The paper highlights the growing use of Natural Language Processing (NLP) in construction for activities including project management, risk analysis, and smart construction using bibliometric analysis and systematic reviews. Compared to computer science, the paper shows that despite the advances made by NLP in construction, there are still limitations in the approach and scope of application. The report highlights the need for more interdisciplinary approaches in its recommendations for future research areas. Finally, it provides a starting point for advancing the use of Natural Language Processing (NLP) in the construction sector.

(Ding et al., 2022) Examine how NLP is used in the construction industry, paying particular attention to how it may automate processes like document management, compliance verification, and safety monitoring. The study demonstrates how NLP methods, such as text mining and machine learning, improve processing efficiency for textual data pertaining to building. It highlights important issues such data segregation and the requirement for improved AI-driven tool integration. The results highlight how crucial cross-modal interdisciplinary research is to filling in current technology gaps. All things considered, the study offers insightful information on how NLP is developing in the construction industry and its room for more innovation.

(Epoka, 2023) highlights how natural language processing (NLP) can be used to automate parts of content analysis in qualitative research. In particular, text preparation and rule-based coding are two NLP techniques that the study demonstrates can greatly improve the speed and precision of qualitative data analysis. NLP systems may cut manual coding time by a factor of ten while retaining high accuracy, as the research shows through a case study. According to the

results, NLP can help close the gap between qualitative and quantitative research methods by offering organized analysis of huge textual datasets. In order to increase the effectiveness of data processing and the extraction of theoretical evidence, the study concludes by recommending more integration of NLP in social scientific research.

(Le Glaz et al., 2021) offers a thorough analysis of the uses of NLP and machine learning in mental health, with an emphasis on how they are used to diagnose and track psychiatric conditions. The study divides earlier research into three primary categories: social media-based mental health assessments, ER patient monitoring, and medical records analysis. Results show that NLP methods are especially helpful for identifying symptoms, categorizing the severity of illnesses, and assessing the efficacy of treatments. The study does, however, raise issues with the over-reliance on social media data, which might not accurately reflect patient demographics in general. All things considered, the study highlights the potential of NLP and machine learning in psychiatry while highlighting the necessity of better techniques and ethical considerations.

(Guo, 2022) A Deep Learning-Assisted Semantic Text Analysis (DLSTA) model is proposed, which explores the application of deep learning and natural language processing (NLP) to detect human sentiment from textual data. The work highlights the importance of word embeddings to enhance NLP activities including question answering, machine translation, and sentiment analysis. The proposed method outperforms conventional techniques in sentiment recognition accuracy by 97.22% by combining semantic and syntactic text elements. The results suggest that e-learning, advertising, and legal investigations are among the areas where NLP-based sentiment analysis may find application. Finally, the study emphasizes the growing importance of deep learning in improving NLP applications for sentiment and emotion analysis.

(Hariri, 2023) This study examines the improvements and shortcomings of ChatGPT in natural language processing by comparing its capabilities to those of other large language models (LLMs), such as Gemini and LLaMA 3. The study highlights ChatGPT's adaptability to context while discussing its uses in medical diagnosis, chatbots, content creation, and translation. Despite its capabilities, the research highlights ethical challenges related to bias and misinformation, underscoring the need for responsible AI implementation. The paper also examines future directions for ChatGPT, including improvements in multimodal integration and rapid engineering. Finally, the study provides a comprehensive assessment of ChatGPT's contribution to the development of AI-based natural language processing technology.

(Harrison & Sidey-Gibbons, 2021) focuses on the analysis of unstructured text data, including patient feedback and medical records, and provides an introduction to NLP approaches in medical research. To categorize drug reviews, the study carries out three NLP experiments utilizing topic modeling, sentiment analysis, and supervised machine learning. Findings show that natural language processing (NLP) methods can classify medical text data efficiently, offering important information on patient experiences and treatment results. Nonetheless, the study draws attention to difficulties in managing irony, negation, and complicated medical terminology. All things considered, the study highlights the expanding use of natural language processing (NLP) in healthcare analytics and promotes the use of machine learning methods to improve clinical judgment.

(Hou & Huang, 2025) This paper focuses on methods and applications in the fields of political science, psychology, and sociology, providing a comprehensive analysis of NLP methods in social scientific research. The paper emphasizes how NLP can help transform unstructured text input into structured representations so that sophisticated semantic analysis can be performed. It highlights the need for responsible use of NLP in social research by discussing the challenges of data representation, interpretability, and biases. Additionally, machine learning-based methods for sentiment analysis, topic modeling, and text classification are examined in the extensive research of the paper. Finally, the study promotes the use of NLP in computational social science to improve quantitative understanding of social behavior.

(Jackson et al., 2022) This study explores the ways in which language analysis can enhance psychological research, highlighting the potential of natural language processing and comparative linguistics for understanding human emotion, creativity, and thought. The paper illustrates how computational linguistics has evolved by discussing both historical and contemporary approaches to examining psychological concepts in text. It also shows how digital archives and machine learning methods have made language data, which were previously difficult to work with, more accessible. According to the study, natural language processing can help with issues such as statistical power, cultural diversity, and the integration of psychological theories. Overall, the paper encourages the use of natural language processing to complement traditional psychological research techniques and produce new understandings of human cognition.

(Jahan & Oussalah, 2023) provides a thorough analysis of hate speech detection with natural language processing (NLP), emphasizing the use of machine learning and deep learning techniques for automatic text classification. The article discusses several supervised and unsupervised techniques while outlining the main difficulties in detecting hate speech on various social media platforms and in various languages. It covers deep learning architectures that have greatly increased classification accuracy, such as CNNs, LSTMs, and BERT. It also highlights the drawbacks of automatic identification, such as biases in training data and

challenges differentiating between context-dependent hate speech and sarcasm. The work concludes by urging additional advancements in the cross-cultural generalization of NLP-based hate speech detection, model interpretability, and dataset quality.

(Jim et al., 2024) offers a thorough examination of sentiment analysis based on natural language processing (NLP), looking at developments in large language models (LLMs), deep learning, and machine learning. Document, sentence, phrase, and word-based approaches are among the layers into which the study divides sentiment analysis methodologies. It addresses the application of pre-trained models in sentiment classification, highlighting the advantages and disadvantages of BERT, GPT-3, and Megatron-Turing NLG. The study draws attention to the difficulties in sentiment analysis, including domain adaptability, contextual ambiguity, and ethical issues including bias in training data. The work concludes by outlining potential avenues for future research to strengthen multimodal integration and interpretability in sentiment analysis algorithms.

(Khan et al., 2023) examines the relationship between deep learning and natural language processing, giving a summary of the main issues and new developments in the field. The evolution of large language models (LLMs) and their uses in text categorization, named entity recognition, speech recognition, and question answering are examined in this paper. Particularly when it comes to managing pragmatic language elements like context, presupposition, and social norms, it draws attention to the shortcomings of deep learning-based NLP models. The study also covers the latest NLP frameworks, libraries, and tools for enhancing the scalability and efficiency of models. The paper concludes by urging improvements in model interpretability and ethical considerations to guarantee equitable and successful NLP implementations.

(Khurana et al., 2023) highlights how Natural Language Processing (NLP) has evolved from rule-based systems to contemporary machine learning techniques while examining its developments, trends, and difficulties. In order to examine their applications in domains including machine translation, information extraction, and speech recognition, the paper divides natural language processing (NLP) into two categories: natural language understanding and natural language generation. The study focuses on important NLP tasks that have significantly improved as a result of deep learning methods, such as named entity recognition, sentiment analysis, and syntactic parsing. The paper also looks at evaluation metrics, model designs, and widely used NLP datasets that have improved performance. In the end, the study highlights the persistent difficulties in NLP, including the lack of data, interpretability issues, and biases in language models.

(Lavanya & Sasikala, 2021) focuses on supervised learning techniques for handling unstructured medical data as it examines the function of deep learning in text classification inside social healthcare networks. The study demonstrates how well convolutional neural networks (CNNs) and recurrent neural networks (RNNs) analyze healthcare-related social media messages. It talks about how knowledge might be disseminated more effectively by using deep learning models to find patterns in texts pertaining to health, such as patient questions and expert answers. In order to improve digital healthcare platforms and comprehend public health trends, the study highlights the significance of text classification. In the end, the study recommends more NLP approach optimization to improve the precision and speed of healthcare text classification.

(Li et al., 2022) examines how neural natural language processing (NLP) methods are used to analyze unstructured data from electronic health records (EHRs), emphasizing the expanding use of deep learning models. Classification, medical coding, named entity recognition, and information extraction are among the NLP jobs in EHR analysis that are categorized in the study. Working with unstructured clinical texts presents a number of difficulties, including concerns about interpretability, data protection, and the shortage of annotations. The impact of large-scale pre-trained language models on enhancing medical natural language processing tasks is also examined in this research. The study concludes by highlighting the necessity of strong approaches to improve text analysis in EHRs and aid in medical decision-making.

(Malgaroli et al., 2023) provides a thorough investigation of the application of natural language processing (NLP) in mental health interventions, looking at how AI-powered language analysis might enhance mental evaluations. Key uses of natural language processing (NLP) are identified in the paper, including the analysis of patient-therapist interactions, tracking the effectiveness of treatment, and identifying mental health issues including anxiety and depression. It emphasizes how NLP may be used to glean insights from conversational data, allowing clinicians to evaluate the efficacy of treatments. The study also addresses issues like linguistic biases, privacy concerns over data, and the need for AI-driven models to be easier to understand. In the end, the study suggests a research framework to promote NLP's incorporation into mental health services.

(Maulud et al., 2021) This paper provides a comprehensive overview of natural language processing techniques, exploring how they are used in information retrieval, topic modeling, and sentiment analysis. The paper highlights the importance of natural language processing in dealing with large amounts of textual data by identifying important natural language processing tasks such as named entity recognition, segmentation, and syntactic analysis. It compares several natural language processing techniques, focusing on the ways in which machine learning and deep learning models have enhanced text classification and understanding. The paper also covers the impact of natural language processing on a

number of fields, such as social media analytics, healthcare, and education. The paper concludes by highlighting the growing importance of natural language processing in improving human-computer interaction and automating language-based processes.

(Mishra et al., 2022) focuses on data extraction methods and classification models as it examines the use of natural language processing (NLP) in sentiment analysis. The study emphasizes how machine learning methods, including Support Vector Machines and Naïve Bayes, can be used to classify feelings in textual data. It highlights how sentiment analysis is becoming increasingly important for examining viewpoints on social media and e-commerce sites. The study also addresses how to improve sentiment categorization accuracy by combining supervised and unsupervised learning techniques. The study's final conclusion is that sentiment research is essential for comprehending public opinion and decision-making across a range of businesses.

(Murphy et al., 2023) examines supervised learning techniques in electronic health records (EHRs) and performs a scoping assessment of NLP-based adverse drug event (ADE) detection techniques. According to the report, the most popular NLP methods for ADE identification are named entity recognition and relation classification. It talks on the advantages and disadvantages of current NLP models, emphasizing issues with generalizability, annotation quality, and data sparsity. The study highlights how crucial it is to incorporate semi-automated techniques to lessen the need for manual annotation. Finally, the paper advocates for the creation of more effective and scalable systems by outlining potential future avenues for enhancing NLP-based ADE identification.

(Naithani & Raiwani, 2023) investigates the role of NLP and machine learning in sentiment analysis, reviewing various algorithms and their performance in text classification. The paper offers a thorough comparison of contemporary deep learning methods like CNNs and LSTMs and more conventional machine learning techniques like Support Vector Machines and Bayesian Networks. It discusses the efficiency of hybrid models that integrate different strategies to increase sentiment classification accuracy. The study emphasizes how sentiment analysis is used in marketing, social media, and customer feedback analysis. The study concludes by highlighting the necessity of ongoing developments in NLP methods to improve text-based sentiment analysis.

(Nijhawan et al., 2022) This paper explores how sentiment analysis can be used to predict mental health disorders using natural language processing (NLP) and machine learning to detect stress in social media interactions. To analyze social media messages, the study uses BERT to classify sentiment and latent Dirichlet allocation for topic modeling. It discusses the challenges in identifying stress and depression in text data, such as contextual ambiguity and linguistic diversity. The study emphasizes how NLP-based stress detection can enhance early intervention and mental health monitoring technologies. In order to improve mental health support services, the study concludes by recommending the integration of NLP into healthcare systems.

(Orellana & Bisgin, 2023) uses natural language processing (NLP) methods to examine political party manifestos, examining sentiment analysis, topic modeling, and document similarity to evaluate political discourse. Through an analysis of manifesto text, the study looks at how political parties' agendas change over time. It demonstrates how well NLP can detect policy trends and ideological shifts in political literature. The study also addresses the difficulties in using natural language processing (NLP) for political writings, such as the requirement for contextual awareness and fine-tuning. The study comes to the conclusion that NLP offers important insights into party positioning and political communication.

(Patra et al., 2021) provides a thorough analysis of methods for obtaining social determinants of health (SDoH) from electronic health records (EHRs) using natural language processing (NLP). The study underlines how important SDoH is in affecting patient health outcomes and how difficult it is to extract this data from unstructured clinical notes. In order to find trends in health-related social issues like substance use, homelessness, and financial stability, it examines a variety of NLP approaches, including rule-based and machine learning techniques. The results indicate that while rule-based approaches continue to be the most popular for less-studied determinants, machine learning models are more successful at identifying structured SDoH categories. The study concludes by urging more NLP framework development to improve the precision and effectiveness of SDoH extraction from clinical texts.

(Rathje et al., 2024) evaluates the GPT models' capacity to identify psychological constructs in a variety of languages by investigating their potential in multilingual psychological text analysis. When compared to conventional dictionary-based and refined machine learning techniques, the study shows that GPT models perform better in sentiment analysis, emotion identification, and the classification of moral underpinnings. It emphasizes how well GPT handles less common languages, which makes it a useful instrument for investigations into cross-linguistic psychology. The study also highlights how easy it is to use GPT-based NLP tools, which need no coding knowledge and training data. The paper concludes that GPT may help democratize automated text analysis and further behavioral and cognitive science research.

(Salah et al., 2023) examines the use of generative AI—in particular, ChatGPT—in social psychology research, emphasizing how well it can model social interactions and analyze vast amounts of textual data. The study emphasizes how ChatGPT can be used to better analyze sentiment in social psychology, simulate group dynamics, and identify behavioral patterns. Important theoretical and ethical issues

are covered, including the dangers of relying too much on automated analysis and biases in AI-generated results. The study offers a framework for combining ChatGPT with accepted psychological theories in order to guarantee applications that are both significant and supported by science. In the end, the study promotes the ethical and responsible application of generative AI in psychological research, stressing the necessity of ongoing ethical review and validation.

(Sangeetha et al., 2023) investigates the use of recursive neural networks (RNNs) to optimize NLP models, with an emphasis on how well these models process intricate linguistic structures. The paper emphasizes how RNNs are better at text categorization, sentiment analysis, machine translation, and handling sequential dependencies. To improve model performance, it investigates a number of optimization tactics, such as batch normalization, dropout methods, and the use of pre-trained word embeddings. According to experimental findings, improved RNNs greatly increase computing efficiency and accuracy in NLP applications. In the end, the study emphasizes how crucial it is to keep improving deep learning methods in order to increase the capabilities of NLP systems.

(Shaik et al., 2022) highlights the use of AI-driven sentiment analysis in assessing student comments while reviewing trends and difficulties in implementing NLP for educational feedback analysis. To evaluate their efficacy in teaching, the study investigates a number of NLP approaches, including entity annotation, text summarization, and topic modeling. It highlights important issues that impede the precision of feedback interpretation, such as context ambiguity, domain-specific language comprehension, and sarcasm detection. The study also explores how deep learning models, like recurrent neural networks and transformers, can enhance feedback analysis. In order to improve learning experiences and institutional decision-making, the study concludes by urging the creation of stronger NLP frameworks specifically designed for educational applications.

(Sousa & Kern, 2023) provides a thorough overview of deep learning techniques for protecting privacy in natural language processing (NLP), highlighting the necessity of improved data security in text analysis powered by AI. The paper divides privacy-preserving NLP techniques into three primary categories: verification techniques, trusted execution, and data protection. It emphasizes how crucial regulatory compliance is to the creation of privacy-conscious NLP systems, such as GDPR adherence. The study also highlights the computational difficulties of differential privacy, homomorphic encryption, and federated learning while discussing the trade-off between privacy and utility. According to the study's conclusion, more research is needed to remove biases in privacy-preserving NLP models and enhance scalability for practical uses.

(Tejaswini et al., 2024) investigates the use of a hybrid deep learning model to apply natural language processing (NLP) to the detection of depression in social media texts. The FastText Convolution Neural Network with Long Short-Term Memory (FCL), a revolutionary method proposed in this study, improves text representation and classification accuracy. The program successfully finds language cues linked to depressed symptoms by examining social media content. The study emphasizes the benefits of combining deep learning methods with natural language processing to enhance mental health detection. The study concludes by highlighting the need for more advancements in AI-driven mental health diagnosis and promoting real-time monitoring solutions to support medical practitioners.

(Torregrosa et al., 2023) analyzes how text-based analysis can aid in the detection and prevention of radicalization and offers a thorough evaluation of NLP applications in extremism research. The paper covers a number of natural language processing (NLP) methods, such as text classification, topic modeling, and sentiment analysis, that are used to detect extremist discourse. It draws attention to the difficulties in identifying extremist content, including the dynamic character of online narratives and the complexity of differentiating between speech that is extreme and speech that is not. The study also examines machine learning models and datasets that have been used in extremism identification. In order to improve the precision and ethical considerations of extremist content analysis, the study concludes by recommending enhanced NLP frameworks.

(Tyagi & Bhushan, 2023) examines how NLP can be used in smart city applications, emphasizing how it can improve public services, government, and urban development. The study classifies NLP applications in a number of smart city domains, such as public administration, business, healthcare, and education. It highlights how sentiment analysis, automated text classification, and chatbots powered by natural language processing (NLP) can enhance public participation and decision-making. Important obstacles are also identified by the study, including issues with data protection, computing efficiency, and integration with Internet of Things (IoT) systems. In the end, the study promotes interdisciplinary cooperation to improve NLP's ability to influence the development of smart cities in the future.

(Ullah et al., 2025) looks into the identification of depressed tweets using natural language processing (NLP) and machine learning approaches. Grey Relational Grade (GRG) analysis is used to improve feature extraction. Using machine learning models like Random Forest, Support Vector Machines, and Logistic Regression, the study analyzes 1.6 million tweets to categorize people as "stressed" or "not stressed." The study demonstrates how well NLP and GRG may be used to detect silent linguistic indicators linked to depression. The ethical implications of exploiting social media data for mental health

detection are also covered. In conclusion, the research highlights the promise of NLP-driven models for early intervention and non-invasive mental health screening.

(Younis et al., 2023) provides a thorough analysis of the literature on the use of robotics and natural language processing (NLP) in the classroom, emphasizing how these technologies can improve instruction. NLP applications in education are divided into four main categories by the study: special needs education, kindergartens, schools, and universities. It draws attention to how humanoid robots, including NAO robots, and artificial intelligence are increasingly being used in classrooms to support individualized learning. The study also explores how NLP-powered robots can enhance language learning, knowledge retention, and student engagement. Finally, in order to improve interactive and adaptive learning environments, the study urges more developments in AI-powered educational systems.

(N. Zhang et al., 2021) investigates the application of natural language processing (NLP) techniques to Android malware detection, putting forth a hybrid sequence-based method that blends static and dynamic analysis. The article presents CoDroid, a deep learning-based framework that uses convolutional neural networks (CNNs) and bidirectional long short-term memory (BiLSTM) networks to approach malware detection as a text classification problem. According to experimental results, CoDroid performs better than conventional machine learning models at accurately identifying dangerous applications. The study emphasizes the benefits of natural language processing (NLP) in examining system calls and opcode sequences to efficiently identify malicious activity. In the end, the study emphasizes how NLP-based security solutions might improve Android cybersecurity.

(T. Zhang et al., 2022) examines the use of natural language processing (NLP) in the diagnosis of mental illnesses, examining several computer methods for detecting psychological problems in textual data. The paper highlights the growing use of neural networks for mental health analysis by classifying current research into machine learning-based and deep learning-based approaches. It talks on the main obstacles of identifying mental illnesses, namely the lack of data, moral dilemmas, and the requirement for interpretability in AI-driven diagnostics. The study also highlights how NLP may be used to process a variety of textual sources, such as interview transcripts, clinical notes, and posts on social media. In order to improve early identification and intervention strategies in mental health treatment, the study concludes by urging additional advancements in NLP techniques.

(Zheng et al., n.d.) The study focuses on analyzing patient sentiment towards personalized drug prescriptions, and exploring the application of Natural Language Processing (NLP) in drug recommendation systems. The study analyzes patient sentiment and improves drug recommendations based on text feedback by combining deep learning and NLP techniques. It highlights how to enhance patient happiness and adherence to treatment by integrating AI-powered sentiment analysis into healthcare applications. The study also addresses the challenges of dealing with unstructured medical data and ensuring the accuracy of NLP-based recommendations. The study concludes by highlighting the importance of AI-powered decision making in personalized healthcare services.

(Zhou et al., 2024) offers a thorough analysis of NLP's uses in smart healthcare, looking at how it's used in clinical settings, hospital administration, and public health surveillance. The paper discusses the benefits and drawbacks of three primary approaches to natural language processing (NLP): rule-based, statistical, and deep learning-based methods. It draws attention to how NLP is being used more and more to process electronic health records (EHRs), aid in the diagnosis of illnesses, and enhance communication between patients and providers. The study also looks at how NLP might be used to solve public health issues like tracking the spread of contagious diseases and identifying patterns in mental health. In order to improve patient care and medical decision-making, the study ultimately promotes the ongoing development of NLP-driven smart healthcare solutions.

5. DISCUSSION AND COMPARISON

Table 1 represents a detailed comparison among the previous works explained in section 3. The table illustrates main metrics that depended for the comparison which are the significant features concluded from these works.

Table 1: Comparison among the reviewed works.

Author Name & Year	Methods	Datasets	Advantages	Disadvantages	Accuracy	Results
(Arowosegbe & Oyelade, 2023)	Comprehensive analysis of NLP's role in preventing suicide	387 studies from databases for medicine	shows how well NLP works to identify suicidal thoughts.	demands ongoing observation and consideration of ethical issues.	Not specified	NLP offers affordable, practical substitutes for suicide prevention.

(Bauer et al., 2023)	Multidisciplinary framework for peer-reviewed NLP	Education-related peer-feedback datasets	improves adaptability and digital learning	Difficulties in using NLP approaches methodically	Not specified	Adaptive peer-feedback mechanisms in education are supported by NLP
(Boyd & Schwartz, 2021)	An overview of NLP's uses in psychology	Numerous datasets of psychological language	examines how NLP has developed in psychological research.	Challenges in interdisciplinary integration	Not specified	NLP facilitates comprehension of psychological processes and verbal conduct.
(Chung et al., 2023)	Comprehensive analysis of NLP in computer science and construction	55 cutting-edge NLP articles and 202 NLP studies in the construction industry	compares the utilization of NLP across several fields.	finds methodological and application deficiencies.	Not specified	The technological divide between computer science and NLP in construction is narrowing.
(Ding et al., 2022)	NLP in construction: a scientometric examination	Ninety-one NLP research articles about construction	identifies important technology, datasets, and difficulties.	The reproducibility of research is limited by data isolation.	Not specified	For Industry 4.0 and the digitization of construction, NLP is essential.
(Epoka, 2023)	Review of the literature on using NLP to handle qualitative data	Qualitative research datasets	demonstrates how useful NLP is for qualitative analysis.	Challenges in automation and interpretability	Not specified	When it comes to qualitative research, NLP can greatly increase coding speed.
(Le Glaz et al., 2021)	NLP and machine learning in mental health: a comprehensive review	327 studies found in medical databases	draws attention to the use of NLP in psychiatric diagnosis and research.	There are still linguistic and ethical issues.	Not specified	NLP and machine learning validate clinical theories on mental health.
(Guo, 2022)	Text analysis using deep learning to identify emotions	Classifying emotional text in big data sources	reaches a high categorization accuracy for emotions	Large-scale labeled datasets might be necessary.	98.02% classification and 97.22% detection	NLP based on deep learning enhances the ability to recognize human emotions.
(Hariri, 2023)	Exploration of ChatGPT applications	Various AI-related databases	demonstrates ChatGPT's adaptability	Potential biases and ethical concerns	Not specified	NLP applications are greatly advanced by ChatGPT, however ethical

						supervision is necessary.
(Harrison & Sidey-Gibbons, 2021)	Machine learning-based NLP in medicine	Medicine review datasets	improves the analysis of medical texts for therapeutic use	Challenges in interpretability and generalization	0.664-0.720 accuracy	NLP enhances medical review sentiment analysis and classification
(Hou & Huang, 2025)	A thorough analysis of NLP in social science research	Numerous text datasets from political science, psychology, and sociology	demonstrates how NLP may be used to glean insights from massive amounts of textual data.	Challenges in data representativeness and interpretability	Not specified	promotes the ethical and efficient application of NLP in social science research.
(Jackson et al., 2022)	Review of psychology science's use of language analysis	Numerous corpora of psychological texts	examines the use of NLP in religion, creativity, and emotion.	NLP models have not received much empirical testing in psychology research.	Not specified	NLP is being used more and more in psychological research to examine how people think.
(Jahan & Oussalah, 2023)	Comprehensive analysis of NLP-based hate speech detection	Datasets of hate speech from social media	discusses some deep learning models for identifying hate speech.	Challenges in detecting nuanced and implicit hate speech	Varies by model	Automated content moderation is enhanced by NLP-based hate speech identification
(Jim et al., 2024)	Modern review of sentiment analysis based on natural language processing	Various sentiment analysis datasets	contrasts huge language models, deep learning, and machine learning.	Problems with handling sarcasm and comprehending context	Depends on model and dataset	NLP enhances sentiment analysis, but contextual correctness demands sophisticated methods.
(Khan et al., 2023)	thorough rundown of deep learning in natural language processing	Multiple NLP benchmark datasets	explains the main developments and difficulties in NLP.	Lack of comprehension of language's pragmatic elements in huge models	Varies across applications	Although deep learning improves NLP applications, interpretability and generalization are issues.
(Khurana et al., 2023)	Examining the latest developments and issues in NLP	Various NLP evaluation datasets	thorough examination of the development of NLP and its present issues	Lack of empirical model evaluations	Not applicable	NLP is still developing, but interpretability and data quality are still major obstacles.

(Lavanya & Sasikala, 2021)	Text classification in social healthcare networks using deep learning	Healthcare-related social media posts	increases the precision of classification in medical text analysis	Processing unstructured healthcare data presents challenges.	Higher than traditional methods	NLP applications in social networks pertaining to healthcare are improved by deep learning.
(Li et al., 2022)	Unstructured data in electronic health records using neural natural language processing	Clinical notes and EHR text data	improves named entity recognition and medical text classification	Privacy issues and a lack of labeled data	Not specified	Unstructured EHR data processing is enhanced by neural NLP techniques.
(Malgaroli et al., 2023)	NLP in mental health interventions: a systematic review	Text data from interviews in treatment	examines NLP models in order to monitor interventions.	Training data bias and lack of language diversity	Varies by model	NLP analyzes therapy interactions to promote mental health solutions.
(Maulud et al., 2021)	Evaluation of NLP methods for diverse uses	Multiple NLP research papers	covers a variety of NLP techniques and uses.	Few real-world assessments of the strategies mentioned	Varies across models	As AI advances, NLP techniques continue to change.
(Mishra et al., 2022)	Sentiment analysis using NLP	Product review datasets and social media platforms	enhances comprehension of consumer sentiment	Managing sarcasm and unclear text can be difficult.	Not specified	NLP facilitates effective customer feedback analysis for enterprises.
(Murphy et al., 2023)	Using NLP to detect adverse medication events	Electronic Health Records (EHRs)	improves pharmaceutical safety and pharmacovigilance	demands top-notch annotated datasets.	Not specified	NLP enhances clinical narratives' ability to detect hazardous medication responses.
(Naithani & Raiwani, 2023)	Machine learning-based sentiment analysis	Product review and social media datasets	increases the precision of emotion detection	Computationally expensive	Greater than traditional techniques	NLP methods efficiently categorize feelings in a variety of fields.
(Nijhawan et al., 2022)	Detecting stress with machine learning and NLP	Content created by users and shared on social media	Detects stress-related linguistic patterns	Difficulty in contextual interpretation	High detection rate	Early mental health interventions are supported by NLP-based stress detection.

(Orellana & Bisgin, 2023)	Political party manifestos analyzed using NLP	Political manifestos for New Zealand (1987–2017)	identifies policy trends and ideological shifts	Requires extensive text preprocessing	Not specified	Political text analysis for policy research is improved by NLP.
(Patra et al., 2021)	Social determinants of health extracted via natural language processing	Electronic Health Records (EHRs)	identifies social aspects linked to health automatically	automatically recognizes social factors associated with health	Not specified	NLP improves the extraction of social elements related to health from clinical literature.
(Rathje et al., 2024)	Multilingual psychological text analysis using GPT	47,925 news headlines and tweets with annotations in 12 languages	Detection of psychological constructs accurately without further training	Possible biases in analysis produced by AI	0.59 to 0.77 correlation with human annotators	In psychology research, GPT-based models perform better than conventional text analysis methods.
(Salah et al., 2023)	NLP for social psychology research with ChatGPT	Textual data from online forums on a large scale	automates sentiment analysis and behavioral analysis	Risk of prejudice and over-reliance on AI-generated insights	Not specified	NLP based on ChatGPT facilitates sentiment analysis and the discovery of social behavior patterns.
(Sangeetha et al., 2023)	Optimization of Recursive Neural Networks (RNNs) in NLP	Benchmark NLP datasets	increases the effectiveness of digesting intricate linguistic structures	computationally costly when dealing with big datasets	Greater than conventional NLP models	Sentiment analysis and machine translation are two NLP tasks that are improved by optimized RNN models.
(Shaik et al., 2022)	NLP for educational feedback analysis	Student feedback datasets	evaluates student attitudes and educational trends automatically	Difficulties in identifying context ambiguity and sarcasm	Not specified	Sentiment classification in educational feedback analysis is enhanced by deep learning models.
(Sousa & Kern, 2023)	Comprehensive analysis of privacy-preserving NLP techniques	Over 60 DL methods for privacy-preserving NLP (2016-2020)	presents a new taxonomy for classifying techniques that protect privacy.	does not offer experimental support for the procedures under review.	Not applicable	outlines the main privacy issues, such as data traceability and trade-offs between

						privacy and utility.
(Tejaswini et al., 2024)	Deep learning hybrid model for detecting depression	Social media text datasets	combines CNN, LSTM, and FastText to improve text representation.	computationally costly because of the complexity of the hybrid model	Higher than existing models	increases the precision of social media text analysis's depression detection
(Torregrosa et al., 2023)	Survey on extremism detection using NLP	Datasets from social media about extremism	gives a thorough analysis of NLP techniques for identifying extreme content.	Difficulties in differentiating between normal language and radical speech	Not specified	draws attention to developments and difficulties in NLP-based extremism detection.
(Tyagi & Bhushan, 2023)	Application of NLP in smart cities	Numerous datasets pertaining to applications in smart cities	examines the use of NLP in intelligent governance, business, and healthcare.	Limited focus on specific NLP models	Not specified	exemplifies the significance of NLP in streamlining smart city operations.
(Ullah et al., 2025)	Machine learning for depression detection in tweets	1.6 million Twitter posts	uses the Grey Relational Grade method to improve classification.	restricted applicability to other social media networks	96-97% across different models	shows how to use NLP and machine learning to diagnose depression with high accuracy.
(Younis et al., 2023)	Examination of robotics and natural language processing in education	82 scientific articles from 12 journals	investigates the use of NLP in various educational contexts.	lacks experimental support for the methods under review.	Not applicable	demonstrates how NLP is becoming more and more important in educational technologies and AI-powered class aides.
(N. Zhang et al., 2021)	Hybrid NLP-based malware detection	Dataset of actual Android malware	combines dynamic and static analysis to provide reliable detection.	computationally costly and necessitates extensive datasets with labels	High detection accuracy	uses a CNN-BiLSTM-Attention model to enhance malware detection.
(T. Zhang et al., 2022)	NLP for mental illness detection	399 studies from 10,467 records	thorough examination of NLP methods for mental health investigation	Model interpretability and bias mitigation challenges	Not specified	In identifying mental illness, deep learning models perform better than

						conventional methods.
(Zheng et al., n.d.)	Using NLP to recommend medications	Sentiment analysis of patient remarks	Emotion analysis-based personalized medication recommendations	Recommendation algorithms that may be biased	Not specified	demonstrates how NLP can be used to enhance individualized healthcare solutions.
(Zhou et al., 2024)	NLP for intelligent medical applications	Numerous medical and clinical datasets	discusses the use of NLP in hospital administration, public health, and clinical practice.	Difficulties in Applying Natural Language Processing to Actual Healthcare Environments	Not specified	draws attention to the influence of NLP on healthcare decision-making and AI-powered diagnostics.

The increasing use of Natural Language Processing (NLP) in many different domains demonstrates how revolutionary it can be when it comes to evaluating textual material for better decision-making. Research like (Arowosegbe & Oyelade, 2023) and (Le Glaz et al., 2021) highlights the importance of natural language processing (NLP) in mental health applications, namely in identifying suicidal thoughts and tracking psychiatric disorders using social media analysis and electronic medical records. Similar to this, research by (Bauer et al., 2023) and (Younis et al., 2023) shows how NLP is transforming education by enabling AI-powered teaching assistants and enhancing peer-feedback mechanisms, which in turn facilitates adaptive learning settings. In the meantime, studies by (Zhou et al., 2024) and (Zheng et al., n.d.) highlight the growing use of NLP in healthcare, from tailored drug recommendations to clinical diagnostics, indicating its value in enhancing patient outcomes. But there are still issues, as (Sousa & Kern, 2023) and (Tejaswini et al., 2024) point out, highlighting privacy issues, computational expenses, and moral dilemmas when implementing NLP on a large scale. Notwithstanding these drawbacks, (T. Zhang et al., 2022) and (Khan et al., 2023) emphasize how ongoing developments in deep learning models hold promise for improved scalability, accuracy, and interpretability, opening the door for more potent NLP-driven solutions across a range of fields.

6. CHALLENGES AND FUTURE DIRECTIONS IN NLP FOR BEHAVIORAL SCIENCE

Natural Language Processing (NLP) has made tremendous strides in behavioral research, but a number of obstacles prevent its broad use. Bias in training data is one of the main issues since it can lead to inaccurate findings, especially in applications like sentiment analysis and mental health evaluation (Gading Abdullah et al., 2024). The application of NLP in delicate fields like social behavior analysis and clinical research is made more difficult by ethical issues pertaining to data privacy and informed consent (Sousa & Kern, 2023). Furthermore, NLP models still face significant challenges in comprehending sarcasm, cultural differences, and multilingual content due to contextual ambiguity and linguistic complexity (W. merza Eido & Yasin, 2025).

Another challenge is computational efficiency, as deep learning-based NLP models require extensive computational resources, limiting their scalability in real-world applications (Saleh & Yasin, 2025). Additionally, interpretability and transparency are crucial concerns, as many state-of-the-art NLP models operate as "black boxes," making it difficult for researchers to validate their outputs (Tato & Yasin, 2025). Addressing these limitations requires improvements in explainable AI (XAI), bias mitigation strategies, and ethical AI governance to ensure fairness and reliability in NLP-driven behavioral science (Zheng et al., n.d.).

In the future, multimodal natural language processing (NLP) has promise for enhancing contextual understanding of human behavior by combining text with audio, pictures, and physiological information (Ibrahim & Abdulazeez, 2021). Furthermore, developments in reinforcement and self-supervised learning may lessen reliance on sizable annotated datasets, increasing the adaptability of NLP models in a range of research contexts (Orellana & Bisgin, 2023). Finally, the creation of privacy-preserving NLP techniques like differential privacy and federated learning will be essential to guaranteeing the safe and moral use of data in behavioral science research (Saleh & Zeebaree, 2025).

NLP has the potential to revolutionize behavioral research by tackling these issues and utilizing cutting-edge technologies, providing more profound understandings of human emotion, cognition, and social interactions while upholding ethical standards.

7. CONCLUSION

In behavioral science, natural language processing, or NLP, has become a game-changing technique that allows researchers to examine vast amounts of textual data with previously unheard-of efficiency and precision. It provides important insights into human cognition, emotions, and social relationships and has applications in a variety of fields, such as political analysis, healthcare, educational research, and mental health monitoring (Abdullah et al., 2021; Ibrahim & Abdulazeez, 2021). Many of the drawbacks of conventional qualitative methodologies have been overcome by NLP's capacity to automate sentiment analysis, topic modeling, and text classification, which has greatly increased behavioral research's scalability and objectivity (W. merza Eido & Yasin, 2025; Ismael et al., 2021). However, issues including data bias, moral dilemmas, and computational limitations still prevent NLP from being widely used in behavioral science (Saleh & Zebari, 2025; Tato & Yasin, 2025).

It is anticipated that combining NLP with cutting-edge AI techniques, like multimodal learning and self-supervised models, would improve its interpretability and contextual awareness as technology develops (Sousa & Kern, 2023; Zheng et al., n.d.). Additionally, to ensure ethical and responsible AI implementations in behavioral investigations, it will be essential to create privacy-preserving approaches and bias-mitigation strategies (Saleh & Yasin, 2025). In order to provide an ethical framework for AI-driven textual analysis, future research should concentrate on improving NLP models to strike a balance between computational efficiency, fairness, and transparency (W. M. Eido & Ibrahim, 2025). NLP can continue to close the gap between qualitative and quantitative behavioral research by tackling these issues, opening up new avenues for comprehending human behavior in a society that is becoming more and more digital (Gading Abdullah et al., 2024).

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