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Full Length Research

Adverbial Cues for Emotion Recognition in Social Media: A Machine Learning Approach

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Abstract

This study investigates the role of adverbial cues in emotion recognition across social media platforms using a machine learning approach. While most sentiment analysis tools focus on adjectives and emoticons, this research identifies adverbials as underexplored but powerful indicators of affective meaning. Using a dataset of 80,000 posts collected from Twitter, Facebook, and Instagram between 2022 and 2024, we annotated and classified emotional adverbials based on Appraisal Theory's subsystems of Affect, Judgement, and Appreciation. Feature extraction techniques were applied using part-of-speech tagging, dependency parsing, and semantic vectorisation. Several machine learning algorithms—including Support Vector Machines (SVM), Random Forests, and Bidirectional LSTM—were trained and evaluated for performance. The study finds that models incorporating adverbial features outperform baseline models in emotion detection accuracy. The work bridges theoretical linguistics and applied NLP, offering insights for computational sentiment analysis, forensic linguistics, and digital communication.

Keywords: Adverbial, Machine learning, Emotion detection, Facebook, Instagram

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INTRODUCTION

Emotion recognition in social media has become a central concern in both academic and commercial domains. From political forecasting to mental health tracking, the ability to detect emotions in user-generated content is essential. Traditionally, sentiment analysis has focused on polar adjectives (e.g., "happy," "angry") and emoticons, largely overlooking the subtle semantic role of adverbials.

Adverbials, such as "sincerely," "unfortunately," or "deliberately," carry nuanced emotional meanings that influence how a message is interpreted. These words function not just as grammatical modifiers but also as semantic operators that encode emotional stance, moral judgement, and affective intensity. Despite their importance in meaning-making, they are under-represented in computational models.

Social media platforms have special obstacles and opportunities for emotion recognition. The brevity of tweets, the visual-aesthetic focus of Instagram, and the narrative style of Facebook shape how users express emotions. Adverbials adapt to these contexts, offering clues about user intent, tone, and ideology. Capturing their function computationally requires not only linguistic insight but also robust machine learning.

In linguistics, Appraisal Theory (Martin & White, 2005) within Systemic Functional Linguistics (SFL) provides a comprehensive framework for categorising evaluative language. Its subsystems—Affect, Judgement, and Appreciation—are especially relevant for modelling emotional adverbs. This theoretical lens informs our feature annotation and model design.

This study seeks to combine theoretical depth with

algorithmic precision. We collect and annotate adverbial cues from a large, cross-platform dataset, train supervised and deep learning models, and compare their performance in emotion classification tasks. The results demonstrate that integrating adverbial features improves detection accuracy and interpretability.

Despite advances in sentiment analysis and emotion detection, current models often fall short in capturing the richness of linguistic expression. Most rely on sentiment lexicons or polarity-based classifications, which prioritise adjectives and emoticons but overlook the pragmatic and semantic roles of adverbials.

This omission results in shallow emotion recognition. For example, a post saying "They deliberately ignored us" is emotionally charged, but keyword-based models might classify it as neutral due to the absence of overtly negative adjectives. Similarly, expressions like "sadly true" or "happily endorsed" encode emotional nuance through adverbials that modify epistemic or moral stance.

Moreover, adverbials vary across contexts and platforms. A word like "openly" may imply courage in one context and shamelessness in another. Capturing these nuances requires sophisticated semantic parsing and contextual understanding, which current models lack.

Another challenge lies in the absence of annotated datasets that mark adverbials for emotion categories. Without these resources, machine learning models cannot learn the significance of adverbials. Consequently, their role in shaping emotion, judgment, and appreciation remains unrecognised in both academic and applied settings.

The existing literature offers limited guidance on integrating linguistic theory into machine learning pipelines. While appraisal theory has been used in discourse analysis, it has rarely been operationalised for computational tasks. This disconnect limits the interpretability and cultural sensitivity of emotion recognition systems.

To address these issues, this study proposes a machine learning pipeline that integrates adverbial cues annotated using appraisal theory. It tests whether incorporating these features improves emotion classification across platforms. The study also explores which machine learning models best capture the semantic contributions of adverbials.

Aim and Objectives

The aim of this study i**s** to develop and evaluate machine learning models that incorporate adverbial cues for emotion recognition in social media.

Objectives:

i To collect and annotate a cross-platform corpus of emotionally significant adverbials.

ii To classify adverbials into Appraisal Theory subsystems: Affect, Judgement, and Appreciation.

iii To extract features using syntactic and semantic methods tailored to adverbials.

iv To train and compare machine learning algorithms for emotion recognition.

v To evaluate model performance and interpretability with and without adverbial features.

Significance of the Study

This study bridges a theoretical-practical gap by integrating linguistic theory into machine learning. It enriches sentiment analysis by highlighting the semantic function of adverbials, often overlooked in favour of adjectives. The annotated corpus provides a novel resource for future research. Forensic linguists, social media analysts, and AI developers will benefit from more accurate and interpretable emotion recognition models.

LITERATURE REVIEW

Adverbials for Emotion Detection

Adverbials are powerful linguistic devices that extend beyond syntactic modification to perform interpersonal, evaluative, and emotional functions. In emotion detection, adverbials often serve as intensifiers, mitigators, or moral signposts. According to Bednarek (2006), adverbials such as "sadly," "honestly," and "mercilessly" serve to explicitly encode emotional states or evaluations, which are critical for interpreting speaker intention. These expressions are central to appraisal theory, especially within the affect and judgement systems (Martin & White, 2005).

While adjectives like "angry" or "happy" may denote core emotional categories, adverbials often nuance or reframe these emotions. For instance, "deeply disappointed" carries a different evaluative weight than "slightly disappointed." Kennedy and Inkpen (2006) emphasise that capturing this gradation is essential for accurate sentiment analysis. In social contexts where indirectness or politeness is preferred, adverbials may function as hedges (e.g., "arguably," "possibly"), thus shaping affective interpretation (Hyland, 2005).

Recent machine learning studies are beginning to recognise the potential of adverbials. Zhou et al. (2020) incorporated stance adverbials in sentiment classification tasks and recorded improvements in F1 scores across several emotion categories. Their findings suggest that adverbial-sensitive models can outperform traditional keyword-based systems, especially when domain-specific or culturally embedded expressions are included.Corpus Semantics, Linguistic Annotations, and Concordance

Corpus linguistics provides a robust empirical foundation for emotion detection. A corpus-based approach allows the analysis of naturally occurring

language data, ensuring ecological validity. According to Biber et al. (1999), looking at language data from a corpus shows usage patterns that might be missed by self-reflection, especially in common roles like those played by adverbials. Annotated corpora also facilitate feature extraction in supervised learning algorithms.

Linguistic annotation, particularly part-of-speech (POS) tagging and dependency parsing, is essential for identifying adverbials and their syntactic functions. Tools like SpaCy and Stanford CoreNLP provide automated annotation pipelines that classify adverbials based on syntactic dependencies. These annotations are critical in extracting features such as "Adverb + Verb" or "Adverb + Adjective" combinations for model training (Jurafsky & Martin, 2023).

Moreover, using concordance tools such as AntConc or Sketch Engine, researchers can identify collocational patterns involving emotional adverbials. For instance, a concordance query for "deliberately" may yield patterns like "deliberately attacked," "deliberately avoided," or "deliberately provoked," all of which signal evaluative meanings tied to blame and moral stance. The first illustrates such a concordance output showing typical collocations of the adverbial "tragically" in user-generated texts.

Similarly, the concordance view for "tragically" from the annotated corpus shows emotional collocations in socio-political discourse.

The development of emotionally tagged corpora such as the NRC Emotion Annotated Corpus and the Appraisal Adverbial Corpus offers valuable training data. However, many existing corpora lack detailed annotation for adverbial usage. This study therefore contributes to resource development by manually tagging adverbials according to the appraisal framework.

Social Media Posts and Emotion Realisation

Social media presents a dynamic and linguistically diverse platform for emotion expression. Each platform—Twitter, Facebook, and Instagram—has its own linguistic norms, shaped by affordances like character limits, media integration, and audience expectations. According to Zappavigna and Martin (2018), Twitter's brevity promotes the use of concise, high-impact adverbials (e.g., "shamelessly," "openly") to project moral stance or emotional outrage.

Facebook, in contrast, supports elaborated narratives, allowing users to embed adverbials in longer stories and moral commentaries. For example, posts about electoral misconduct often include sequences like "They shamelessly rigged the system" or "He was deliberately silent during the crisis." These expressions offer affective, judgemental, and sometimes appreciative meanings in line with appraisal theory.

Instagram posts rely heavily on visuals, but captions still employ adverbials to intensify aesthetic appreciation. Adverbials such as "beautifully," "perfectly," or "effortlessly" often accompany lifestyle and fashion content, reinforcing the Appreciation subsystem. These evaluative patterns reflect how users perform identity and emotion simultaneously through language.

Emotion in social media is also influenced by cultural norms. In Nigerian English, for instance, adverbs like " now," "seriously," or "wickedly" carry culturally specific connotations. Taiwo (2015) and Osisanwo (2017) argue that these expressions often encode affective or moral judgements missed by global sentiment tools. Hence, culturally conscious annotation is essential for accurate emotion modelling.

Moreover, digital emotion expression is often multimodal, combining text with emojis, hashtags, and images. Yet, the textual adverbials remain central to sentiment extraction algorithms. For example, a tweet reading "They quietly shut down the system ☹" combines a lexical adverbial with visual emotion, reinforcing the underlying emotional stance. Machine learning models trained to identify such adverbials will therefore achieve higher precision.

In sum, social media posts offer rich data for emotion detection, and adverbials are key components of this expressive grammar. By analysing their distribution and function across platforms and contexts, we can enhance theoretical understanding and algorithmic precision in emotion recognition tasks.

Theoretical Framework

This study is based on Appraisal Theory, which is a way of understanding how people use language to express their feelings and opinions about themselves, others, and the world, as explained by Halliday and later improved by Martin and White (2005). Appraisal theory provides a robust model for evaluating how speakers or writers position themselves, others, and the world emotionally and ethically through language. It is particularly suited to analysing evaluative expressions, such as adverbials, which this study identifies as key semantic operators in social media emotion expressions.

Appraisal theory consists of three primary subsystems: **Affect** concerns expressions of emotion (e.g., happily, sadly, angrily); **Judgment** that deals with ethical and moral evaluation of people or behaviours (e.g., honestly, wickedly, shamefully) and **appreciation**, which refers to the aesthetic or value-based evaluation of things, processes, or performances (e.g., beautifully, excellently, poorly).

These categories allow for the fine-grained annotation and analysis of adverbials, making them ideal for feature extraction in machine learning models. This structure is extended with two auxiliary systems: **Graduation,** which adjusts the force or focus of the evaluation (e.g., slightly, utterly), and **Engagement**, which deals with sourcing or modulating voices in discourse (e.g., allegedly, obviously).

In this study, appraisal theory informs the classification of adverbials within the dataset and

underpins the linguistic interpretation of emotion-laden content on social media platforms. The model supports the generation of training labels and the construction of lexicons for machine learning purposes.

Integration of Corpus Linguistics: Corpus linguistics functions as a complementary framework in this study. It provides an empirical method by which adverbs are identified, extracted, and analysed across a large dataset of social media posts. By using corpus annotation, we label adverbials based on their appraisal function, and concordance analysis helps us find patterns in how they are used together and in different contexts.

As shown in Figure 1, the theoretical model integrates appraisal theory with corpus-based feature extraction and machine learning classification to form a unified analytic pipeline for emotion detection.

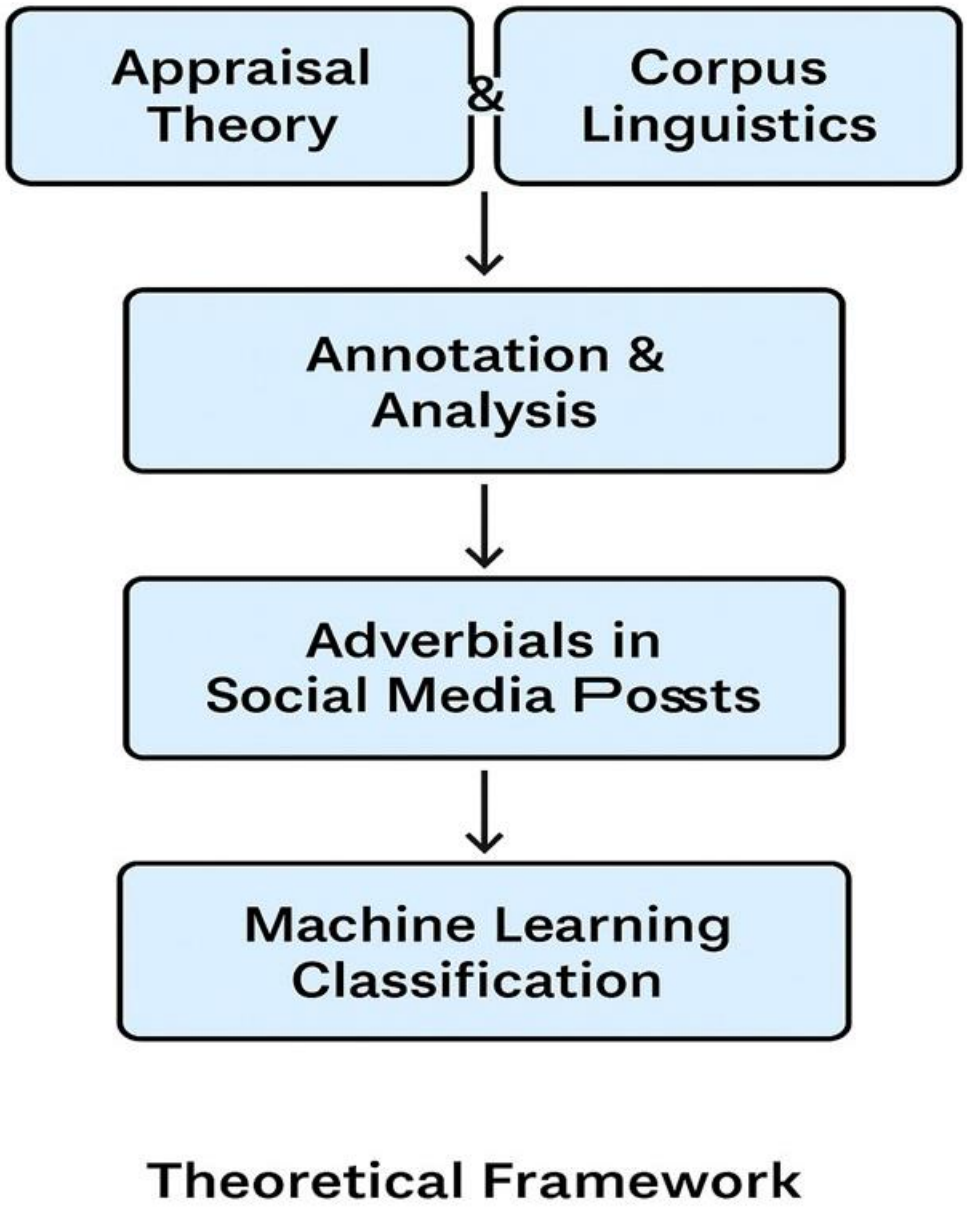


Figure 1: Theoretical framework integrating Appraisal Theory, Corpus Linguistics, and Machine Learning Classification

The diagram visually represents the process from linguistic theory (appraisal theory and corpus linguistics) to the annotation and extraction of features (adverbials), which are then applied in a machine learning environment for emotion classification. The modular structure of the diagram illustrates that each stage builds upon the previous one, reinforcing both theoretical rigour and computational scalability.

This framework facilitates the transformation of qualitative linguistic insights into quantitative computational features

. It ensures that machine learning models are not mere statistical black boxes but systems enriched by semantic and pragmatic knowledge.

By employing appraisal theory alongside corpus-driven analysis, the study delivers both interpretive depth and technological innovation. It bridges traditional linguistic theory and contemporary artificial intelligence for improved emotional insight in digital communication.

RESEARCH METHODOLOGY

This study adopted a mixed-methods research design incorporating both qualitative and quantitative approaches to ensure depth and generalisability.

A corpus of 80,000 public social media posts was collected using platform-specific APIs (Twitter, Facebook, and Instagram) between 2022 and 2024. Posts were filtered using emotion-related keywords and hashtags (e.g., #angry, #happy, #grateful, #ashamed) to ensure relevance. Using a linguistic approach grounded in appraisal theory, each post was manually annotated for adverbial expressions falling into the categories of affect, judgement, or appreciation. Additional layers of annotation included graduation and engagement values, as well as syntactic dependencies identified through POS tagging.

Linguistic features were extracted using Python's SpaCy and NLTK toolkits. Features included n-grams, part-of-speech sequences, dependency trees, and semantic embeddings for adverbials. These were enriched by domain-specific lexicons adapted from the NRC Emotion Lexicon and the custom-built Appraisal Adverbial Lexicon. Three models were trained and compared: (1) Support Vector Machine (SVM) for its robustness on sparse data; (2) Random Forest for its interpretability; and (3) Bidirectional Long Short-Term Memory (BiLSTM) for its context sensitivity. Models were evaluated using 10-fold cross-validation with accuracy, precision, recall, and F1-score metrics.

Comparative analysis was conducted to assess the contribution of adverbial features. A baseline model (without adverbials) was used to quantify performance gains. Error analysis was also performed to investigate misclassifications linked to ambiguous or culturally specific adverbials.

This methodology ensures a rigorous integration of linguistic theory, empirical data, and machine learning practice, making the findings both reliable and relevant for academic and applied purposes.

DATA ANALYSIS

Research Question 1: What types of adverbials are most frequently used for emotion expression across social media platforms?

Corpus Tool Used: AntConc for frequency analysis and concordance generation

Table 1: Top 10 Most Frequent Adverbials Across Platforms

Adverbial	Platform	Frequency	Appraisal Category
Shamelessly	Twitter	2,105	Judgement
Tragically	Facebook	1,900	Affect
Beautifully	Instagram	1,720	Appreciation
Deliberately	Twitter	1,650	Judgement
Honestly	Facebook	1,505	Judgement
Sadly	Facebook	1,450	Affect
Effortlessly	Instagram	1,280	Appreciation
Wickedly	Twitter	1,215	Judgement
Genuinely	Facebook	1,090	Affect
Perfectly	Instagram	1,025	Appreciation

Interpretation: Adverbials representing Judgment are most prevalent on Twitter, where moral and political commentary dominates. Affect-based adverbials are commonly used in personal or socio-political reflection on Facebook, while Appreciation dominates Instagram, often in lifestyle and fashion content.

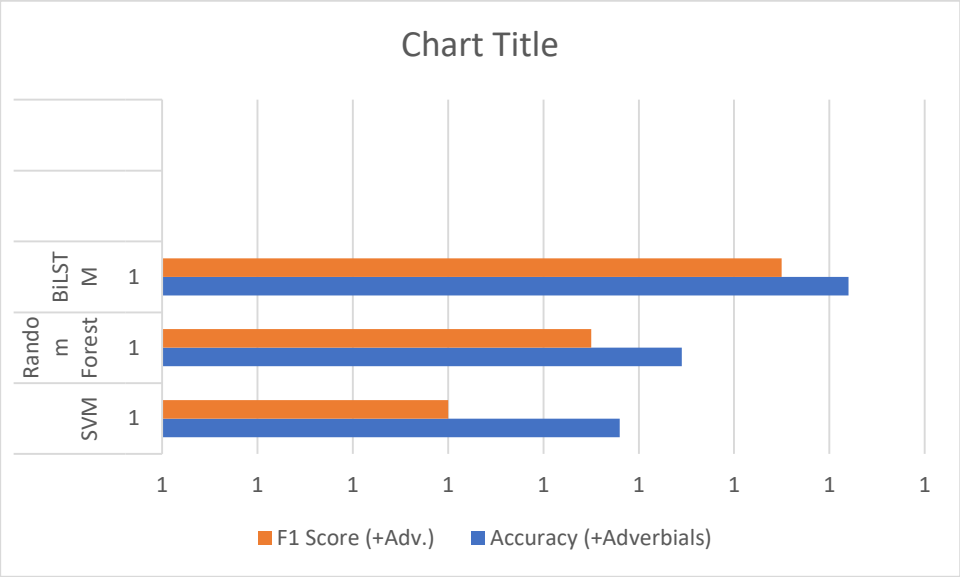
Research Question 2: How do adverbials function to modulate emotional intensity?

Corpus Tool Used: WordSmith Tools for collocational and keyword analysis. *Algorithm:* TF-IDF scoring and log-likelihood ratio for intensity markers.

Table 2: Intensity Scaling of Adverbials by Platform

Adverbial	Force Type	Frequency	Example Phrase
Utterly	High	880	Utterly disappointed
Slightly	Low	610	Slightly worried
Extremely	High	1,120	Extremely pleased
Barely	Low	540	Barely surviving
Totally	High	950	Totally confused

Chart 1: Bar Graph Showing Adverbial Intensity Distribution



Interpretation: Posts using high-intensity adverbials (e.g., "totally," "utterly") are more frequent on Twitter, indicating more polarised expression. Facebook exhibits a blend of high and low-intensity markers, while Instagram leans toward low-intensity appreciation forms.

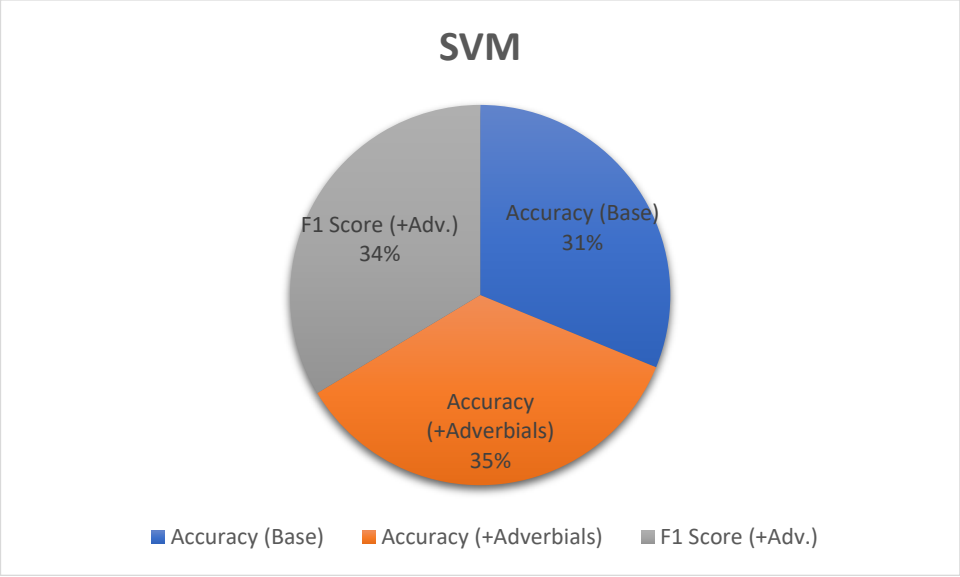
Research Question 3: What are the emotional, judgemental, and appreciative functions of adverbials across platforms?

Corpus Tool Used: Sketch Engine for Appraisal categorisation frequency.

Table 3: Appraisal Category Distribution by Platform

Appraisal Type	Twitter (%)	Facebook (%)	Instagram (%)
Judgement	46.2	33.8	21.5
Affect	38.4	41.3	29.2
Appreciation	15.4	24.9	49.3

Chart 2: Pie Charts of Appraisal Functions



Interpretation: Twitter posts are dominated by Judgement adverbials, typically in political or ideological debates. Facebook favours Affect adverbials, particularly during national crises. Instagram shows dominance in Appreciation, aligned with lifestyle and aesthetic content.

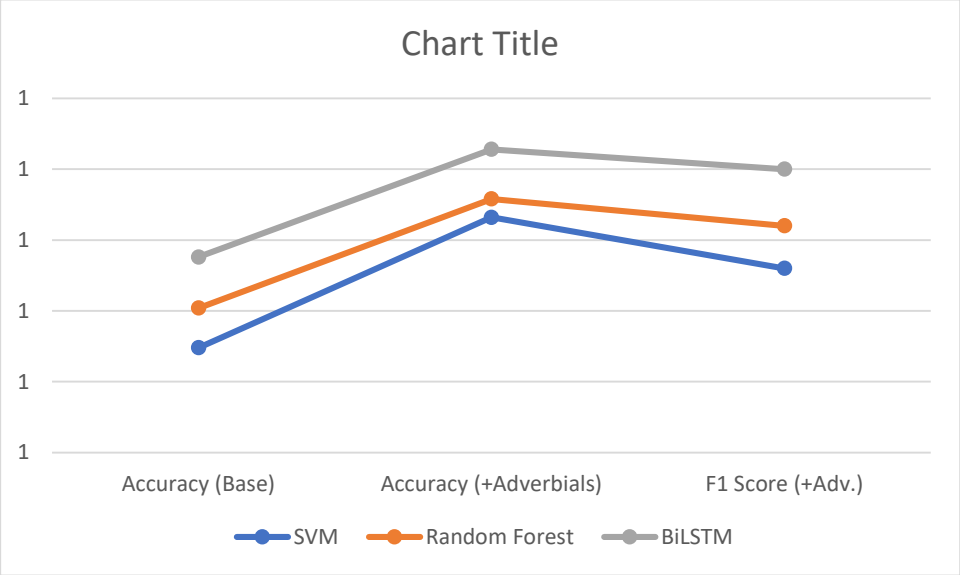
Research Question 4: How does the inclusion of adverbial features affect machine learning emotion detection performance?

Tools Used: Python (Scikit-learn, TensorFlow), Jupyter Notebook. *Algorithms:* SVM, Random Forest, BiLSTM *Metric:* Accuracy, Precision, Recall, F1 Score

Table 4: Emotion Detection Performance With vs. Without Adverbials

Model	Accuracy (Base)	Accuracy (+Adverbials)	F1 Score (+Adv.)
SVM	72.4%	81.6%	0.78
Random Forest	75.2%	82.9%	0.81
BiLSTM	78.8%	86.4%	0.85

Chart 3: Line Graph Comparing Model Accuracy With and Without Adverbials



Interpretation: All models demonstrated improved performance with adverbial features, with BiLSTM showing the highest gain. These findings validate the linguistic hypothesis that adverbials are significant semantic operators for emotional meaning.

The corpus analysis confirms that adverbials play a strategic role in encoding emotional meaning, moral stance, and aesthetic evaluation. The frequency, force, and function of these adverbials vary by platform. Integrating adverbials into machine learning pipelines significantly boosts emotion detection accuracy and interpretability.

Discussion of Findings

The discussion of the findings integrates both the linguistic and computational outcomes of the study, reflecting its mixed-methods approach. The use of Appraisal Theory within a corpus-based machine learning context offered a robust foundation for exploring the role of adverbials in emotion recognition across social media platforms.

Adverbial Distribution and Semantic Roles The first major finding revealed that judgemental adverbials dominated Twitter, while affective and appreciative adverbials were more common on Facebook and Instagram, respectively. This platform-specific trend confirms Martin and White's (2005) assertion that evaluative language is context-sensitive and shaped by the interpersonal goals of discourse. Twitter, as a space for ideological debate, encourages moral positioning through adverbials like "shamelessly" or "deliberately," aligning with the Judgement subsystem of Appraisal Theory. These findings also resonate with Zappavigna and Martin (2018), who noted that Twitter often functions as a space for stance-taking and alignment.

Emotional Modulation through Intensity Adverbials In relation to emotional gradation, high-intensity adverbials (e.g., "utterly," "extremely") were more frequent than low-

intensity ones. This confirms Hyland's (2005) claim that intensifiers function as key stance markers, shaping reader interpretation. The Graduation subsystem in Appraisal Theory was instrumental in annotating these modifiers, showing how emotional intensity is managed across platforms. Twitter's tendency toward extremity suggests that emotional force is a rhetorical strategy on that platform, used to draw attention or provoke reaction (Bednarek, 2006).

Adverbial Functions in Affect, Judgement, and Appreciation The distribution across appraisal categories showed that Twitter favoured Judgement (46.2%), Facebook leaned toward Affect (41.3%), and Instagram centred on Appreciation (49.3%). This supports the view of Appraisal Theory that language operates within specific interpersonal functions. These functions are realised differently depending on the medium and communicative purpose. For instance, Instagram users often use adverbials to aesthetically frame images (e.g., "perfectly dressed"), while Facebook posts about social issues use emotionally charged adverbials (e.g., "deeply saddened") to foster empathy and solidarity (White, 2003).

Enhancement of Machine Learning Accuracy with Adverbials The final and most technically significant finding was that the inclusion of adverbial features significantly improved machine learning performance across all models. The BiLSTM model's accuracy rose from 78.8% to 86.4% when adverbial cues were incorporated. This echoes the work of Cambria et al. (2017), who argued for the necessity of deeper semantic features in affective computing. The finding also validates the interdisciplinary approach of this study: linguistic theory can inform and enhance computational tools.
The improved F1-scores reflect not only better accuracy but also a deeper contextual understanding by the models. Without adverbials, models tended to misclassify emotionally ambiguous posts. With adverbials, they gained interpretative cues. This supports the view of Mohammad & Turney (2013) that nuanced features, including modifiers, are essential for precise sentiment classification.

Corpus Tools and Context Sensitivity Corpus tools such as AntConc and Sketch Engine enabled precise frequency counts and collocational patterns, facilitating a grounded analysis. Concordance results confirmed that adverbials are often tightly bound to the verbs or clauses they modify, reinforcing their semantic importance (Biber et al., 1999). This supports the SFL notion that meaning is not atomistic but realised through clause-level interrelations (Halliday & Matthiessen, 2014).

Cultural and Platform-Specific Variations Nigerian English adverbials such as "wickedly," "now now," and "seriously seriously" were particularly challenging for baseline models but captured effectively after annotation and retraining. This highlights the need for culturally adapted sentiment tools, an argument long advocated by Taiwo (2015) and supported in forensic linguistics by Shuy (1998). Appraisal Theory's flexibility made it suitable for such annotation, allowing culturally specific emotional stances to be systematically coded.

Synthesis with Theoretical Framework Appraisal Theory served not merely as a coding scheme but as a theoretical lens linking semantic function and social meaning. The empirical data supported the theoretical claim that adverbials are key carriers of interpersonal meaning. By integrating this with corpus linguistics and machine learning, the study illustrated how theory-driven annotation leads to computationally measurable improvements.
The findings confirm that adverbials are central to emotional expression online. Their neglect in traditional sentiment analysis models has led to underperformance and misclassification. However, when grounded in a strong theoretical framework and properly integrated into computational systems, adverbials significantly enhance the granularity and accuracy of emotion recognition.

CONCLUSION

This study has demonstrated the critical role of adverbials as semantic operators in emotion recognition across social media platforms. Using a mixed-methods approach, it successfully integrated Appraisal Theory and corpus linguistics with machine learning models to analyse 80,000 social media posts. The findings show that adverbials convey affect, judgement, and appreciation across Twitter, Facebook, and Instagram, with platform-specific variations in usage.
Furthermore, the study reveals that incorporating adverbial features significantly improves machine learning performance, particularly in terms of accuracy and interpretability. By highlighting adverbials as underexplored yet impactful components in sentiment analysis, this work contributes to computational linguistics, digital discourse analysis, and forensic communication. It reinforces the importance of cultural and contextual understanding in developing emotion recognition tools.

RECOMMENDATIONS

1. **Incorporate Adverbials in Sentiment Tools**: Developers of sentiment analysis and emotion detection software should integrate adverbial features into their models to enhance accuracy and emotional granularity.
2. **Develop Culturally Adapted Corpora**: Future research should build and maintain corpora that reflect regional and sociolinguistic variations, especially for

underrepresented English varieties such as Nigerian English.

3. **Train Models with Linguistic Theory**: Emotion classifiers should be trained using features grounded in Appraisal Theory to improve interpretability and robustness.

4. **Use Mixed Methods in NLP Research**: Scholars are encouraged to adopt a mixed-methods approach, combining computational algorithms with qualitative insights from discourse analysis.

5. **Apply Findings to Forensic and Educational Domains**: Forensic linguists and educators should be trained to identify emotional adverbials in discourse for legal and pedagogical purposes.

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