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RESEARCH ARTICLE

Detecting Creative States From Emotional Cues: Insights From Speech With Focus on Text Modality

SEPIDEH KALATEH, SANAZ NIKGHADAM-HOJJATI, (Member, IEEE), AND JOSÉ BARATA, (Member, IEEE)
Centre of Technology and Systems (CTS-UNINOVA), NOVA University of Lisbon, 2829-516 Caparica, Portugal
Associated Laboratory on Intelligent Systems (LASI), NOVA University of Lisbon, 2829-516 Caparica, Portugal

Corresponding author: Sepideh Kalateh (sepideh.kalateh@uninova.pt)

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ABSTRACT Creativity and emotion are fundamental aspects of human expression, interaction, and innovation, shaping various facets of modern society. This paper explores the intersection of technology, human creativity and emotional expression by proposing a novel approach to detecting creative states through the analysis of emotional cues derived from speech. To validate the findings, a linguistic prompt creativity test was conducted, incorporating both human evaluations and AI-driven assistance as the co-collaborative approach, using the Torrance Test of Creative Thinking (TTCT) as the evaluation criteria. The study analysed 50 creative speech samples from 25 participants, each exposed to happy and sad video stimuli to evoke distinct emotional responses. The results reveal a correlation between emotional states and creativity. A paired t-test revealed a difference in creativity scores between the happy and sad conditions ($t(24) = 2.46$, $p = 0.021$), with higher creativity observed in the happy condition. In 80% of the participants, higher creativity levels were observed when they experienced positive emotions and happiness, highlighting the significant influence of emotional context on creative expression and creative states and also aligning with the psychological research on exploring the effects of emotions on creativity.

INDEX TERMS Computational creativity, affective computing, emotion detection, sentiment analysis, linguistic computation, LLM, NLTK, Emroberta.

I. INTRODUCTION

Creativity is a fundamental aspect of human cognition, shaping how individuals express themselves, solve problems, and contribute to innovation across various fields. In recent years, technological advancements have begun to explore and augment this uniquely human capability, particularly through the application of artificial intelligence (AI) under the umbrella of computational creativity [1].

Creativity manifests in various domains such as art, science, writing, and problem-solving. It drives innovation and encourages individuals to push boundaries and generate novel ideas, which are then refined to find the most effective solutions [2], [3]. These creative products are the results and outcomes of the creative states in humans. The creative state refers to a mental and emotional condition where an individual feels inspired, imaginative, and open to generating new ideas, often influenced by internal and external factors [4]. Creativity and the creative state can be influenced by various internal and external factors, including emotions and emotional states, personality traits, environmental conditions, concentration and focus, and more [4], [5].

Emotions—ranging from happiness and sadness to anger, fear, and love—are intricate phenomena that impact both

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our physical and mental states. These emotions are pivotal in shaping how we communicate, interact socially, creative products, and make decisions [6]. The interaction between creativity and emotion is a dynamic and deeply interconnected aspect of human experience. While creativity fuels progress and innovation across various fields [7], emotions influence our perceptions, thoughts, and interactions with the world [8], [9]. The ability to effectively navigate and understand emotions is important in harnessing creativity. Emotions can act both as a catalyst and as a barrier to creative expression, shaping the direction, depth, and quality of the ideas produced [10].

Understanding the intricate relationship between emotions and creativity has various implications for fields such as psychology, neuroscience, education, and human-computer interaction. Emotions motivate behaviour, shape cognitive processes and influence problem-solving approaches, making them integral to creativity [11], [12]. However, much of the existing research on creativity tends to overlook the role of emotions or focuses narrowly on specific aspects of emotional experience, limiting our comprehension of the complex, multifaceted nature of creativity [13]. Since creative outcomes emerge from specific emotional and cognitive states, identifying and understanding these creative states and their subtle connection with emotions presents opportunities to enhance or replicate creativity in environments where innovative results are critical [14].

One emerging area of study focuses on detecting creativity through the emotional cues under the umbrella of affective computing and computational creativity embedded in language computation [15], [16]. Language serves as a rich medium for this investigation, as it inherently encapsulates both emotional expression and creative thought, offering a unique lens to examine their interplay [17]. Emotions, which are frequently manifested in speech, are deeply intertwined with cognitive processes and can act as catalysts for creative expression [18]. Analyzing speech empowered researchers to capture both the emotional and creative states of individuals. This approach not only mirrors natural human communication but also facilitates a more subtle understanding of the dynamic relationship between emotions and creativity [17].

From a technological point of view, voice and speech inputs offer a natural and intuitive mode of expression, allowing the analysis of spoken words and the emotional nuances [19]. The nature of speech analysis makes it an accessible tool for a wide demographic. This approach ensures that even people with disabilities or limited mobility can participate, enhancing the applicability of voice-based creativity assessment tools. With these considerations, the following research question and hypotheses have been formulated to address existing gaps and explore the role of emotion and speech in creative expression.

In this regard, the research question and hypothesis are:

RQ1:*What is the impact of two contrasting emotional states (happiness and sadness) on the creativity expressed in speech?*

H1: *Expressed emotional states are positively correlated with the level of creativity in speech and linguistics. Specifically, speech from a positive emotional state (happy state) will exhibit higher creativity scores compared to speech with a negative emotional state (sad) in people.*

RQ2:*How the impact of two contrasting emotional states (happiness and sadness) on the creativity expressed in speech can be automated and evaluated?*

H2: *Emotional cues (happiness and sadness) influence speech creativity, and these variations can be detected and quantified using automated systems that analyze linguistic, emotion detection and sentiment characteristics. Specifically: Happiness Hypothesis: Speech influenced by happiness and positive emotions will exhibit higher levels of creativity, characterized by more novel word associations, and greater use of metaphorical or imaginative language alongside higher flexibility and fluency. Sadness Hypothesis: Speech influenced by sadness will manifest distinct but less overt creative patterns, potentially through introspective or metaphorically rich language.*

RQ3: *How do express emotional cues in speech relate to the speaker's creative state?*

H3: *Expressed emotional cues in speech can be indicative of the speaker's emotional state. Positive emotional states reflected in emotional cues like enthusiasm and joy, are more likely to foster a heightened creative state, while negative emotional cues result in a more divergent but less fluent creative output.*

This research explores the relationship between emotional states (happiness and sadness) and creativity expressed in speech, aiming to understand and quantify this connection through both empirical observation and automated analysis. The study seeks to examine how contrasting emotions influence creative speech patterns, hypothesizing that happiness fosters higher levels of linguistic creativity, while sadness evokes distinct but less overtly creative expressions. It also aims to establish a model for automating the evaluation of creativity in speech using emotion detection and sentiment analysis techniques by focusing on the textual part of the speech. Ultimately, the goal is to link emotional cues in speech to the speaker's creative state, providing insights into how emotions shape creative expression and enabling advancements in automated systems for creative state assessment.

However, this study also recognizes a couple of challenges. An important limitation is the variability in individual emotional responses, as participants may experience and express emotions differently based on personality traits, cultural influences, or past experiences [20]. Furthermore, factors such as emotional regulation and linguistic proficiency may influence creativity scores independently of emotional state.

Variations in linguistic output across emotional conditions present a potential methodological challenge as well. Differences in word choice, lexical complexity, or speech fluency may reflect cognitive processing differences rather than purely emotional effects. Additionally, automated emotion detection models pose another limitation due to domain mismatch. These models are primarily trained on social media text rather than transcribed creative speech, the focus of this study, which may lead to misclassification of emotional states due to differences in linguistic structure and context.

Despite these challenges, this study has taken steps to mitigate their impact and contribute meaningfully to the field. Taking into account these limitations, our work offers the following contributions:

- The current study introduces a novel methodology that combines AI-driven emotion detection with creativity assessments to reach the creative states detection. The research aims to identify creative states through emotional cues present in speech. The study aims for two distinct emotional states (happiness and sadness) and their influence on creative and emotional cues in speech.
- This research highlights the potential for AI to complement human intuition in evaluating creative states, enhancing co-creative collaboration between humans and machines through the processes of the proposed methodology.
- In this regard, a comprehensive creativity test, based on linguistic prompts, is used to validate the approach, involving both human evaluations and AI assessments. The study further incorporates the TTCT to examine the creative output of participants and put into the picture the dynamic relationship between language, emotion, and creativity.

The remainder of this paper is organized as follows: Section II explains the fundamental necessary concepts for this research; Section III presents an overview of the backgrounds and related works; Section IV proposes a methodology to assess the relation between expressed emotional cues in the speech with creativity empowered by AI; Section V represents the experimental design and the procedure in details and collaborative evaluation procedure between human and AI for creativity evaluation; Sections VI and VII are devoted to showcasing the Results and Discussions; and finally, Section VIII provides a conclusion and possible future direction for this work.

II. CONCEPTS

This section aims to introduce the fundamental and essential concepts underlying this research.

A. CREATIVITY

is a multifaceted and dynamic cognitive process that involves the generation of novel ideas, solutions, or expressions characterized by originality, relevance, and value. It extends beyond conventional thinking, encouraging individuals to make unique connections, explore alternative perspectives, and transcend established boundaries [4], [21].

1) CREATIVE STATE

refers to the mental and cognitive condition of an individual during creative endeavours. It encapsulates a dynamic spectrum of cognitive and affective aspects, influencing the generation of innovative ideas, solutions, or expressions. A creative state is characterized and influenced by the various internal and external drives, which contribute to the less or more richness and uniqueness of creative experiences and expression [22].

2) CREATIVE PRODUCT

is the tangible or intangible output of a creative process and creative state, characterized by originality, usefulness, and the capacity to inspire or evoke emotion. It can take various forms, such as artworks, literary works, scientific theories, technological inventions, or problem-solving solutions. In creativity research, evaluating a creative product often involves assessing its novelty, relevance, and quality within a specific context or domain. For instance, a poem crafted during an experiment may be judged based on its linguistic innovation, thematic coherence, and emotional resonance. The concept of a creative product is central to understanding how creative thinking translates into outcomes that contribute to cultural, technological, or intellectual advancement. Moreover, it is important to consider that not all the creative states and processes will result in creative products but a creative product is the result of being in a creative state [14].

3) CREATIVITY DRIVES

encompass the motivational forces that propel individuals to explore new ideas, solve complex problems, and pursue innovative endeavours. These drives are rooted in intrinsic motivation, the desire for self-expression, and the pursuit of novel and meaningful experiences. They can fuel the process of ideation, experimentation, and the willingness to step outside established boundaries. Creativity drives serve as the catalysts that inspire individuals to push the limits of conventional thinking or leave it [7]. personality traits, environmental effects, cultural background, mood, and emotional states are some of the important creative drives.

B. EMOTIONS

Emotions are a complex and integral aspect of the human experience, encompassing a range of subjective feelings and physiological responses that shape our perception and interaction with the world. Emotions serve as powerful signals, representing some part of our internal states and influencing our thoughts, behaviours, and decision-making processes [23], [24].

1) SENTIMENTS

Sentiments are complex, long-lasting emotional attitudes or opinions toward people, objects, or concepts, influenced by emotions, feelings, and beliefs. They include enduring social connections that trigger emotions, emphasizing their social origins and influence [25], [26]. They range from negative, neutral, and positive.

2) EMOTION MODELS

Different regions of the brain elicit various emotions. Emotional responses typically fall into three categories: reactive, hormonal, and automatic. In psychological terms, emotions are reactive phenomena triggered by stimuli and linked with qualitative physiological alterations. Researchers employ two primary methodologies to investigate the essence of emotions: the discrete method and the multidimensional approach.

3) DISCRETE EMOTIONS THEORY

In this theory, emotions are distinctly categorized, each characterized by its own set of cognitive, psychological, and behavioural elements. These emotions can be either positive or negative, with proponents of this idea suggesting the existence of a small number of fundamental emotions that are universally recognized across cultures. These basic emotions include happiness, sadness, anger, surprise, fear, and disgust. Robert Plutchik expanded on this concept with his comprehensive emotional model known as Plutchik's wheel of emotions, which comprises eight primary emotions: fear, joy, sadness, trust, anger, surprise, anticipation, and disgust. Additional emotions, which blend these primary ones, are determined by their position on the wheel, with intensity increasing towards the centre and decreasing towards the periphery. Figure 1 illustrates an overview of Plutchik's wheel of emotions [27].

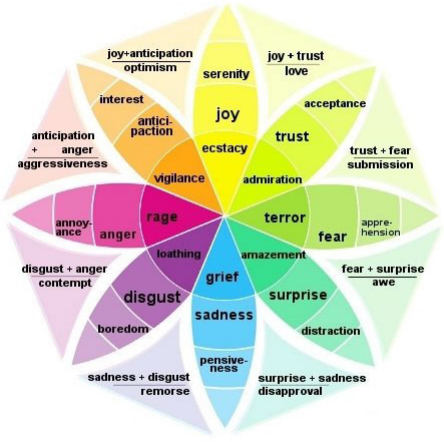

FIGURE 1. Plutchik's wheel of emotions [27].

This discrete emotions theory is used as the emotional model in this research.

III. RELATED WORKS

This section aims to address **Q1** and its **H1** of this research by reviewing relevant literature on the intersection of creativity and emotions and their interplay and providing the necessary background context.

A. LINGUISTIC COMPUTATION

Linguistic computation refers to the use of computational tools and techniques to analyze language patterns, structures, and usage. Linguistic computation is a valuable method for quantitatively and qualitatively assessing the linguistic creative outputs (stories, poems, or essays) generated by participants. Employing natural language processing (NLP) techniques, can evaluate various dimensions of creativity, such as lexical diversity, syntactic complexity, and sentiment alignment with the elicited emotional states. Tools like word embedding models (e.g., Word2Vec or GloVe) can help identify semantic connections between participants' word choices and the emotional valence of the stimuli [28].

Linguistic computation can also aid in measuring creativity through textual features such as fluency (total word count), originality (use of novel or rare words), and flexibility (shifts in thematic focus or syntactic structures). Advanced computational tools, like Coh-Metrix, allow for an exploration of these features, including cohesion, narrative flow, and rhetorical sophistication [29], [30].

B. CREATIVE LINGUISTIC

In the area of speech and language, creativity manifests through the generation of original and valuable ideas communicated verbally. This process relies on both cognitive and linguistic capabilities, combining the speaker's ability to think divergently with their fluency and flexibility in expressing ideas [31]. Divergent thinking, as noted by Guilford's [5] studies on creativity, emphasizes the capacity to produce multiple, diverse responses to a given prompt, which is essential in tasks involving creative speech. Linguistic creativity, therefore, is evaluated not just by the novelty of the ideas but also by the richness, elaboration, and originality of how these ideas are communicated verbally [32].

Simulating creativity through machines, a field known as computational creativity, has become an intriguing and rapidly growing area of research [1]. This multidisciplinary domain explores how computational algorithms and systems can be designed to generate novel, valuable ideas, solutions, or artistic expressions, traditionally seen as uniquely human endeavours. The process often begins with analyzing vast datasets to identify patterns, associations, and trends that form the basis for creative generation [33]. Machine learning algorithms, including neural networks and genetic algorithms, play a critical role in this data-driven phase. Furthermore, generative models like deep learning networks and probabilistic graphical models allow machines to synthesize new combinations and variations of existing information, producing outputs that mimic creative

processes [34] Natural language processing (NLP) techniques, in particular, are essential for enhancing machine creativity in text generation, enabling computers to produce coherent, contextually relevant, and novel content that resonates with human communication styles [35].

Recent advances in NLP and large language models (LLMs) have introduced advanced methods for assessing creative language use, such as semantic distance measures, which quantify the novelty and relevance of word associations in speech [36] alongside the creative text generation [37]. These methods complement traditional human assessments of linguistic creativity by offering a more objective and scalable way to evaluate speech-based creative outputs.

Recent research has advanced the integration of cognitive theories—such as creative thinking and creative states—with NLP, machine learning, and LLMs [15], [17]. This approach enables a deeper understanding of how machines can emulate the human creative process, enhancing both the study of creativity and the development of tools that support human-machine co-creative collaboration in creative tasks.

1) LINGUISTIC CREATIVITY ASSESSMENTS

Creativity recognition from text involves automating the process of evaluating readability and linguistic creativity. In the area of health information, a study by Kher et al. [38] focused on the readability of online articles related to congestive heart failure, aiming to assess their ease of comprehension. Similarly, Chiru's work [39] proposed a model to differentiate between creative and non-creative news articles by developing a classifier using text mining techniques. These studies highlight the growing interest in automating creativity assessment, utilizing various methods such as word counting, sentence length analysis, fluency, imagery, metaphor usage, emotional tone, and lexical choices to detect creativity in written content [2], [40], [41].

While virtually all text can exhibit creative elements, assessing and comparing creativity across different texts requires the application of specific evaluative criteria [42]. Universally applicable metrics can help gauge creativity across various formats of text [40], [43]. The Torrance Tests of Creative Thinking (TTCT) [44], a widely respected framework in educational and psychological research, serves as an effective tool for evaluating creativity in writing. The TTCT breaks down creativity into four key dimensions that are adaptable to textual analysis:

Fluency refers to the capacity to generate a substantial number of ideas or responses in reaction to a given prompt. In written texts, this metric captures the number of distinct ideas, sentences, or phrases that the writer produces. A high-fluency response would include numerous suggestions.

Flexibility measures the variety and diversity of ideas across different categories or perspectives. In writing, flexibility is observed through the range of concepts or approaches a writer utilizes. Flexibility would be demonstrated by generating ideas across multiple domains, such as construction, art, education, or practical tools.

Originality assesses the uniqueness or novelty of the ideas presented. This dimension evaluates how rare or uncommon the ideas are compared to standard responses. In textual analysis, originality is reflected in innovative or unexpected ideas. For instance, suggesting that a brick could serve as a historical artefact to teach ancient construction techniques exemplifies originality.

Elaboration gauges the depth and detail with which ideas are developed. It measures how well the writer expands on their ideas by adding richness and thoroughness to their descriptions. For example, elaborating not just on the use of a brick to build a wall, but also describing the design, the type of mortar, and the architectural style would reflect high elaboration.

Recent research aimed to adapt the TTCT specifically for text and written stories, proposing the Torrance Test of Creative Writing (TTCW) to evaluate creativity as a product [43], [45]. In this research, we adhere to the four main criteria of the TTCT for evaluating the creativity of speeches, while providing clear and concrete definitions for each criterion. The evaluation and ranking process is thoroughly detailed in section V.

C. EMOTION IN LINGUISTIC

Emotions are an important element in human communication, shaping not only the content of our language but also its delivery and reception [23], [46]. Linguistics, the scientific study of language, has long recognized the profound influence of emotions on language production and comprehension. Emotions can manifest in language through various channels, such as word choice, sentence structure, intonation, and even non-verbal cues like pauses and hesitations. For instance, emotionally charged words or expressions may carry connotations that evoke specific emotional responses in both speakers and listeners, enhancing the depth and meaning of an interaction [8], [47].

Recent advancements in NLP, LLMs, and computational models have opened new avenues for exploring emotional dynamics in linguistic structures. These models can analyze large corpora of text to detect patterns in how emotions are expressed and understood across different languages and cultural contexts.

For example, emotion analysis tools, including LLM-powered systems, can examine emotional polarity (positive, neutral, or negative) within texts and provide insights into how emotional valence influences communication patterns [48].

1) LINGUISTIC EMOTION DETECTION

Linguistic emotion detection involves the identification and classification of emotions conveyed through language, typically using computational methods to analyze text. These techniques often rely on machine learning models that have

been trained on large datasets annotated with emotional labels [49]. One common approach is the use of sentiment analysis methods, where predefined emotional words are used to score the positive or negativity of the text based on their emotional content [50], [51]. Another prevalent method involves supervised machine learning models [52], such as deep learning and transformer architectures like BERT (Bidirectional Encoder Representations from Transformers), which have shown high accuracy in identifying emotions in both structured and unstructured text data [53]]

Tools such as EmoRoBERTa [54] have been fine-tuned on large emotion-labeled datasets, such as GoEmotions [55], enabling them to detect a wide range of emotions beyond basic positive or negative sentiment. These advanced models are capable of recognizing more nuanced emotional states, such as empathy, frustration, or surprise, making them valuable in applications ranging from mental health diagnostics to customer service. EmoAtlas [29] is also a computational framework for extracting emotions and word associations from texts using interpretable AI and psychologically-validated lexicons for Plutchik's 8 emotions. EmoAtlas demonstrates strong predictive power in psychometric tasks, especially when combined with semantic features, showcasing its potential for analyzing creativity and emotional framing in narratives.

D. INTERSECTION OF CREATIVITY AND EMOTIONS

Creativity is a complex and multifaceted cognitive process defined by the ability to generate novel and valuable ideas, solutions, or expressions that deviate from conventional patterns of thought. It involves connecting seemingly unrelated concepts, breaking free from established norms, and producing outcomes that are characterized by originality, relevance, and often, an element of surprise. As highlighted by Young [56], creativity transcends singular domains, influencing diverse areas such as the arts, sciences, and everyday problem-solving. It reflects an individual's capacity to embrace ambiguity, foster curiosity, and synthesise disparate elements into coherent, innovative expressions [57]. According to Runco and Jaeger [3], the traditional understanding of creativity rests on two core components: originality and effectiveness. Originality refers to the uniqueness and novelty of ideas, while effectiveness encompasses the usefulness, appropriateness, or meaningfulness of these ideas. These criteria serve as benchmarks for evaluating creative thinking, which is often assessed through divergent thinking — the ability to generate a wide range of ideas from a given stimulus.

A creative state refers to a heightened mental or cognitive condition in which individuals exhibit enhanced creativity, marked by their ability to produce novel and valuable ideas or solutions. When engaging in creative tasks, individuals can experience a range of cognitive and psychological states, each potentially influencing the level of creativity they achieve. Various drives contribute to the emergence of a creative state [58]. These creative drives represent the underlying motivations, impulses, or forces that propel individuals toward creative thinking and problem-solving. These drivers can be internal or external, stimulating and energizing the creative process [7].

Internal creative drives are particularly strong in fostering creativity, as they stem from personal passions, intrinsic motivation, and the innate curiosity to explore or innovate. Unlike external factors, internal drives are more accessible and within an individual's control, making it possible to acquire skills to navigate and harness them for creative purposes [59]. These internal drivers encompass a range of psychological factors, including emotions, arousal, valence, and the fundamental need for self-expression. Understanding and managing these internal forces, help individuals more effectively enter and sustain creative states [15].

Emotions play an important role in shaping creative drives. They are complex psychological and physiological states triggered by various stimuli or situations, influencing thoughts, behaviours, and bodily responses [8]. Emotional experiences consist of subjective feelings, moods, and affective states, which have the potential to influence creativity by guiding thought processes and problem-solving efforts [60], [61]. Emotional intelligence, or the ability to recognize, reason about, and regulate emotions, is integral to this process, providing individuals with the capacity to use emotions as cognitive tools for creative problem-solving [62].

Addressing **Q1** and validating **H1**, it is established that emotional states are positively correlated with the creativity level of speech and linguistic features. Specifically, speech produced in a positive emotional state (happiness) tends to exhibit higher creativity scores compared to speech produced in a negative emotional state (sadness). With this foundation and supporting background, the next section will focus on developing and proposing a methodology to detect creative states from emotional cues in speech.

IV. PROPOSED METHOD

The proposed methodology seeks to provide an approach to the relationship between emotional cues embedded in speech and the speaker's corresponding levels of speech creativity. This approach aims to identify how these cues influence the speaker's creative output. The goal is to establish a link between the expressed emotions and creativity levels of speech and map these insights to the overall creative state of the speaker. This integrated approach considers both the linguistic elements and expressed emotional elements. It comprises two main processes: one for emotion and sentiment analysis of the speech's textual content, and the other for assessing speech creativity. The emotion detection and sentiment analysis phase is fully automated, with some quality control involving human oversight. In contrast, the creativity assessment process is a co-creative collaboration between humans and machines, with the final decision made by humans and machines serving as an assistant agent [63]. Below is a detailed explanation of the processes based on

the visual flow in Figure 2. This methodology represents a contribution toward addressing **RQ2**.

1) *Recoding The participants prompting speech:* The detailed procedure for this stage is thoroughly explained in Section V. During this step, participants' audio is recorded for further analysis and to serve as input for subsequent processes. The recordings for this study were conducted in a controlled environment with minimal background noise. A high-quality microphone with noise reduction was used to ensure that no significant interference affected speech transcriptions or emotion detection accuracy. Since this experiment focused solely on the textual content of speech rather than acoustic or signal-based analysis, additional noise cancellation measures were not necessary. To maintain consistency and minimize environmental influences, all experiments were conducted in an isolated room under the same conditions for all participants. This controlled setup helped ensure authentic speech expression while reducing potential variability in the data collection process.
2) *Text Emotion Detection and Sentiment Analysis Process:* This part of the methodology analyzes the emotional content of speech. The process begins by converting speech to text and follows several steps:
   a) *Speech-to-Text Conversion:*
   The spoken input from participants is converted into a text format. A speech-to-text model is used to convert audio files into text [64]. To ensure transcription accuracy and maintain data quality, we adopt a human-in-the-loop approach. A subset of the transcriptions is reviewed and corrected by human transcribers, providing a quality control mechanism. This method not only ensures the accuracy of the automated transcriptions but also incorporates human-machine collaboration into the experimental process. Also before converting the audio files to text, we had to convert the format of the files from .m4a to .wav, which has been done by AudioSegment python libraries .[1]
   b) *Data Pre-Processing:* This step involves cleaning and preparing the transcribed text to remove irrelevant data. This include tasks such as tokenization, removing stopwords, and ensuring the data is ready for feature extraction.
   c) *Feature Extraction and Emotion Recognition:* After preprocessing, the text undergoes feature extraction, where specific emotional and linguistic features are identified. This uses tools such as Emotion Detection (powered by model EmoRoBERTa) and Sentiment Detection (using NLTK). These tools detect and classify various emotions (e.g., joy, sadness, anger) and sentiments (positive, negative, neutral) present in the speech. The EmoRoBERTa [54] model [2] was employed for emotion detection. EmoRoBERTa is a fine-tuned version of the pre-trained RoBERTa [65] model, which was trained on the GoEmotions dataset [55]. Developed by Facebook, RoBERTa is an extension of the BERT model [53], created by Google. Both RoBERTa and BERT are transformer-based models that use self-attention mechanisms to process input sequences and generate language representations, making them highly effective for various NLP tasks. RoBERTa has been shown to outperform BERT in several areas. The GoEmotions dataset, comprising 58,000 Reddit comments, is annotated with 27 emotion categories and a neutral class. EmoRoBERTa was used to generate emotion scores for all abstracts, representing the percentage weight of each emotion detected in the text.
   The detected emotions are: *admiration, amusement, anger, annoyance, approval, caring, confusion, curiosity, desire, disappointment, disapproval, disgust, embarrassment, excitement, fear, gratitude, grief, joy, love, nervousness, optimism, pride, realization, relief, remorse, sadness, surprise*. Moreover, the emotions were categorised within the positive and negative categories [66], [67] for further investigation, Table 1 shows the distribution. These emotions are 27 emotions in Plutchik's theory [27]. The steps undertaken for emotion recognition by EmoRoBERTa are summarized in Figure 3.

TABLE 1. Emtions categries.

Category	Emotions
Positive	admiration , amusement, approval, caring, excitement, gratitude, joy, love, optimism, pride, relief, realization, relief, surprise
Negative	anger, annoyance, disappointment, disapproval, disgust, embarrassment, fear, grief, nervousness, remorse, sadness

   d) *NLTK Sentiment Analysis* was conducted by using the NLTK library in Python, leveraging the VADER (Valence Aware Dictionary and Sentiment Reasoner) sentiment analysis tool [68]. VADER assigns a compound score to each text sample, representing its overall sentiment polarity. This score ranges from -1 (extremely negative) to +1 (extremely positive), with values around 0 indicating neutral sentiment. VADER analyzes lexical elements such as individual

[1]https://pypi.org/project/audiosegment/, Accessed on November 5, 2024

[2]https://huggingface.co/arpanghoshal/EmoRoBERTa, Accessed on November 5, 2024

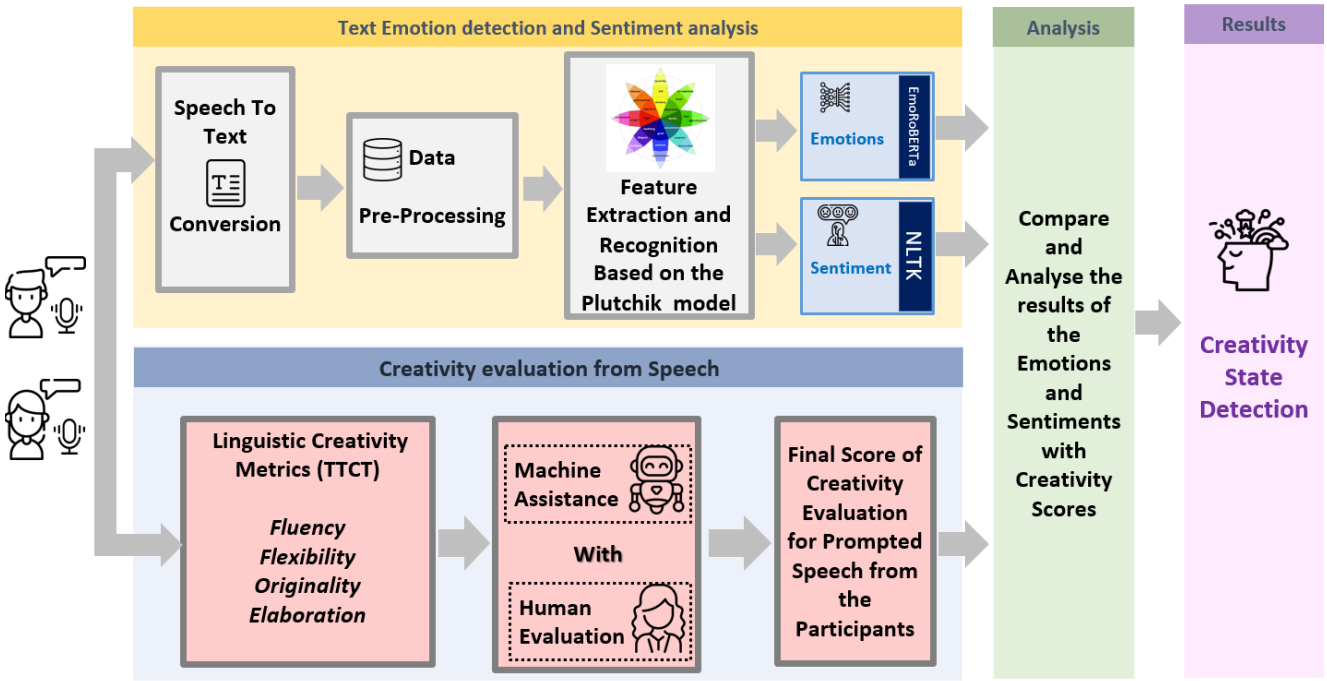

FIGURE 2. Proposed methodology for assessing the relationship between emotional cues and creativity in speech and finally the creative state of the individuals.

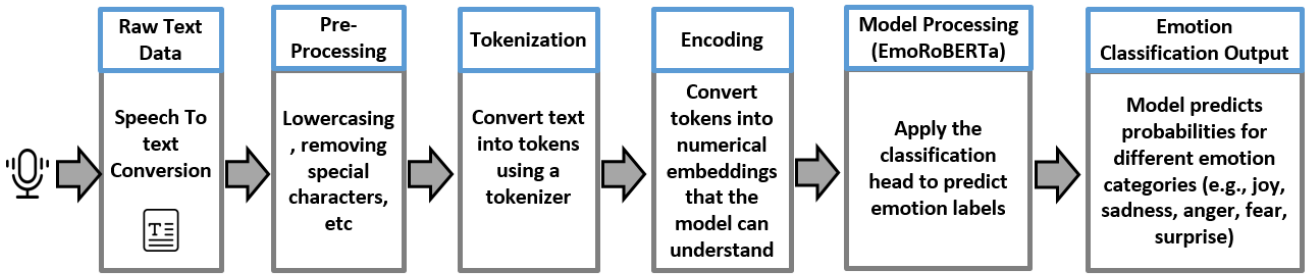

FIGURE 3. The steps undertaken for emotion recognition by EmoRoBERTa.

words, punctuation, and capitalization to determine the sentiment.

Drawing from the literature review in Section III and the validation of hypothesis **H1**, it is anticipated that participants experiencing positive emotions are more likely to achieve a higher creative state. These individuals are expected to deliver speeches with elevated creativity scores. Subsequently, the next parallel step involves implementing the evaluation procedure accordingly.

In this study, EmoRoBERTa and VADER were used in complementary roles. EmoRoBERTa provided fine-grained emotion detection by identifying specific emotions, while VADER assessed overall sentiment polarity (positive, neutral, or negative). The sentiment results from VADER were compared with the emotions detected by EmoRoBERTa to ensure consistency in expected emotional trends. Additionally, VADER was utilized to evaluate the effectiveness of video stimuli in inducing emotions, serving as a secondary check to assess tonal variations in responses after participants watched the videos. This cross-validation approach helped manage potential misclassifications and have more accurate results.

3) *Creativity Evaluation from Speech Process:* This section focuses on measuring creativity using established linguistic creativity metrics.

   a) Linguistic Creativity Metrics (TTCT) [44]: This involves evaluating the speech text according to the TTCT, which includes four key metrics: 1. *Fluency:* It refers to the ability to produce a large number of ideas or solutions in response to a given stimulus. It is measured by counting the total

number of ideas or responses provided. A higher fluency score indicates an individual's capability to think broadly and generate multiple options.
2. *Flexibility:* It is the ability to think in diverse categories or to approach problems from different perspectives. It assesses the variety in the types of responses provided. A flexible thinker can shift between different modes of thinking and adapt to new situations.
3. *Originality:* It measures the uniqueness or novelty of the ideas generated. It focuses on how rare or unconventional the responses are. Responses are scored based on their rarity compared to those of other participants. Originality highlights a person's capacity for innovative thinking.
4. *Elaboration:* It involves the ability to expand on an idea by adding details, depth, and complexity. It is measured by the richness of the descriptions or the level of detail provided in the responses. A higher score reflects thoroughness and imaginative enhancement.

b) *Machine With Human Evaluation:* A combination of machine-based evaluation (using algorithms and models) and human assessment is used to measure the creativity of the speech based on the TTCT metrics. Machine evaluation provides consistent results, while human evaluation offers subjective, more in-depth and experienced insights into creativity. This section is been explained in more detail in the section V.

c) *Final Creativity Score:* Human evaluations are the results to provide a final creativity score for each participant's speech. This score represents the overall level of creativity demonstrated by the speaker.

4) *Data Analysis and Synthesis of detected emotions and sentiments vs creativity scores:*
After completing both the emotion detection and creativity evaluation processes, the results are synthesized in the final stage of the methodology to determine the speaker's creativity state. This synthesis involves analyzing the interaction between emotional expressions and creativity levels in speech to identify whether specific emotional states (e.g., joy, hope, sadness) facilitate creativity. The recognized emotions and sentiments are then compared and analyzed against predefined creativity metrics and final scores. This step evaluates how emotional states and sentiments within speech align with established characteristics of creative expression.
In this stage, a *Random Forest decision* tree model is employed to quantify the impact of different detected emotions on creativity scores derived from textual data. Several analytical measures were employed to ensure the robustness of the findings. Pearson correlation analysis is performed to explore the relationships between these variables. Significance levels (p-values) were reported to determine statistical significance, while 95% confidence intervals (CIs) were provided for key comparisons, such as paired t-test mean differences, to indicate the range within which the true effect is likely to fall. Additionally, effect size measures were included to quantify the strength of observed effects, with Cohen's d used for the paired t-test to assess the magnitude of differences between conditions. with findings supported by visualizations such as graphs and bar charts. All analyses are conducted using Python within a Google Collab and SPSS software (version 26.0) environment.

5) *Final Results:* After analyzing the relationship between emotions, creativity scores derived from individuals' speech, and emotional states, the evaluation examines whether automation can effectively recognize individuals' creative states. The final stage of the methodology is dedicated to addressing Research Question **RQ2** completely and **RQ3**.
In this stage, the speaker's creativity state of the participants is determined and discussed, integrating emotional and linguistic cues to provide a comprehensive assessment of creativity.

The methodology aims to evaluate the creativity of speech by analyzing the emotional cues, sentiment, and linguistic creativity of participants. Combining machine-based analysis with human evaluation ensures an accurate assessment of creativity in speech. The next section provides a detailed explanation of the experimental design and the procedure for recording individuals' speech.

V. EXPERIMENTAL DESIGN

The Experimental Design section outlines the scientific approach employed to design the experimental steps for data collection. It details the methods used for speech recoding from individuals, the sampling strategies, the operational definitions of variables, and the controls implemented to ensure the validity and reliability of the gathered data and the results. The experimental procedure to assess linguistic creativity is grounded in the following principles and decisions:

A. WHY SPEECH?

In the experimental design, the audio speech inputs were selected to assess linguistic creativity with several important considerations in mind. A key factor in our selection was the presence of emotional cues and creativity within the speech samples at the same time [17], [69].

Additionally, the speech samples were perceived as more authentic. Authentic speech, characterised by genuine emotional expression and personal engagement, often provides a richer perception of the speaker's creative process. This authenticity is important for evaluating the true nature of linguistic creativity, as it reflects real-world communication and expression.

1) AUTHENTICITY AND SPONTANEITY

Audio recordings capture the spontaneous and authentic responses of participants, which reveal a more natural and creative use of language compared to written responses. Written responses tend to be more polished and edited, losing the raw, impromptu nature of spoken language. Capturing verbal responses allows for the observation of how creativity emerges in real-time, without the benefit of extensive revision [70].

2) REAL-WORLD APPLICATION

Creativity is frequently expressed verbally in real-world situations, such as in storytelling, speeches, and conversations. Thus, evaluating creativity through spoken responses offers more practical insights into how creativity manifests in everyday scenarios. Analyzing verbal responses empowers us to better understand how creativity functions in environments where speech is the primary mode of expression [71], [72].

3) PRIVACY CONCERNS

Privacy concerns were also a significant consideration in our selection process. Speech data, when anonymized and used with consent, typically presents fewer privacy concerns compared to more personal or sensitive forms of data, and people are more expressive and provide more realistic content for the experiments.

B. EXPERIMENT MATERIALS

In this section, we will outline the materials used in the experiment, providing essential information to ensure reproducibility and consistency in experimental procedures.

1) VIDEO PRESENTATION FOR EMOTIONAL ELICITATION

A video presentation for emotional elicitation is a technique used to evoke specific emotional responses in viewers by presenting carefully crafted or selected visual and auditory content. This approach is commonly used in psychological and affective computing research to understand emotions, reactions, and emotional triggers in a controlled setting. Video presentations are effective for emotional elicitation because they engage multiple senses and allow for consistent, reproducible emotional stimuli across participants with higher accuracy [73], [74].

The experimental design leverages scientific findings from research, such as De Dreu et al. and Fernández-Abascal and Díaz [12], [75], to explore the impact of emotional valence and arousal on creative thinking. It emphasizes the use of videos to induce emotions and assess creativity, supporting the dual-pathway model where emotions influence creativity based on arousal and task conditions.

2) FIXED ORDER OF VIDEO PRESENTATION

In this study, a fixed order of presenting the sad video first, followed by the happy video has been maintained, based on theoretical and methodological considerations. Prior research [12], [76] suggests that emotional states are not equally inducible in all directions; specifically, it is easier to transition from a sad state to a happy state than the reverse. If the happy video were presented first, participants might experience a carryover effect that dampens the impact of the subsequent sad video, making it more challenging to induce sadness effectively [77]. Since the integrity of our experimental design relies on achieving distinct emotional states, maintaining a consistent order ensures that the emotional manipulation remains strong and comparable across participants.

Additionally, previous studies on emotional priming indicate that certain emotions have asymmetric effects on cognition and behaviour, further justifying the need for a fixed order [14]. Standardizing the sequence reduces the likelihood of uncontrolled emotional fluctuations that could confound the results. While counterbalancing video order is a common approach to addressing sequence effects, in this case, it could compromise the reliability of the emotional induction. Therefore, the decision opted for a fixed order to maintain methodological consistency and ensure the validity of our findings.

3) EMOTIONAL BASELINE EVALUATION

Controlling baseline emotional states is important in studies examining the influence of emotions on cognitive and creative processes. To address this, the Affect Grid [78] has been implemented before each experimental session, allowing us to assess participants' initial emotional states and ensure they began from a neutral or comparable baseline. Participants who reported highly deviant emotional states were asked to return at another time to prevent unintended biases. Incorporating this measure, enabled us aimed to minimize variability and enhance the reliability of emotional induction while maintaining a naturalistic setting that reflects real-world emotional fluctuations [78].

4) CONSIDERING A 3 TO 24-HOUR PERIOD TO RETURN TO A NEUTRAL EMOTIONAL STATE

The variation in time gaps (3–24 hours) between experimental conditions was a necessary design choice to accommodate participants' availability while ensuring sufficient emotional reset between sessions. Emotional carryover effects can influence responses in repeated measures designs, making it crucial to allow adequate time for participants to return to a neutral emotional baseline. To address this, the Affect Grid [78] has been incorporated as a control measure, assessing participants' emotional states before each session and ensuring they began in a neutral state. This approach helped mitigate the potential impact of variable time gaps on the study's results, allowing us to maintain the integrity of the emotional manipulation.

5) SELECTION OF DISTINCT WORD SETS FOR EXPERIMENTAL CONDITIONS

The use of distinct word sets across conditions was a deliberate methodological decision to prevent familiarity effects from influencing the results. Repeating the same word set in both emotional conditions could have introduced practice effects [], where prior exposure enhances coherence or fluency independent of the experimental manipulation. To mitigate this, unique word sets were designed for each condition while maintaining linguistic comparability. The selection process prioritized emotional neutrality, concreteness, and thematic relevance to the corresponding mood induction videos, ensuring that the words appropriately reflected the intended emotional context without introducing bias.

To further minimize confounding effects, the word sets underwent rigorous validation by a panel of experts in psycholinguistics and cognitive psychology. The selection criteria included word frequency, emotional valence, and concreteness, all of which were statistically analyzed and found to be comparable across conditions (all $p > 0.05$).

- *Concreteness and Neutrality:* The words in both sets are concrete nouns that are emotionally neutral, reducing the likelihood of confounding due to emotional valence [79], [80].
- *Matching on Key Variables:* The word sets were matched on key linguistic variables, including word frequency and length, to ensure comparability across conditions [81].
- *Thematic Alignment:* The word sets were chosen to align with the thematic content of the mood induction videos (e.g., 'rain' for the sad condition and 'rainbow' for the happy condition), ensuring ecological validity [81].

These measures ensured that any observed differences in creative performance were attributable to emotional manipulation rather than discrepancies in word characteristics. A detailed linguistic analysis Table 2 has been included to further clarify the selection process and reinforce the validity of the chosen methodology.

Overall, The study aimed to examine the short-term impact of emotions on creativity, making a single-session approach suitable [82]. The creative tasks were novel and distinct, reducing the likelihood of practice effects influencing participant responses [83]. Also, the change in the word sets makes it a new challenge rather than repetitive for the participants. Additionally, a time gap was provided between conditions to minimize carryover effects [84].

C. PARTICIPANTS

A total of twenty-five adults (N=25) participated in the experiment. The group consisted of 15 men and 10 women, aged between 20 and 50 years. All participants had high-level educational backgrounds and advanced English-speaking skills, not all native English speakers but at the level of professional (C1), ensuring they could engage in the creative prompting tasks effectively.

The study employed a within-subjects design where each participant served as their own control. This approach is widely used in affective computing and creativity research due to its ability to minimize inter-individual variability, such as differences in cognitive styles, personality traits, and baseline creativity levels [12], [85]. Aiming at reducing between-subject noise, this design enhances the sensitivity of detecting within-subject changes in creative performance attributable to emotional state manipulations [86], [87].

D. NARRATIVE PROMPTS FOR CREATIVE PRODUCTION

To evaluate creativity, narrative prompts have been used and considered as creative products. These prompts were aided with a couple of words to encourage participants to produce creative content such as stories, poems, or normal speech [88], [89]. This method allows for the assessment of participants' creative abilities through their spontaneous responses under elicitated emotions. A key aspect of experimenting was that the participants were unaware of the specific measures being evaluated or the factors that would influence the outcomes. In other words, they were not informed about which parameters would be assessed in their prompted speech, ensuring that their responses were natural and unbiased by any knowledge of the experiment's focus. However, they have been acknowledged that this is an Affective computing and computational creativity research.

E. ENVIRONMENTAL SETTINGS

The environmental setting was another important consideration in designing the experiments. Both processes of the experiment were conducted in the same environment and at the same spot. During the experiment, there was no verbal interaction between the assistant and the participants. The assistant's responsibilities were limited to showing the video, handing over the papers containing the words, and managing the microphone settings and recordings.

In the designed experiment, some fixed measures were considered to reduce variability and ensure the same experimental environment for all participants. These measures included using the same room, the same spot in the room, identical microphones, the same words on the papers, the same monitors for showing the videos, the same person experimenting with all participants, and maintaining consistent timing during daylight hours. Figure 4 summarizes the experimental steps.

F. EXPERIMENTAL PROCEDURE

Participants were tasked with crafting creative content (stories, poems, or normal speech) within a set time frame in two distinct emotional states (Happy and Sad). These verbal responses were recorded for analysis, and 50 outputs were collected. The experimental steps are outlined as follows:

1) *Step 1: Initial Inquiry and Consent* Participants' emotional states were gauged, and they provided informed consent to take part in the study. This step ensures that participants know the process [90]. Additionally,

TABLE 2. Descriptive statistics for word sets.

Word Set	Word	Frequency (SUBTLEX)	Emotional Valence (ANEW)	Concreteness (Brysbaert et al.)
Sad State	Mouse	50.2	5.1 (neutral)	4.8 (concrete)
	Cheese	45.7	5.3 (neutral)	4.9 (concrete)
	Sunglasses	30.4	5.0 (neutral)	4.7 (concrete)
	Rain	60.1	4.9 (neutral)	4.6 (concrete)
Happy State	House	55.3	5.2 (neutral)	4.9 (concrete)
	Rainbow	40.8	5.4 (neutral)	4.8 (concrete)
	Wine	35.6	5.1 (neutral)	4.7 (concrete)
	Alien	25.9	5.0 (neutral)	4.6 (concrete)

Frequency values are per million words. Emotional valence ratings range from 1 (negative) to 9 (positive), with 5 being neutral. Concreteness ratings range from 1 (abstract) to 5 (concrete).

providing a privacy consent form was a crucial part of this process. In this step also the Affect Grid [78] was used to evaluate the emotional baseline (Neutral). It is considered an effective tool for rapidly and repeatedly capturing emotional states [74], [91]. The ideal starting point for the experiment is a neutral emotional state. If a participant is not in a neutral condition, they are asked to reschedule and attend the experiment at another time, regardless of whether they are experiencing a happy or sad state.

2) *Step 2: Video Presentation for Emotional Induction* Proceed with having participants view a video selected to evoke two distinct emotions, aligning with the quarters of the Circumplex model [92]. These videos typically range from 1 to 2 minutes in duration and tried to be tailored to the participant's desire about Happy and Sad. To make it personalized, it has been asked from the participants, *What makes you happy?* and *What makes you sad?* before the experiments. The sad video is the first video to be shown and within a 3 to the 24-hour gap, the happy video is shown, ensuring a neutral state for the beginning of the next experiment.
3) *Step 3: Word Presentation* Participants were briefly shown a group of words to prime their thoughts and encourage associative thinking. The words were written on a piece of paper and handed to them after watching the videos. They had about one minute to look at the words before proceeding to the next step. The words were designed to stimulate creativity by prompting a wide range of ideas [5]. The word selection process was conducted under the guidance of psychological experts, to trigger activating associated memories [93]. The words interpretation can vary for each participant based on their background experiences. Moreover, the selection of words also considered the odds and aimed to be out-of-the-box.
   - Words Group 1 for sad video content:
   Mouse, Cheese, Sunglasses, Rain
   - Words Group 2 for happy video content:
   House, Rainbow, Wine, Alien
4) *Step 4: Verbal Response to Prompts* Participants verbally responded to the creative prompts, allowing for spontaneous articulation of ideas. Their responses were recorded, capturing not only their verbal output but also the emotional and prosodic elements essential for a comprehensive creativity assessment [94].
5) *Step 5: Final Interview after each experiment* A reflective interview was conducted to gather participant feedback on the process. This allowed for an exploration of their creative experience and any challenges or constraints they encountered. It also ensured the ethical handling of their involvement in the study [95]. In this step, participants were also asked if they show video had an impact on them to elicit the desired emotions. Moreover, a structured debriefing process after the experiment has been implemented to provide participants with an opportunity to discuss their experiences, address any lingering emotional effects, and offer feedback about the procedure.
   This step is particularly important in experiments involving emotional manipulation, as it ensures ethical handling of participants' well-being by helping them process any negative emotions elicited during the study. To further safeguard their mental state, provide access to support resources, such as counselling services or informational materials, to help manage adverse emotional responses if they arise. These measures collectively ensure that participants leave the experiment in a neutral or positive emotional state, fostering a sense of closure and ethical responsibility in the research process.
6) *Step 6: Reward* Participants were rewarded with tokens for completing the experiment.

G. DATA PRIVACY AND ETHICAL CONSIDERATION

To safeguard the privacy of all participants, strict measures were implemented to ensure that their recorded audio data was only used for the specific purposes outlined in this research, namely further analysis and creativity assessments. This means that the audio recordings were not shared outside of the research team or used for any other purposes beyond the scope of the study. All data was handled with utmost confidentiality, ensuring that personal identifiers or sensitive information were either anonymized or securely stored to prevent unauthorized access. Ethical standards, including informed consent, data protection, and participant rights, were rigorously followed at every stage of the process to

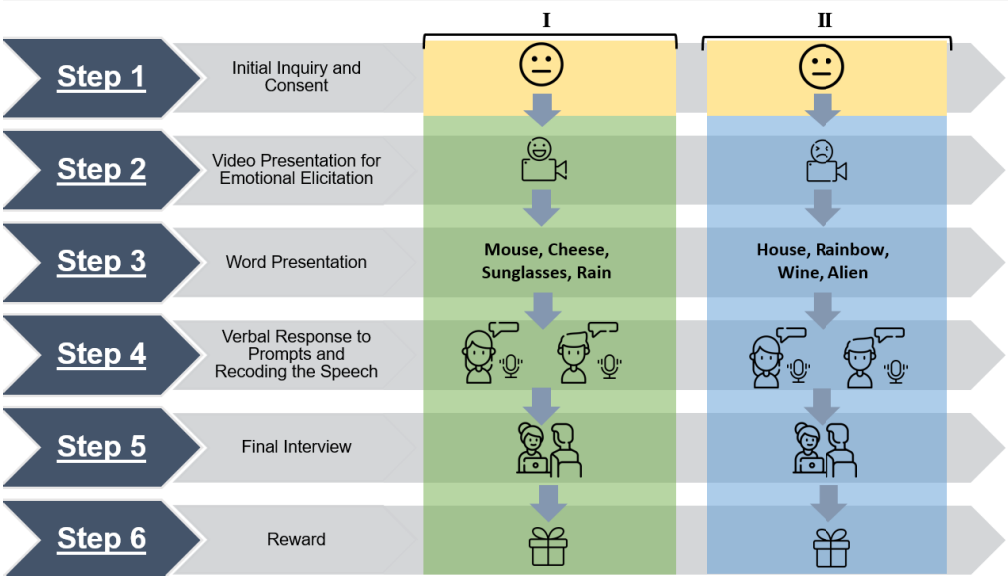

FIGURE 4. Experimental design procedure.

ensure that the research respected both legal requirements and ethical guidelines for participant privacy. This approach was clarified and discussed with the participants before their inclusion in the experiments.

H. LIMITATIONS AND CONSIDERATION

Creativity is a multifaceted phenomenon influenced by various cognitive, emotional, and environmental factors, which collectively shape how it is both expressed and perceived [56], [69].

While some research supports the idea that emotional expression is universal—where emotions like happiness, sadness, and anger are recognized across cultures—other studies argue that emotional expression is deeply rooted in cultural norms and can vary from person to person. Cultural differences might affect how individuals display emotions in their speech, which in turn influences the emotional cues detected by both human evaluators and AI models. For instance, people from certain cultures might suppress or downplay emotions, while others might express them more overtly. These cultural factors can alter how creative states are identified, as the emotional intensity and style of expression may not align with traditional or expected patterns of creativity [66], [67], [96], [97], [98].

In this study, an additional layer of complexity arose due to the inclusion of non-native English speakers. Language proficiency can impact how participants articulate their thoughts, express emotions, and engage with creative tasks. Non-native speakers might struggle with fluency or word selection, which could affect their creative output, even if their ideas are highly original. The nuances of emotional expression may also differ between native and non-native speakers, as non-native speakers might not have the same linguistic range to express complex emotions. This can potentially influence how their creativity is perceived during speech-based assessments since fluency and expressiveness are often linked to creativity in verbal tasks.

Addressing the mentioned limitations can be quite challenging, and at times, they must be accepted as an imperfect aspect of the study. However, since each individual is compared with themselves, these limitations are considered within the context of the overall analysis.

The technical limitation regarding the imbalance in detecting emotions also arises because the selected state-of-the-art methods can identify fewer negative emotions compared to positive emotions. This disparity creates a bias in the analysis, as the range and granularity of negative emotional states are underrepresented. Such an imbalance could lead to incomplete insights into how emotions, both positive and negative, influence the target variable (e.g., creativity or performance). Moreover, EmoRoBERTa was trained on social media text, which differs from the transcribed creative speech used in this study. This domain mismatch may lead to misclassifications, as creative speech often incorporates figurative language, complex narratives, and varied sentence structures, unlike the shorter, more direct expressions commonly found in social media. To mitigate this issue to some extent, complementary sentiment analysis using VADER was applied to ensure overall sentiment trends aligned with expected emotional conditions. Additionally, preprocessing adjustments were made by carefully cleaning and formatting the transcribed text to enhance compatibility with text-based models and reduce discrepancies. Finally, validation was conducted to assess whether the detected emotions aligned with established psychological theories of emotion and creativity. Highlighting this limitation provides a clear direction for future research. Specifically, it opens up opportunities to develop improved models that can detect a

more balanced and comprehensive set of emotions, including subtle and diverse negative/positive emotions.

Finally, we acknowledge the limitation of the sample size (N=25). While a larger and more homogeneous sample could enhance the generalizability of the findings, this study serves as an exploratory step in the field. Despite the sample size, the methodology is grounded in well-established psychological and neuroscientific principles that have been rigorously tested and validated over time. This research aims to build upon these foundations by integrating technological advancements, particularly in automation and Human-AI collaboration, to further interdisciplinary exploration. Moreover, many pioneering and prototyping studies in this domain have begun with even smaller sample sizes before expanding their research [77], [99], [100]. Inspired by these precedents, this study is designed as an initial investigation, with plans to include a larger participant pool in future work.

I. EVALUATION METHODOLOGY

Human-AI collaborative approaches represent a rapidly evolving field that integrates human creativity and insight with the computational power of AI. This synergy has proven effective in enhancing creativity, problem-solving, and decision-making. Research highlights the success of these collaborations, particularly through the use of crowd-sourcing platforms that combine human intelligence with AI algorithms. Studies by Kittur et al. [101], [102] demonstrate how such platforms leverage the collective input of individuals, augmented by AI's data processing capabilities, to tackle complex tasks. This integration harnesses the diverse perspectives of humans and the efficiency of AI, resulting in innovative solutions that neither could achieve alone.

Recent advancements in human-computer interaction and machine learning have further refined these collaborative efforts [103]. Interactive AI systems now adapt dynamically to human input, fostering a more interactive and responsive relationship between users and intelligent agents [104]. These systems enhance the collaborative experience and enable more effective, personalized solutions [45].

Prior research [63] has investigated the complementary roles of humans and machines in the collaborative evaluation of creative speech, to improve the accuracy, reliability, and efficiency of creativity assessments. Research [45], [63] provides that machines can estimate the Fluency and Flexibility of text with a high correlation to human judgment but cannot evaluate Originality and Elaboration. The study also addresses the limitations of traditional evaluation methods, which rely heavily on human judges who, despite their intuition and contextual understanding, face challenges related to subjectivity and scalability. In this regard, utilising the Torrance TTCT [45], [63], the proposed evaluation methodology in the current research builds upon this foundational research, advancing the approach by integrating insights from both human and machine evaluations to enhance the overall assessment of creative speech.

The proposed method is built upon prior research, utilizing machines as assistant agents in evaluating creativity. The steps for the process of creativity evaluation from the speech by Human-AI collaboration based on TTCT approach, are outlined below (See Figure 5):

1) The textual part of the speech has been carefully extracted from the recorded audio.
2) The TTCT guideline has been defined and already chosen as the creativity evaluator and been discussed in the meeting with evaluators to reach a unified understanding.
3) The textual part of the speech prompts has been fed to the machine for evaluating fluency and flexibility based on TTCT. The output scores are based on the Likert scale.
4) Scored data from the machine alongside the text part of the speech is delivered to the experts separately for deciding on the final score of all parameters, the human expert has the autonomy over the final decision and the provided scores from the machine are there to help them for more accurate decisions. All four criteria of TTCT (Fluency, Flexibility, Originality, and Elaboration) carry equal weight in this experiment. The final score from each human evaluator is calculated by summing the scores for fluency, flexibility, originality, and elaboration, then dividing by four.
5) The final score for each prompt is calculated by averaging the scores given by all evaluators, with each evaluator having equal weight.

A more detailed explanation of the creativity assessment procedure follows.

1) MACHINE ASSISTANCE FOR CREATIVITY EVALUATION PROCESS: AI AS ASSISTANCE AGENT

The machine creativity evaluation process supports advanced AI algorithms, including NLP and emotion detection models, to assess speech data. Computational models then generate creativity scores based on TTCT factors of fluency and flexibility. This automated assessment complements human evaluation.

Figure 6 presents a creativity evaluation process of a participant's prompt based on the TTCT factors. In this step, the speech which already has been converted to text is fed to GPT-4 with contextual explanation, to evaluate its creative content. The transcribed text is input into the AI system, which assesses it based on creativity parameters from the TTCT, including fluency, and flexibility. GPT-4, developed by OpenAI, identifies and quantifies these creative elements by counting distinct ideas (fluency) and categorizing ideas to evaluate the range of concepts (flexibility). The AI then generates a creativity score based on these criteria using a Likert scale. For data privacy, the subscribed format of the GPT-4 is being used. Presetting has been applied to GPT-4 to incorporate it in the experiment and creativity analysis steps. To ensure consistency and control, the model was initialized with the following parameters:

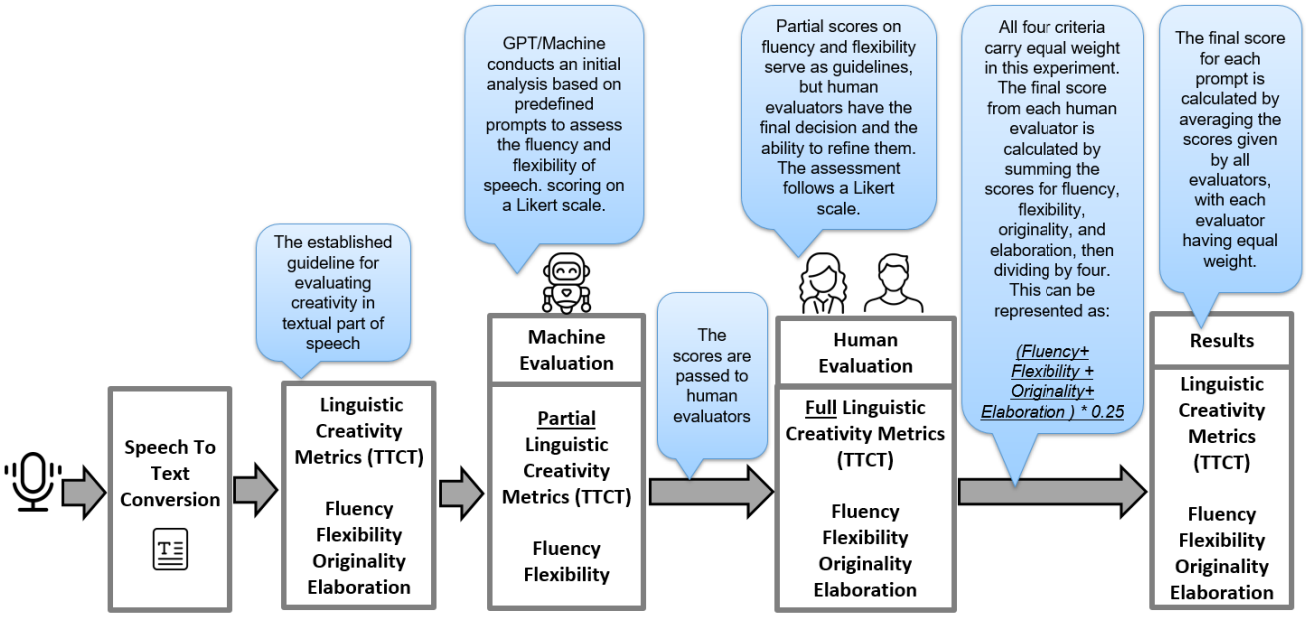

FIGURE 5. Speech creativity evaluation flow.

Temperature = 0.7, max tokens = 512, with a predefined prompt text role instructing it to focus on creativity assessment.

These adjustments will control the randomness and creativity of GPT-4. A value of 0.7 strikes a balance between creativity and consistency—responses will be varied but still relevant and coherent. Also, Max token controls, limit the response length to 512 tokens (words and symbols). Ensures responses are concise and won't be overly long. While GPT-4 can produce variations due to its generative nature, setting a moderate temperature (0.7) helped balance response diversity and stability.

Moreover, Each participant's data was processed independently, with GPT-4 re-initialized for every session to prevent unintended context carryover. No prior responses influenced subsequent ones, ensuring participant-level independence.

2) CREATIVITY EVALUATION BY HUMAN

In this evaluation process, the prompts are evaluated by human experts (In this experiment two experts), who assess the responses based on established creativity criteria from TTCT. The experts have been selected with a high educational and experimental background and PhD degrees in psychology and creativity evaluation.

Figure 7 presents an evaluation of a participant's prompt based on the TTCT and the whole human evaluation in a nutshell. For the human assessments, the experts were asked to rate each TTCT criterion on a Likert scale from 1 to 5. Before the evaluations, three meetings were held to ensure a shared understanding and clear definitions of the four TTCT criteria between experts. Ultimately, the following definitions were agreed upon by the creativity assessment experts.

The GPT-4 scores for Fluency and Flexibility have been handed over to experts to assist them through scoring as well. However, the final decision for all four criteria belongs to human experts. Rate each criterion of TTCT on a Likert scale from 1 to 5 (1 = low, 5 = high), and assign a final score for each metric based on the evaluation.

3) FINAL SCORE OF SPEECH CREATIVITY EVALUATION

The final creativity score for each speech is determined by averaging the scores from human evaluation sources. This approach balances objective analysis and subjective insight, combining the strengths of AI and human intuition.

Finally, by having the scores from each expert, the overall creativity score for each prompt was calculated by taking the average of the scores given by the two experts:

$$\text{Score} = \frac{\text{Fluency} + \text{Flexibility} + \text{Originality} + \text{Elaboration}}{4}$$

The next section will present the findings and results.

VI. RESULTS

This section is dedicated to presenting detailed results obtained from the experimental analysis. Furthermore, this section addresses **RQ2** and aims to assess **H2**.

A. VIDEO CONTENTS AND ITS EFFECT ON THE SENTIMENTS

Although the experimental design included asking participants about their moods and the effects of the videos before and after each step, as well as after watching the videos, the sentiments reflected in their recorded prompted speech also have been considered to see the effects of the videos to bring the automation as additional validation to the responses.

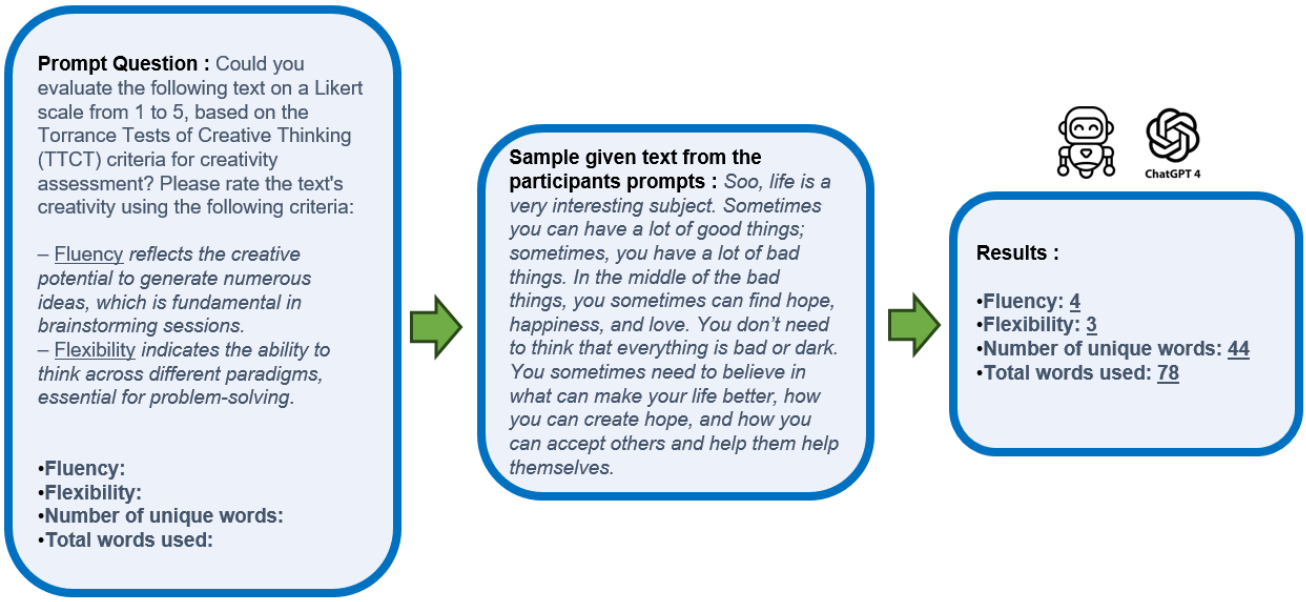

FIGURE 6. Machine assistance as an agent in creativity evaluation process from speech based on TTCT.

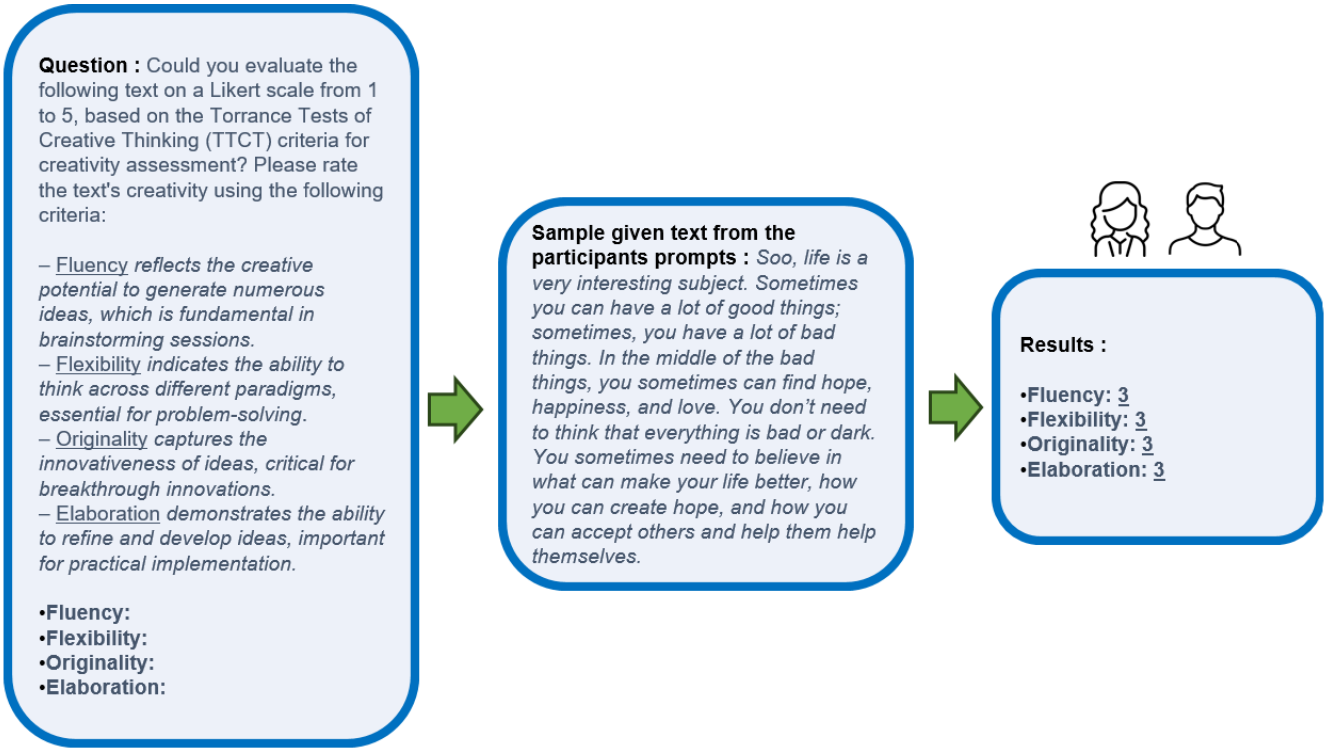

FIGURE 7. Human creativity assessment from speech process.

The boxplot in Figure 8 compares positive sentiment scores generated from participants' verbal responses after viewing videos with Happy and Sad emotional content. The figure reveals a clear difference in sentiment between the two conditions. The Happy video content elicited higher positive sentiment, as indicated by the higher median and a wider range of positive scores compared to the Sad video. In contrast, responses after the Sad video display a lower median and more compressed range, reflecting fewer positive sentiments overall. The variability in the Happy condition is

greater, as shown by the larger interquartile range (IQR) and longer whiskers, suggesting that positive sentiment responses to happy stimuli were more diverse.

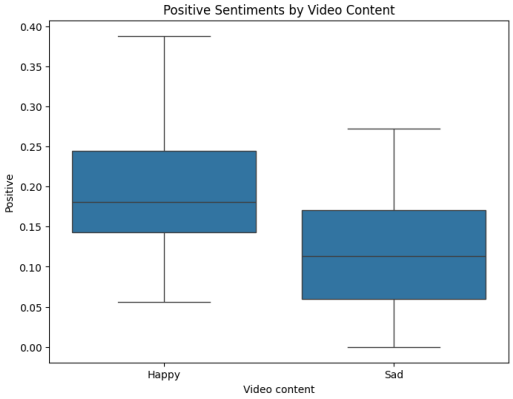

FIGURE 8. Videos and their effects on the positive sentiments reflected on the recorded prompted speech.

Also, Figure 9 demonstrates a contrast in negative sentiment between the two conditions in the participants' prompts after watching the sad videos. The Sad video content elicited higher negative sentiment, as indicated by a higher median and a larger interquartile range (IQR), showing a sad emotional influence on participants' outputs. In contrast, the Happy video condition resulted in minimal negative sentiment, with a low median and few outliers. The distribution of negative scores in the Sad condition shows greater variability, as reflected in the extended whiskers.

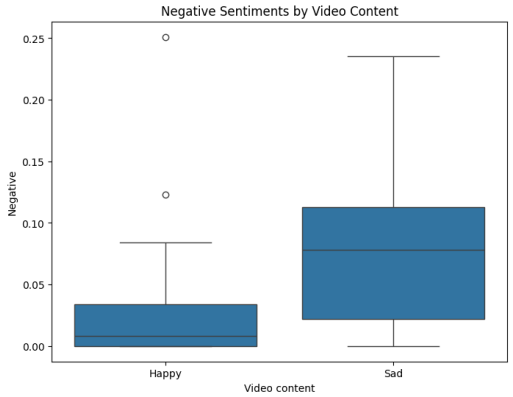

FIGURE 9. Videos and their effects on the negative sentiments reflected on the recorded prompted speech.

After confirming that the videos elicited the desired sentiments through both self-reported declarations and automated sentiment analysis, the next step involved a deeper analysis of the relationships between creativity scores, emotions, sentiments, and video content.

B. CREATIVITY SCORE ANALYSIS

To evaluate the effects of different features on creativity scores, the importance of key features was analyzed first. This step involved identifying and ranking the most influential factors for understanding how various emotions attributes contribute to creativity outcomes.

1) CREATIVITY SCORE VERSUS EMOTIONS

The bar chart in Figure 10 displays the Feature Importance of various emotions as they contribute to the creative responses in the experiment. The x-axis represents the importance scores which are the obtained creative scores, while the y-axis lists the emotional features ranked from the most to least significant. The green bars indicate emotional features contributing positively, while the red bars represent emotional features contributing negatively.

Relief among the emotions has the highest feature importance, followed closely by excitement, both being key contributors to the creative outcomes and categorised as positive emotions. Emotions like optimism, pride, and amusement also play prominent roles, highlighting their positive impact on creative expression in this experiment. Conversely, features such as disgust, disapproval, and annoyance carry significant weight but are less favourable, as shown by their red colour. Negative emotions like grief, disappointment, and sadness have lower importance scores, suggesting a limited but still notable influence on creative outputs.

Emotions such as love, curiosity, and admiration appear midrange, emphasizing their balanced contribution. Meanwhile, emotions like fear, caring, and surprise show minimal impact. This distribution highlights that emotions associated with positive states (e.g., relief, excitement) tend to enhance creativity, whereas strong negative emotions (e.g., disgust, grief) inhibit or influence creative outcomes less productively. This observation aligns with theories linking emotional states to cognitive flexibility and creativity.

The bar graph in Figure 11 illustrates the correlation between various emotions and creativity scores, with emotions plotted on the y-axis and their respective correlation values on the x-axis. The bars are colour-coded to distinguish between positive and negative emotions: green bars represent positive emotions, while red bars signify negative emotions.

Emotions with higher positive correlations include pride, joy, and excitement, which show the highest positive associations with creativity scores. This suggests that these emotions enhance or are linked to higher creativity. Other positive emotions like relief and admiration also exhibit notable positive correlations, albeit to a lesser extent.

On the other hand, emotions with higher negative correlations include disapproval, disgust, and remorse, which are associated with lower creativity scores. These emotions appear to inhibit or suppress creative performance. Additionally, emotions such as confusion, embarrassment, and anger show moderate negative associations with creativity.

More emotions, such as fear, gratitude, and surprise, hover close to zero, indicating weak or negligible relationships with creativity. These emotions likely play a minimal role in influencing creativity scores.

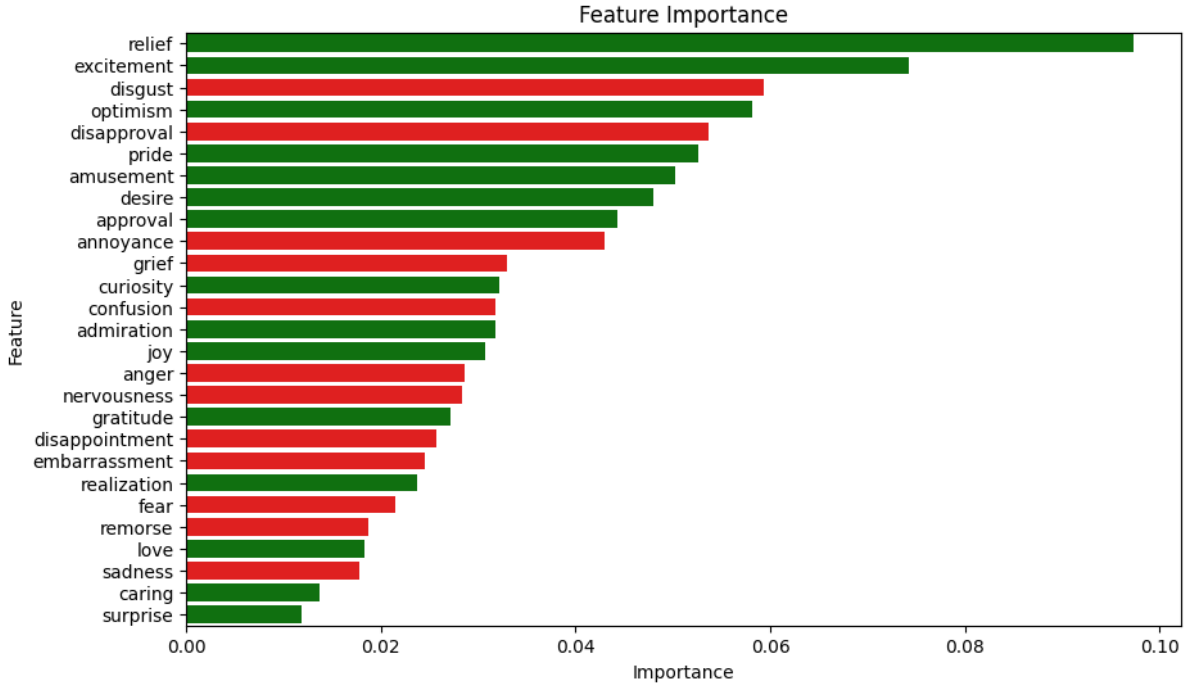

FIGURE 10. Feature Importance of various emotions as they contribute to the creative responses.

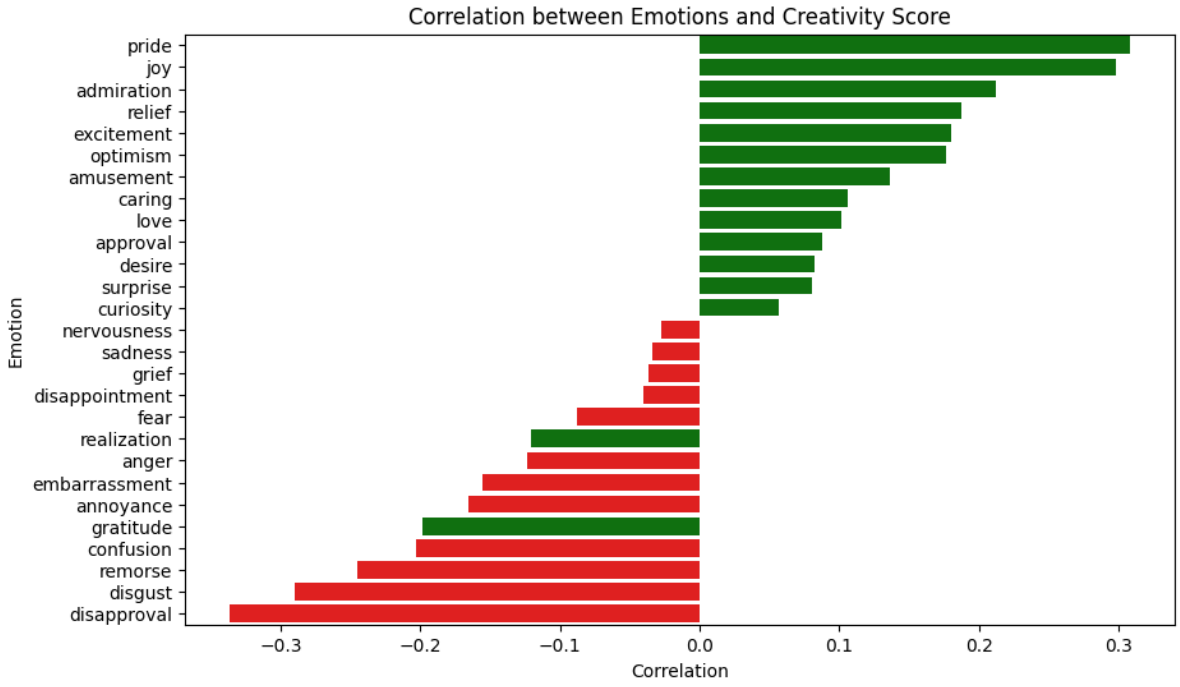

FIGURE 11. The correlation between various emotions and creativity scores.

Presented here are the subsequent analyses derived from the collected data.

2) CREATIVITY SCORE VERSUS SENTIMENTS

The bar graph displayed in Figure 12 and Figure 13 show the features' importance and correction of positive and negative sentiments to creativity scores. The x-axis represents the importance values/correlation scores, while the y-axis lists the two feature categories: Positive and Negative.

The Positive feature has a higher importance value, reaching approximately 0.58. This indicates that positive features contribute more to creativity scores compared to negative features within this experiment. On the other hand, the Negative features have a relatively lower importance

value, close to 0.42, indicating that they play a smaller, yet still notable, role in influencing creativity.

The graph highlights that positive features are more impactful in driving creativity, while negative features contribute to a lesser extent. This demonstrates the influence of positivity on creative outcomes.

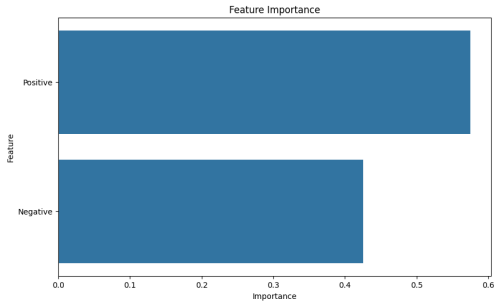

FIGURE 12. Sentiments feature importance vs creativity score.

Figure 13 shows the correlation of two sentiment categories—Positive and Negative—with creativity score. The x-axis represents the correlation values ranging from 0.00 to approximately 0.13, and the y-axis lists the sentiment types. The ''Positive'' sentiment, represented by a green bar, has a higher correlation (around 0.13) with creativity scores, while the ''Negative'' sentiment, shown with a red bar, has a lower correlation (about 0.06). This indicates that positive sentiment is more associated with creativity scores compared to negative sentiment, though both correlations appear relatively small.

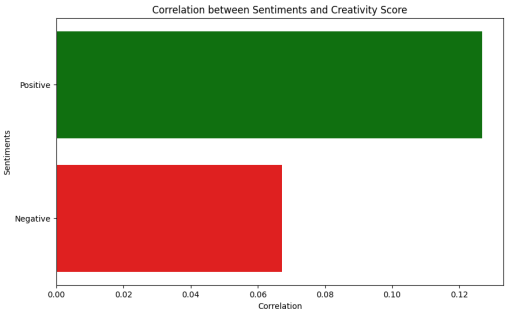

FIGURE 13. Sentiments correlations vs creativity score.

3) CREATIVITY SCORE VERSUS VIDEO CONTENT

The box plot in Figure 14 compares creativity scores for two types of video content: Happy and Sad. The x-axis represents the two video categories, while the y-axis shows the corresponding creativity scores.

For Happy video content, the median creativity score is higher compared to sad content. The scores for happy videos also exhibit a wider range, spanning approximately from 2.0 to 4.5, which indicates greater variability in creativity outcomes. Additionally, the interquartile range (IQR)—the middle 50% of scores—is larger for happy content, showing that creativity scores are more spread out.

On the other hand, Sad video content has a lower median creativity score and a narrower range of scores, approximately between 2.0 and 3.8. It implies that the creativity scores for sad content are more consistent but generally lower. The compact IQR further highlights that there is less variability in creativity scores for sad content compared to happy content.

The box plot demonstrates that happy video content is associated with higher and more variable creativity scores, while sad video content leads to lower and more consistent scores. This highlights that positive emotional content (happy videos) may have a stronger and broader impact on creativity compared to negative emotional content (sad videos).

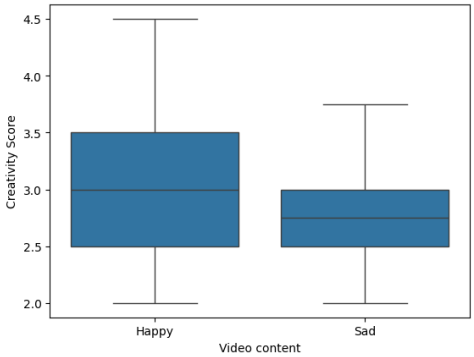

FIGURE 14. Video content vs creativity score.

C. STATISTICAL ANALYSIS RESULTS

A paired t-test was conducted to compare creativity scores between the sad and happy conditions, aiming to assess the impact of emotional state on creative performance. The results revealed a statistical difference between the two conditions (Happy and Sad), $t(24) = 2.46$, $p = 0.021$, with a 95% confidence interval (CI) [0.042, 0.478] for the mean difference. These results suggest that participants exhibited higher creativity scores following the happy condition compared to the sad condition. The effect size was calculated as Cohen's $d = 0.49$, indicating a moderate effect, which reflects a meaningful influence of positive emotional states on creative output within the scope of this experiment. Table 3 summarises the statistical analysis. This finding aligns with existing literature suggesting that positive emotions can enhance cognitive flexibility and divergent thinking, both of which are crucial for creative expression [7], [12], [56], [58].

Building on the response to **RQ2** and **H2**, the findings within the scope of this experiment suggest that positive emotions such as pride, joy, and excitement have a positive effect on creativity, creating a mental state that fosters innovative and imaginative thinking. Conversely, negative emotions like disapproval, disgust, and remorse appear to suppress creative expression, potentially limiting the ability to think divergently or generate novel ideas.

From an emotional perspective, these observations support the hypothesis (**H2**), indicating that it cannot be rejected. The results align with the notion that emotional states influence

TABLE 3. Paired t-test results for creativity scores between sad and happy conditions.

Statistic	Value	Interpretation
t-value	2.46	Statistical difference between conditions (Happy vs Sad)
Degrees of Freedom (df)	24	Number of participants minus 1 (paired test)
$p - value$	0.021	The p-value indicates the significance of the results
Confidence Interval (95%)	[0.042, 0.478]	Confidence interval for the mean difference between Happy and Sad conditions
Effect Size (Cohen's d)	0.49	Moderate effect size, reflecting meaningful influence of emotional states on creativity

creative output, with positive emotions contributing to a higher likelihood of entering a creative state and achieving better creativity scores. The subsequent section offers a comprehensive discussion of the analysis.

The next chapter provides a more in-depth discussion of the findings. With the results of the analysis in hand, the next chapter is dedicated to discussing the findings and providing responses to RQ2, as well as evaluating H2 of the research.

VII. DISCUSSION

The analysis of emotional responses and creativity scores from both happy and sad video content reveals a relationship between emotional cues expressed in speech and the resulting creativity levels within the scope of this experiment. While the data illustrates the correlation between emotions and creativity, it also underscores the variability of this relationship among individuals, which highlights other significant factors such as personality, cultural background, etc which have been considered their roles beforehand. However, this research aims to look at creativity through the lens of emotions and study the relationship between these two complex areas. Overall, the results suggest that most participants exhibit higher creativity scores when experiencing happiness, although individual variations exist.

To address **RQ3**, How do expressed emotional cues in speech relate to the speaker's creative state? the research investigated the intricate interplay between emotional expression and creativity in spoken prompts. The hypothesis posits that the emotional tone, intensity, and variety in speech not only reflect the creativity of the outcome products but also potentially are indicators of the creative state of the speaker. This relationship is grounded in psychological and neuroscientific research linking emotional regulation and cognitive flexibility—key components of creativity [105], [106], [107].

Prior research elucidates the complex interplay between emotional expression and creativity within narratives. For instance, the EmoAtlas package, which is also employed in this study [29], illustrates how the articulation of emotions within texts can influence assessments of creativity, notably through the evocation of specific emotional overtones. Employing z-scores and emotional-syntactic networks, EmoAtlas reveals that creative expression can be directed by particular emotional associations, substantiating our findings that emotions such as relief and excitement contribute to elevated levels of creativity.

Additional evidence comes from [30], who found that emotionally expressive language with unique tones and voices strongly predicts higher creativity ratings. Moreover, studies on mood and emotion regulation reveal that the emotional states of individuals during the creative process significantly impact narrative creativity. For instance, activating positive emotions, such as happiness, boosts creativity, while neutral moods or suppressed positive emotions do not. Conversely, deactivating negative emotions like anxiety or fear often results in lower creative output [12]. This outcome from previous research has also been evident in the current study.

In the sentiment and emotions analysis, the data suggest a relationship between positive emotional stimuli (Happy) and increased linguistic creative output, positive sentiment, and higher creativity scores for most participants. However, there are individual variations in how emotions influence creativity. The findings align with existing research, which posits that while positive emotions typically enhance creative performance, negative emotions may also promote creativity in certain contexts by encouraging deep reflection or novel problem-solving approaches but are harder to cope with [108].

Based on prior studies, positive emotions generally foster a more active and creative cognitive state, stimulating greater verbal fluency, originality, and flexibility [109], [110]. However, negative emotions like sadness or disappointment can also contribute to creativity, often by encouraging deeper reflection or allowing individuals to tap into complex emotional experiences [111]. The variability in responses across participants emphasizes that creativity is not solely dependent on positive emotional arousal; rather, a broad spectrum of emotional experiences can influence it, each shaping the speaker's creative state in unique ways [112].

Ultimately, with this analysis can be observed that emotional cues expressed in speech serve as a valuable window into the speaker's creative speeches and as a result in a creative state. Considering that creative products are the results of the creative states, although the relationship between emotional state and creativity levels in speech is not unidimensional but rather multidimensional. Thus, Positive emotions tend to enhance creative states for more individuals compared to negative emotions. However, it was visible that negative emotions also catalyze creativity, particularly when they stimulate deeper cognitive processing or emotional engagement [113] but they are harder to process and analyse by individuals. The percentage of participants who showed higher creativity in the happy content compared to the sad content is approximately 80% in this research. Whether driven by joy, sadness, or anger, these emotional expressions provide some clues into how individuals navigate and harness their emotions to generate creative ideas and outputs within creative states [12].

A. CHALLENGES AND ROAD TO THE FUTURE WORKS

Building on the findings of this study, future research could go deeper into several areas to further understand the relationship between emotional cues, creativity, and creative states. Below are suggestions categorized into technical and theoretical scopes due to the interdisciplinary nature of the current research:

1) EXPERIMENTAL AND THEORETICAL POINT OF VIEWS

Fixed Time gaps: While a more standardized interval (e.g., a fixed 12-hour gap) could enhance consistency, it also presents logistical challenges that may reduce participant retention and overall sample size. Given the nature of the study, balancing methodological rigour with practical feasibility was essential. Future studies can refine this approach by implementing more controlled timing intervals while maintaining flexibility to ensure participant engagement and compliance.

a: SEQUENCE AND ORDER EFFECTS OF SHOWING THE VIDEOS

The fixed order of emotional stimuli (e.g., presenting the sad video first and the happy video second) introduces the possibility of sequence effects, where the order itself, rather than the emotional state, influences creativity scores. While this study focused on within-subject comparisons and varying the task(the samples of the word for creative prompts) to mitigate inter-individual variability, future research could explore counterbalanced or randomized stimulus orders to further control for sequence effects.

b: EXPANDED PARTICIPANT DEMOGRAPHICS

Increasing the diversity and number of participants in terms of age, cultural background, number of samples, and professional fields could provide a more comprehensive understanding of how emotional states influence creativity across different populations and will enable to conduct more generalized and broader conclusion

c: LONGITUDINAL STUDIES

Conducting longitudinal research to observe how the relationship between emotions and creativity evolves would offer insights into whether these patterns are consistent or fluctuate with changes in personal circumstances or developmental stages.

d: BEYOND ENGLISH

Replicating this experiment with participants speaking in their native language offers a huge advantage. When individuals communicate in their first language, they tend to feel more comfortable, which may influence both their expressive abilities and emotional depth. This increased comfort could, in turn, alter the way emotions are conveyed in the text, potentially showing the other aspects of the relationship between emotional state and creativity. Comparing results across different languages would provide valuable information into how linguistic and cultural factors shape emotional expression and creative output as well.

e: VARIED CREATIVE TASKS

Expanding the scope of creative tasks beyond verbal and written responses could offer a broader perspective on the interplay between emotions and creativity. Investigating domains such as visual arts (e.g., painting, digital illustration, or sculpture), music composition, or even non-traditional creative activities like design thinking could reveal whether the observed relationships between emotions and creativity are universal or medium-specific. Additionally, exploring creativity in problem-solving contexts—such as scientific innovation, engineering solutions, or entrepreneurial ideation—could provide insights into how emotional states influence different cognitive processes across creative disciplines.

f: IMPACT OF SPECIFIC EMOTIONAL STATES

While broad emotional categories like happiness and sadness have been studied extensively, a more granular approach to emotional influence on creativity is needed. Examining specific emotional states—such as frustration, awe, curiosity, or nostalgia—could help differentiate how these emotions uniquely affect various dimensions of creativity. For example, does curiosity enhance divergent thinking in problem-solving, while awe fosters originality in artistic expression?

g: IMPACT OF CONTEXTUAL FACTORS

Creativity does not occur in isolation; it is deeply affected by the surrounding environment and social interactions. Exploring how contextual factors—such as workspace design, exposure to nature, cultural influences, or social collaboration—interact with emotional states to shape creative output could provide a more holistic understanding of the creative process. For instance, does a highly stimulating environment amplify the effects of positive emotions on creativity, or does a minimalistic setting enhance focus-driven problem-solving? Similarly, examining how social dynamics, such as teamwork, competition, or audience feedback, influence emotion-driven creativity could have implications for optimizing creative performance in group settings.

h: INCORPORATING THE NEUTRAL STATES AS WELL

In current research, emotional states such as happiness and sadness have been examined for their impact on creativity. However, including neutral emotional states as a point of comparison could provide a more comprehensive view of how emotional valence influences creative output. Studying creativity in a neutral emotional state, allows researchers to determine whether certain types of creativity are driven primarily by emotions or whether a baseline level of creativity remains constant regardless of emotional fluctuations. Instead of relying solely on self-reported emotional states,

incorporating biometric or behavioral data could enhance the accuracy of emotional assessments.

2) TECHNOLOGICAL POINT OF VIEW

a: MULTIMODAL EMOTION AND CREATIVITY ANALYSIS

While this study focused on the textual part of the speech-based emotional cues, incorporating other modalities such as facial expressions, physiological signals (e.g., heart rate, galvanic skin response), and body language could offer a more comprehensive view of how emotions influence creativity.

b: FULL AUTOMATION FOR EMOTIONAL STATES EVALUATION

It was identified that self-reported measures have inherent limitations, as they rely on participants' subjective evaluations, which may not always capture subtle emotional shifts. While this approach provides a practical and widely used method for assessing baseline emotional states, future studies can improve upon it by integrating automated measures, to achieve greater objectivity even for the baseline emotional evaluation.

c: ACCURACY AND DOMAIN ADAPTATION IN EMOTION DETECTION MODELS

Automated emotion detection models, such as EmoRoBERTa and VADER, introduce another potential limitation due to domain mismatch. These models were trained on social media text rather than transcribed creative speech, which may result in misclassification of emotional states due to differences in linguistic structure and context. While the models provide valuable detection from emotional trends, future work should explore fine-tuning these models on spoken datasets or incorporating multimodal emotion analysis to improve classification accuracy and more sophisticated llms to increase the accuracy level.

d: CREATIVE TEXT DATATEST

Needs for a domain-based dataset. A major challenge in building a Creative Text Dataset lies in balancing originality with diversity while ensuring high-quality data curation. Creative texts, such as poetry, fiction, and marketing copy, often involve abstract themes, nuanced emotions, and stylistic variations that are difficult to quantify and annotate. Ensuring a dataset captures these complexities without bias or overrepresentation of certain styles is a key hurdle. Looking ahead, future directions include leveraging AI-assisted curation to detect and classify creative elements more effectively, incorporating multilingual and cross-cultural texts to enhance diversity, and developing dynamic datasets that evolve with emerging creative trends. Additionally, integrating human-AI collaboration in dataset expansion can help refine authenticity and innovation, making creative text datasets more robust and adaptable for various applications, from AI-generated storytelling to personalized content generation.

VIII. CONCLUSION

This research explored the intricate relationship between expressed emotional cues in speech and the creativity states of individuals by providing three main research questions **RQ1**, **RQ2**, **RQ3** and their hypotheses to ignite the research curiosity and propose a methodology to form a method to response to the asked questions and evaluate the hypothesis. The findings from the paired t-test ($p = 0.021$) and the moderate effect size (Cohen's $d = 0.49$) suggest that positive emotions foster higher levels of creativity, highlighting the role of emotional cues in enhancing creative performance. The 95% confidence interval for the mean difference further corroborates the robustness of the results. The analysis of the emotional responses and creativity scores of participants exposed to happy and sad video content revealed that emotional states influence creative expression. Still, the nature of this influence varies among individuals. For many participants, positive emotions such as love, excitement, and joy generally correlated with higher creativity scores. Participants exhibited heightened creativity in response to happy stimuli, aligned with prior studies, suggesting that positive emotional arousal stimulates cognitive processes conducive to creative thinking.

The **RQ1** aimed to establish the theoretical and scientific foundation for understanding the interplay between emotions and creativity while exploring technological approaches to automate related tasks. This was addressed alongside the evaluation of **H1**, which was accepted, in Section III. The **RQ2** focused on formulating the methodology and the validation process, which are detailed in Section 2, with the corresponding hypothesis evaluated and accepted in Section VI. Finally, the **RQ3** and its associated hypothesis, **H3**, were addressed and accepted in Section VII, providing a deeper analysis of the results and validating the influence of emotions on individuals' creative states.

Conversely, the study also revealed that negative emotions do not hinder creativity completely within the participants. Some participants, demonstrated increased creativity when experiencing sadness or disappointment. This may indicate that negative emotional states can, for certain individuals, deepen cognitive engagement and foster a reflective form of creativity. The findings highlight that creativity is not solely dependent on positive or negative emotions, although it shows a high correlation with emotional cues, but is a complex interplay of various emotional experiences alongside the personal and environmental factors that can differently impact an individual's creative state.

The challenges in studying the relationship between emotions and creativity stem from the complexity of both constructs and their dynamic interplay. One key difficulty is ensuring a comprehensive evaluation of creativity without bias toward specific creative forms. Additionally, distinguishing the effects of nuanced emotional states—such as frustration, awe, or curiosity—poses a challenge, as their influence on creativity remains underexplored. Contextual factors, including environmental settings and social dynam-

ics, further complicate the understanding of creativity by introducing external variables that may amplify or hinder emotional impact. Moreover, the reliance on self-reported emotional states in neutral states highlights the need for objective measures in these states as well.

Another highlight of the research was combining human intuition with AI-driven assistance for TTCT creativity evaluation of the prompted speech. Although this was the primary study in the field, there is potential in Our findings, that they can contribute to AI-assisted creative collaboration tools, improve emotion-aware AI systems for adaptive learning and mental health support, and refine AI-driven creativity assessment methods. These advancements have the potential to enhance human-computer interaction, educational technologies, and content generation. In conclusion, the expressed emotional cues in speech serve as an indicator of a speaker's creative state and emotional states. Emotional expressions, whether positive or negative, can reflect the cognitive and psychological conditions that correlate to creativity. Addressing these challenges and exploring existing gaps and opportunities will open the way for future research, providing deeper investigation into how emotions influence creative processes while also enabling automation in creativity-related tasks.

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SEPIDEH KALATEH received the B.Sc. degree in electronic and electrical engineering and the M.Sc. degree in information technology management from IAU, Iran, in 2012 and 2017, respectively, and the Ph.D. degree in electrical and computer engineering from the Nova University of Lisbon, Portugal. She is currently a Researcher with the CTS-UNINOVA Research Institute. In addition to her academic background, she has gained extensive professional experience across various industrial sectors, particularly in ICT, data management, and data science. She has participated in several European Union projects as well as proposal writing. Her research interests include affective computing, computational creativity, and data science, with an emphasis on human–machine emotive interaction and the role of AI in enhancing creative processes.

SANAZ NIKGHADAM-HOJJATI (Member, IEEE) received the Ph.D. degree in information technology management (business intelligence) from IAU, in 2017. From 2018 to 2019, she was a Postdoctoral Researcher with the Nova School of Science and Technology, Nova University of Lisbon. In addition, she has worked as a University-Invited Professor. She is currently a Senior Researcher with the CTS-UNINOVA Institute, Nova University of Lisbon. She is also the Director of the Women In Science, Technology, Engineering, and Mathematics (WoSTEM) Program, CTS-UNINOVA. She has led and participated in several European Union projects, and Portuguese and Iranian National projects. She has published several books and academic papers in a number of peer-reviewed journals and presented various academic papers at conferences. Her research interests include computational creativity, affective computing, business intelligence, human behavior, emerging technologies, ICT, and innovation management.

JOSÉ BARATA (Member, IEEE) received the Ph.D. degree in robotics and integrated manufacturing from the NOVA University of Lisbon, in 2004. He is currently a Professor with the Department of Electrical Engineering, NOVA University of Lisbon, and a Senior Researcher with the UNINOVA—Instituto de Desenvolvimento de Novas Tecnologias. He has participated in more than 15 international research projects involving different programs, including NMP, IST, ITEA, and ESPRIT. Since 2004, he has been leading the CTS-UNINOVA participation in EU projects, namely, EUPASS, self-learning, IDEAS, PRIME, RIVERWATCH, ROBO-PARTNER, and PROSECO. In the last years, he has participated actively in researching SOA-based approaches for the implementation of intelligent manufacturing devices, such as within the Inlife Project. He has authored or co-authored over 100 original papers in international journals and international conferences. His main research interest includes intelligent manufacturing, with an emphasis on complex adaptive systems, involving intelligent manufacturing devices. He is a member of the IEEE Technical Committee on Industrial Agents (IES), Self-Organization and Cybernetics for Informatics (SMC), and Education in Engineering and Industrial Technologies (IES).