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The role of related humor in facilitating instructional information processing in video lectures: insight from EEG

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Abstract
Related humor is a well-established pedagogical strategy in traditional education; however, its impact on learning from video lectures has been understudied. This study investigated whether related humor, as predicted by Instructional Humor Processing Theory (IHPT), enhances learning in a video-based educational context. Employing a within-subjects design, 25 undergraduate students viewed two video lectures presenting distinct sets of English vocabulary words, each illustrated with either related humorous or related neutral instructional information. Electroencephalography (EEG) signals were recorded while participants viewed the illustrative information, and self-reported learning experiences (motivation, elaboration) and learning performance (recall) were assessed post-lecture. Paired samples *t*-tests revealed that video lectures incorporating related humorous information outperformed those with related neutral information, as evidenced by increased EEG beta and theta band oscillations, higher motivation scores, and superior recall performance. While related humor elicited greater neural activation associated with memory encoding, no differences were observed in self-reported elaboration between conditions. Taken together, these findings highlight the unique benefits of related humor in facilitating learners' processing of instructional information within the context of video lectures. Future research should continue to explore the effects and boundaries of related humor, considering variations in humor format and delivery method.

Keywords Related humor · Video lectures · Motivation · Elaboration · EEG

Introduction

The proliferation of online courses in recent years has led to the predominance of pre-recorded video lectures as a pedagogical approach (Jeong et al., 2024). However, learners exhibit low engagement with this format, characterized by brief video viewing times and poor completion rates. Given the pivotal role of learner interest in fostering autonomy and self-direction within the online learning environment, careful video lecture design is essential. Positive learning experiences derived from well-crafted video lectures can significantly influence learners' intentions to engage with this format, thereby enhancing motivation and ultimately achieving desirable outcomes.

Humor has garnered growing interest from educators within traditional instructional contexts, such as in second language (L2) education (Qi & Wang, 2024). By creating an entertaining learning environment, humor can effectively capture students' attention and sustain their engagement. Moreover, humor can bridge the power distance between educators and learners, fostering a more intimate and conducive classroom atmosphere that motivates student participation (Hackworth, 2024). The inherent entertainment value of humor can also focus students' attention and encourage sustained involvement in learning, leading to deeper comprehension of course content (Masek et al., 2019). Consequently, educators are increasingly encouraged to incorporate humor strategically into their teaching to enhance student satisfaction, engagement, and instructional efficacy.

However, the effectiveness of humor in instruction is contingent upon humor comprehension, which requires cognitive resources to resolve incongruities (Wanzer et al., 2010).

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In other word, the pleasurable nature of humor may divert learners' attention from systematic information processing and elaboration toward the humorous elements themselves. This suggests that humor's ability to attract attention may inadvertently hinder learning by prioritizing humorous content over instructional material. Consequently, students may be more likely to recall humorous elements than essential course content (Bolkan et al., 2018). Such results raise concerns about potential trade-offs between emotional engagement and cognitive processing.

Accordingly, Wanzer et al. (2010) proposed Instructional Humor Processing Theory (IHPT) to elucidate the critical conditions for effective humor use in education. First, appropriate humor should attract learners' attention and motivate them to process instructional information. Second, and more importantly, humor should enhance learners' ability to process information through elaboration. Therefore, IHPT advocates for humor directly related to course material, such as humorous examples or illustrations, as it offers both cognitive and affective benefits by clarifying knowledge and motivating learners. Preliminary support for this perspective comes from a study by Tsukawaki and Imura (2020), which found positive correlations between related humor, learners' self-reported motivation and processing ability, and perceived learning performance. In essence, learners exhibit greater enjoyment and interest when teachers employ course-related humor, as it fosters entertainment and motivates engagement (Masek et al., 2019; Rudick et al., 2024). Thus, related humor was regarded as a positive and suitable tool in facilitating learning process (Nusrat et al., 2025).

Despite the established benefits of related humor, the literature also presents less optimistic perspectives on its role in promoting learning. For instance, Machlev and Karlin (2016) conducted a longitudinal study in a psychology classroom, finding no correlation between humor use and students' final grades despite students' perceived gains. This suggests that humor's contribution to learning performance may stem primarily from its influence on learners' autonomy and self-efficacy rather than from enhanced cognitive processing or elaboration (Bolkan & Goodboy, 2015). It is crucial to note that inconsistencies across studies may arise from using perceived learning as a measure of performance rather than actual test scores. Perceived learning, influenced by self-assessment, can diverge from actual knowledge acquisition, necessitating further research on the impact of related humor as measured by objective performance indicators.

While humor, particularly related humor, has been extensively investigated in traditional classrooms, its impact on online learning remains relatively unexplored. Similar to face-to-face instruction, humor can enhance online learning by increasing student interest and active engagement with digital materials (Erdoğdu & Çakıroğlu, 2021). Specifically, students report heightened interest in courses when instructors incorporate related humor, leading to improved learning outcomes due to increased cognitive engagement and active learning behaviors (Luo & Zhan, 2021; Luo et al., 2023). For example, Cazes et al. (2024) developed content-related humorous drawings in a computer-based course and discovered that learners' visual attention and comprehension were enhanced. Within the context of video lectures, humor can motivate students and prevent boredom, and improve perceived concentration and concept comprehension (Tam, 2022; Wegener, 2022). The aforementioned results are consistent with the assumption of the Cognitive Affective Theory of Learning with Media (CATLM), which posits that positive emotions may activate learners' motivation, thereby enhancing the information processing process within a multimedia learning environment. (Moreno & Mayer, 2007). However, contradictory findings exist in the literature, suggesting that humorous elements in video lectures may not always enhance learning outcomes (Wang & Chen, 2022). For example, while humor in video lectures can increase student motivation, it may not necessarily lead to better learning performance (Suzuki & Heath, 2014). Therefore, while integrating related humor into video lectures holds promise for improving learning outcomes, further research is needed to determine its effectiveness in enhancing processing motivation and ability as predicted by IHPT.

Another significant limitation of existing research on humor in education pertains to the assessment of learners' processing motivation and ability, which typically relies on post-learning self-report questionnaires (Zhou & Lee, 2025). This methodology hinders our understanding of how humor influences learning processes despite its potential to provide some inferential value. Subjective biases inherent in retrospective self-reports can distort recall and judgment of processing motivation, compromising the reliability of such assessments. Furthermore, previous studies have employed self-evaluated knowledge comprehension to investigate elaborative processing (Bieg & Dresel, 2018; Tsukawaki & Imura, 2020) or alternatively, measured sustained attention and cognitive engagement as proxies for elaboration (Bolkan & Goodboy, 2015). It is essential to emphasize that increased attention and engagement do not necessarily equate to enhanced elaborative processing and comprehension. In summary, the prevalent use of self-reported measures for motivation and elaboration raises concerns about their accuracy in capturing the core tenets of IHPT regarding the role of related humor in fostering processing motivation and ability.

Electroencephalography (EEG) offers a real-time window into cognitive processes by measuring neural oscillations (Davidesco et al., 2023). Beta (13–30 Hz) and theta (4–8 Hz) frequency bands provide indirect evidence of cognitive control and memory activity, fundamental to learning (Zavala et al., 2018; Xie et al., 2021). Beta oscillations, which are particularly pronounced in the frontal and parietal regions, are associated with active cognition and sustained mental effort, indicative of proactive cognitive control and engagement in motivational states (Lin & Kao, 2018; Howells et al., 2010). Theta oscillations are associated with working memory and cognitive load (Castro-Meneses et al., 2020). Enhanced theta activity signifies successful memory encoding and deep information processing, primarily evident in frontal and central regions (Friese et al., 2013; Güntekin et al., 2020). Investigating the neural correlates of learning from video lectures incorporating related humor can illuminate the underlying mechanisms by which humor influences learning outcomes.

Given the mixed effects of related humor reported in existing literatures and its varying roles in different instructional and interactional contexts (Banas et al., 2011), it is essential for researchers to investigate the impacts of incorporating related humor into video lectures on both the learning process and outcomes. In the current study, we examined the impact of related humor on learners' processing motivation and capacity within the context of video-based vocabulary instruction. Video lectures presented English vocabulary words alongside example sentences (as illustrative instructional information) to facilitate word comprehension (Zhang, 2009). Humorous video lectures incorporated pre-written humorous example sentences to provide an additional lexical explanation, while neutral video lectures featured non-humorous examples for comparison. To investigate whether related humor influenced processing motivation and elaboration, learners' EEG beta and theta band oscillations were recorded during exposure to instructional information (i.e., humorous versus neutral example sentences). Post-lecture, self-reported learning experiences (motivation and elaboration), and recall performance were assessed.

We adopted the CATLM and IHPT as theoretical frameworks to formulate hypotheses regarding the effects of related humor in video lectures. We posited that the positive emotion induced by humor would motivate learners to actively engage in processing instructional information. Furthermore, we hypothesized that humor directly related to the learning content would facilitate deeper elaboration and comprehension of the material. Compared to neutral video lectures, we anticipated that video lectures incorporating related humor would enhance learners' processing motivation and capacity, ultimately leading to improved learning experiences and performance. Based on these theoretical underpinnings, the present study proposed the following hypotheses.

Hypothesis 1 *Learners exposed to video lectures incorporating related humorous information will exhibit stronger EEG oscillations in the beta and theta bands than those exposed to video lectures incorporating related neutral information. Specifically, heightened beta band oscillations will be observed in frontal and parietal regions, while increased theta band oscillations will be prominent in frontal and central regions.*

Hypothesis 2 *Learners will report higher levels of learning experience, as measured by motivation and elaboration, when exposed to video lectures incorporating related humorous information compared to those exposed to video lectures incorporating related neutral information.*

Hypothesis 3 *Learners will demonstrate superior learning performance when exposed to video lectures incorporating related humorous information compared to those exposed to video lectures incorporating related neutral information.*

Method

Participant and experimental design

The present study involved 25 non-English major undergraduate students who were randomly recruited from a Chinese university via online advertisement. Their ages ranged from 19 to 23 years (M=20.12, SD=0.88), with four males among them. All participants were right-handed and reported having normal or corrected-to-normal vision and hearing, with no history of psychiatric or neurological disorders. To ensure adequate English proficiency for the experimental tasks, participants were at least with a passing score on the College English Test-6 (CET-6), a standardized English proficiency test for Chinese undergraduates that certifies a high level of English competence in non-English majors. Additionally, none of the participants had prior exposure to the Graduate Record Examination (GRE), which served as the source of vocabulary in the video lectures. After receiving detailed information about the study procedures, all participants provided written informed consent and were compensated with 30 RMB for their participation.

Procedure and design

A within-subjects design was employed in the present study. Each participant engaged in two experimental conditions, the order of which was counterbalanced using a Latin

Square design. In the related humorous condition, participants viewed a video lecture comprising 40 short clips introducing 40 English vocabulary words. Following each clip, a humorous example sentence illustrating the word was presented for 15 s. In the related neutral condition, participants watched a different video lecture teaching 40 distinct vocabulary words through 40 short clips. In this condition, a neutral example sentence followed each clip, with a duration of 15 s. This sequential presentation of learning and humor content aligns with a previous study on humor in video-based learning (Suzuki & Heath, 2014).

Prior to the commencement of the formal experiment, each participant washed their hair and were informed about the experimental procedure. Subsequently, participants signed the informed consent and completed a personal information questionnaire (e.g., age, major), and were fitted with an electrode cap on the head for EEG recording throughout the learning process. During each experimental condition, participants learned English vocabulary words from a video lecture, and were required to complete a learning experience questionnaire followed by a recall test assessing vocabulary retention. A five-minute break was provided upon completion of the first video lecture condition to mitigate carryover and overload effects on the second video lecture condition. The entire experiment approximated one hour in duration (Fig. 1).

Measurements

Learning experience

The Learning Experience Questionnaire developed by Stull et al. (2018) was employed in this study. The questionnaire consisted of four items assessing motivation (*enjoyment in learning process*, *future willingness of learning in this way*, *desire for further knowledge about this topic*, *and overall motivation of trying to understand the learning material*) and one item measuring elaboration (*depth of content understanding*). Participants rated items on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Cronbach's alpha for the learning experience measure was found to be 0.951 in the related humorous condition and 0.932 in the related neutral condition, indicating high internal consistency.

Learning performance

To assess participants' vocabulary learning outcomes in both conditions, two equivalent multiple-choice tests were developed by two English professors. Each test comprised 40 items, with each item targeting one of the 40 taught vocabulary words. Participants were required to select the most appropriate word to complete a sentence based on semantic compatibility. Among the four options, one was correct, while the other three were incorrect yet familiar from the video clips. For example, a question might be: "*Today I shall _____ my children while they are young; tomorrow they will be gone, and so will I. A. fondle; B. overlap; C. acme; D. dangle*". Participants earned one point for each correct answer and zero for incorrect ones, with a maximum score of 40. Both the related humorous and related neutral condition tests demonstrated high split-half reliability ($t(23) = 5.87$, $p < .001$; $t(23) = 8.04$, $p < .001$).

Materials

Eighty video clips were created to teach 80 English vocabulary words randomly selected from GRE preparation materials. Each clip featured a single female instructor presenting a word, providing its English pronunciation and Chinese equivalent. The word, accompanied by its part of speech and Chinese translation, was displayed on the left side of the screen, while the instructor appeared on the right. The video clips were randomly assigned into the related humorous condition and the related neutral condition, each consisting of 40 clips, with an average duration of approximately three seconds.

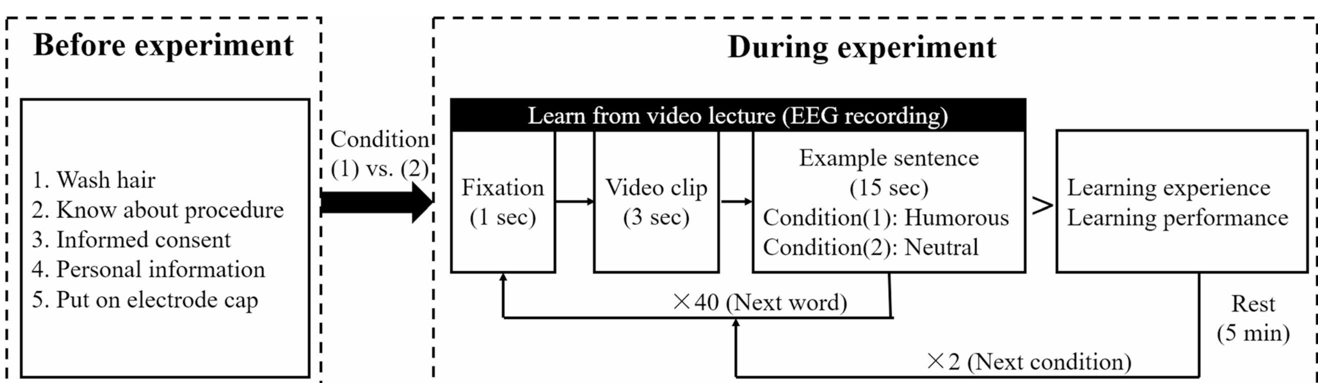


Fig. 1 Experimental Procedure

($M=3.05$, $SD=0.17$; $M=3.09$, $SD=0.22$). Additionally, the average number of letters in the words presented in the video clips was six ($M=6.48$, $SD=1.66$; $M=6.85$, $SD=1.76$). No significant differences in video duration or word length were found between the two experimental conditions ($t(78)=-0.73$, $p=.469$; $t(78)=-0.98$, $p=.331$). We also invited 25 non-English major undergraduates who did not participate in the formal experiment to view both groups of video clips. Then, they were required to rate the perceived difficulty levels of the vocabulary on a 5-point Likert scale and complete the learning performance test mentioned in the Sect. 2.3.2. The result verified the equivalence of the two words lists based on comparable perceived difficulty levels and test scores ($t(24)=-1.16$, $p=.110$; $t(24)=-0.16$, $p=.876$).

Humorous example sentences served as instructional information for vocabulary words in the related humorous condition, providing humorous explanations of word meaning and usage. In contrast, neutral example sentences were used in the related neutral condition. Pre-written example sentences for each word were integrated with corresponding video clips to create the video lectures for each experimental condition. (1) For the humorous example sentences, three undergraduate students with high humor orientations, informally recommended by peers, independently generated 40 humorous Chinese sentences for each of the 40 target words based on their primary meanings. Subsequently, three English postgraduates collaboratively translated these sentences into English while preserving the target vocabulary. An online questionnaire was distributed to undergraduate students from diverse majors and universities across China to assess the humor of these sentences. Participants selected the funniest example sentence for each word, and the most popular choice was adopted for the study. (2) For the neutral example sentences, three English majors collectively sourced appropriate Chinese-English bilingual sentences for each word from online dictionaries (e.g., Youdao, Oxford, Collins). These dictionary-derived sentences are widely considered high-quality resources for vocabulary acquisition. Two English professors jointly reviewed all 80 sentences to eliminate potential ambiguity or inappropriate language. The average length of example sentences in the related humorous condition and the related neutral condition were over 20 words ($M=26.85$, $SD=8.81$; $M=23.75$, $SD=5.77$), and no significant differences were found in word counts between them ($t(78)=1.86$, $p=.067$). The above 25 undergraduates also read these example sentences and reported that they were relatively similar in terms of the complexity and understandability ($t(24)=1.05$, $p=.306$).

An illustrative example was provided, detailing the constructed sentences under both the related humorous and related neutral conditions. For the word "fondle" (抚弄) in the humorous condition, the target word and its Chinese equivalent appeared in separate English and Chinese sentences: "In the pictures of beautiful women on internet, the wind, quiet and good, gently fondles their ears; while in my pictures, the wind, wild and rebellious, blew my hair in a mess" (网络上的美女拍照: 风轻轻抚弄耳畔, 岁月静好; 而我拍照°好自由不羁的头发, 好桀骜不驯的风). Conversely, for the word"obbligato" (伴奏) in the neutral condition, the target word and its Chinese translation also occurred independently within their respective language sentences: "Soon his right arm reached around to the other side of the child and he added a running obbligato" (然后, 他的右手也绕到男孩的另一边, 加上行云流水般的伴奏).

EEG recording and analysis

EEG data were collected from participants using a 32-channel amplifier (EGI's Net Amps 300) within an electrically shielded and sound-attenuated environment. Electrodes were arranged according to the international 10–20 system. Horizontal (hEOG) and vertical (vEOG) electrooculogram electrodes were positioned above and below the left eye, and near the external canthi of each eye, respectively. The Cz electrode served as the reference, and the COM electrode as the ground. Electrode impedance was maintained below 10 kΩ. EEG signals were initially sampled at 1000 Hz and subsequently resampled to 250 Hz for offline analysis.

EEG data analysis was performed using MATLAB. Raw EEG data underwent preprocessing, including re-referencing to the average of mastoid electrodes (placed bilaterally) to mitigate laterality bias. Ocular artifacts (horizontal and vertical electrooculography) were corrected, and EOG components were removed through independent component analysis (ICA). Artifactual epochs were identified and excluded using software algorithms. Subsequently, EEG epochs were segmented from −1000 to 10,000 milliseconds relative to example sentence onset. Baseline correction was applied using the pre-video interval (−200 to 0 milliseconds), and spectral analysis was conducted within the example sentence presentation window (500 to 9500 milliseconds).

For outcome analysis, EEG data were spectrally analyzed using fast Fourier transform (FFT) to examine oscillations in the beta (13–30 Hz) and theta (4–8 Hz) bands. Oscillation strength, measured in microvolts (μV), was computed by averaging the amplitude of alpha and beta frequencies within specific time periods. To assess regional brain activity, scalp electrodes were clustered into six regions: (1) Frontal: Fp1, Fp2, Fz, F3, F7, F4, F8; (2) Central: C3, C4; (3) Parietal: Pz, P3, P4; (4) Occipital: Oz, O1, O2; (5) Left temporoparietal: T7, P7; (6) Right temporoparietal: T8, P8. Beta and theta power were subsequently calculated for each region.

Results

EEG oscillations

To examine differences in neural oscillations between the related humorous and related neutral conditions, paired samples *t*-tests were conducted for beta and theta band oscillations within each of the six brain regions. Condition (related humorous vs. related neutral) was the within-subjects independent variable. Effect sizes were calculated using Cohen's *d*, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively.

Significant differences in beta band oscillations emerged between conditions within the central, parietal, occipital, and left temporoparietal regions (respectively: $t(24)=2.63$, $p=.015$, $d=0.53$; $t(24)=2.18$, $p=.040$, $d=0.44$; $t(24)=2.20$, $p=.038$, $d=0.44$; $t(24)=2.29$, $p=.031$, $d=0.46$), with a marginally significant difference observed in the right temporoparietal region ($t(24)=2.06$, $p=.050$, $d=0.41$). Conversely, no significant difference was found in the frontal region ($t(24)=1.93$, $p=.065>.05$). These findings indicate that participants exhibited greater beta band oscillations across all brain regions (except frontal) during the related humorous condition compared to the related neutral condition (see Fig. 2).

Furthermore, significant differences in theta band oscillations emerged between conditions within the central, parietal, occipital, left temporoparietal, and right temporoparietal regions (respectively: $t(24)=2.66$, $p=.014$, $d=0.53$; $t(24)=2.18$, $p=.039$, $d=0.44$; $t(24)=2.21$, $p=.037$, $d=0.44$; $t(24)=2.33$, $p=.028$, $d=0.47$; $t(24)=2.08$, $p=.049$, $d=0.42$). No significant difference was observed in the frontal region ($t(24)=1.94$, $p=.064>.05$). These findings indicate that participants exhibited greater theta band oscillations across all brain regions (except frontal) during the related humorous condition compared to the related neutral condition (Fig.3)

Collectively, our findings provide partial support for the initial hypothesis concerning EEG oscillations. Learners exhibited enhanced beta and theta band oscillations when exposed to video lectures containing related humorous information relative to those with related neutral information. Nonetheless, these differences in oscillatory activity were observed across multiple brain regions, excluding the frontal cortex.

Learning experience

To assess learning experiences, two paired-sample *t*-tests were conducted with motivation (sum score of four items) and elaboration as dependent variables and condition (related humorous vs. related neutral) as the within-subjects independent variable. Participants reported significantly higher motivation scores in the related humorous condition compared to the related neutral condition ($t(24)=2.83$, $p=.009$, $d=0.57$), while no significant differences were found in elaboration scores between conditions ($t(24)=0.89$, $p=.380>.05$, Fig.4). These findings partially support our second hypothesis, indicating that video lectures incorporating related humorous information enhanced learners' motivation but did not significantly impact self-reported elaboration.

Learning performance

To assess differences in participants' learning performance between the related humorous and related neutral conditions, a paired-sample *t*-test was conducted with condition (related humorous vs. related neutral) as the within-subjects independent variable. Participants in the related humorous condition exhibited significantly higher scores than those in the related neutral condition ($t(24)=2.45$, $p=.022$, $d=0.49$).

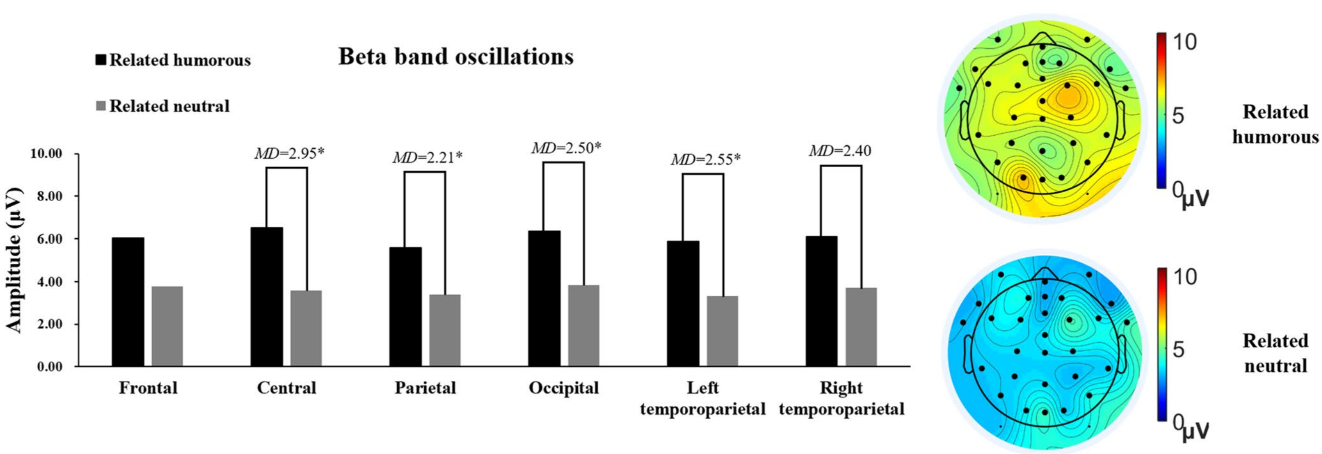


Fig. 2 The figure illustrates beta band oscillation differences between related humorous and related neutral conditions across six brain regions, and presents topographical maps

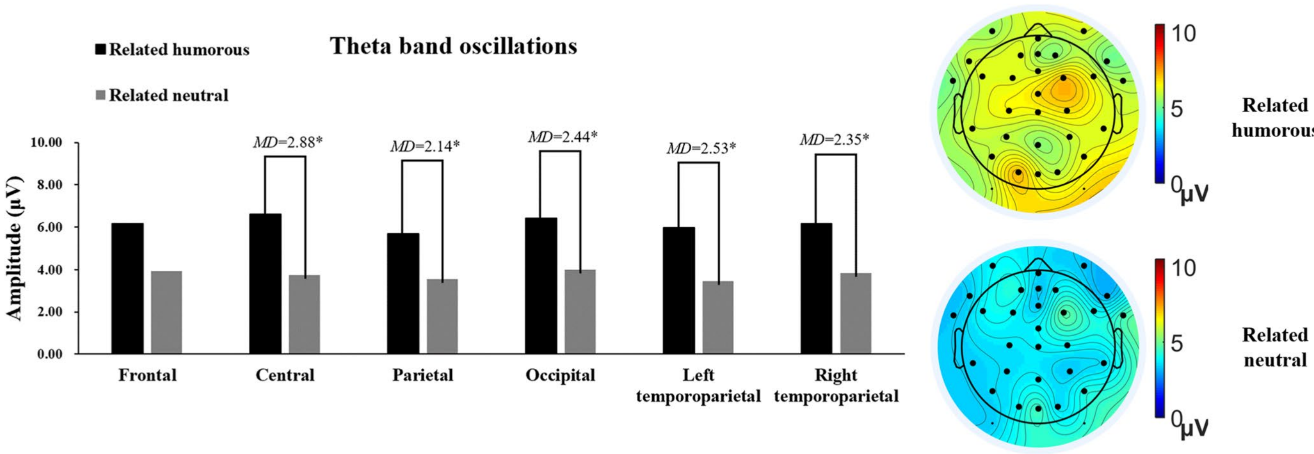
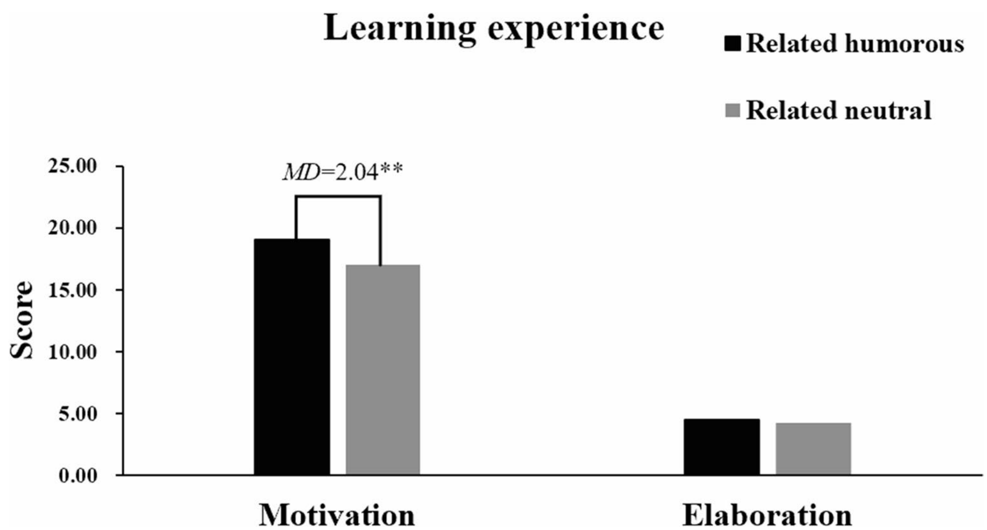


Fig. 3 The figure illustrates theta band oscillation differences between related humorous and related neutral conditions across six brain regions, and presents topographical maps

Fig. 4 The figure compares learning experiences between related humorous and related neutral conditions



This result strongly supports our third hypothesis that learners benefited more from video lectures incorporating related humorous information than those incorporating related neutral information.

Discussion

This study investigated the efficacy of related humor in enhancing learning from video lectures, as proposed by IHPT in the context of traditional education. Results indicated that video lectures incorporating related humor surpassed those without humor in terms of learning outcomes. EEG oscillations revealed heightened neural activation associated with cognitive processes, self-reported questionnaires demonstrated increased motivation and learning performance test scores were superior in the humor condition. However, no significant differences emerged in self-reported elaboration between the two conditions. These findings suggest that EEG can detect subtle cognitive processes, such as elaborative processing of instructional information, that may not be apparent through traditional measures. The present study constitutes a pioneering investigation into the motivational and elaborative benefits of related humor in video-based learning, providing novel neural evidence for the underlying mechanisms of humor's influence.

The present study focused on beta and theta EEG frequency bands, associated with cognitive control and memory activity, respectively (Zavala et al., 2018; Xie et al., 2021). These frequency bands are crucial indicators of active cognitive engagement and learning. Beta oscillations, particularly in frontal and central regions, reflect active cognitive processing and sustained mental effort (Lin & Kao, 2018; Howells et al., 2010). Increased beta activity has been documented during focused engagement with demanding tasks, correlating with heightened motivation and subsequent performance. Complementarily, theta oscillations, predominantly in frontal and central regions, are associated with memory processes (Friese et al., 2013; Güntekin et al., 2020). Enhanced theta activity signifies the allocation of cognitive resources for encoding information into working memory. Consequently, increased theta power reflects deeper processing, facilitating long-term retention. Combined, elevated beta and theta oscillations suggest optimal conditions for encoding and consolidating new information.

Related humorous information elicited significantly stronger neural oscillations in both beta and theta frequency bands compared to related neutral information, suggesting heightened cognitive control and memory processes associated with humor. These findings indicate that related humor enhances learners' processing motivation and capacity when engaging with instructional content delivered via video lectures. The results align with the assumptions of CATLM and IHPT (Moreno & Mayer, 2007; Wanzer et al., 2010), as well as previous research demonstrating the benefits of related humor in both online and traditional educational contexts (Luo & Zhan, 2021; Luo et al., 2023; Masek et al., 2019; Tsukawaki & Imura, 2020). Notably, the observed neural differences across most brain regions (central, parietal, occipital, and bilateral temporoparietal, excluding frontal) suggest that the cognitive advantages conferred by related humor may have widespread effects. This study constitutes the first investigation into the cognitive processes underlying the impact of related humor on instructional information processing.

Enhanced beta oscillations were observed in the central, parietal, occipital, and bilateral temporoparietal regions during the related humorous condition compared to the related neutral condition, with no significant differences in frontal beta activity. Frontal beta, associated with executive functions and cognitive control, reflects goal-directed thought processes and potential cognitive fatigue (Stoll et al., 2016). The comparable frontal beta activity between conditions suggests that learners engaged in efficient cognitive processing of new information regardless of the instructional condition. Conversely, central beta increases with heightened cognitive engagement in current tasks (Subbaraj et al., 2014), while parietal and occipital beta activation is linked to motivational states associated with visual information processing (Howells et al., 2010; Miller et al., 2010). Additionally, beta activation in the temporoparietal region is associated with mental solution construction and improved task performance, as evidenced in second language acquisition studies (Prat et al., 2016). This suggests that learners may have been more actively engaged in constructing word meanings when exposed to related humorous information. In summary, while increased beta oscillations in the aforementioned regions indicate heightened processing motivation, this is likely not the sole advantage of incorporating related humor into video lectures.

Second, while frontal theta activity did not differ between conditions, stronger theta oscillations were observed in the central, parietal, occipital, and bilateral temporoparietal regions for the related humorous condition compared to the related neutral condition. Frontal theta has been linked to cognitive tasks and increases with working memory load during problem-solving (Castro-Meneses et al., 2020). The comparable frontal theta activation across conditions suggests that learners engaged in memory-related activities with similar cognitive demands regardless of the illustrative information type. However, central, parietal, and occipital theta oscillations have been associated with working memory encoding, indicating successful memory formation of previously presented stimuli (Güntekin et al., 2020; Killanin et al., 2024). Additionally, temporoparietal theta is involved in encoding and mnemonic processes for declarative knowledge, such as novel vocabulary acquisition (Bakker-Marshall et al., 2018). These findings suggest that related humor facilitates deeper elaborative processing during knowledge acquisition from video lectures.

While EEG data indicated heightened cognitive activation during the related humorous condition compared to the related neutral condition, traditional self-report measures of learning experience yielded mixed results. Learners reported significantly higher motivation when exposed to related humor in video lectures, aligning with previous research in traditional educational settings (Bieg & Dresel, 2018; Tsukawaki & Imura, 2020). This enhancement in motivation is likely attributed to the positive emotions elicited by humor (Luo et al., 2023), which can foster active learning behaviors in media-based environments (Moreno & Mayer, 2007). Consequently, related humor appears to effectively enhance motivation for engaging with and processing instructional content in video lectures, similar to its benefits in face-to-face classrooms (Banas et al., 2011). Conversely, no significant differences in self-reported elaboration were observed between conditions despite prior studies reporting positive associations between related humor and elaboration (Bieg & Dresel, 2018; Tsukawaki & Imura, 2020). This discrepancy may be attributed to differences in measurement. Previous research included measures of attentive listening and active thinking as indicators of elaboration, factors potentially influenced by motivation and perceived effort; in contrast, learners reported depth of understanding as an indicator of elaboration in the present study, which refers to the ability to identify, explain, and apply content knowledge. Using example sentences as instructional information in both conditions, regardless of humor, may have provided sufficient support for vocabulary comprehension (Zhang, 2009), potentially leading to comparable self-reported elaboration levels. These findings underscore the value of EEG data in revealing underlying cognitive processes related to humor's impact on learning, even when traditional self-report measures may not detect significant differences.

Furthermore, learners demonstrated superior learning performance in the related humorous condition compared to the related neutral condition. This finding contradicts previous research indicating no improvement in knowledge recall from video lectures incorporating related humor (Suzuki & Heath, 2014). This discrepancy may be attributed to variations in the implementation of related humor across studies. The present study employed text-based humorous examples to illustrate vocabulary words, whereas previous research utilized verbal, nonverbal, and visual humor within instructional content. The complex nature of video lectures, characterized by multiple forms of information and dynamic presentation, may hinder focused attention on humor-embedded key information, thereby mitigating potential benefits. Conversely, the concise and direct humorous examples in this study facilitated attention to crucial vocabulary information. Given the established link between related humor and increased learner interest and engagement in online education (Luo et al., 2023; Luo & Zhan, 2021), these findings suggest that related humor can also stimulate active cognitive processing during video lecture learning. The resulting motivated processing of conceptually relevant information may contribute to deeper comprehension and improved knowledge retention.

In summary, integrating related humor into video lectures enhances learners' processing motivation and capacity for information processing, leading to improved learning outcomes. However, our findings also underscore the need for a comprehensive assessment of the effects of related humor strategies, both in traditional and video-based educational contexts. For instance, the discrepancy between EEG-measured memory encoding and self-reported elaboration highlights the importance of employing multiple measures to fully understand the impact of humor on learning.

Contributions and implications

The present study advances our understanding of the impact of related humor on video lecture learning. We investigated whether integrating related humor into video lectures yields distinct learning benefits compared to humor-free counterparts. While previous research on related humor primarily focused on traditional educational settings, the influence of related humor on video lecture learning has been relatively unexplored. Notably, this study is the first to examine the neural correlates of related humor's effects on information processing, whereas prior studies relied solely on self-reported measures. Specifically, compared to the related neutral condition, the related humorous condition elicited stronger EEG beta and theta band oscillations associated with cognitive control and memory, higher reported motivation, and enhanced learning performance. These neural and behavioral findings suggest that learners were more motivated to process instructional information and demonstrated deeper elaborative comprehension when exposed to video lectures incorporating related humor. Our results extend previous behavioral research on the relationship between related humor, learner motivation, and elaboration by providing neural evidence of underlying cognitive processes (Bieg & Dresel, 2018; Tsukawaki & Imura, 2020), and corroborate the benefits of related humor in video-based learning, complementing its established efficacy in traditional education as suggested by IHPT.

Our findings regarding related humor hold significant implications for the design of video lectures in educational contexts. Humor emerges as a potent strategy for knowledge delivery via video and should be intentionally integrated into learning materials. Compared to neutral illustrative content, learners exhibit heightened cognitive engagement, including increased motivation and enhanced elaborative comprehension, when exposed to humorous illustrative information. Accordingly, educators are advised to incorporate related humor within video lectures to stimulate learners' processing motivation and capacity for information assimilation. Furthermore, neural data indicate comparable levels of working memory load and cognitive fatigue between humorous and neutral illustrative conditions. Overall, these results suggest that humor does not impose additional cognitive burden, thereby reinforcing the notion that related humor constitutes an effective and efficient approach to augment learning from video lectures.

Limitations and future directions

While this study offers potential contributions, three limitations warrant acknowledgment and address in future research. First, the *p*-value for the word counts comparison between the two groups of example sentence was 0.067, which is close to the 0.05 confidence threshold. This suggested that the sentence lengths were likely not entirely equivalence, potentially offering varying levels of contextual information for word meanings (Tang & Chan, 2022). Previous research has demonstrated that the comprehension of sentence, as induced by contextual integration after deriving sentence meanings (Bell et al., 2019), evokes neural activations, which might intertwine the effects of related humor with the neural activation associated with comprehension of sentence context. However, our design did not permit disentangling the effects because the content and characteristics of related humor make it challenging to fully balance the difference between humorous sentences and neutral sentences. Notably, the development process of the sentences in the present study ensured their comprehensibility, and participants from an independent test self-reported comparable levels of complexity and understandability of the sentences across groups, thereby partially mitigating this limitation. To further elucidate how related humor influences cognitive function as measured by EEG oscillations, future research could explore the relative contributions of motivation and processing ability by comparing video lectures with varying humor characteristics (comprehensible vs. incomprehensible, complex vs. brief) to isolate the neural effects of contextual integration.

Secondly, this study focused exclusively on text-based related humor, limiting the investigation to a single presentation format. While humor can be integrated through various modalities, including video, images, and text within instructional materials, as well as through instructor speech and actions, the current research prioritized text-based humor to maintain experimental control and ensure the effectiveness of example sentences as scaffolds for vocabulary comprehension (Zhang, 2009). Given the influence of multimedia elements on learning and the impact of instructor behavior on video-based education (Jeong et al., 2024; Moreno & Mayer, 2007), it is plausible that the form and source of related humor moderate its learning outcomes. Indeed, previous studies have reported varying effects of humor based on format and origin (Bolkan et al., 2018; Suzuki & Heath, 2014). Future research should explore the interactive effects of humor format (e.g., text, image, video) and source (e.g., materials, instructor) on learning from video lectures.

Thirdly, the sample size in our study was relatively small compared to the recommended number of over 30 subjects (Ross, 2004). However, this requirement is not always feasible in educational research; therefore, the determination of appropriate size for sampling depends on the utilized analysis techniques and sample size reported in similar research (Delice, 2010). A review of published scientific literatures indicates that the number of subjects in EEG experiments in educational research tends to be small, with nearly half involving fewer than 40 participants (Xu & Zhong, 2018). In fact, quite a few numbers of studies have recruited approximately 20 or fewer participants per experimental condition (e.g., Chettouf et al., 2022). The present study included 25 participants and adopted within-subjects design, ensuring that each experimental condition comprised 25 samples to maintain the reliability and generalizability of the findings. Considering the impact of sample size on reliability assessment, future research should aim to validate and expand upon our conclusions using a larger sample size.

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Data Availability The data are not available online in any institutional database. However, the raw data supporting the conclusions of this article will be made available by the corresponding author, without undue reservation.

Declarations

Competing interest The authors have no relevant financial or non-financial competing interests to disclose.

Ethical approval The study was approved by the Ethics Committee of University of Malaysia Sarawak and the Ethics Committee of School of Education and Psychology in Shaoxing University, and was conducted in accordance with the local legislation and institutional requirements.

Compliance with Ethical Statement On behalf of all authors, the corresponding author states that there is no conflict of interest. The participants provided their written informed consent to participate in this study.

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