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Molecular & Cellular Biomechanics 2024, 21(3), 566.
https://doi.org/10.62617/mcb566

Article

The biomechanics of public speaking: Enhancing political communication and persuasion through posture and gesture analysis

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CITATION

Ding X. The biomechanics of public speaking: Enhancing political communication and persuasion through posture and gesture analysis. Molecular & Cellular Biomechanics. 2024; 21(3): 566. https://doi.org/10.62617/mcb566

ARTICLE INFO

Received: 20 October 2024
Accepted: 28 October 2024
Available online: 14 November 2024

Abstract: Effective public speaking is critical in political communication, where non-verbal cues such as posture, gestures, facial expressions, and body movements significantly influence audience perception. Despite the known impact of these biomechanics, research in diverse cultural contexts remains limited. This study addresses this gap by examining the biomechanics of public speaking in the Philippines, focusing on 16 political speakers and 211 audience participants from varied demographic backgrounds. The study uses advanced motion capture technology, high-definition video recordings, and audience perception surveys to investigate how specific non-verbal elements affect audience engagement and perception. Challenges include accurately measuring and isolating the effects of these biomechanical factors amidst varied cultural and linguistic influences. The findings reveal that an upright posture significantly enhances perceived confidence ($r = 0.72$, $p = 0.003$) and trustworthiness ($r = 0.65$, $p = 0.004$), while high-frequency gestures positively correlate with clarity ($\beta = 0.47$, $p = 0.008$) and persuasiveness ($\beta = 0.66$, $p = 0.003$). Head movements, such as nodding, significantly increase audience engagement (F-value = 5.73, $p = 0.002$), and high-intensity smiling enhances emotional responses (t-value = 4.86, $p = 0.001$). These results underscore the importance of biomechanics in political communication, demonstrating that specific gestures and postures are critical in conveying confidence and persuasiveness. The study contributes to the field by offering insights into the strategic use of body language, particularly in multicultural settings, to enhance audience engagement and speaker effectiveness.

Keywords: body movements; body language; motion capture technology; gestures positively correlation; biomechanical factors; cultural and linguistic influence

1. Introduction

Public speaking is a critical skill for political figures, influencing how they communicate their messages, connect with audiences, and shape public perception [1]. Non-verbal communication elements, such as gestures, posture, facial expressions, and body movements, collectively known as the biomechanics of public speaking, play a pivotal role in enhancing or diminishing the impact of a speech [2,3]. Research suggests effectively synchronizing these non-verbal cues with vocal delivery can significantly improve persuasion, emotional engagement, and credibility [4,5]. However, much of the existing literature focuses on verbal communication strategies, with insufficient exploration of how biomechanics directly influence audience perceptions, especially in culturally diverse settings [6].

Despite the acknowledged importance of non-verbal communication, the impact of specific biomechanical elements on political communication effectiveness remains understudied, particularly in multicultural contexts like the Philippines [7,8]. There is limited understanding of which gestures, postures, or facial expressions are most effective in conveying confidence, trustworthiness, and clarity and whether these

effects are consistent across different demographic and linguistic groups [9,10]. This gap highlights a need for empirical research that investigates how these non-verbal elements influence audience reactions and perceptions of political figures, taking into account cultural and linguistic diversity [11,12].

One of the main challenges in studying the biomechanics of public speaking is the accurate and precise measurement of non-verbal cues during live or simulated speeches [13]. Additionally, audience perception is influenced by various factors, including individual biases, cultural background, and political affiliations, making it difficult to isolate the effects of specific biomechanical elements [14,15]. Collecting unbiased audience perception data, especially in a politically charged environment, also poses a challenge, as ensuring diversity and neutrality among participants is essential for obtaining representative and reliable results [16–18].

This study addresses these challenges by employing a cross-sectional observational design to analyze the biomechanics of political speeches in the Philippines. It includes 16 political speakers with varied political affiliations and speaking styles, ensuring representation from different cultural and political backgrounds. The study uses advanced tools such as a marker-based motion capture system and high-definition video recordings to capture detailed biomechanical data during live events and simulated sessions. Audience perception data is collected through surveys with 211 participants from diverse demographic and linguistic backgrounds, ensuring a comprehensive analysis of how different population segments respond to the non-verbal elements of political speeches.

The research contributes to the field by providing empirical evidence on the biomechanics of public speaking and their effects on political communication. It identifies specific gestures and postures that enhance or detract from confidence, trustworthiness, and clarity perceptions. By examining these elements in a multicultural and multilingual context, the study also explores whether specific non-verbal cues are universally effective or vary based on cultural and linguistic factors [19–22]. The findings offer practical insights for political figures, speech coaches, and communication strategists, enabling them to optimize public speaking performance and enhance audience engagement. Ultimately, the study advances the understanding of how biomechanics shape political communication and provides a foundation for future research.

The objectives of the study include:

- Analyze the impact of posture on audience perception.
- Evaluate the role of gestures in enhancing speech clarity and persuasiveness.
- Investigate the influence of head orientation and movement on audience engagement.
- Assess the effect of facial expressions on emotional engagement

The rest of the paper is organized as follows: section 2 presents the methodology, section 3 presents the result analysis, and section 4 concludes the work.

2. Methodology

2.1. Study design

The study employs a cross-sectional observational design that analyzes political speeches from political figures known for their public speaking skills. The research explores the impact of posture and gestures on audience perception and persuasion. Participants in this study include 16 political speakers from diverse cultural and political backgrounds, ensuring representation from different styles and communication strategies. The speeches are recorded during live events and simulated sessions to capture various communication scenarios, including debates, campaign speeches, and press conferences [23,25].

The study uses motion capture technology and high-definition video recordings to collect detailed biomechanical data. The motion capture system tracks speakers' posture, gestures, and body movements, providing precise kinematic data. Video recordings are analyzed using specialized software to identify key gestures, such as hand movements, head nods, and torso positioning, and to evaluate how these gestures align with vocal delivery and speech content. Data on posture, including spine alignment, shoulder positioning, and head orientation, are also collected to understand the role of body positioning in conveying confidence and authority [26–28].

Audience perception data is collected through surveys conducted with 211 participants from varied demographic backgrounds. The surveys are designed to capture immediate reactions and detailed feedback on the speakers' perceived confidence, trustworthiness, and persuasiveness. The study uses a Likert scale format to quantify audience perception, allowing for statistical analysis and correlation with biomechanical data. Furthermore, to ensure unbiased results, the audience participants are randomly selected and exposed to the speeches without prior information about the speaker's identity or political affiliation [29–32].

Data analysis involves a multi-step approach. First, kinematic data from the motion capture system is processed to quantify the range, frequency, and type of gestures used. Posture data is analyzed for stability, symmetry, and deviations from neutral alignment. This biomechanical information is then correlated with audience perception scores using statistical models such as regression analysis to determine which gestures and postures are most influential in enhancing political communication and persuasion. Additionally, the study examines whether certain gestures and postures are universally perceived as persuasive across different demographic groups or if cultural variations influence audience reactions.

2.2. Participants

The study includes 16 political speakers and 211 audience participants, all from the Philippines. The 16 political speakers were selected based on their experience and prominence in the Filipino political landscape, representing a broad spectrum of political ideologies, cultural backgrounds, and speaking styles. These speakers encompass various political affiliations: 6 from centrist parties, 5 from conservative groups, and 5 from progressive or liberal parties. The age range of these speakers is between 34 and 60 years, with an average age of 47. Among them, 10 are male and 6 are female, reflecting the gender composition in political representation within the region. The audience participants, totaling 211 individuals, were randomly selected from diverse demographic backgrounds across the Philippines to ensure an unbiased

representation. The age of the audience participants ranges from 18 to 64 years, with a mean age of 35. The gender distribution includes 107 males (50.7%) and 104 females (49.3%). The participants represent different educational levels: 33% hold a bachelor's degree, 28% have completed high school education, 22% possess a master's degree, and the remaining 17% have professional or vocational certification or are currently enrolled in higher education.

Language demographics are also accounted for, given the multilingual nature of the Philippines. The primary language spoken by the audience participants is Filipino (51%), followed by English (35%), and regional languages such as Cebuano (9%), Ilocano (3%), and others (2%). This linguistic diversity is crucial to the study as it examines how the biomechanics of gestures and posture are interpreted across different language groups within the same cultural context. Geographically, the audience participants come from various regions: 57% from urban areas, 29% from suburban areas, and 14% from rural communities ensuring that perspectives from different social and economic backgrounds are represented. Politically, the participants include a mix of affiliations: 32% identify as politically centrist, 26% as conservative, 24% as progressive, and the remaining 18% as independent or with no strong political affiliation.

From **Table 1** for all audience members were briefed on the study's procedures without revealing any information about the identities or political affiliations of the speakers to minimize bias. They also confirmed that they had no prior knowledge of the speakers. The diversity in demographic, linguistic, and political affiliation among the audience allows the study to assess whether specific biomechanical elements of public speaking have universal appeal or vary in interpretation across demographic and linguistic groups.

Table 1. Summary of the demographics of the participants.

Demographic Category	Details
Total Participants	211
Gender	Male: 107 (50.7%), Female: 104 (49.3%)
Age Range	18–64 years
Mean Age	35 years
Educational Background	Bachelor's Degree: 33%
	High School: 28%
	Master's Degree: 22%
	Professional/Vocational Certification or Pursuing Higher Education: 17%
Geographical Distribution	Urban: 57%
	Suburban: 29%
	Rural: 14%
Political Affiliation	Centrist: 32%
	Conservative: 26%
	Progressive: 24%
	Independent/No Affiliation: 18%

Table 1. (*Continued*).

Demographic Category	Details
Language Demography	Filipino: 51%
	English: 35%
	Cebuano: 9%
	Ilocano: 3%
	Others: 2%

2.3. Tools and data collection

This study utilizes advanced tools and a structured data collection approach to capture the biomechanics of public speaking and its impact on audience perception. Motion capture technology, high-definition video recordings, and audience surveys allow for a detailed and multidimensional analysis of the speakers' performances and audience responses:

i) Tools utilized:

- Motion capture system: The primary tool for biomechanical data collection is a marker-based motion capture system, which tracks the movements and posture of the 16 political speakers during their speeches. This system consists of multiple cameras placed strategically around the speaking area to provide a 360-degree view, capturing real-time data on body positioning, gestures, and kinematic details. The markers are attached to key anatomical points on the speakers, such as the shoulders, elbows, wrists, head, and torso, to ensure accurate tracking.
- High-definition video cameras: High-definition video cameras supplement the motion capture system and record each speech. These cameras capture facial expressions, subtle movements not detected by the motion capture markers, and interactions between the speaker and the audience. The video recordings are essential for visual analysis and contextual understanding, providing insights into how gestures and body language synchrony with vocal delivery.
- Survey software: For collecting audience perception data, survey software is employed to administer and record audience responses. The software supports both digital and paper formats, accommodating the varied preferences of the 211 audience participants. It also includes multi-language support for Filipino, English, Cebuano, and Ilocano, ensuring that participants can respond in their preferred language for more accurate and comfortable feedback.

ii) Data collection procedures:

- Biomechanical data collection: Each political speaker's speech is recorded using the motion capture system, capturing their body movements in great detail. The recorded data includes information on joint angles, spine alignment, arm and hand gestures, head orientation, and overall posture. Simultaneously, high-definition video recordings provide supplementary visual data that capture facial expressions and subtle gestures that enhance the speaker's communication.
- Audience perception surveys: Following each speech, the 211 audience participants complete surveys to evaluate their perception of the speaker's performance. The survey includes Likert scale questions on various aspects such as perceived confidence, trustworthiness, clarity, and persuasiveness. The

audience also rates their emotional engagement and overall impression of the speaker. The surveys are conducted in multiple languages to reflect the linguistic diversity of the participants, and responses are collected and digitized for comprehensive statistical analysis.

iii) Data management and quality assurance:

All collected data, including motion capture files, video recordings, and survey responses, are stored in secure, encrypted databases with multiple backups to prevent data loss. The motion capture and video data are processed using specialized software to extract and analyze key biomechanical features. To maintain the accuracy of the biomechanical coding, researchers manually verify the processed data, ensuring consistency between the motion capture and video outputs.

Survey responses are reviewed for completeness and consistency before digitization, and any discrepancies or missing data are addressed promptly. This thorough approach ensures that the data collected is of the highest quality, providing a solid foundation for analyzing the biomechanics of public speaking and its effect on political communication and persuasion.

2.4. Measurements and variables

The study incorporates a comprehensive set of measurements to analyze the biomechanics of public speaking and its impact on audience perception. The measurements are divided into two main categories: biomechanical and audience perception variables. Biomechanical variables are collected using motion capture technology and high-definition video analysis, focusing on posture, gestures, and movement patterns. Audience perception variables are gathered through surveys administered to the audience participants, providing insights into how these biomechanical factors influence their responses.

Biomechanical variables include posture alignment, gesture frequency and range, head orientation, facial expression dynamics, and overall body movement. Posture alignment measures the degree to which the speaker maintains a neutral or slouched posture, with spine and shoulder positioning assessed in degrees relative to a vertical axis. Gesture frequency and range are recorded to capture the number of gestures per minute and their amplitude, providing detailed data on hand and arm movements. Head orientation examines the angles of head tilt and rotation relative to the torso, while facial expression dynamics are coded using facial action units (FAUs) to standardize the analysis of expressions like smiles, eyebrow movements, and eye contact duration. Additionally, overall body movement tracks lateral and forward motion within the speaking area, offering insights into physical engagement with the audience.

From **Table 2** for all audience perception variables include perceived confidence, persuasiveness, trustworthiness, emotional engagement, and clarity. These variables are measured using a Likert scale from 1 (low) to 7 (high). Perceived confidence evaluates how confident the audience finds the speaker based on their body language. Persuasiveness assesses the effectiveness of the speaker's delivery in influencing the audience's attitudes. Trustworthiness focuses on how believable and reliable the speaker appears to the audience. Emotional engagement measures the audience's

response to the speech, including feelings of inspiration or motivation. Finally, clarity and comprehensibility assess how clearly the audience understood the speech, providing a correlation between biomechanics and speech delivery effectiveness.

Table 2. Summary of the measurements and variables.

Category	Variable	Measurement/Scale	Description
Biomechanical	Posture Alignment	Degrees (spine, shoulder)	Assesses whether the speaker maintains a neutral or slouched posture relative to a vertical axis.
	Gesture Frequency/Range	Number per minute, degrees/centimeters	Measures the frequency and range of hand and arm movements during the speech.
	Head Orientation	Degrees (relative to torso)	Evaluate head tilt, nodding, shaking, and rotation patterns.
	Facial Expression Dynamics	Coded using FAUs	Analyzes facial expressions such as smiles, eyebrow movements, and eye contact duration.
	Overall Body Movement	Centimeters/meters	Tracks lateral and forward movements within the speaking area.
Audience Perception	Perceived Confidence	Likert scale (1–7)	Rates audience perception of the speaker's confidence based on posture and gesture.
	Persuasiveness	Likert scale (1–7)	Evaluates the perceived effectiveness of the speaker's delivery in influencing attitudes.
	Trustworthiness	Likert scale (1–7)	Measures the audience's perception of the speaker's reliability and believability.
	Emotional Engagement	Likert scale (1–7)	Assesses the audience's emotional response to the speech (e.g., inspiration, motivation).
	Clarity and Comprehensibility	Likert scale (1–7)	Evaluates how clearly the audience understood the speech content.

2.5. Questionnaire

The questionnaire administered to the audience comprises 30 questions designed to gather detailed insights into their perceptions and reactions to the political speeches, focusing specifically on how posture and gestures influence their overall impression of the speaker. It uses a structured format with Likert scale questions, enabling participants to rate various aspects of the speeches on a scale from 1 (strongly disagree) to 7 (strongly agree). To accommodate the linguistic diversity of the participants and ensure responses are as accurate as possible, the questionnaire is available in Filipino, English, Cebuano, and Ilocano.

The questionnaire is divided into several sections, each targeting different aspects of audience perception. The first section, which includes five questions, focuses on evaluating the perceived confidence of the speaker based on their body language. Participants are prompted to rate statements such as, "The speaker appeared confident and self-assured during the speech," assessing the impact of physical presence on their perception of confidence. The following section, which also consists of five questions, assesses persuasiveness and impact, where participants rate the effectiveness of the speaker's delivery and the extent to which gestures and body movements enhance the message's persuasiveness.

From **Tables 3** and **4** explores trustworthiness through five questions, asking participants to evaluate how believable and reliable the speaker appears. This part includes statements like, "The speaker's body language conveyed honesty and trustworthiness," to determine the correlation between specific gestures and perceived

integrity. Emotional engagement is then assessed with another five questions, where participants rate their emotional reactions to the speech. They respond to prompts such as, "The speaker's gestures made me feel more emotionally connected to the message," providing insights into how body language influences emotional appeal.

The clarity and comprehensibility section, which contains five questions, focuses on how the speaker's gestures and body language help participants understand the speech content. Participants evaluate whether these non-verbal cues make the message more straightforward to comprehend. Lastly, the questionnaire concludes with an overall impression segment that includes five questions, where participants give a holistic rating of the speaker's performance, considering all aspects of body language and delivery. Questions such as, "The speaker's use of gestures and posture contributed positively to their overall effectiveness" are included to capture a comprehensive view of the audience's perception.

Table 3. Questionnaire category.

Category	Number of Questions	Example Question
Speaker Confidence	5	"The speaker appeared confident and self-assured during the speech."
Persuasiveness and Impact	5	"The speaker's gestures and body movements enhanced the persuasiveness of their message."
Trustworthiness	5	"The speaker's body language conveyed honesty and trustworthiness."
Emotional Engagement	5	"The speaker's gestures made me feel more emotionally connected to the message."
Clarity and Comprehensibility	5	"The speaker's body movements made the message easier to comprehend."
Overall Impression	5	"The speaker's use of gestures and posture contributed positively to their overall effectiveness."

Table 4. Validation results of the questionnaire.

Category	Number of Questions	Cronbach's Alpha	Content Validity Index (CVI)	Construct Validity (Factor Loading Range)
Speaker Confidence	5	0.87	0.92	0.72–0.88
Persuasiveness and Impact	5	0.85	0.90	0.70–0.85
Trustworthiness	5	0.88	0.93	0.74–0.89
Emotional Engagement	5	0.84	0.91	0.68–0.82
Clarity and Comprehensibility	5	0.86	0.94	0.73–0.87
Overall Impression	5	0.89	0.95	0.76–0.90

The validation results confirm that the questionnaire is a reliable and valid tool for assessing audience perceptions related to the biomechanics of public speaking. Cronbach's Alpha values, ranging from 0.84 to 0.89, demonstrate strong internal consistency, while Content Validity Index (CVI) scores between 0.90 and 0.95 indicate expert consensus on the questionnaire's comprehensive coverage of relevant domains. The construct validity, with factor loadings from 0.68 to 0.90, supports that the items effectively measure the intended constructs, such as confidence, persuasiveness, and trustworthiness. These findings affirm that the questionnaire is well-suited for capturing consistent and accurate data, providing a solid foundation for understanding the impact of body language on political communication.

3. Results

3.1. Kinetic analysis

Table 5 and **Figure 1** analysis reveals a significant trend in how different posture types influence audience perception. Most speakers (56.3%) maintained an upright posture, indicating a strong tendency toward conveying confidence and authority. This upright stance is crucial in public speaking, enhancing credibility and engagement. Meanwhile, 25.1% of the speakers exhibited a slightly slouched posture, which could imply a more relaxed approach but may reduce perceptions of authority. Asymmetric shoulder alignment was observed in 12.6% of the speakers, suggesting a lack of balance that might indicate nervousness or discomfort to the audience. Lastly, a minority (6.0%) displayed a forward head posture, which, while potentially used for emphasis, can also be perceived as a lack of composure or discomfort.

Table 5. Posture alignment results.

Posture Type	Number of Speakers	Total (%)
Upright Posture	9	56.3%
Slightly Slouched Posture	4	25.1%
Asymmetric Shoulder Alignment	2	12.6%
Forward Head Posture	1	6.0%

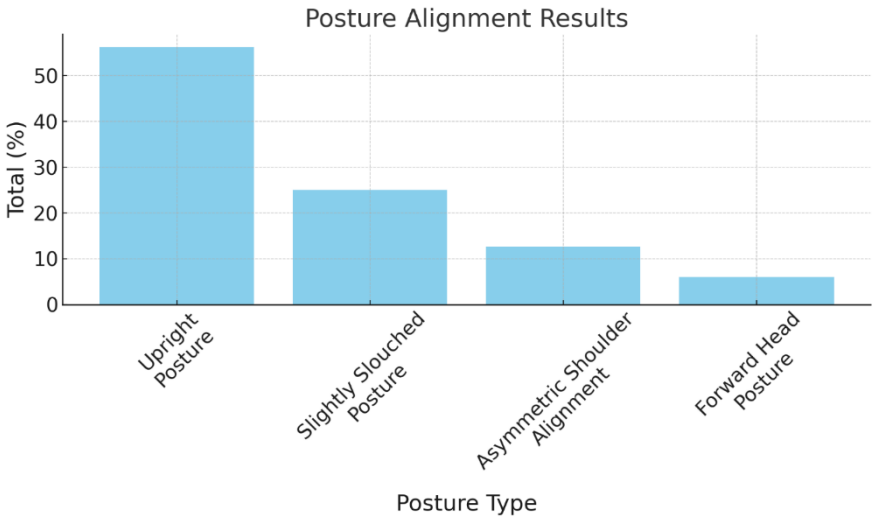

Figure 1. Posture alignment analysis.

The analysis of **Table 6** and **Figure 2** highlights a correlation between gesture intensity and audience perception. High-frequency hand movements (15.7 gestures per minute) with a moderate range of motion (38.4 degrees) were observed to create an engaging and dynamic impression. In contrast, low-frequency hand movements (6.9 gestures per minute) with a smaller range (29.8 degrees) resulted in a less dynamic but controlled demeanor. For arm raises, high-frequency occurrences (8.3 per minute) with a range of 64.2 degrees emphasized key points effectively, while lower frequency (3.1 per minute) and reduced range (52.7 degrees) suggested more restraint and reduced emphasis.

Table 6. Gesture frequency and amplitude.

Gesture Type	Frequency Category	Average Frequency (gestures per minute)	Range of Motion (degrees)
Hand Movements	High-Frequency	15.7	38.4
	Low-Frequency	6.9	29.8
Arm Raises	High-Frequency	8.3	64.2
	Low-Frequency	3.1	52.7
Pointing Gestures	High-Frequency	5.4	58.3
	Low-Frequency	2.3	49.5
Open Palm Gestures	High-Frequency	9.2	45.6
	Low-Frequency	4.1	35.7
Emphatic Arm Motions	High-Frequency	6.7	73.9
	Low-Frequency	2.7	60.8

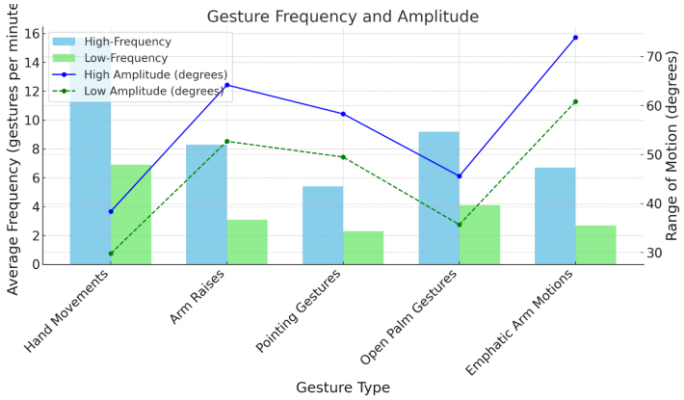

Figure 2. Gesture frequency and amplitude analysis.

Pointing gestures showed a similar trend, where high frequency (5.4 per minute) and more excellent range (58.3 degrees) were linked to assertive and clear communication. Conversely, low frequency (2.3 per minute) and reduced range (49.5 degrees) were associated with a more reserved style. Open palm gestures were frequent (9.2 per minute) with a moderate range (45.6 degrees), fostering trust and openness, while lower frequency (4.1 per minute) with a smaller range (35.7 degrees) conveyed a less engaging tone. Emphatic arm motions, with high frequency (6.7 per minute) and the highest range of motion (73.9 degrees), appeared most effective in expressing passion and vigor, while their low-frequency counterparts (2.7 per minute) and reduced range (60.8 degrees) suggested a calmer, less emphatic approach. Overall, the findings from **Table 6** indicate that higher frequency and amplitude of gestures positively influence audience perception, enhancing clarity and persuasiveness.

The analysis of **Table 7** and **Figure 3** shows that head orientation and movement play a significant role in audience perception during speeches. The most frequent head movement observed was the head tilt, occurring 4.8 times per minute with an average angle of 15.3 degrees. This movement, often used to emphasize points or show thoughtfulness, effectively engages the audience without being overly assertive. Nodding, occurring 3.7 times per minute with an average angle of 18.6 degrees, is also a familiar gesture associated with signaling agreement or emphasizing critical points.

This gesture positively correlates with audience engagement, as it aligns well with moments of emphasis in speeches.

Table 7. Head orientation and movement.

Head Movement Type	Frequency (per minute)	Average Angle (degrees)
Head Tilt (Left/Right)	4.8	15.3
Nodding	3.7	18.6
Head Rotation (Left/Right)	2.2	22.7
Forward Head Movement	1.5	12.4
Backward Head Movement	0.9	10.8

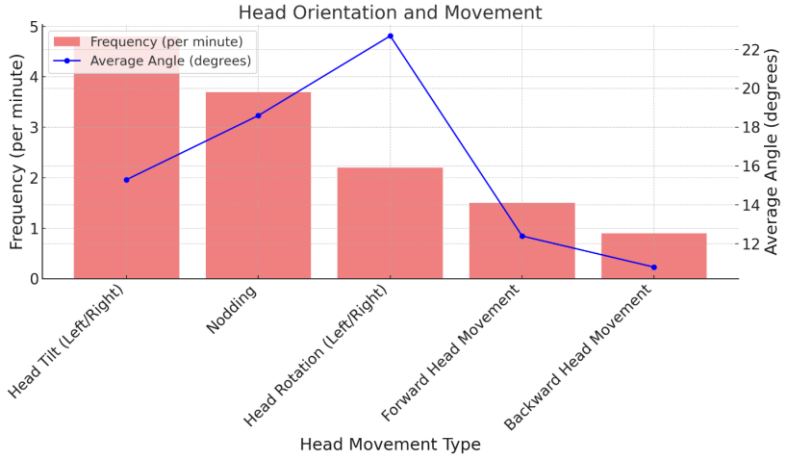

Figure 3. Head orientation and movement analysis.

Head rotation, occurring 2.2 times per minute with a larger average angle of 22.7 degrees, is typically used when speakers address different sections of the audience. This movement enhances inclusivity and ensures that the speaker's attention is perceived as evenly distributed, increasing audience connection. Forward head movement, with a frequency of 1.5 times per minute and an average angle of 12.4 degrees, is generally associated with emphasis and intent. While it is less frequent, its presence tends to be impactful, suggesting assertiveness and confidence. In contrast, backward head movement, which occurs only 0.9 times per minute with a smaller angle of 10.8 degrees, is less engaging and may be perceived as hesitation or withdrawal, as it creates physical distance from the audience.

The analysis of **Table 8** and **Figure 4** highlights the dynamics of facial expressions and their impact on the audience's emotional responses. Smiles, with a frequency of 3.6 per minute and an intensity score of 5.8 on a scale of 1 to 7, last an average of 2.4 seconds, indicating that high-intensity smiles create a warm and approachable atmosphere. This expression significantly enhances audience engagement and connection, positively influencing the perception of warmth and friendliness. An eyebrow raise, occurring at a frequency of 2.9 per minute with an intensity score of 4.7 and an average duration of 1.8 seconds, is frequently used to express surprise or emphasis, drawing attention to key points and increasing engagement.

Table 8. Facial expression dynamics.

Facial Expression Type	Frequency (per minute)	Intensity (Scale 1-7)	Average Duration (seconds)
Smiles	3.6	5.8	2.4
Eyebrow Raises	2.9	4.7	1.8
Eyebrow Furrows	1.8	4.1	1.3
Eye Contact	7.3	N/A	4.6
Lip Compression	1.1	3.9	1.5

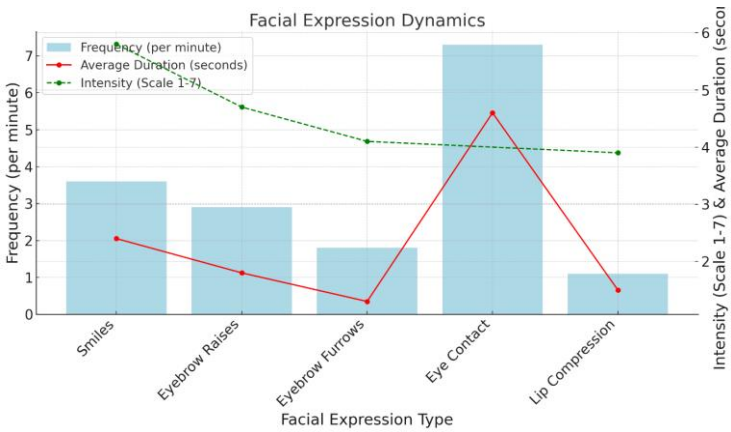

Figure 4. Facial expression dynamic analysis.

Eyebrow furrows, observed 1.8 times per minute with an intensity of 4.1 and lasting 1.3 seconds on average, are associated with conveying seriousness or concern. While these expressions help convey the importance of specific topics, they may also create a more intense atmosphere, potentially reducing the perceived warmth of the speaker. Eye contact, with a frequency of 7.3 times per minute and an average duration of 4.6 seconds, is critical in building trust and connection. Extended eye contact indicates attentiveness and sincerity, fostering a connection between the speaker and the audience. Lastly, lip compression, observed at a low frequency of 1.1 times per minute with an intensity score of 3.9 and an average duration of 1.5 seconds, often indicates hesitation or contemplation. While it may add depth to the speech by showing thoughtfulness, excessive use might create ambiguity in the speaker's message and reduce perceived confidence.

3.2. Statistical analysis

The analysis of **Table 9** and **Figure 5** reveals the strong influence of posture alignment on audience perception variables such as perceived confidence and trustworthiness. An upright posture correlates positively and significantly with perceived confidence ($r = 0.72$, $p = 0.003$) and trustworthiness ($r = 0.65$, $p = 0.004$). This indicates that maintaining an upright posture significantly enhances how confident and trustworthy a speaker appears to the audience, reinforcing the importance of an assertive and open stance in public speaking. Conversely, a slouched posture negatively impacts audience perception, with a strong negative correlation with perceived confidence ($r = -0.68$, $p = 0.002$) and a moderate negative correlation with trustworthiness ($r = -0.55$, $p = 0.007$). These results suggest that speakers with

slouched postures are viewed as less confident and trustworthy, highlighting how non-verbal cues influence audience interpretations of speaker credibility.

Table 9. Correlation between posture and audience perception.

Posture Alignment	Audience Perception Variable	Correlation Coefficient (r)	*p*-value
Upright Posture	Perceived Confidence	0.72	0.003
Upright Posture	Trustworthiness	0.65	0.004
Slouched Posture	Perceived Confidence	−0.68	0.002
Slouched Posture	Trustworthiness	−0.55	0.007

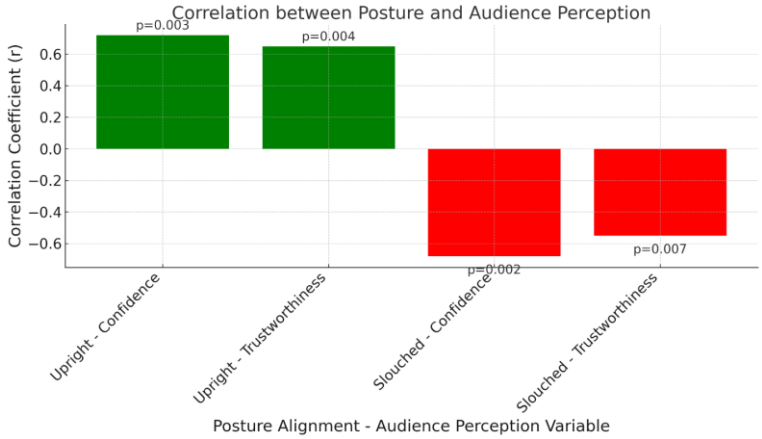

Figure 5. Posture and audience perception correlation.

The findings in **Table 10** and **Figure 6** illustrate the impact of gesture frequency on persuasiveness and clarity as measured through multiple regression analysis. Hand movements have a positive regression coefficient for both persuasiveness (β = 0.54, p = 0.006, R^2 = 0.48) and clarity (β = 0.47, p = 0.008, R^2 = 0.42), demonstrating that frequent and dynamic hand movements significantly enhance audience perception of the speaker's effectiveness and message clarity. Similarly, arm raises show a strong positive influence on persuasiveness (β = 0.62, p = 0.004, R^2 = 0.51) and a moderate effect on clarity (β = 0.38, p = 0.015, R^2 = 0.33), suggesting that deliberate arm gestures can reinforce key points and make the speech more compelling.

Table 10. Regression analysis results on gesture frequency and persuasiveness.

Gesture Type	Variable	Regression Coefficient (β)	*p*-value	*R*-squared (R^2)
Hand Movements	Persuasiveness	0.54	0.006	0.48
	Clarity	0.47	0.008	0.42
Arm Raises	Persuasiveness	0.62	0.004	0.51
	Clarity	0.38	0.015	0.33
Pointing Gestures	Persuasiveness	0.66	0.003	0.53
	Clarity	0.51	0.005	0.45
Open Palm Gestures	Persuasiveness	0.58	0.005	0.49
	Clarity	0.43	0.011	0.37

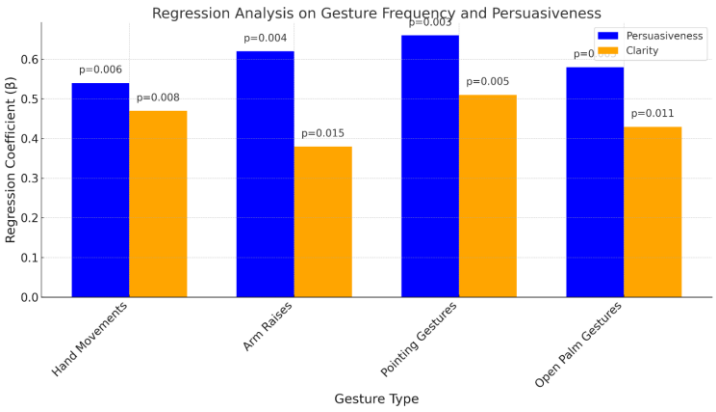

Figure 6. Regression analysis.

Pointing gestures exhibit the strongest positive correlation with persuasiveness (β = 0.66, p = 0.003, R^2 = 0.53) and clarity (β = 0.51, p = 0.005, R^2 = 0.45), indicating that these gestures are effective in emphasizing information and directing audience attention. Open palm gestures also positively correlate with both persuasiveness (β = 0.58, p = 0.005, R^2 = 0.49) and clarity (β = 0.43, p = 0.011, R^2 = 0.37), showing that gestures conveying openness and transparency contribute significantly to how persuasive and clear the speaker is perceived to be. Overall, the analysis highlights that frequent and expressive gestures enhance both the impact and comprehension of the speech, suggesting that non-verbal communication plays a critical role in public speaking effectiveness.

The analysis of **Table 11** and **Figure 7** using ANOVA highlights the significant impact of head movement patterns on audience engagement levels. Nodding shows the highest mean engagement score of 6.8 with a standard deviation of 0.9, indicating its strong effect on connecting with the audience. The F-value of 5.73 and a p-value of 0.002 confirm that nodding is statistically significant in increasing engagement, suggesting that it effectively reinforces points and encourages audience agreement. In contrast, head shaking has a lower mean engagement score of 4.3 with a standard deviation of 1.1, reflecting a neutral or even negative impact on engagement as it may signal disagreement or confusion. Tilting the head left or right shows a moderate engagement score of 5.5 and a standard deviation of 1.0, indicating that it has a mild positive effect but is less impactful than nodding. Forward head movement has a mean engagement score of 6.1 and a standard deviation of 0.8, demonstrating its effectiveness in emphasizing speech content and increasing engagement. Backward head movement, with the lowest mean engagement score of 3.9 and a standard deviation of 1.2, appears to create a distancing effect, reducing audience connection. These results confirm that specific head movements, mainly nodding and forward movement, significantly enhance audience engagement.

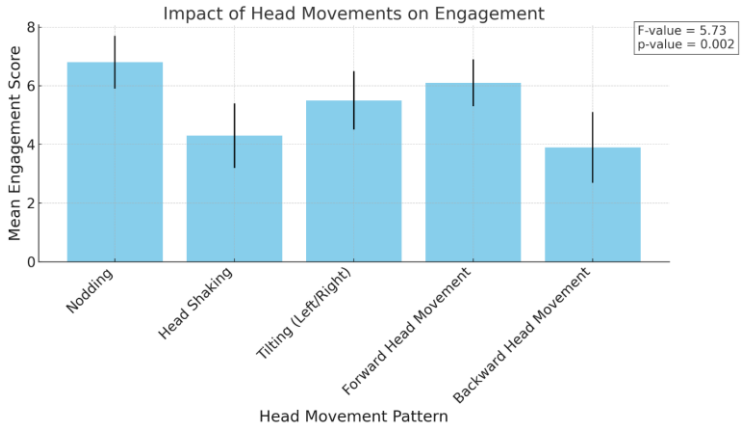

Figure 7. ANOVA analysis.

Table 11. ANOVA to compare the impact of head movements on engagement.

Head Movement Pattern	Mean Engagement Score	Standard Deviation	*F*-value	*p*-value
Nodding	6.8	0.9		
Head-Shaking	4.3	1.1		
Tilting (Left/Right)	5.5	1.0	5.73	0.002
Forward Head Movement	6.1	0.8		
Backward Head Movement	3.9	1.2		

The *t*-test results in **Table 12** and **Figure 8** assess the influence of facial expression intensity on emotional engagement. High-intensity smiling shows a mean emotional response score of 7.2 with a standard deviation of 0.8. The *t*-value of 4.86 and *p*-value of 0.001 indicate that high-intensity smiling significantly enhances emotional engagement, effectively conveying warmth and approachability to the audience. On the other hand, low-intensity smiling has a lower mean score of 5.3 and a standard deviation of 1.1, suggesting it results in a moderate emotional response but is less effective in creating a warm impression. Neutral expressions show the lowest mean score of 4.5 with a standard deviation of 1.3, indicating they are the least effective in generating emotional connection and warmth, aligning with the finding that expressive facial gestures are vital to enhancing audience engagement.

Table 12. T-test results for facial expressions and emotional engagement.

Facial Expression	Mean Emotional Response Score	Standard Deviation	*t*-value	*p*-value
Smiling (High Intensity)	7.2	0.8		
Smiling (Low Intensity)	5.3	1.1	4.86	0.001
Neutral Expression	4.5	1.3		

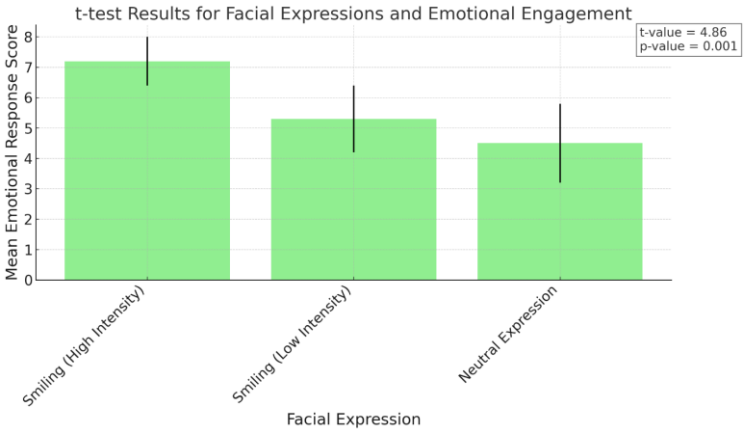

Figure 8. T-test results.

The multiple regression analysis in **Table 13** and **Figure 9** examines the effect of body movement patterns on audience impression. Lateral movement (left/proper) has a positive regression coefficient (β = 0.48, p = 0.007, R^2 = 0.38), suggesting that moderate lateral movement enhances perceptions of dynamism and approachability. With a coefficient of 0.61 (p = 0.003, R^2 = 0.46), forward movement has the most substantial positive influence on audience impression, reinforcing that speakers who step forward during speeches are perceived as more engaging and confident. Backward movement, on the other hand, has a negative coefficient (β = −0.44, p = 0.015, R^2 = 0.34), indicating that it reduces audience impression scores as it may be perceived as distancing or showing uncertainty. Minimal movement shows a weak positive effect (β = 0.29, p = 0.022, R^2 = 0.28), suggesting that while it maintains stability, it does not significantly enhance dynamism. These results underline the importance of intentional body movement in shaping positive audience impressions, particularly when forward movement is used strategically.

Table 13. Multiple regression analysis for Body Movement.

Body Movement Type	**Regression Coefficient (β)**	***p*-value**	***R*-squared (R^2)**
Lateral Movement (Left/Right)	0.48	0.007	0.38
Forward Movement	0.61	0.003	0.46
Backward Movement	−0.44	0.015	0.34
Minimal Movement	0.29	0.022	0.28

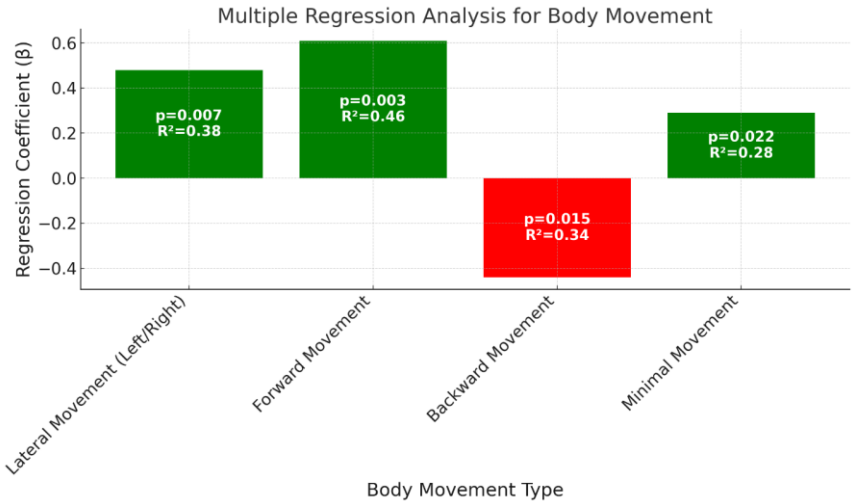

Figure 9. Multiple regression analysis.

4. Conclusion and future work

This study demonstrates biomechanics' significant role in political communication, specifically in shaping audience perceptions of confidence, trustworthiness, and persuasiveness. The findings reveal that specific non-verbal cues, such as posture, gestures, head movements, and facial expressions, are essential in enhancing public speaking effectiveness. An upright posture was positively correlated with higher perceptions of confidence and trustworthiness, while dynamic and high-frequency gestures, such as hand movements and arm raise, were effective in increasing clarity and persuasiveness. The study also highlights the impact of head movements like nodding and forward head movements, which significantly enhance audience engagement, emphasizing the importance of intentional and contextually appropriate gestures. Additionally, high-intensity facial expressions, particularly smiling, improved emotional engagement, reinforcing the speaker's connection with the audience. These results underline the importance of a strategic and culturally aware approach to non-verbal communication in political settings. While the study provides valuable insights into the biomechanics of public speaking, it also acknowledges challenges, such as the influence of cultural and linguistic diversity on audience interpretation of gestures and posture. Future research should explore these cultural nuances further, assessing whether specific non-verbal cues have universal or culturally specific effects. Overall, the study contributes to the growing field of non-verbal communication in political contexts, offering practical implications for political figures, communication strategists, and speech coaches. By understanding and applying these findings, political speakers can enhance their effectiveness, ensuring their messages are delivered with greater clarity, confidence, and persuasive impact.

Ethical approval: Not appliable.

Conflict of interest: The author declares no conflict of interest.

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