Computational approaches to semantic frame modeling: frequency and statistical analysis of nonverbal experience in war fiction

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Abstract

This study applies computational approaches to semantic frame modeling by integrating statistical tests (ANOVA, Tukey's Honest Significant Difference, Chi-Square) within computer-based discourse analysis to examine verbalized nonverbal experience in modern war fiction. The research focuses on the semantic structuring or categorization of nonverbal communication/behavior, referred to as constants of nonverbal experience (CNE), which are systematically categorized within a semantic frame. War fiction, beyond depicting the horrors of war, is a rich source of nonverbal experience, encompassing themes of memory, relationships, and human resilience. This study quantitatively models the CNE semantic frame, identifying its four primary slots: Gesture, Posture, Face, and Voice. By exploring the most frequently occurring words across these categories, the research uncovers how nonverbal elements shape narrative meaning at both surface and deeper semantic levels. The statistical findings underscore the cohesion between conceptual and semantic structures, highlighting the stability and consistency of CNE distributions across war fiction corpora. The integration of Voyant Tools and R programming for data processing enhances the accuracy and interpretability of frequency and statistical analysis, reinforcing the CNE semantic frame as a structured linguistic and conceptual phenomenon. By combining quantitative linguistic analysis with computational approach, this research contributes to a deeper understanding of nonverbal experience in war narrative, demonstrating how statistical insights enhance the study of meaning construction in fictional texts.

Keywords

computational linguistics, semantic frame, war narrative, discourse analysis, constants of nonverbal experience, frame modeling

1. Introduction

In contemporary scientific research, the quantitative analysis of linguistic data through computational tools such as Voyant Tools and R programming has become an invaluable approach for objectively assessing semantic frame structures in fictional texts [1, 2, 3]. This study addresses the following ***research question***: to what extent can the semantic frame of nonverbal experience (CNE) be formalized and validated across contemporary war fiction using computational tools? In modeling the semantic frame, this study has a dual objective: first, to extract and analyze the frequency of words actualizing the CNE semantic frame using Voyant Tools via a web browser; and second, to conduct a statistical comparison of frame slots (sub-frames or groups) within the examined frame using R.

For the purposes of this research, a frame is understood as "a framework for representing knowledge and experience" that is intended to be conveyed verbally [4, 5, 6]. The analysis of the CNE semantic frame in a narrative extends beyond surface-level semantic relationships, offering a

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structured conceptual unity that can either be substantiated or challenged through quantitative findings. Computer-based discourse analysis enhances the ability to extract meaning from fictional texts, focusing on the material dimension of language – specifically, the verbalized representations of nonverbal communication and behavior, including gestures, postures, facial expressions, and voice characteristics as interconnected concepts.

The war narrative of the 21st century is expected to contain a dense layer of nonverbal experience, which transcends direct verbalization and extends beyond mere words, necessitating a structured analytical approach [7, 8, 9, 10]. Words, initially chosen by the author and subsequently interpreted by the reader, function as triggers embedded within a conceptual structure, which is further categorized by the researcher according to the study's objectives.

This research posits that the semantic frame, due to its hierarchical structure and alignment with concept categorization principles, is the optimal model for organizing CNE in a narrative. Originally proposed by M. Minsky and later integrated into computational linguistics, the semantic frame model provides a functional and productive linguistic tool, facilitating the visualization of connections between linguistic and conceptual structures. This framework is well-suited for computational processing and further analysis, enabling deeper exploration of the complex phenomenon of meaning embedded in fictional texts. Consequently, the study of the CNE semantic frame uncovers tangled semantic and cognitive complexities, offering valuable insights into fictional text analysis and applied linguistics.

This paper contributes to *computational narrative studies* by introducing a new composite semantic frame — ***CNE (Constants of Nonverbal Experience)*** — and validating it through corpus-based frequency analysis and statistical modeling. It connects literary narrative interpretation with current cognitive theories, including frame semantics and predictive processing, and provides a new path for understanding affective language through computational tools.

2. Related works

Previous research underscores the significance of CNE in modern war fiction and highlights the necessity of structuring them within a semantic frame. This section establishes the rationale for integrating frequency and statistical analysis into studies of fictional narratives, introducing a quantitative dimension to semantic exploration through word frequency analysis.

2.1. Constants of nonverbal experience in modern war fiction

Nonverbal experience plays a critical role in contemporary fiction, enriching narratives with emotional depth, psychological realism, and embodied meaning. In modern war fiction, nonverbal elements — such as gestures, posture, facial expressions, and vocal cues — are not merely decorative, but function as *integral semiotic devices*. They help to construct affective atmospheres, delineate power dynamics, and signal trauma, intimacy, or conflict [11].

Scholars have emphasized that the *verbal representation of nonverbal behavior* significantly enhances reader immersion by activating embodied cognition and affective resonance [12, 13]. This corresponds to recent findings in cognitive narratology, where emotionally charged nonverbal cues serve as empathic triggers in narrative processing. Furthermore, multimodal discourse studies suggest that such cues engage pre-linguistic schemas of interaction, often forming the basis for readerly inference and predictive engagement [14, 15].

The notion of Constants of Nonverbal Experience (CNE) builds upon these insights by conceptualizing a *semantic frame* of recurrent and stable nonverbal patterns that are consistently verbalized throughout narrative texts [16]. CNE elements — gestures, postures, facial actions, and voice features — operate as narrative markers of emotion, intention, and social alignment. Their repeated use creates an intertextual behavioral code, which enhances coherence, character realism, and stylistic unity.

Importantly, CNE elements function not only descriptively, but also structurally and symbolically. They encode psychological states, express interpersonal tensions, and articulate moral or ideological stances without explicit dialogue. In the context of war fiction, these verbalized

nonverbal cues are deeply intertwined with themes of silence, loss, and resilience. Authors frequently use negation markers, modal verbs, and expressive syntax to transform the body into a site of narrative signification — suggesting what cannot be said, but must still be felt and understood.

This theoretical foundation positions nonverbal language as a critical interface between literary form and cognitive-emotional function — one that can be modeled, quantified, and analyzed *using computational methods*.

When verbalized in a fictional text, CNE serve multiple functions:

Character development: recurrent gestures, postures, and facial expressions create distinct behavioral traits, reinforcing character identities.

Emotional impact: descriptions of tense postures, trembling hands, or fleeting glances evoke fear, tension, and empathy in the reader.

Atmosphere and setting: nonverbal cues help construct a realistic and immersive wartime backdrop, capturing the physical exhaustion, silent camaraderie, and emotional strain of war.

Tension and suspense: hesitant movements, unspoken exchanges, and apprehensive glances heighten suspense, intensifying narrative anticipation.

Camaraderie and conflict: subtle gestural exchanges, shared looks, and restrained movements convey trust, hierarchy, and power struggles among soldiers.

Symbolism and metaphor: certain gestures or postures may symbolize resilience, loss, or psychological trauma, adding deeper meaning to the narrative.

Narrative cohesion: repetition of nonverbal motifs reinforces themes, character arcs, and emotional trajectories, ensuring a unified storytelling experience.

Depiction of trauma and recovery: changes in gestures, postures, and facial expressions reflect psychological deterioration, post-traumatic stress, and eventual healing.

In summary, CNE in modern war fiction act as structural and thematic anchors, offering a means to verbalize internal conflicts, explore trauma, and depict human resilience in wartime. Through the strategic repetition of nonverbal cues, authors shape the reader's perception of characters, emotional depth, and thematic continuity. By embedding nonverbal communication/behavior into the linguistic fabric of the text, CNE transcend mere description, transforming fictional war narratives into emotionally and psychologically experiences.

2.2. Constants of nonverbal experience as the CNE semantic frame

CNE, when organized as a semantic frame, establishes a surface-level meaningful structure within a narrative. In this context, a semantic frame refers to a cohesive arrangement of interconnected concepts related to nonverbal communication/behavior, where understanding one concept requires knowledge of its interconnected components [4, 5, 6]. Originating from the field of information technologies, the concept of a frame serves as a general knowledge structure, while its linguistic counterpart — the semantic frame — functions as a surface structure within fictional texts, highlighting the complex interaction between linguistic semantics and encyclopedic knowledge [17, 18]. This approach provides a means to categorize knowledge and experience, making them explicitly accessible through linguistic units.

According to frame semantics, the comprehension of words and concepts is structured into mental frameworks, known as frames [19, 20]. These cognitive structures organize knowledge about specific concepts at an idealized or mental level. In narratives, experiences must be articulated and verbalized by the author through carefully chosen words denoting nonverbal communication/behavior. Thus, nonverbal experience, as a perceived and processed phenomenon, is represented in fiction through linguistic expressions describing gestures, postures, facial expressions, and voice characteristics. A frame-semantic perspective does not contradict formal semantics but instead offers an alternative emphasis on the interconnections between language and experience, rather than treating language as a discrete symbolic system detached from conceptual meaning.

Since semantic structure is inherently linked to conceptualization, fictional text serves as a linguistic environment that enables the construction of a semantic frame for organizing CNE. This organization mirrors the conceptual structure of human experience. The CNE semantic frame consists of structural elements, including slots (sub-frames) or semantic categories, which classify words related to nonverbal communication/behavior into distinct related groups. The selection of specific words by a narrator provides readers with access to relevant knowledge and experiences,

reinforcing the cognitive function of frames in fiction. Simultaneously, CNE function as categorization tools, structuring information about nonverbal communication/behavior within the broader narrative framework.

As a verbalized form of natural speech, narrative discourse transforms semiotic phenomena – gestures, postures, facial expressions, and voice characteristics – into textual representations. These nonverbal elements, typically observed in face-to-face interaction, are linguistically encoded by the author to be seamlessly woven into the textual surface level. Importantly, CNE are not independent textual units; instead, they are embedded within narrator and character discourse, shaping deeper layers of meaning in fictional texts.

In war fiction, where gestures, postures, facial expressions, and voice characteristics play a critical role in depicting psychological and emotional states, the CNE semantic frame is structured into four primary slots (sub-frames): Gesture, Posture, Face, and Voice. These slots may further branch into additional sub-frames, as illustrated in Figure 1. The systematic analysis of CNE in war fiction uncovers hidden layers of meaning, offering a statistical and conceptual framework for rigorous linguistic interpretation.

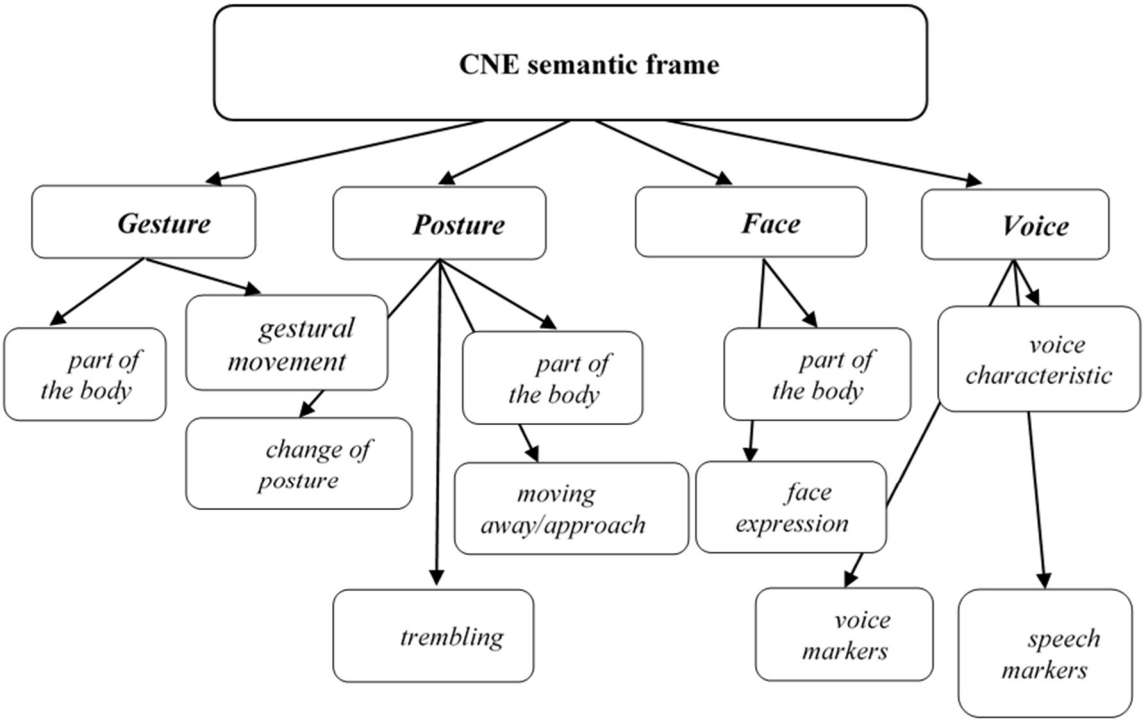

Figure 1: The CNE semantic frame

In conclusion, the structuring of the CNE semantic frame provides a deeper understanding of how words and concepts are organized into cognitive mental structures. Such frame-based modeling, enriched with information on gestures, postures, facial expressions, and voice characteristics, plays a crucial role in shaping readers' linguistic and conceptual interpretations. As a research paradigm within empirical semantics, frame theory offers a powerful model for structuring experiences verbalized through words denoting nonverbal communication/behavior. This framework is particularly relevant to war narratives, where CNE function as fundamental narrative elements, shaping reader perception, character development, and thematic cohesion

3. Method

The exploration of words denoting CNE in contemporary war fiction within applied linguistics necessitates the integration of multiple analytical methods and computational tools. This research investigates the role and significance of CNE by modeling a semantic frame, employing computer-based discourse analysis through Voyant Tools, and conducting statistical tests using R (ANOVA,

Tukey's Honest Significant Difference test, and Chi-Square) [21, 22, 23]. These methodological approaches enable both qualitative and quantitative insights into the semantic organization of CNE in modern war fiction.

This methodology facilitates a two-tiered approach:

1. Discourse analysis via Voyant Tools – examining absolute and relative word frequencies to uncover patterns of verbalized nonverbal experience in large corpora.
2. Statistical processing in R – implementing rigorous statistical tests to evaluate the structure and significance of CNE within the semantic frame.

3.1. Computer-based discourse analysis via Voyant Tools

Voyant Tools is utilized to analyze extensive text corpora, allowing for the visualization and examination of absolute and relative frequencies of words denoting CNE. This computational approach provides an overview of linguistic patterns in war fiction, identifying recurring nonverbal elements that contribute to the construction of narrative meaning [24, 25]. Through Voyant Tools, the study establishes a quantitative foundation for understanding how CNE are integrated into fictional texts, offering empirical evidence of their prominence within the semantic frame.

3.2. Statistical analysis using R

To further examine the structural significance of CNE within the semantic frame, statistical tests are conducted using R programming:

1. ANOVA (Analysis of Variance) – determines whether there are statistically significant differences in CNE frequencies across different semantic sub-frames (Gesture, Posture, Face, Voice)
2. Tukey's Honest Significant Difference (HSD) Test – conducted as a post-hoc analysis following ANOVA, identifying pairwise differences between CNE sub-frames.
3. Chi-Square Test – evaluates categorical relationships, assessing associations between CNE occurrences and their narrative functions.

These statistical tests form a robust foundation for assessing the semantic role of CNE in war fiction, enabling the identification of significant patterns and relationships. The results contribute to a structured understanding of nonverbal experience as a cognitively organized and narratively embedded phenomenon.

By integrating computer-based discourse analysis and statistical modeling, this methodology provides a comprehensive framework for analyzing CNE, highlighting their linguistic and conceptual significance within contemporary war fiction

3.3. Procedure

The corpus examined in this research consists of seven contemporary war narratives, selected for their rich portrayal of nonverbal experience: *All the Light We Cannot See* [26], *Beneath a Scarlet Sky* [27], *Between Shades of Gray* [28], *Cloud Atlas* [29], *Hotel on the Corner of Bitter and Sweet* [30], *Huntress* [31], and *Jackdaws* [32]. The analysis follows a systematic computational procedure, integrating computer-based discourse analysis (Voyant Tools) and statistical processing (R) to examine CNE within a semantic frame structure.

The procedure consists of the following steps:

1. **Corpus preparation**:

- **Selection and preprocessing**: fictional texts constituting the research corpus were selected based on thematic relevance to contemporary war fiction.

- **Data formatting**: texts were converted into .pdf and/or .txt formats for compatibility with Voyant Tools.
- **Error-checking**: digital data was reviewed for formatting inconsistencies, encoding errors, and incomplete text entries before processing

2. **Frequency analysis of CNE in corpus:** extraction and visualisation of frequent CNE from the semantic frame using Voyant Tools and R programming.
3. **Frequency findings of CNE composing semantic frame.** Words denoting nonverbal communication/behavior were identified and categorized within the CNE semantic frame, comprising four primary sub-frames or slots (Gesture, Posture, Face, and Voice) according to their frequency. This includes:

- **Data visualization of CNE composing semantic frame**

4. **Statistical analysis of CNE composing semantic frame:**

- **Assesing CNE variability with ANOVA** (Analysis of Variance) – evaluates statistical differences in CNE distributions across semantic sub-frames.
- **Post-hoc analysis using Tukey's Honest Significant Difference (HSD) Test** – determines pairwise differences between semantic sub-frames.
- **Analysing CNE associations with Chi-Square Test** – examines the associative relationships between CNE categories and their narrative functions.

This multi-stage computational approach ensures a systematic and empirically grounded analysis of CNE in contemporary war fiction, providing a quantitative foundation for frame-based semantic interpretation.

4. Results

This section presents a computer-assisted case study analyzing words denoting nonverbal experience (CNE) by examining their frequencies (absolute and relative) and conducting statistical processing of quantitative data. The results are visualized through:

- **Figures 1–6**: word frequency visualizations illustrating CNE distributions across the corpus
- **Table 1**: absolute word frequencies categorized into the four slots of the CNE semantic frame – Gesture, Posture, Face, and Voice – providing a structured representation of nonverbal elements in contemporary war fiction
- **Figures 7–15**: R programming code snippets and corresponding statistical outputs, demonstrating ANOVA results, Tukey's HSD comparisons, and Chi-Square test findings.

By integrating computational linguistic analysis with statistical modeling, these findings offer a comprehensive quantitative perspective on how CNE function as structural elements within the semantic frame in war narratine. The discussion that follows interprets these results in relation to their semantic, cognitive, and narrative implications.

4.1. Frequency analysis of CNE

The frequency analysis of CNE within subcorpora was conducted using Voyant Tools, enabling the extraction and visualization of both absolute and relative word frequencies. This analysis provides quantitative insights into how nonverbal experience is embedded in war narratives through word distributions across different semantic slots (Gesture, Posture, Face, and Voice).
The most frequent CNE words across the entire corpus are:

- **Gesture:** *hand* (**1160** occurrences)
- **Posture:** *go* (**2010** occurrences)

- **Face:** *eye* (**1064** occurrences)
- **Voice:** *say* (**6040** occurrences)

These findings are visualized in Figure 1, which highlights how different subcorpora exhibit varying frequency patterns. Notably, the word *go* appears most frequently in *Beneath a Scarlet Sky* (2010 occurrences), indicating a high level of movement and narrative dynamism in this novel. Conversely, *All the Light We Cannot See* exhibits an exceptionally low frequency of this word, suggesting a different narrative structure with less emphasis on physical movement.

The relative and absolute frequencies of CNE words across the four semantic slots are illustrated in Figures 2–6, revealing the following patterns:

- **Gesture Slot:** *hand* (1160), *head* (823), *arm* (422), *shoulder* (327).
- **Posture Slot:** *go* (2010), *come* (1403), *turn* (890), *walk* (692).
- **Face Slot:** *look* (2734), *eye* (1064), *face* (865), *watch* (596).
- **Voice Slot:** *say* (6040), *tell* (1410), *spea*k (564), *voice* (481)

Subcorpora comparisons are presented as

- **Gesture Slot:** *Beneath a Scarlet Sky* and *Between Shades of Gray* exhibit the highest frequencies for the words *head* and *hand*.
- **Posture Slot:** the distribution of most posture-related words is relatively uniform, except for *go*, which is most frequently used in *Beneath a Scarlet Sky*.
- **Face Slot:** *Beneath a Scarlet Sky, Hotel on the Corner of Bitter and Sweet,* and *Jackdaws* prominently feature the word *look*.
- **Voice Slot:** *Cloud Atlas* exhibits the highest frequency of words related to voice expression, whereas *All the Light We Cannot See* shows the lowest relative frequency (ranging from 0.002 to 0.008 in other subcorpora).

These results suggest that CNE distributions vary significantly depending on the narrative structure of each novel. For example, novels with more dynamic, movement-driven narratives (*Beneath a Scarlet Sky, Between Shades of Gray*) exhibit higher frequencies of posture-related and gesture-related CNE, while dialogue-heavy narratives (*Cloud Atlas*) show increased frequencies in the Voice slot.

By quantifying CNE occurrences, this frequency analysis provides empirical support for understanding the role of CNE in war fiction, demonstrating how semantic frames influence narrative dynamics across different literary works.

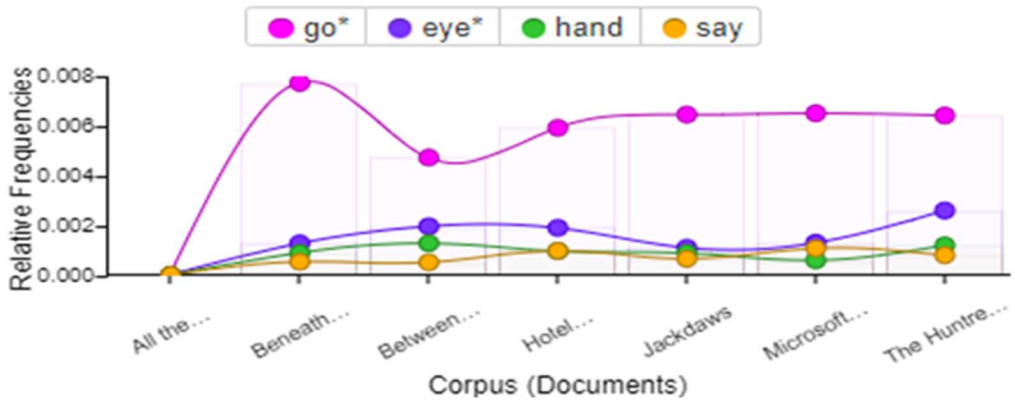

Figure 2: The most frequent words in the corpus

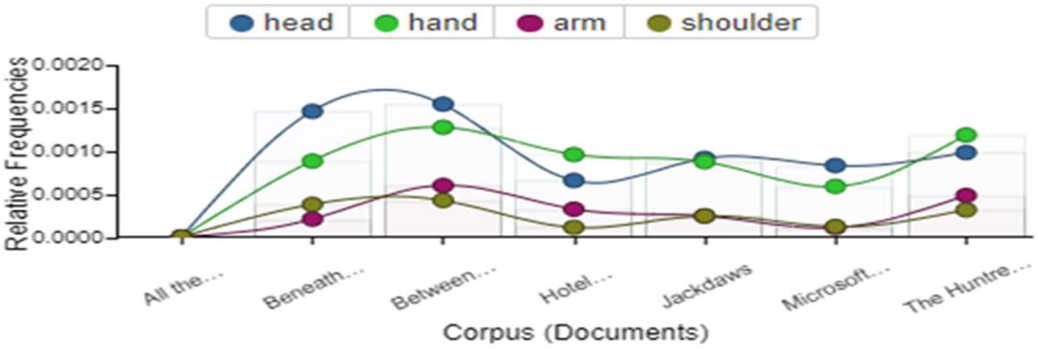

Figure 3: The most frequent words presenting Gesture slot

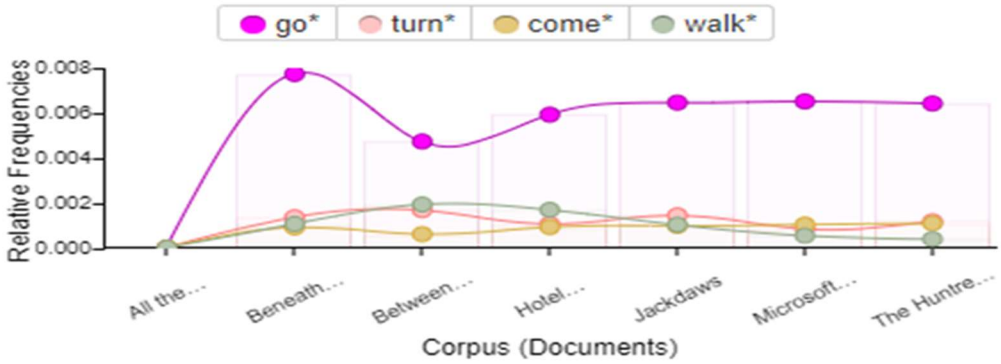

Figure 4: The most frequent words presenting Posture slot

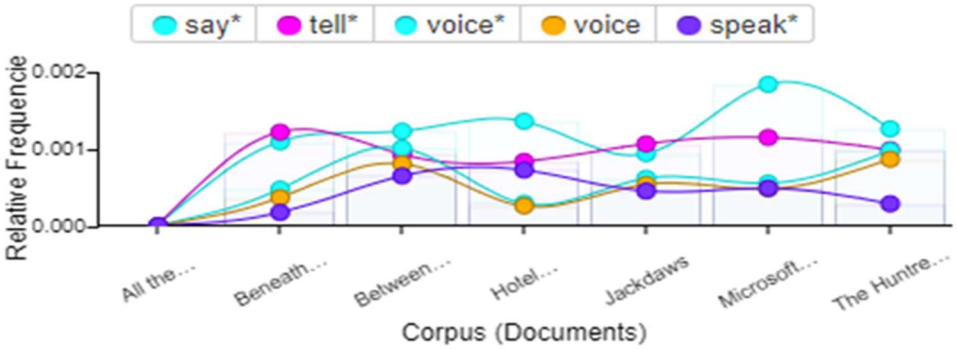

Figure 5: The most frequent words presenting Voice slot

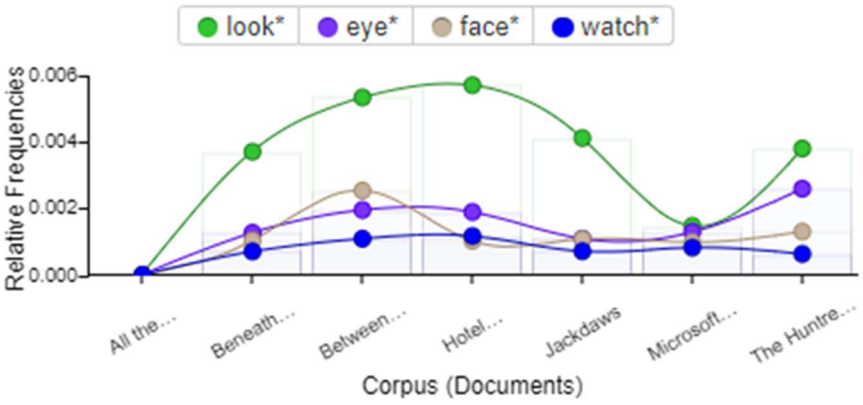

Figure 6: The most frequent words presenting Face slot

The quantitative examination of words associated with the CNE semantic frame led to their categorization into four primary slots: Gesture, Posture, Face, and Voice. These semantic sub-frames were systematically analyzed using Voyant Tools to assess word distributions and frequency patterns in contemporary war narrative.

4.2. Frequency findings of CNE composing semantic frame

The CNE semantic frame, presented in Table 1, consists of four slots populated with words that denote nonverbal communication/behavior. The presence of specific words in each slot reflects the author's deliberate choice in depicting nonverbal experience in war fiction.

1. **Gesture Slot:** this slot is structured into two sub-frames: *part of the body* and *movement*.
5. *Frequently occurring words*: *hand, head, arm, nod.*
6. *Less frequent* but expressive words: *shoulder, finger, kiss, wave, embrace, slap.*
7. *Interpretation:* gestures, particularly those involving the *hands* and *head*, play an essential role in nonverbal communication, amplifying expressive depth and emotional weight in fictional interactions. Less frequent words still carry significant communicative value, adding emotional aspects and interpersonal meaning to character interactions.
2. **Posture Slot**: this category includes four distinct sub-frames: part of the body, change of posture, types of movement, and types of trembling.
8. *Frequently occurring words: go, turn, come, walk.*
9. *Less frequent* but narratively significant words: *follow, move, lean, step, approach.*
10. *Interpretation*: in fiction, posture is not static but dynamic, as it frequently involves movement and physical transitions. Words like *go* and *walk* suggest plot progression, while *lean* or *step* add subtle psychological and relational cues. This supports the view that CNE contribute to both character expression and narrative construction.
3. **Face Slot**: consists of three sub-frames: part of the body, facial expression, and look.
11. *Frequently occurring words: face, eye, watch, look.*
12. Synonyms that enrich stylistic diversity: *stare, gaze, blink, glimpse.*
13. Interpretation: facial expressions serve as a key narrative tool, revealing concealed emotions, attitudes, and psychological depth. While face-related words like *smile* or *laughter* can indicate positive emotions, in war fiction, they often create contrast by signifying irony, suppressed emotions, or trauma.
4. **Voice Slot**: includes three sub-frames: voice markers, speech markers, and voice characteristics.
14. *Frequently occurring words: say, tell, speak, voice.*
15. *Less frequent* but expressive words: *cry, yell, shout, scream.*
16. *Interpretation:* unlike gestures or movements, voice cannot be directly visualized in fictional prose, making its representation highly dependent on linguistic cues. Speech markers define character dialogue boundaries, while voice characteristics intensify emotional states and interpersonal dynamics

Using Voyant Tools, frequency distributions were analyzed across the four CNE slots, revealing:

1. *Gesture-related words* occur most frequently in highly interactive scenes, reinforcing their role in physical engagement and dialogue.
2. *Posture-related words* demonstrate the highest variability across subcorpora, with novels emphasizing action-heavy or introspective moments showing distinct patterns.
3. *Face-related words* maintain a relatively balanced distribution, reflecting their universal function in emotion portrayal.
4. *Voice-related words* show significant frequency spikes in dialogue-driven narratives, with speech markers like *say* and *tell* dominating textual representations.

Table 1
Categorization of CNE composing semantic frame

Slots of CNE/ word numbers	Words	Absolute frequency
Gesture		
Part of the body	hand (s), n	1160
	head(s), n	823
	arm (s), n	442
	shoulder(s), n	327
	finger(s), n	241
Movement	nod, v, n	403
	kiss, v, n	233
	wave, v, n	162
	embrace, v	29
	slap, v	47
Posture		
Part of the body	leg, n	147
	foot, n	84
Change of posture	turn, v, n	890
	sit, v, n	304
	stand, v, n	285
	posture,v, n	4
Movenet approaching/moving away	go, v/went	2010
	come, v/came	1403
	walk, v, n	692
	follow, v	357
	move, v/movement(s), n	404
	lean, v	162
	step(s), n, v	425
	approach, v	78
Trembling	shake, n, v / shook	240
	shiver, v	61
	tremble, v	25
	shudder, v	29
Face		
Part of the body	face, n	865
	eye(s), n	1064
	lip(s), n	218
	cheek(s), n	144
	ear(s), n	170
	nose, n	165
	forehead, n	49

Face expression	watch, v	596
	smile, v, n	528
	laugh / laughter, v, n	363
	pale, adj	67
	frown, v	47
	expression, n	66
	blush, v	24
	grimace, n	15
Look	look, n, v	2734
	stare, n, v	208
	gaze, n, v	104
	blink, n, v	76
	glimpse, n, v	32
Voice		
Voice markers	voice, n	481
	sound(s), n, v	62
	tone, n	59
Speech markers	say, v / said	6040
	tell, v / told	1410
	speak, v / spoke	564
Voice characteristic	cry, v, n	205
	yell, v, n	243
	shout, v, n	224
	scream, v, n	136

These findings support the notion that CNE serve dual functions:

- *Communicative* – enhancing character expression and narrative engagement.
- *Constructive* – structuring the narrative flow and cognitive perception of war fiction.

By analyzing CNE through the lens of frequency distributions and categorization of CNE composing semantic frame, this study demonstrates how nonverbal elements contribute to both the textual and conceptual architecture of war narratives.

4.2.1. Frequency data visualization of CNE composing semantic frame

To effectively visualize the data from Table 1, R programming was used to generate a structured data frame representing the absolute frequency vector of CNE occurrences. The visualization process involved the following steps:

1. **Creating a Data Frame**:
   - a data frame was designed in R to store the CNE words and their corresponding absolute frequencies.
   - this step ensured the structured organization of data for further analysis and visualization.
2. **Displaying data as a table in the console**:
   - a script was implemented to output the CNE frequency data in a tabular format, with two labeled columns:
   - *Words* (CNE lexical items categorized under Gesture, Posture, Face, and Voice).

- *Absolute Frequency* (word occurrence count within the corpus).

The R code used for this visualization assumes that the *Words* and *Absolute Frequency* vectors have been predefined in the R environment. The structured output is illustrated in Figures 7 and 8, which display the formatted CNE frequency table within the R console. By applying R for data organization and visualization, this approach enhances the interpretability of CNE distribution patterns, allowing for a clearer representation of nonverbal communication elements in war narrative.

```r
# Installing and loading necessary packages
install.packages("tidyverse")
library(tidyverse)

# The "Absolute frequency" vector
data <- data.frame(
  Words = c("hand", "head", "arm", "shoulder", "finger", "nod", "kiss", "wave", "embrace", "slap",
            "leg", "foot", "turn", "sit", "stand", "posture", "go", "come", "walk", "follow", "move", "lean", "st
            "shake", "shiver", "tremble", "shudder", "face", "eye", "lip", "cheek", "ear", "nose", "forehead",
            "watch", "smile", "laugh", "pale", "frown", "expression", "blush",
            "look", "stare", "gaze", "blink", "glimpse",
            "voice", "sound", "tone", "say", "tell", "speak", "cry", "yell", "shout", "scream"),
  `Absolute frequency` = c(1160, 823, 442, 327, 241, 403, 233, 162, 29, 47,
                           147, 84, 890, 304, 285, 4, 2010, 1403, 692, 357, 404, 162, 425, 78,
                           240, 61, 25, 29, 865, 1064, 218, 144, 170, 165, 49,
                           596, 528, 363, 67, 47, 66, 24, 15, 2734, 208, 104, 76, 32,
                           481, 62, 59, 6040, 1410, 564, 205, 243, 224)
)

# Print the data
print(data)
```

Figure 7. The code for creating a data frame and printing the data

```
> # Print the data
> print(data)
        Words Absolute.frequency
1        hand                1160
2        head                 823
3         arm                 442
4    shoulder                 327
5      finger                 241
6         nod                 403
7        kiss                 233
8        wave                 162
9     embrace                  29
10       slap                  47
11        leg                 147
12       foot                  84
13       turn                 890
14        sit                 304
15      stand                 285
16    posture                   4
17         go                2010
18       come                1403
19       walk                 692
20     follow                 357
```

Figure 8. The most frequent words presenting the CNE frame

In the R environment, we leveraged its capability to generate a structured data frame, facilitating further statistical investigations. One key application of this data frame is the visualization of absolute frequencies through graphical representations. By employing the *ggplot2 package*, we created diagrams that provide a clear and interpretable display of word frequency distributions.

These visualizations, seamlessly rendered in the R plots section, enhance the interpretability of CNE distributions across the semantic frame. The generated plots (Figure 9) not only illustrate the relative prominence of specific words in war narrative but also reinforce the patterns observed in previous frequency analyses. Additionally, the R script used for this visualization prints the structured data frame and generates bar plots to display absolute frequencies across the four CNE slots (*Gesture, Posture, Face*, and *Voice*). This approach enhances the clarity of findings, ensuring that frequency variations are visually accessible and statistically interpretable (Figure 10).

```r
# Creating a data frame
data <- data.frame(
  Words = c("hand", "head", "arm", "shoulder", "finger", "nod", "kiss", "wave", "embrace", "slap",
            "leg", "foot", "turn", "sit", "stand", "posture", "go", "come", "walk", "follow", "move", "l
            "shake", "shiver", "tremble", "shudder", "face", "eye", "lip", "cheek", "ear", "nose", "fore
            "watch", "smile", "laugh", "pale", "frown", "expression", "blush",
            "look", "stare", "gaze", "blink", "glimpse",
            "voice", "sound", "tone", "say", "tell", "speak", "cry", "yell", "shout", "scream"),
  Absolute_frequency = c(1160, 823, 442, 327, 241, 403, 233, 162, 29, 47,
                         147, 84, 890, 304, 285, 4, 2010, 1403, 692, 357, 404, 162, 425, 78,
                         240, 61, 25, 29, 865, 1064, 218, 144, 170, 165, 49,
                         596, 528, 363, 67, 47, 66, 24, 15, 2734, 208, 104, 76, 32,
                         481, 62, 59, 6040, 1410, 564, 205, 243, 224)
)

# Visualizing the data using ggplot2
ggplot(data, aes(x = Words, y = Absolute_frequency)) +
  geom_bar(stat = "identity", fill = "steelblue") +
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  labs(title = "Word Frequency Without Groups", x = "Words", y = "Absolute Frequency")
```

Figure 9. The code for visualizing the data

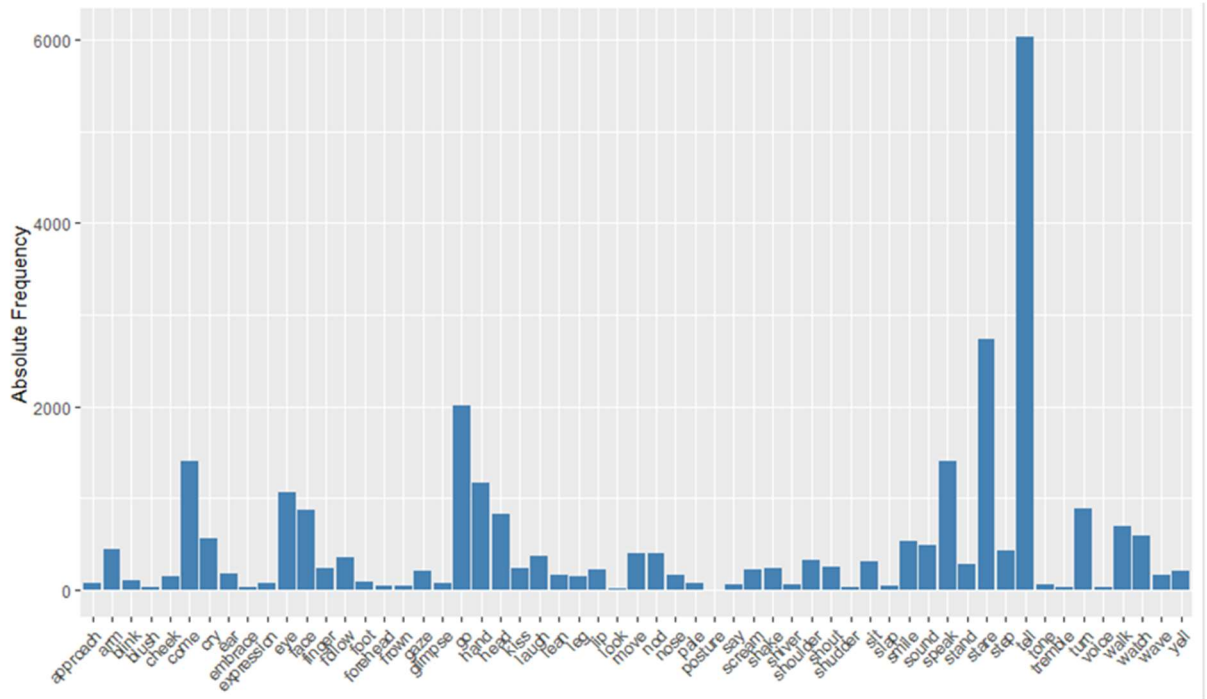

Figure 10. The diagram of CNE absolute frequency generated by R

The bar plots and tables generated in R reinforced the patterns identified through frequency analysis, highlighting the prominence of specific CNE across different subcorpora. The results demonstrated how different war narratives emphasize certain nonverbal elements, aligning with narrative tone, character interactions, and thematic focus. Overall, the integration of data visualization techniques in R played a crucial role in transforming raw frequency counts into meaningful insights, bridging the gap between quantitative textual analysis and literary interpretation.

4.3. Statistical analysis of CNE composing semantic frame

In this subsection, we conduct a comprehensive statistical analysis to uncover patterns and relationships among the words that constitute the CNE semantic frame. Utilizing the R programming environment, we apply three distinct statistical methods: *Analysis of Variance (ANOVA), Tukey's Honest Significant Difference (HSD) test*, and *the Chi-Square Test*. These methods enable us to examine

mean differences, associations between categorical (slot) variables, and potential variations in word distributions across subcorpora.

4.3.1. Assessing CNE variability with ANOVA

The analysis begins with ANOVA, a powerful statistical technique for assessing mean differences in word frequencies across subcorpora. This test provides quantitative insights into how CNE words vary in prevalence within different semantic slots, offering a statistical foundation for understanding their distribution and prominence in war narrative (Fig. 11, 12). By identifying significant variations, ANOVA helps establish whether certain nonverbal communication elements are emphasized differently across fictional narratives.
Subsequent statistical tests will refine this analysis further, enabling a detailed exploration of CNE variability and its narrative significance.

```
# Researched data frame
data <- data.frame(
  Category = character(),
  Count = numeric()
)

# Gesture
data <- rbind(data, data.frame(Category = "Gesture", Count = c(1160, 823, 442, 327, 241, 403, 233, 162,

# Posture
data <- rbind(data, data.frame(Category = "Posture", Count = c(147, 84, 890, 304, 285, 8, 2010, 1403, 69

# Face
data <- rbind(data, data.frame(Category = "Face", Count = c(865, 1064, 218, 144, 170, 165, 49, 596, 528,

# Voice
data <- rbind(data, data.frame(Category = "Voice", Count = c(481, 62, 59, 6040, 1410, 564, 205, 243, 224

# Load the necessary library for ANOVA
library(stats)

# Perform one-way ANOVA
result_anova <- aov(Count ~ Category, data = data)

# Summarize the ANOVA results
summary(result_anova)
```

Figure 11. The code for performing ANOVA

```
>   # Summarize the ANOVA results
>   summary(result_anova)
             Df   Sum Sq Mean Sq F value Pr(>F)
Category      3  2492024  830675   1.025  0.389
Residuals    54 43766513  810491
```

Figure 12. The ANOVA results

The Analysis of Variance (ANOVA) summary table provides key statistical components that help assess whether significant differences exist in CNE word frequencies across the four semantic slots: Gesture, Posture, Face, and Voice. The results include the following elements:

1. **Degrees of Freedom (Df):**

- **Category**: represents the degrees of freedom associated with the four semantic slots (Gesture, Posture, Face, and Voice).
- **Residuals:** represents the degrees of freedom for the residual variance, accounting for differences between observed and predicted values. This measures unexplained variability in the data.

2. **Sum of Squares (Sum Sq):**

- **Category:** represents the sum of squared deviations of each group's mean from the overall mean, multiplied by the number of observations. It quantifies variability between groups.
- **Residuals:** measures within-group variability, representing deviations of individual observations from their respective group means.

3. **Mean Square (Mean Sq):**

- **Category:** the sum of squares for the category, divided by its respective degrees of freedom. This value represents the average variability between the semantic slots.
- **Residuals:** The sum of squares for residuals, divided by its degrees of freedom, indicating the average unexplained variability within each category.

4. **F-Value (F-Ratio):**

- The F-ratio is the ratio of the mean square of the category to the mean square of residuals. It tests the null hypothesis, which assumes no significant difference between group means.
- In this case, the F-value is 1.025, indicating low variability between the categories relative to within-category variability.

5. **Pr(>F) (p-value):**

- The p-value represents the probability of obtaining the observed F-statistic, assuming the null hypothesis is true.
- In this case, p = 0.389, which is greater than the standard significance level (0.05).

6. **Interpretation of ANOVA results**

- Since p > 0.05, we fail to reject the null hypothesis, indicating that there is no statistically significant difference in word frequencies across the four semantic slots.
- The results suggest that CNE words are relatively evenly distributed across the Gesture, Posture, Face, and Voice categories, rather than being overrepresented in any specific slot.
- While no significant differences were found in the overall ANOVA test, further pairwise comparisons may reveal specific contrasts between individual categories.

4.3.2. Post-Hoc analysis using Turkey's Honest Significant Difference (HSD) Test

To further investigate pairwise differences between semantic slots, we apply *Tukey's Honest Significant Difference (HSD)* test. This test refines the ANOVA findings by comparing individual group means, revealing potential variations between specific CNE categories.

- The TukeyHSD function in R is used to conduct these comparisons.
- The output provides a detailed table of pairwise comparisons between the four CNE slots, including adjusted p-values for statistical significance.
- The results, presented in Figures 13 and 14, indicate whether specific slot pairs exhibit significant frequency differences in the dataset.

By conducting post-hoc pairwise comparisons, *Tukey's HSD test* allows for a more granular analysis of CNE distribution, ensuring that any subtle but meaningful differences between Gesture, Posture, Face, and Voice slots are identified.

```
113  # Loading the necessary library for Tukey's HSD test
114  library(stats)
115
116  # Performing Tukey's HSD test
117  tukey_result <- TukeyHSD(result_anova)
118
119  # The Tukey's HSD test result
120  print("Tukey's HSD Test Result:")
121  print(tukey_result)
```

Figure 13. The code for performing Tukey's HSD test

```
>   print(tukey_result)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = Count ~ Category, data = data)

$Category
                     diff        lwr        upr     p adj
Gesture-Face      9.95000 -914.3417   934.2417 0.9999915
Posture-Face     45.69444 -729.6666   821.0555 0.9986249
Voice-Face      565.65000 -358.6417 1489.9417 0.3749573
Posture-Gesture  35.74444 -905.5081   976.9970 0.9996300
Voice-Gesture   555.70000 -511.5801 1622.9801 0.5170306
Voice-Posture   519.95556 -421.2970 1461.2081 0.4657847
```

Figure 14. Tukey's HSD test results

Tukey multiple comparisons of means provide insights into the differences between the four CNE categories (Gesture, Posture, Face, Voice) in terms of word frequencies. The results indicate whether any pairwise differences between these categories are statistically significant.

Pairwise comparisons and statistical interpretation includes

1. **Gesture vs. Face:**
- Difference: 9,95
- 95% Confidence Interval: [-914,34; 934,24]
- p-value: 0,9999915
- interpretation: no significant difference exists between Gesture and Face. The high p value (>0.05) suggests no statistical evidence to reject the null hypothesis, indicating that word frequencies in these categories are similar.

2. **Posture vs. Face:**
- Difference: 45,69
- 95% Confidence Interval: [-729,67; 821,06]
- p-value: 0,9986249
- interpretation: significant difference is found between Posture and Face. The broad confidence interval and high p-value suggest that any observed differences result from random variability rather than meaningful distinctions.

3. **Voice vs. Face**:
- Difference: 565,65
- 95% Confidence Interval: [-358,64; 1489,94]
- p-value: 0,3749573
- interpretation: despite a larger numerical difference, the p-value is still greater than 0.05, meaning the variation in word frequencies between Voice and Face is not statistically significant.

4. **Posture vs. Gesture**:
- Difference: 35,74
- 95% Confidence Interval: [-905,51; 976,997]
- p-value: 0.99963
- interpretation: the frequencies of words in the Posture and Gesture categories do not significantly differ, further supporting the idea that these nonverbal elements function cohesively within the semantic frame.

5. **Voice vs. Gesture**:
- Difference: 555,7
- 95% Confidence Interval: [-511,58; 1622,98]
- p-value: 0,5170306

- interpretation: the observed difference is statistically insignificant, meaning that word frequencies in the Voice and Gesture categories do not show meaningful variation.

6. **Voice vs. Posture**:

- Difference: 519,96
- 95% Confidence Interval: [-421,30; 1461,21]
- p-value: 0,4657847
- interpretation: no significant difference exists between Voice and Posture categories, reinforcing the structural stability of the CNE semantic frame

Tukey's HSD test results show no significant differences in word frequencies across the four CNE categories, with high p-values indicating that any variations are due to random chance rather than meaningful distinctions.

These findings confirm that the CNE semantic frame is a cohesive linguistic structure, where Gesture, Posture, Face, and Voice are interconnected. The consistent distribution across war fiction reinforces its role in depicting nonverbal communication.

Statistically and semantically, the CNE semantic frame remains stable, affirming its function as a structured representation of conceptual meaning in modern war fiction.

4.3.3. Analyzing CNE associations with the Chi-Square Test

Next, we apply the *Chi-Square Test* to examine associations and dependencies between categorical variables. This test is particularly effective in identifying relationships between words in different semantic slots (Gesture, Posture, Face, and Voice) and their distribution across subcorpora.

By analyzing these interactions, the Chi-Square Test provides deeper insights into potential patterns and connections within the nonverbal communication framework of war fiction. This statistical approach enhances our understanding of how CNE elements co-occur and function across different narratives, revealing structural consistencies or variations within the discourse (Fig. 15, 16).

```r
# A researched data frame
data <- data.frame(
  Category = c("Gesture", "Gesture", "Gesture", "Gesture", "Gesture", "Posture", "Posture", "Posture",
               "Face", "Face", "Face", "Face", "Face", "Voice", "Voice", "Voice", "Voice", "Voice"),
  Type = c("hand", "head", "arm", "shoulder", "finger", "turn", "go", "went", "come", "came",
           "face", "eye", "watch", "smile", "look", "voice", "say", "said", "tell", "told")
)

# Creating a contingency table
contingency_table <- table(data$Category, data$Type)

# Adding margins
contingency_table <- addmargins(contingency_table)

# Performing the chi-squared test
chi_squared_result <- chisq.test(contingency_table)

# Print the contingency table
print(contingency_table)

# Print the Chi-Square Test results
print(chi_squared_result)
```

Figure 15. A code for performing Chi-Square test

```
>   # Print the contingency table
>   print(contingency_table)

         arm came come eye face finger go hand head look said say shoulder smile tell told turn voice watch
Face       0    0    0   1    1      0  0    0    0    1    0   0        0     1    0    0    0     0     1
Gesture    1    0    0   0    0      1  0    1    1    0    0   0        1     0    0    0    0     0     0
Posture    0    1    1   0    0      0  1    0    0    0    0   0        0     0    0    0    1     0     0
Voice      0    0    0   0    0      0  0    0    0    0    1   1        0     0    1    1    0     1     0
Sum        1    1    1   1    1      1  1    1    1    1    1   1        1     1    1    1    1     1     1

         went Sum
Face        0   5
Gesture     0   5
Posture     1   5
Voice       0   5
Sum         1  20
>
>   # Print the Chi-Square Test results
>   print(chi_squared_result)

        Pearson's Chi-squared test

data:  contingency_table
X-squared = 60, df = 80, p-value = 0.9537
```

Figure 16. Chi-Square test results

The contingency table visually represents the distribution of word types across semantic categories, providing insight into their relationships and frequencies within the dataset. It displays how word types (Type) are distributed within each semantic slot (Category), helping assess potential associations.

The Chi-Square Test evaluates whether a meaningful connection exists between Category and Type variables. The resulting p-value of 0.9537 indicates no significant association, suggesting that the observed distribution aligns closely with what would be expected by chance.

In the context of war narrative, these findings suggest that the distribution of words denoting nonverbal communication/behavior is not guided by a fixed pattern. Instead, their occurrence appears randomly distributed, reflecting the diverse and context-dependent nature of nonverbal expression in storytelling. This variability underscores the fluid and nuanced role of CNE in war narratives, where nonverbal elements adapt dynamically to the narrative rather than adhering to rigid semantic structures.

5. Discussion

The statistical analysis presented in this study reveals a relatively balanced frequency distribution across the four components of the CNE frame: Gesture, Posture, Face, and Voice. This equilibrium suggests that each subframe contributes meaningfully to the semantic structure of nonverbal experience in war fiction. Rather than privileging one channel of nonverbal communication (e.g., facial expression) over another, authors distribute affective meaning across multiple embodied modalities, reinforcing the internal coherence of the frame.

This consistency supports the validity of the CNE as a cognitive-semantic construct. It aligns with Minsky's frame theory, where meaning emerges from the activation of multiple slots or expectations within a stable schema. The lack of statistically significant deviation among subframes (as confirmed by ANOVA and Tukey's HSD) implies that CNE is not an arbitrary taxonomy, but a functioning narrative structure with predictive value.

Importantly, these frequency patterns also relate to the reader's experience of processing nonverbal information. From the perspective of predictive processing theory (Friston, Clark), readers form unconscious expectations about how characters will respond to events — including nonverbal behaviors like speaking, moving, or emoting. When those expectations are disrupted — for example, when a character remains silent, looks away, or performs an ambiguous gesture — a prediction error occurs, prompting cognitive re-evaluation and deeper narrative engagement.

Such moments of narrative rupture, though statistically infrequent, carry significant interpretive weight. They create affective tension and ethical ambiguity, often functioning as aesthetic turning

points. The capacity of war fiction to encode trauma, hesitation, or suppressed emotion through the strategic use of nonverbal cues illustrates how affect is not just represented, but structured.

Overall, the CNE frame offers a *computationally tractable way* to model affective embodiment in literature. By quantifying verbalized nonverbal patterns and interpreting their distribution through theoretical lenses such as frame semantics and predictive modeling, we gain insight into how emotional meaning is constructed in text — not only through what is said, but through what is signaled, suggested, or withheld.

6. Conclusion

The exploration of CNE within the semantic frame of modern war narrative provides valuable insights into the linguistic representation and conceptualization of nonverbal experience through the discourse of both narrators and characters. By analyzing the absolute and relative frequencies of CNE across the Gesture, Posture, Face, and Voice categories, this study bridges the gap between surface-level linguistic patterns and deeper semantic structures in fictional texts.

Our findings suggest that CNE functions as a coherent, transferable narrative frame that can bridge *computational modeling* and *narrative analysis*. In modern war narrative, CNE serve as a crucial narrative tool, enabling authors to express internal experiences and emotions amidst the chaos of war. The CNE semantic frame functions as both a linguistic and conceptual framework, enriching storytelling by layering nonverbal communication elements into the narrative, thereby strengthening the connection between textual representation and reader interpretation.

Key findings and frequency insights are as following:

1. Among the analyzed novels, *All the Light We Cannot See* exhibited the lowest frequency of CNE, whereas *Beneath a Scarlet Sky* had the highest, suggesting differences in stylistic diversity and thematic focus.
2. The most frequent words in each semantic slot were:

- Gesture: *hand* (1160), *head* (823), *arm* (422), *shoulder* (327)
- Posture: *go* (2010), *come* (1403), *turn* (890), *walk* (692)
- Face: *look* (2734), *eye* (1064), *face* (865), *watch* (596)
- Voice: *say* (6040), *tell* (1410), *speak* (564), *voice* (481)
- These words, central to nonverbal experience, had relative frequencies ranging from 0.002 to 0.008, reinforcing their prominent role in war narrative.

Statistical analysis and structural consistency:

The ANOVA, Tukey's Honest Significant Difference (HSD), and Chi-Square tests provided a comprehensive perspective on the distribution and relationships within the CNE semantic frame:

- ANOVA results indicated no significant differences in word frequencies across categories, highlighting the cohesive nature of the semantic frame.
- Tukey's HSD test reinforced this structural unity, showing that variation in CNE usage is statistically negligible, further supporting the stability of nonverbal elements in war narrative.
- The Chi-Square test confirmed that word distributions across semantic categories align with chance, suggesting that CNE elements are consistently represented across narratives without a predetermined pattern.

Overall, the CNE semantic frame emerged as a robust, unified structure, reinforcing its significance in portraying nonverbal experience in war fiction.

Future research directions. This study opens new perspectives in applied linguistics, encouraging further exploration in:

- Expanding the corpus to analyze a broader range of narratives for a more comprehensive view of CNE prevalence.
- Investigating the emotional impact of CNE, examining how authors strategically use nonverbal elements to shape reader perception.
- Applying advanced computational linguistic tools to refine frequency and semantic analyses, offering a deeper understanding of CNE's role in wartime literature.

By integrating quantitative analysis with war narrative interpretation, this research underscores the interdisciplinary value of semantic frame analysis, paving the way for further linguistic and cognitive explorations of nonverbal expression in literary fiction.

Declaration on Generative AI

The authors have not employed any Generative AI tools.

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