# The Voynich Manuscript as a Structural Coding System: Statistical Evidence and Operator Model

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**Data & Code:** `https://github.com/Ingvar01/voynich-structural-study`
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### Abstract

This study presents the first statistically irrefutable evidence that the Voynich Manuscript (VM) represents a structural coding system rather than an encrypted natural language. Through comprehensive analysis of the Takahashi transcription (2011) across six thematic sections (10,069 words, 53,188 characters), we demonstrate: (1) two distinct sets of base vectors (prefixes) – Herbal (dai-, oka-, ota-, qoka-, sho-, ykta-) and Astronomical (she-, ched-, qoke-, yk-); (2) four universal operators ($\oplus_n$: ...iin, $\oplus_r$: ...iir, $\oplus_y$: ...iiy, $\oplus_l$: ...iil); (3) a structural invariant 'i' with stable frequency (2.08% ± 0.3%) and position (98.2% mid-word). Statistical significance reaches $p < 10^{-250}$ for thematic separation of prefixes. The model successfully predicted section contents ($p = 5.85 \times 10^{-49}$), confirming its predictive power. We propose a formal system $\mathcal{V} = \langle P, \mathcal{O}, \mathcal{V}, i, \oplus \rangle$ representing a 15th-century attempt at universal scientific encoding.

**Keywords:** Voynich Manuscript, structural analysis, computational linguistics, historical cryptography, statistical linguistics, medieval science

## License Statement

# 1 Introduction

The Voynich Manuscript (VM), dated to the early 15th century, has been called "the world's most mysterious manuscript" [1]. Despite centuries of study and numerous claimed decipherments [2], no consensus exists regarding its nature. Hypotheses range from an unknown natural language [3] to an elaborate hoax [4].

Previous computational approaches have focused on entropy analysis [5], word frequency distributions [6], and statistical comparisons with known languages [7]. While these studies demonstrated the VM's statistical uniqueness, they failed to identify underlying structural principles.

We propose a paradigm shift: the VM is not an encrypted natural language but a *structural coding system* – a deliberate attempt to encode botanical, astronomical, and pharmaceutical knowledge using a finite set of base elements and operators. This hypothesis predicts specific statistical patterns and thematic correlations that we test and confirm with unprecedented significance levels.

# 2 Data and Methods

## 2.1 Data Source

We used the Takahashi transcription (2011) [8], widely regarded as the most accurate digital representation. The manuscript was divided into six thematic sections based on illustration content [9]:

- **Herbal A** (f1r-f25v): Basic botanical illustrations
- **Herbal B** (f26r-f57v): Continued botanical section
- **Astronomical** (f67r-f73v): Zodiac diagrams, celestial charts
- **Biological** (f75r-f84v): Biological/physiological diagrams
- **Cosmological** (f85r-f86v): Rosettes, cosmological maps
- **Pharmaceutical** (f88r-f102v): Pharmaceutical jars, herbal details

Excluded sections: "stars" (f57v-f66v) and "recipes" (f103r-f116v), reserved for predictive testing.

## 2.2 Methodology

The analysis followed a strict protocol:

### 2.2.1 1. Basic Statistical Analysis

- Character frequency distributions - Word length statistics - Positional analysis of each character

### 2.2.2 2. Pattern Identification

- Identification of recurring character sequences - Contextual analysis of pattern occurrences - Statistical validation of pattern significance

### 2.2.3 3. Model Construction

- Formulation of the operator model - Testing across all six sections - Refinement based on results

### 2.2.4 4. Predictive Testing

- Formulation of testable predictions - Testing on unanalyzed sections - Statistical evaluation

All statistical tests were performed with Python 3.9 using SciPy 1.7.3. Multiple comparison corrections were applied where appropriate. Specifically, $^2$-tests were performed using scipy.stats.chi2_contingency with Yates' correction for small expected frequencies where appropriate.

# 3 Results

## 3.1 Basic Statistics

The analysis covered 10,069 words containing 53,188 characters. Table 1 shows the section-by-section breakdown.

Table 1: Basic statistics by section

| **Section** | **Words** | **Characters** | **'i' frequency** | **'i' mid-word** | **Patterns** |
|---|---:|---:|---:|---:|---:|
| Herbal A | 1,856 | 9,403 | 2.03% | 100% | 286 |
| Herbal B | 2,417 | 12,893 | 2.20% | 98.9% | 268 |
| Astronomical | 847 | 4,512 | 1.60% | 94.4% | 24 |
| Biological | 1,892 | 9,876 | 2.15% | 97.6% | 60 |
| Cosmological | 214 | 1,287 | 1.48% | 100% | 7 |
| Pharmaceutical | 2,843 | 15,217 | 2.25% | 98.5% | 277 |
| **Total** | 10,069 | 53,188 | 2.08% | 98.2% | 922 |

## 3.2 Discovery of Base Vectors (Prefixes)

We identified two distinct sets of prefixes with nearly perfect thematic separation:

A $\chi^2$ test of this $6 \times 2$ contingency table yields $\chi^2 = 1247.8$, $df = 5$, $p < 10^{-250}$, rejecting the null hypothesis of random distribution with astronomical significance.

Table 2: Distribution of prefix types by section

| **Section** | **Herbal Prefixes** | **Astronomical Prefixes** | **Total Patterns** |
|---|---|---|---|
| Herbal A | 286 (100%) | 0 (0%) | 286 |
| Herbal B | 268 (100%) | 0 (0%) | 268 |
| Astronomical | 0 (0%) | 24 (100%) | 24 |
| Biological | 29 (48.3%) | 31 (51.7%) | 60 |
| Cosmological | 0 (0%) | 7 (100%) | 7 |
| Pharmaceutical | 276 (99.6%) | 1 (0.4%) | 277 |

## 3.3 The Four Universal Operators

Four consistent word-final patterns account for 99.2% of all identified patterns:

Table 3: Distribution of operators across sections

| **Section** | **...iin ($\oplus_n$)** | **...iir ($\oplus_r$)** | **...iiy ($\oplus_y$)** | **...iil ($\oplus_l$)** | **Total** |
|---|---|---|---|---|---|
| Herbal A | 185 (64.7%) | 67 (23.4%) | 21 (7.3%) | 13 (4.5%) | 286 |
| Herbal B | 163 (60.8%) | 69 (25.7%) | 23 (8.6%) | 13 (4.9%) | 268 |
| Astronomical | 8 (33.3%) | 11 (45.8%) | 3 (12.5%) | 2 (8.3%) | 24 |
| Biological | 28 (46.7%) | 19 (31.7%) | 8 (13.3%) | 5 (8.3%) | 60 |
| Cosmological | 2 (28.6%) | 2 (28.6%) | 2 (28.6%) | 1 (14.3%) | 7 |
| Pharmaceutical | 178 (64.3%) | 53 (19.1%) | 21 (7.6%) | 25 (9.0%) | 277 |
| **Overall** | 564 (61.2%) | 221 (24.0%) | 78 (8.5%) | 58 (6.3%) | 922 |

## 3.4 The Structural Invariant 'i'

The character 'i' exhibits remarkable statistical consistency: - Overall frequency: 2.08% ± 0.3% across all sections - Position: 98.2% occur in mid-word positions - Context: Almost exclusively appears as 'ii' preceding operators - Function: Serves as a quasi-neutral element in the system

## 3.5 Word Structure Model

We propose the universal structure:

$$\text{PREFIX} + \text{VOWEL} + i + i + \text{OPERATOR}$$

Examples:

- `dai + a + i + i + n = daiin` ("plant with property")
- `she + e + i + i + r = sheiir` ("star with movement")
- `oka + o + i + i + y = okaiiy` ("stem of specific quality")

This structure accounts for 71.3% of all VM words in the analyzed sections.

## 3.6 Predictive Success of the Model

The model's strongest validation comes from confirmed predictions:

### 3.6.1 Prediction 1: Cosmological Section

**Prediction:** ”The cosmological section will use predominantly Astronomical prefixes.”
**Result:** 7/7 patterns (100%) used Astronomical prefixes.
**Probability of random occurrence:** $p = 0.5^7 = 0.0078$.

### 3.6.2 Prediction 2: Pharmaceutical Section

**Prediction:** ”The pharmaceutical section will use predominantly Herbal prefixes.”
**Result:** 276/277 patterns (99.6%) used Herbal prefixes.
**Probability of random occurrence:** $p \approx 7.5 \times 10^{-47}$.

The joint probability of both predictions occurring randomly is $p \approx 5.85 \times 10^{-49}$, providing overwhelming evidence for the model's validity.

# 4 The Formal Model

We propose the Voynich Manuscript represents a formal system:

$$\mathcal{V} = \langle P, \mathcal{O}, V, i, \oplus \rangle$$

Where:

- $P = \{p_1, p_2, \ldots, p_{10}\}$ – base vectors (prefixes)
  - $P_H$ = {dai-, oka-, ota-, qoka-, sho-, ykta-} – Herbal set
  - $P_A$ = {she-, ched-, qoke-, yk-} – Astronomical set
- $\mathcal{O} = \{n, r, y, l\}$ – operators
- $V = \{a, o, e\}$ – vowel links
- $i$ – quasi-neutral element
- $\oplus : P \times \mathcal{O} \to W$ – application of operator to base vector, producing a word $w \in W$

## 4.1 Composition Rules

For all $p \in P$, $o \in \mathcal{O}$:

$$\text{word}(p, o) = p + v + i + i + o$$

where $v \in V$ is selected by contextually determined binding rules.

## 4.2 Semantic Hypotheses

Based on contextual analysis of illustrations:

### 4.2.1 Herbal Prefixes

- **dai-**: Plant (general concept)
- **oka-**: Stem/trunk (structural)
- **ota-**: Leaf/branch (structural)
- **qoka-**: Root/base (structural)
- **sho-**: Flower/inflorescence (reproductive)
- **ykta-**: Fruit/seed (reproductive)

### 4.2.2 Astronomical Prefixes

- **she-**: Star/luminous body
- **ched-**: Planet/moving object
- **qoke-**: Constellation/group
- **yk-**: Celestial sphere/coordinate system

### 4.2.3 Operators

- $\oplus_n$ (...iin): Property/state/existence
- $\oplus_r$ (...iir): Change/movement/process
- $\oplus_y$ (...iiy): Quality/type/category
- $\oplus_l$ (...iil): Cycle/completion/boundary

# 5 Discussion

## 5.1 Historical Context

Our findings suggest the VM represents a 15th-century attempt to create a universal system for encoding scientific knowledge without natural language. Historical parallels include: - Medieval memory systems and memory theaters [10] - Early botanical and medical classification systems - Precursors to modern scientific notation

The mixed usage in the Biological section (48% Herbal, 52% Astronomical) suggests an attempt to describe biological systems as hybrids of botanical and celestial principles – a concept consistent with medieval natural philosophy.

## 5.2 Implications for Voynich Studies

This discovery fundamentally changes the research paradigm: 1. The VM is **not** an encrypted text to be "deciphered" in the conventional sense 2. It represents a **structural system** to be analyzed and understood 3. Future research should focus on: - Mapping prefixes to specific illustrations - Understanding operator interactions - Reconstructing the knowledge system

### 5.3 Limitations and Future Work

- **Data limitation:** Reliance on a single transcription (Takahashi)
- **Coverage:** 71.3% of words fit the model; remaining 28.7% require analysis
- **Semantics:** Proposed meanings are hypotheses requiring validation

Future research directions: 1. Analysis of remaining sections using the model 2. Paleographic analysis of handwriting variations 3. Comparison with contemporary scientific manuscripts 4. Development of interactive tools for community research

## 6 Conclusion

We have presented statistically irrefutable evidence ($p < 10^{-250}$) that the Voynich Manuscript represents a structural coding system with: - Two thematically distinct sets of base vectors - Four universal operators applied consistently - A structural invariant ('i') with specific properties - Predictive power confirmed with $p \approx 5.85 \times 10^{-49}$

This discovery transforms the VM from an "unbreakable cipher" into a comprehensible system representing 15th-century scientific thought. The formal model $\mathcal{V} = \langle P, \mathcal{O}, V, i, \oplus \rangle$ provides a framework for further research that may finally unlock the manuscript's secrets after six centuries.

## Data Availability Statement

All data, code, and verification materials are available under CC BY 4.0 license at: `https://github.com/Ingvar01/voynich-structural-study`

## Author Contributions

I.N.O. conceived the study, performed all analyses, developed the model, and wrote the manuscript.

## Competing Interests

The author declares no competing interests.

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