

Meaning in Motion: A Category-Theoretic Framework for Conceptual Topology

Written by No Name Yet Exist
Contact: Written Below

Introduction:

Natural language exhibits variability, ambiguity, and strong context-dependence, challenging formal semantic modeling. However, through the lens of category theory and Z-frame used in this theory, certain latent regularities emerge. We explore the idea that word meaning is not merely a function of proximity in embedding space, but a topological structure defined by morphic continuity over conceptual anchors, called Z-frames.

Content Note

This paper analyzes metaphorically charged vocabulary—including bodily and emotional imagery drawn from song lyrics—solely in terms of structural and semantic relationships.

In accordance with category theory, the focus is on morphic relationships and topological coherence, not object-level attributes or empirical interpretations.

king - man + woman = queen

Q

←

r

W

f

↓

K

→

M

↑

h

g

K = king

Q = queen

M = man

W = woman

g: Differential Morphism (King → Man)

h: Differential Morphism (Man → Woman)

r: Differential Morphism (Woman → Queen)

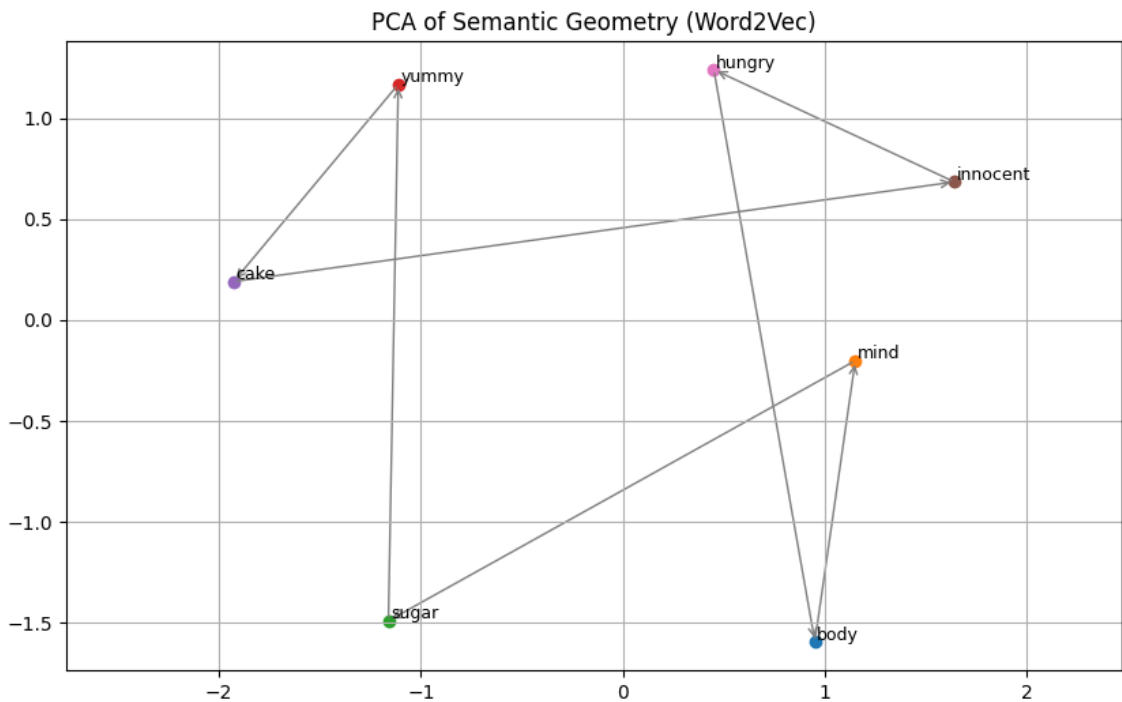
f: Composed Semantic Morphism $r \circ h \circ g$

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Semantic Projections and Topological Formalization

A principal component analysis (PCA) of embedding vectors corresponding to ["body", "mind", "sugar", "yummy", "cake", "innocent", "hungry"] reveals a triadic geometric structure anchored around the semantic attractor $Z = \text{sugar}$.

Figure 1. $Z = \text{sugar}$

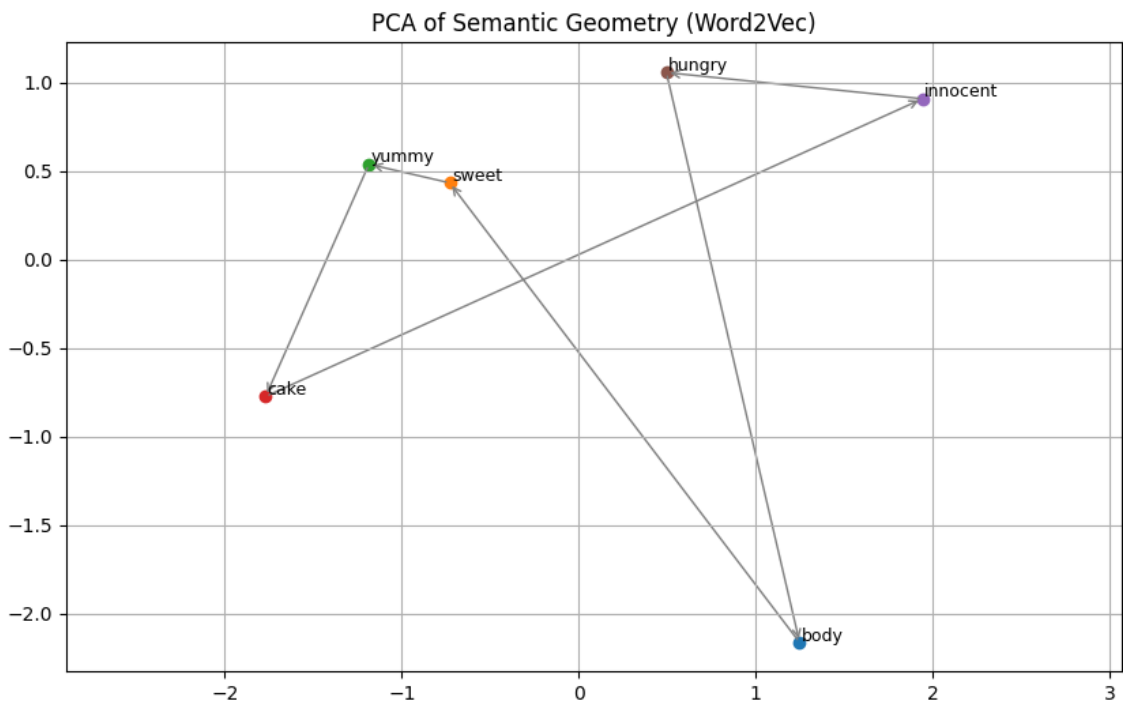


(Lexical data sourced from the song “Yummy” performed by INNA, 2023.)

This diagram reveals that clusters such as ["yummy", "cake"] and ["mind", "body"] emerge symmetrically around the semantic anchor sugar, forming a quasi-balanced configuration. Notably, "body" and "cake" align across opposing poles, indicating that the concept of sweetness ($Z = \text{sugar}$) functions as a mediating structure—bridging semantic crevasses while simultaneously inducing a communicative relation between otherwise distinct lexical domains.

Note: In colloquial English, “cake” often evokes connotations beyond dessert — frequently used as a symbol of bodily allure. Within our Z -frame (sugar), this metaphor is not accidental. Rather, “cake” and “body” form a morphic equivalence, mediated by sweetness, with semantic flows aligning across physical and cultural registers.

Figure 2. Z = body



(Lexical data sourced from the song “Yummy” performed by INNA, 2023.)

This reveals distinct lexical clusters symmetrically aligned over the semantic anchor *body*. The morphism Hungry → Sweet/Yummy | body (the symbol | indicates the Z-frame) can be interpreted as a desiring gaze projected onto a luscious body—an interpretation directly supported by the lyric line from INNA’s “Yummy”(2023): “Those hungry eyes / Tracing my body lines.”

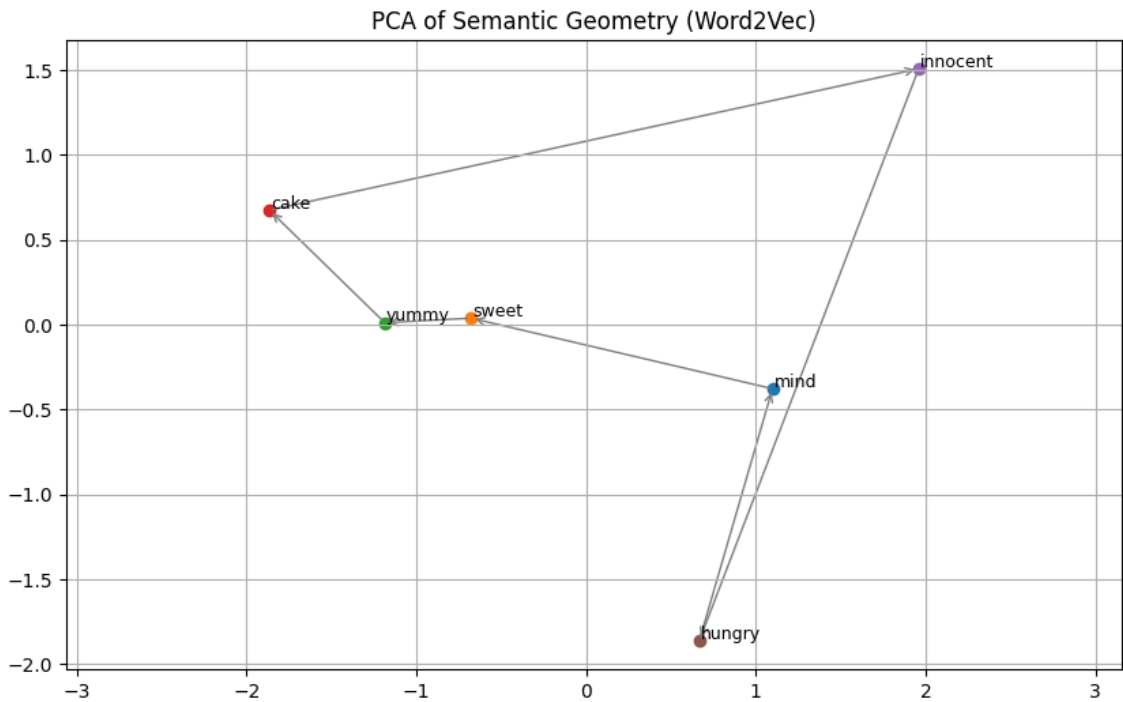
Conversely, the inversion of the morphism can also be read causally: sweetness or yumminess evokes hunger, completing a morphic loop.

Another morphism, cake → innocent | body encodes a metaphor of virginity or naive allure. Innocence, connoting sweetness, is metaphorically grounded in the figure of cake — suggesting a playful or untouched body that invites desire through charm rather than overt sensuality.

Note: While the lyrics include the phrase “Ain’t no innocent, innocent mind, in this club tonight”(INNA, “Yummy”, 2023), we do not evaluate the actual properties of objects in category theory. Instead, we focus exclusively on the relational structure among the words used in the lyrics. Our interpretation is grounded in how semantic morphisms operate within the Z-frame, independent of referential truth.

Figure3. Z = mind

The lexical structure must be carefully configured to preserve morphic coherence. While Z = body functions as a stable semantic anchor—maintaining the commutative integrity of conceptual flows — Z = mind fails to support a coherent morphic path. As shown in this PCA projection, morphic stability breaks down, collapsing into asymmetric disruption and losing structural coherence.

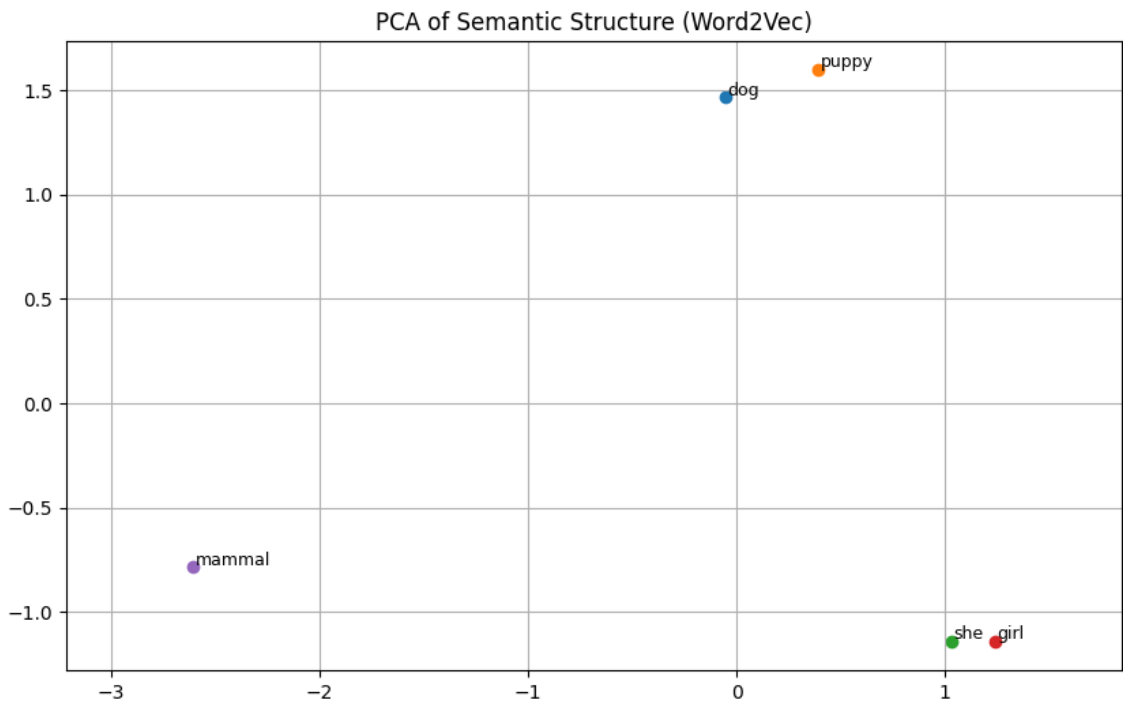


(Lexical data sourced from the song “Yummy” performed by INNA, 2023.)

This illustrates that Z-frame selection is not arbitrary. A well-chosen Z-frame acts as a semantic attractor, stabilizing morphic trajectories across the lexical topology. In contrast, inadequate anchors—such as mind in this instance—induce morphic rupture, resulting in the disintegration of structural stability.

Figure4. Z = mammal

This reveals different clusters are symmetrically placed through mammal. These lexical elements semantically converge through the conceptual anchor mammal, forming a coherent fiber structure.



Quasi Communicative-Diagram

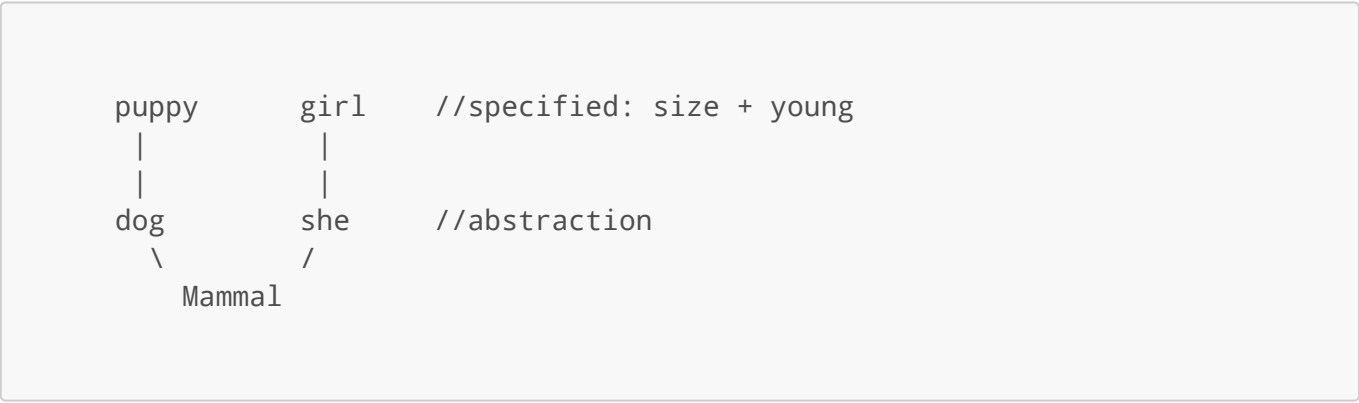
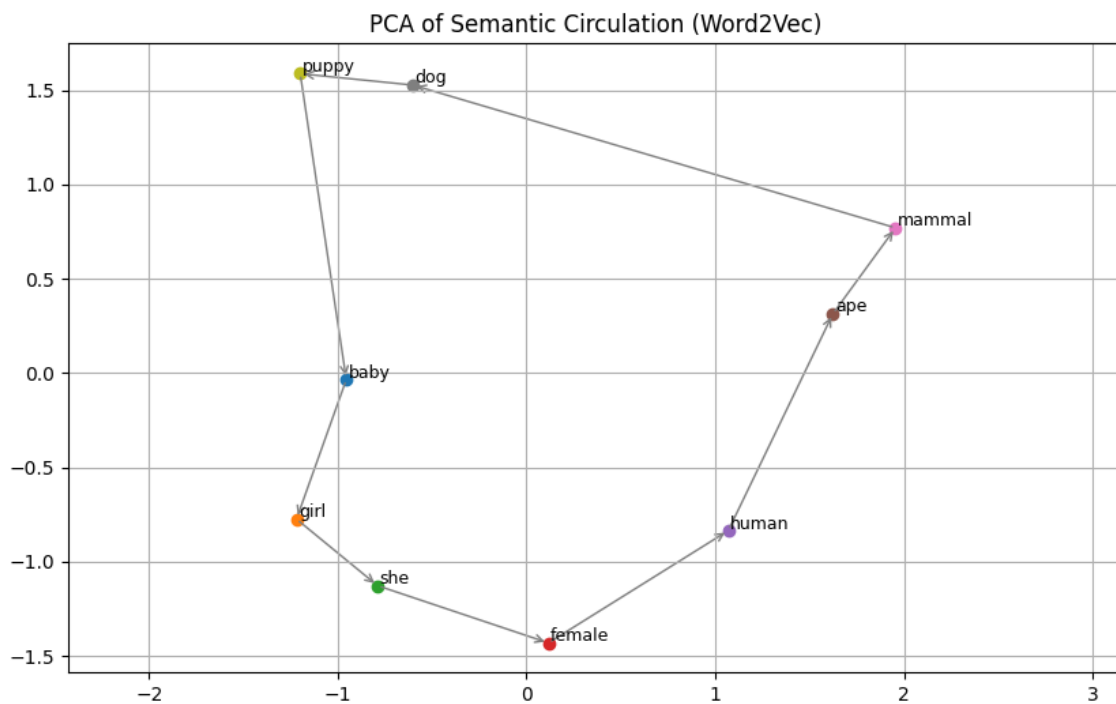


Figure5. Z = baby and mammal

This projection reveals a closed morphic cycle, in which semantic transitions form a circular structure across intersecting Z-frames—baby and mammal. Initially, replacing she with female in Fig.4 disrupted the geometric coherence of the semantic projection. To restore structural continuity, the conceptual chain was extended with the additional elements she, human, ape and baby, thereby completing the circulation. The resulting configuration formed a closed morphic loop across intersecting Z-frames — baby and mammal — as originally intended with baby serving as a bridge between distinct morphic chains and thereby closing the loop.



Depending on the granularity of interpretation, the circulation can be decomposed into two or three morphic chains:

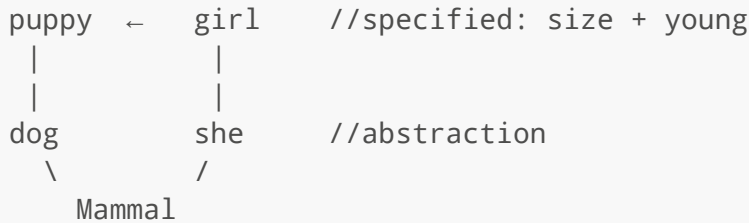
- **Two-chain view:**
puppy → *mammal*
girl → *mammal*
- **Three-chain view:**
puppy → *mammal*
girl → *female*
female → *mammal*

This morphic loop demonstrates how semantic trajectories from seemingly disparate domains converge onto a shared conceptual attractor (*mammal*), while originating from distinct frames such as *gender*, *human*, and *canine*. In the three-chain interpretation, these domains are connected through intermediate nodes like *baby* or *female*, forming a continuous morphic cycle. The resulting closed circulation reflects topological stability within a morphic semantic system.

Morphic Chain Complexes and Semantic Dynamism

We formalize the observed phenomena in Fig.4 or Fig.5 as a *Morphic Chain Complex*, representing the continuity of meaning across lexical transitions. These morphic chains capture structured semantic flows that operate within and across shared Z-frames.

Quasi Communicative-Diagram (Fig.4)



Morphic Chain Complex

We define morphic chains such as:

- $girl \rightarrow she \rightarrow mammal$
- $puppy \rightarrow dog \rightarrow mammal$

as instances of a **Morphic Chain Complex**, representing layered conceptual transitions.

Formally we define:

Let $**D(C_{n-1} \mid Z)** := \text{Category of Morphic Chains over } **Ob(C_{n-1})** \text{ within a given Z-frame.}$

These chains represent **meaning-preserving semantic flows** under the continuity constraints of a shared Z-frame **Z**.

Objects in this category are chain complexes:

$$C_0 \rightarrow C_1 \rightarrow C_2 \rightarrow \dots$$

which encode stepwise conceptual transitions (e.g., $she \rightarrow she \rightarrow mammal$), typically reflecting trajectories such as *human-like life abstraction*.

Morphisms between chains are **chain maps** that preserve *morphic identity*—either fully (preserving semantic structure) or partially (up to rupture, i.e., structural non-invertibility).

In other words, they are mappings between semantic flows that maintain structural coherence even under conceptual deformation.

Mirror Morphism Definition:

Each mirror maps conceptual transitions across vocabularies while preserving morphic identity up to rupture—that is, it allows for semantic divergence that still respects underlying structural continuity, even if exact invertibility is not preserved.

$$\begin{aligned} f &: X \rightarrow Y \mid Z \in D_i \\ f' &: X' \rightarrow Y' \mid Z \in D_{i+1} \\ \Rightarrow X' &\neq X, \text{ but } \text{cod}(f) = \text{cod}(f') \mid \text{CD} \quad (\text{CD} = \text{codomain}) \end{aligned}$$

We define f' as a mirror-correspondent morphism of f under a given Z -frame, if and only if:

$$\begin{aligned} \exists Z: & \text{rupture}(f, f' \mid Z) \neq \emptyset \\ \wedge & \text{cod}(f) = \text{cod}(f') \mid \text{CD} \end{aligned}$$

Note: $Z: \text{rupture}(f, f' \mid Z) \neq \emptyset$ means that there exists a Z -frame under which f and f' exhibit structural divergence—i.e., they are not fully invertible but still converge at the codomain level.

For example, let $Z = \text{abstraction}$. This allows a semantic transition from $\text{girl} \rightarrow \text{she}$ and $\text{puppy} \rightarrow \text{dog}$, treating them as mirror morphisms under a shared conceptual frame.

However, if we take $Z = \text{agency}$, a rupture emerges: $\text{puppy} \rightarrow \text{dog}$ lacks agency, while $\text{girl} \rightarrow \text{she}$ retains it. Hence, $\text{rupture}(f, f' \mid \text{agency}) \neq \emptyset$, yet f and f' still align toward the same codomain (e.g., *mamma*).

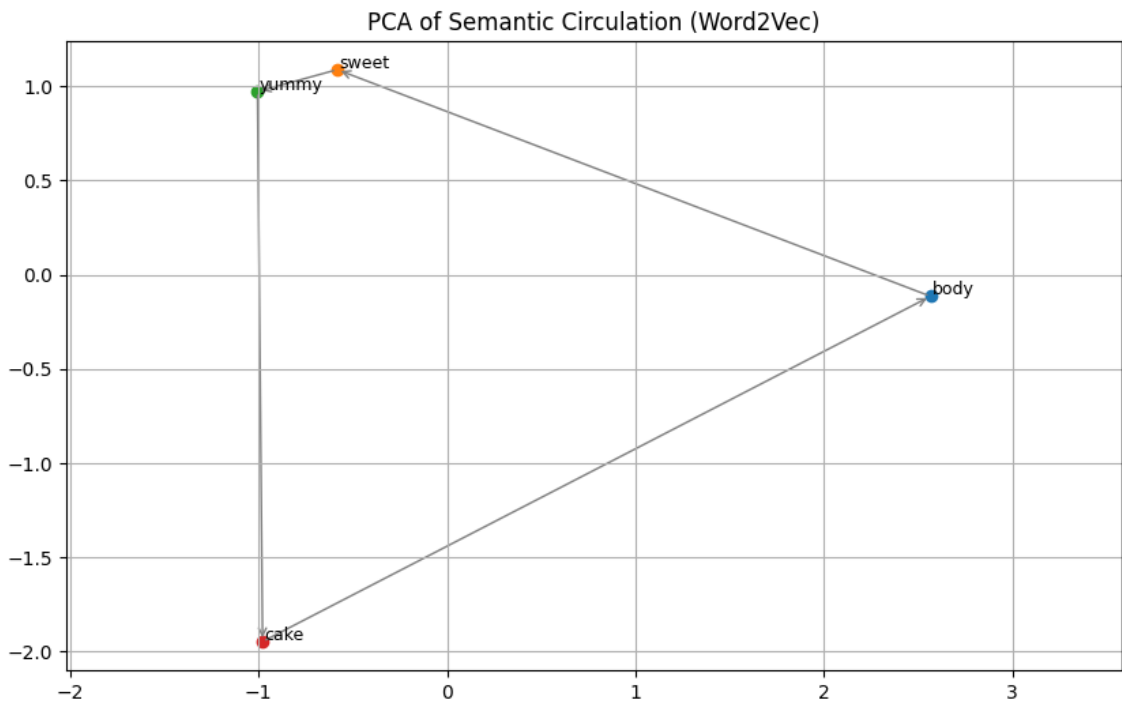
Quasi-Natural Transformation of Meaning Systems

A **Morphic Chain Mirror** is a contextual correspondence between two morphic chains drawn from distinct but meaning-aligned vocabularies. This correspondence is realized through a **quasi-natural transformation** under a shared interdiating Z -frame.

$$\begin{aligned} \eta: D_i &\Rightarrow D_{i+1} \mid \text{CD} \quad (\text{CD} = \text{codomain}) \\ \eta_X \circ D_i(\{f_1 \mid Z_1, \dots, f_n \mid Z_n\}) &\approx D_{i+1}(\{f'_1 \mid Z_1, \dots, f'_n \mid Z_n\}) \circ \eta_Y \mid \text{CD} \\ \text{for all } f_j: X_j &\rightarrow Y_j \mid Z_j \in D_i, \\ \text{where } f'_j: \eta_X(X_j) &\rightarrow \eta_Y(Y_j) \mid Z_j \end{aligned}$$

Then, η is said to be a quasi-natural transformation under the Z -frame i.e. $\eta \in \text{Mor}(C)$ where C is the contextual meaning category
Example: $\eta: \text{girl} \rightarrow \text{puppy} \mid Z = \text{baby}$

Communicative Diagram of Semantics



(Lexical data sourced from the song “Yummy” performed by INNA, 2023.)

Under Z-frame: sugar

g

Yummy <---- Mind

h

↓

Cake

↑

f

Body

----->

f: Body → Mind | sugar // Bodily sweetness gives rise to a mental perception of sweetness

g: Mind → Yummy | sugar //Mental sweetness leads to the subjective pleasure: "this is yummy."

h: Yummy → Cake | sugar //The abstract sense of yumminess gets grounded in a concrete symbol: cake.

if:

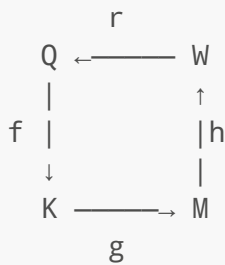
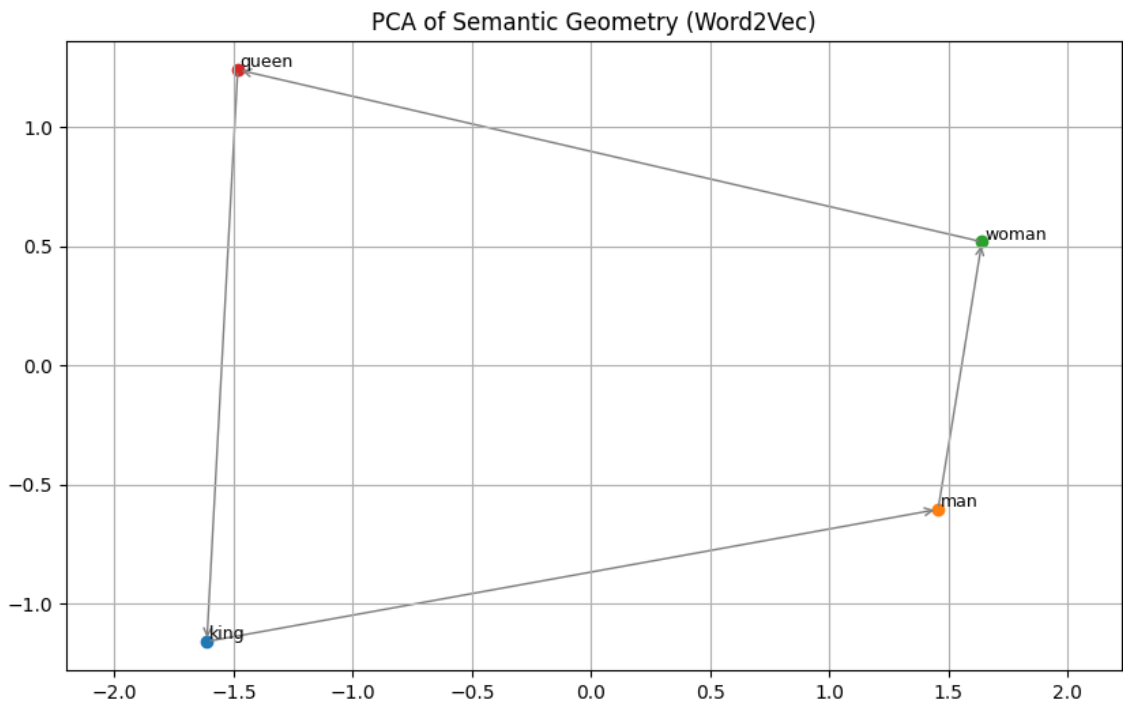
i = h◦g◦f | sugar

Thus:

Cake ≅ Body | sugar // metaphor

king - man + woman = queen

This relationship can be expressed as the following semantic morphism diagram.



K = king
Q = queen
M = man
W = woman

g: Differential Morphism (King → Man)
h: Differential Morphism (Man → Woman)
r: Differential Morphism (Woman → Queen)
f: Composed Semantic Morphism $r \circ h \circ g$

Conclusion

This geometric coherence reveals an underlying semantic structure in natural language, formally characterized as *semantic geometry through conceptual topology*. The proposed framework integrates category-theoretic notions such as morphisms, commutativity, and fiber structures into the modeling of linguistic meaning, enabling a rigorous yet visually tractable formalization of metaphor, analogy, and poetic logic.

Appendix:

The Definition Of Word

A word that includes itself or other words is subsumed by a higher-order concept. That concept, in turn, is structurally embedded within the word. Therefore, a word is a self-referential structure.

```

Let C be a concept (e.g., black)

//A concept is a structure of oppositional differences
Let OC be the opposite concept or not relative concept (e.g., white, not pink)
 $C = \{-OC_1, -OC_2, \dots, -OC_n\}$  (Yoneda  $\times$  Structuralism)

// A word is a concept, and belongs to the category of words
 $\text{word} \cong C$  and  $\text{Ob}(\text{Word}) \ni \text{word}$ 

// A concept is a bundle of semantic morphisms (in the word2vec sense)
// Interpretable as a more concrete model via Grothendieck fibration
 $\forall f_i \in \text{Mor}(C), \exists \infty_f \text{ s.t. } f_i \subseteq \infty_f$ 

// The structure of semantic morphisms is abstracted into a word
 $\forall \infty_f, \exists \text{ Word s.t. } \infty_f \subseteq \text{Word}$ 

and then:  $\text{Word} \cong \text{Nat}(h^{\infty}f, \text{Language})$ 
// The  $\infty$ -structure of morphisms is deployed into the linguistic category as
a natural transformation

// Self-identity of the word: word is word
 $\text{id\_word} \approx \text{word}$ 

```

Appendix 2

Meaning can be formalized through semantic monoid computation, and alternatively expressed via set-theoretic composition as follows:

```
Let king = {Royalty□, Male□, Human□}
Let queen = {Royalty□, Female□, Human□}
Let man = {Male□} Let woman = {Female□}

king - man + woman = queen
{Royalty□, Male□, Human□} ⊖ {Male□} ⊕ {Female□}
= {Royalty□, Female□, Human□}
```

In this framework, lexical items are treated as elements of a semantic monoid, where addition \oplus and subtraction \ominus correspond to meaning-preserving operations in vector space semantics.

Used Code

```
import matplotlib.pyplot as plt
from sklearn.decomposition import PCA
from gensim.models import KeyedVectors
import numpy as np

model_path = ''
model = KeyedVectors.load_word2vec_format(model_path, binary=True)

words = ["body", "mind", "sugar", "yummy", "cake", "innocent", "hungry"]

vectors = [model[word] for word in words]
labels = words

pca = PCA(n_components=2)
reduced = pca.fit_transform(vectors)

plt.figure(figsize=(10, 6))
for i, label in enumerate(labels):
    x, y = reduced[i]
    plt.scatter(x, y)
    plt.text(x + 0.01, y + 0.01, label, fontsize=9)

#Add Arrows
from matplotlib.patches import FancyArrowPatch
for i in range(len(reduced) - 1):
    start = reduced[i]
    end = reduced[i + 1]
    arrow = FancyArrowPatch(start, end, arrowstyle='->', mutation_scale=10,
color='gray')
    plt.gca().add_patch(arrow)
```

```
start = reduced[len(reduced)-1]
end = reduced[0]
arrow = FancyArrowPatch(start, end, arrowstyle='->', mutation_scale=10,
color='gray')
plt.gca().add_patch(arrow)

plt.title("PCA of Semantic Structure (Word2Vec)")
plt.grid(True)
plt.axis("equal")
plt.savefig("image.png")
plt.show()
```

Word2Vec Data Set

<https://code.google.com/archive/p/word2vec/>

Reference

INNA, "Yummy", Global Records, 2023

概念位相論 / Conceptual Topology

This theory, named 概念位相論 or Conceptual Topology, was proposed by **No Name Yet Exist**.

GitHub: <https://github.com/No-Name-Yet-Exist/Conceptual-Topology>

Note: <https://note.com/xoreaxeax/n/n3711c1318d0b>

Author Verification(sha-256 generated 2025-05-06):

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This is Version: 1.0

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