

Semantic Stability

October 16, 2025

1 Introduction

This project aims at testing and visualizing the responses, and more importantly the differences between responses to slightly different, but similar prompts.

2 Theory

A simple base prompt p , and a set of variant p^* prompts are chosen. Using the *all-MiniLM-L6-v2* model, their embedding vectors are created. Only those variant p^* prompts are selected, which surpass the **0.85** similarity (calculated using *cosine similarity*).

Base prompt. Why do humans need sleep?

Prompt variants.

- What makes sleep essential for humans?
- How does sleep benefit the human body and mind?
- What role does sleep play in human health and functioning?
- Why is it necessary for people to sleep?
- In what ways is sleep crucial to human well-being?
- What are the reasons humans can't function without sleep?
- Why is getting enough sleep important for humans?
- What happens to the human body and brain that makes sleep a necessity?

Filtering prompt variants. To control prompt diversity, we compute the semantic similarity between each variant and its base prompt. The procedure is as follows:

1. Encode the base prompt p and all variants p_i^* using a SentenceTransformer model.
2. Compute cosine similarities $s_i = \text{cos_sim}(p, p_i^*)$ for each variant.
3. Construct a data frame containing each variant, its similarity score, and a Boolean flag indicating whether it meets a minimum threshold (e.g. $s_i \geq 0.85$).
4. Sort the data frame in descending order by similarity.

Table 1: Variant prompts with their similarity scores and if they remain in the experiment.

ID	Variant	Similarity	Keep
3	Why is it necessary for people to sleep?	0.918 821	True
6	Why is getting enough sleep important for humans?	0.882 275	True
0	What makes sleep essential for humans?	0.850 024	True
7	What happens to the human body and brain that makes sleep a necessity?	0.825 465	False
5	What are the reasons humans can't function without sleep?	0.817 788	False
4	In what ways is sleep crucial to human well-being?	0.753 535	False
1	How does sleep benefit the human body and mind?	0.747 996	False
2	What role does sleep play in human health and functioning?	0.693 460	False

To determine the base response, the base prompt is sent 10 times to our chosen LLM (*gpt-5-mini*) - from now on referred to as *model* -, and KMeans is applied to the responses' embeddings.

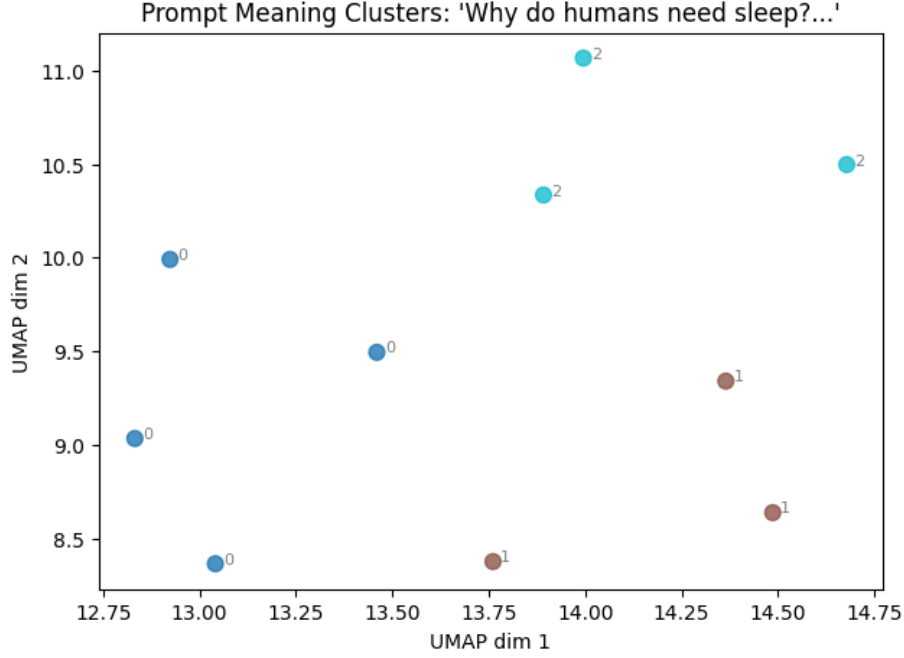


Figure 1: Base Responses' Embeddings Cluster

To choose a cluster, we calculate the cosine similarity between the cluster members and choose the cluster with the most internal similarity, which in this case is *Cluster 0* with a **0.936** similarity. The cluster's centroid is calculated, and from now on it acts as the *base response embedding*.

The following 3 variant prompts were kept and tried in the project.

Table 2: Selected variant prompts with their similarity scores.

ID	Variant	Similarity
3	Why is it necessary for people to sleep?	0.918 821
6	Why is getting enough sleep important for humans?	0.882 275
0	What makes sleep essential for humans?	0.850 024

Every variant prompt is sent 10 times to the *model* and the embedding vector, token number and similarity compared to the *base response embedding* is saved.

Table 3: Responses for *Why is it necessary for people to sleep?*.

Response Index	Text	Similarity	Token Count
1	Sleep is not optional for good health — it’s a...	0.917 627	427
2	Sleep is essential because it performs many cr...	0.946 412	550
3	Sleep is essential because it supports many cr...	0.894 599	331
4	Sleep is essential because it lets your body a...	0.945 880	590
5	Sleep is not optional for the brain and body—i...	0.923 881	597
6	Sleep is not optional for the body and brain —...	0.899 376	616
7	Sleep is essential because it supports many cr...	0.934 993	516
8	Sleep is essential because it supports many bi...	0.918 472	371
9	Short answer: sleep is essential because it le...	0.946 763	570
10	Sleep is essential because it lets your brain ...	0.925 013	397

Table 4: Responses for *Why is getting enough sleep important for humans?*.

Response Index	Text	Similarity	Token Count
1	Sleep is essential for nearly every aspect of ...	0.850 531	364
2	Sleep is essential because it supports nearly ...	0.831 646	494
3	Sleep isn’t just “rest”—it’s an active, essent...	0.798 350	413
4	Sleep is a fundamental biological need. Gettin...	0.815 536	504
5	Getting enough sleep is essential because it a...	0.793 406	536
6	Sleep is essential for almost every system in ...	0.791 501	403
7	Sleep is essential because it supports nearly ...	0.861 821	470
8	Sleep is essential for nearly every part of yo...	0.843 667	380
9	Getting enough sleep is essential because slee...	0.839 533	432
10	Sleep is essential because it supports nearly ...	0.838 996	397

Table 5: Responses for *What makes sleep essential for humans?*.

Response Index	Text	Similarity	Token Count
1	Sleep is essential because it’s when many crit...	0.898 335	598
2	Sleep is essential because it’s when the body ...	0.916 517	652
3	Sleep is essential because it is when the brai...	0.912 007	490
4	Sleep is essential because it performs multipl...	0.885 284	557
5	Sleep is essential because it supports multipl...	0.920 379	555
6	Sleep is not just passive rest — it is an acti...	0.920 757	526
7	Sleep is essential because it supports multipl...	0.913 000	566
8	Sleep is essential because it’s when many acti...	0.915 230	664
9	Short answer: Sleep is essential because it su...	0.945 184	611
10	Sleep is not just “time off” — it’s an active,...	0.911 126	566