Artful Writing, Authentic Emotions: Distinguishing Human-Written from LLM-Generated Metaphors by Annotation and Classification

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Abstract

We analyze differences between human-written and automatically generated metaphors. Using two syntactically standardized datasets containing novel metaphors from poetry and science communication, we generate new figurative expressions with LLMs that describe the same concepts as human-written texts. Using crowdsourcing, we conduct extensive annotation across multiple dimensions (e.g., writing quality and creativity) and ask annotators to judge whether the metaphor was generated automatically. For the poetry set, we also asked annotators for the emotions conveyed by the metaphor. We find that, consistent with prior work, the authorship of scientific metaphors is difficult to determine. However, our results reveal that human-written poetic metaphors stand out by their capacity to convey emotion. We also analyze which types of metaphors are merely *perceived as human*. Finally, we show that, while human annotators cannot distinguish human from machine metaphors, automated approaches achieve high accuracy in identifying human writers, which suggests substantial differences in text structure.

1. Introduction

Metaphors are pervasive in human language. While conventional metaphors (e.g., *Time is money*) have become deeply intertwined with language use and are also reflected in dictionary entries (Lakoff and Johnson, 2003), novel (i.e., non-conventional) metaphors are a highly productive part of language. The inventive use of non-literal figures of speech is remarkable in multiple respects: from a cognitive and communicative perspective, new figurative language images are both an authorial creative effort and a communicative challenge for the reader. From a research perspective, it is thus interesting that figurative language can effectively convey emotions (as in poetry) or aid understanding of complex, abstract concepts (as in science communication).

With the advent of Large Language Models (LLMs), questions surrounding the successful use of figurative language become even more complex. While the ability to use metaphors appears to require empathy, for which LLMs lack the capacity, research has shown that LLMs can produce figurative language that humans cannot tell apart from real poetry (Porter and Machery, 2024; Wang et al., 2025).

Our study analyzes the differences between human-written and automatically generated metaphors in greater detail. We first collect two datasets of human-generated novel metaphors. One dataset is derived from poetry and allows to analyze the metaphor's inherent purpose in conveying emotion. The second dataset comprises metaphors from science communication that explain complex concepts through concrete, tangible imagery. We standardize both datasets to the form of analogies ("X is like a Y") to ensure that grammatical variation does not confound our semantic analysis. In a second step, we generate metaphors by using different LLMs. These metaphors describe the same concepts (the X in the analogy) as the human-written metaphors do. We prompt LLMs either to produce emotion-conveying poetic analogies or explanatory metaphors for science communication. To identify features that distinguish human-written and machine-generated metaphors, we annotate all 200 analogies via crowdsourcing and then assess the correlation between the annotations and the metaphors' origins. In a last step, we train automated classifiers on both the metaphors themselves and their annotations, and evaluate how easily the metaphor origins can be identified.

Our main contributions are as follows:

- We provide an extensively annotated

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dataset of novel metaphors with poetic and scientific metaphors. The metaphors are standardized in analogy syntax, and they comprise human-written and machine-generated examples, matched to each other by a corresponding concept.

- We show that human-written metaphors are distinguished by their less polished writing and, especially, their ability to *convey emotions*: human-written poetry conveys emotions more effectively than automatically generated ones.
- We also analyze what makes metaphors *appear human*. One of the relevant features directly relates to emotion conveyance, namely the annotators' ability to assess the analogy's underlying emotion.
- Regarding the distinction of human-written and LLM-generated metaphors, we show that this is basically impossible for human annotators, possible by automated classification on poetic metaphors, and very accurate using LLMs.

Our results contribute to understanding the subtle differences between the surprisingly large capacities of LLMs for using figurative language and their limits in using metaphors for emotion-driven communication. Our annotated dataset is publicly available.[1]

2. Background and Related Work

Research on metaphor theory and computational methods for understanding it predates LLMs. With this new technology available, new foundations for metaphor identification, creation, and interpretation emerge, raising broader questions about how to identify language generated automatically. Recent work evaluates state-of-the-art models' ability to distinguish metaphorical expressions from literal language and semantic anomalies (Neidlein et al., 2020), and examines how modeling strategies, such as prompt engineering (Kramer, 2025; Jia and Li, 2024), fine-tuning (Haagsma and Bjerva, 2016), retrieval-augmented generation (Fuoli et al., 2025), and detection frameworks (Wang et al., 2025; Lin et al., 2024) improve performance in metaphor identification (Choi et al., 2021; Jia et al., 2025). Despite good results on detection and generation benchmarks, growing evidence suggests that LLMs often rely on superficial cues rather than genuine understanding of the analogy (Sanchez-Bayona and Agerri, 2025), raising new questions about LLMs' capacities to reason about metaphors. While we also use LLMs for classification (among other algorithms), our approach focuses on identifying human-written text rather than identifying figurative language as such.

Beyond identification, recent work explores LLMs' capacity for metaphor generation. Models can create domain-specific metaphors (Stowe et al., 2021; Shou et al., 2024) and metaphors for science communication (Kim et al., 2023). Relating to these approaches, we will analyze whether the generated metaphors share communicative characteristics with human-written ones, and how scientific metaphors differ from poetic ones.

There are multiple datasets containing figurative language, e.g., the LCC Metaphor dataset (Mohler et al., 2016) with metaphors in multiple languages, along with scores for novelty, metaphoricity, affect, and target and source domains. While most other corpora are designed to distinguish literal from figurative expressions, several also annotate the conceptual mappings expressed by the metaphors (e.g., Dodge et al., 2015; Gordon et al., 2015; Shutova and Teufel, 2010). Like in our work, crowdsourcing is often used to collect metaphor annotations, e.g., for metaphoricity (Hovy et al., 2013; Jang et al., 2015; Pedinotti et al., 2021), aptness (Bizzoni and Lappin, 2019), novelty (Parde and Nielsen, 2018; Lugli and Strapparava, 2024; Do Dinh et al., 2018), or to elicit the metaphors (Zayed et al., 2019).

Our work is also located within the broader context of manually or automatically identifying LLM-generated language. The results are mixed: Automatically generated medical student essays can be reliably identified even by medical laypeople (Doru et al., 2025), and LLMs are perceived as less creative than very creative humans (Bellemare-Pepin et al., 2026). In other studies, LLMs do not differ from

[1] https://osf.io/3bgn4/overview?view_only=addb6107053149e387df54647a30f063

average humans in story-telling creativity (Orwig et al., 2024), and LLM-generated poetry is not distinguishable from human-authored poems (Porter and Machery, 2024; Wang et al., 2025). Metaphor interpretations by LLMs are even rated as more useful than those by humans (Ichien et al., 2024). Automated approaches for identifying LLMs as authors are generally more reliable, probably due to structural syntactic differences between LLM-generated and human-written text (Zamaraeva et al., 2025), but they can also be deceived (Shahriar et al., 2025). We extend prior work by analyzing metaphors and the criteria establishing human authorship, using analogy syntax to avoid purely grammatical distinctions.

To the best of our knowledge, we present the first study to investigate which features distinguish human-written metaphors in both the poetry and science domains, both in annotation and classification, and to analyze why metaphors are *perceived* as human-produced. In particular, we highlight the importance of conveying emotion in poetic language.

3. Dataset

Our dataset of novel analogies has two parts: A **poetry** dataset and a **science** communication dataset, both containing human-written and LLM-generated figurative language.

The datasets contain metaphors in the form of analogies. The analogy syntax helps us to keep the expressions comparable and avoid confounding factors (e.g., differences in grammatical structure). Analogies are comparisons of the form "X *(the target)* is like a Y *(the source)*", possibly followed by an explanation that elaborates on the properties of the source that are transferred to the target. While conceptual metaphor theory (Lakoff and Johnson, 2003) emphasizes that metaphors are more deeply intertwined with language than analogies, structural mapping theory supports the view that, particularly for novel metaphors (which often require explanation), they can be understood as analogies. (Bowdle and Gentner, 2005). Just like metaphors, analogies can vary in their degree of novelty: "Life is like a rollercoaster" uses "rollercoaster" as a source, which has a dictionary entry for its non-literal meaning. On the other hand, "Love is like a wanderer who enters the house without knocking" (from our data) is a novel analogy. In this paper, we will use the terms "metaphor" and "analogy" interchangeably.

For the poetry dataset, we adopt the approach of Ichien et al. (2024), who translated Serbian poetry into English to elicit novel metaphors. We extract metaphorical comparisons from Persian and German poetry, as well as 3 originally English metaphors. We rephrase each metaphor as an "X is like a Y" analogy if it is not already phrased that way. E.g., if the text states "My life is an empty notebook", we would record it in our dataset as "My life is *like* an empty notebook", recording "my life" as the target. If the poem contained an explanation, we include it in the analogy. Overall, we collected 20 examples. Two expert annotators noted the primary emotions conveyed by the metaphors, drawing from 6 types: *love, pain, longing, fear, pleasure, regret*, with each analogy assigned one or two emotion labels.

For the science dataset, we collect 20 analogies that explain scientific concepts across disciplines, using the Deep Research component of various LLMs, and manually verify their origin. We include only metaphors whose figurative meanings are not defined in dictionaries. All texts are originally written in English; therefore, the metaphors differ from the poetry set not only in purpose and sentiment but also in the degree of novelty, since they were already part of the English language and accessible to LLMs. All scientific analogies contained explanations, which, again, we noted with the analogies.

In the next step, we used different LLMs to generate novel analogies (Claude Sonnet 4.5, ChatGPT 5, Gemini 2.5 and Mistral). The LLMs were instructed to adhere to the analogy syntax ("X is like a Y") and invent a source "Y" for a given "X" (the target). As a stimulus, we provide each LLM with the list of targets from the human analogies. We thus arrive at five distinct analogies per target (one human-authored and 4 LLM-generated). For the poetry dataset, we instructed the LLM to select two of our fixed set of 6 emotions and generate an analogy such that it conveys those emotions. The distribution of emotions in both

	Poetry			Science		
Origin	words	min	max	words	min	max
Human	20.4	9	56	54.0	19	110
LLM ∅	23.3	9	39	44.1	26	75
Claude	25.2	22	30	47.2	39	60
ChatGPT	14.8	9	19	32.6	27	41
Gemini	31.1	25	39	58.6	36	75
Mistral	21.9	16	27	37.8	26	50

Table 1: Analogy word count by model

human-written and LLM-generated metaphors leans toward "longing" and "love" (in 50% of the analogies), with the remaining emotions distributed roughly evenly.

For the science dataset, we provided identical instructions for syntax and novelty, omitted emotion, and prompted the LLM to serve as a science communicator. Each LLM generated one metaphor for each of the 2x20 targets, yielding 100 metaphors per dataset (20 written by humans, 80 generated by LLMs). Table 1 shows the average, minimum, and maximum word count of the analogies. The poetry and science subsets differ not only in the emotion conveyed but also in structure: human poetic analogies are, on average, 20.4 tokens long, whereas scientific metaphors are 54 tokens long, with much more variance in the human analogies. For LLMs, poetic analogies are longer than human ones (+3 tokens), whereas scientific analogies are shorter (-7 tokens), with substantial variance across LLMs.

4. Annotation and Analysis

We first describe our crowdsourced annotations. Then we conduct an initial analysis of features that distinguish human metaphors and features that make annotators *perceive* them as human-written.

4.1. Annotation via Mechanical Turk

We used Amazon Mechanical Turk[2] to crowdsource annotations along the following dimensions for all metaphors: quality (asking whether the analogy is a well-fitting image), writing (whether the author appears to be a professional writer), creativity, and comprehensibility, each rated on a Likert scale from 1 (very negative) to 5 (very positive). Further, we asked participants whether they thought the analogy could have been generated by a machine, with 1 indicating it was definitely human and 5 indicating they definitely considered it machine-generated.

For the poetic metaphors, we also asked participants to assign the analogies' conveyed emotions by multiple choice. For the science metaphors, we asked instead whether they found the metaphors helpful ("helpfulness") and whether they considered the author an expert on the scientific topic ("expertise"). We will provide the full set of questions in the Appendix. The results are shown in Table 2.

Each analogy was presented to 10 different annotators, yielding high standard deviations across all dimensions (0.74 for poetry and 0.78 for science, with "machine" showing the highest at 0.99). The overall picture indicates that distinguishing human-written analogies from generated analogies is difficult using the given dimensions, with average LLM scores close to human performance. Additionally, humans cannot identify LLM metaphors (as shown by the *machine* rating, which rates ChatGPT's analogies as most "human-like").

4.2. What marks human analogies?

Overall, we find very few dimensions that distinguish human-written from machine-generated analogies, and no significant differences for scientific metaphors.

For the poetry dataset, humans showed *lower* average scores for creativity, professional writing style, and overall quality. Across individual models, only Claude differed significantly from human writing in creativity and overall quality, whereas all models exceeded human scores for writing style. While both writing style and overall quality might have been influenced by translating and rephrasing the metaphors as analogies, this should not affect creativity. We also noted that annotators disagreed more when judging human poetry: we observed significantly lower inter-annotator agreement for writing style in human metaphors (standard deviation increased from

[2] https://www.mturk.com

Origin	quality		writing		creativity		comprehensible		machine?		helpful	expert
	Poe	Sci	Poe	Sci	Poe	Sci	Poe	Sci	Poe	Sci	(Sci only)	
Human	3.74	3.83	3.57	3.88	3.75	3.69	3.83	4.03	3.23	3.21	3.81	3.36
LLM ∅	**3.87**	3.87	**3.85**	3.85	**3.94**	3.75	3.86	4.02	3.25	3.24	3.73	3.36
Claude	**3.94**	3.93	**3.90**	3.92	**4.09**	3.82	3.83	4.06	3.24	3.14	3.78	3.34
ChatGPT	3.80	3.81	**3.73**	3.80	3.85	3.79	3.92	3.96	3.18	3.25	3.65	3.35
Gemini	3.87	3.90	**3.88**	3.83	3.87	3.73	3.78	3.99	3.33	3.33	3.82	3.40
Mistral	3.87	3.83	**3.89**	3.85	3.94	3.66	3.92	4.08	3.27	3.23	3.65	3.33

Table 2: Annotation scores for Poe[try] and Sci[ence]; scores ranging from 1 to 5; Values in boldface differ significantly ($p < 0.05$) from human analogies.

Model	Fear	Longing	Love	Pain	Pleasure	Regret	Overall
Human	73.5	57.0	68.5	63.5	73.5	76.0	68.7
LLM ∅	71.1	57.6	**54.1**	65.8	**65.5**	73.6	**64.6**
Claude	73.5	59.0	**56.0**	67.0	65.0	73.5	65.7
ChatGPT	69.5	61.5	**57.5**	68.5	65.0	74.0	66.0
Gemini	74.0	62.0	**56.0**	70.0	70.5	75.5	68.0
Mistral	67.5	48.0	**47.0**	57.5	**61.5**	71.5	**58.8**

Table 3: Annotators' emotion guessing accuracy by model (Poetry dataset only)

0.66 in LLMs to 0.82). While polished writing is a sign of "LLM language," human-authored poetic metaphors are more controversial, mirroring debates over the quality of artwork.

Subjectivity plays another role in differentiating humans and LLMs: humans use metaphors more reliably to convey emotion. Table 3 shows the accuracy with which annotators guessed the emotions underlying the analogies. Note that the task is different for human metaphors: LLMs selected the emotions for which they generated analogies. For humans, emotions were annotated post-hoc. Thus, we would expect the emotions in the LLM metaphors to be *easier* to infer because the analogies are specifically generated to convey those emotions, whereas in human analogies we measure rater agreement with expert annotators. Nevertheless, we find that, especially for "love" but also for "pleasure", conveying emotions is significantly more effective with human metaphors.

4.3. Which analogies *appear* human?

After having shown which features distinguish human metaphors, we now investigate what makes metaphors *appear* more human, i.e., which features correlate with a low "machine" rating in our annotation scheme. A "machine" score of 1 indicated that the annotator was certain the analogy was human-written, whereas 5 indicated that they attributed it to an LLM.

We find that human annotators cannot identify LLM-generated metaphors. This is already evident from the insignificant difference in the "machine" rating of human and LLM metaphors (0.02 for poetry, 0.03 for science). We also evaluated the accuracy of the annotators: by averaging each example's "machine" ratings and treating an average score below 3 as indicating human-written text, the accuracy of human annotation is below chance (0.42 for poetry, 0.41 for science). Still, the perception of what distinguishes human metaphors is partially accurate: as shown in Table 4, annotators assigned higher machine scores to poetic texts when they also rated them as more professionally written, which is consistent with the true correlation. However, ratings are inconsistent with respect to overall quality: for poetic metaphors, the annotators considered higher overall quality a sign of human-written language, the opposite of the actual result.

We also observe several differences between the two datasets: More comprehensible poetry appears more machine-like (perhaps because humans are assumed to ex-

Dimension	Poetry	Science
writing	+ **0.29**	+ 0.09
comprehensibility	+ **0.12**	− **0.13**
creativity	0.00	+ **0.26**
quality	+ **0.25**	+ 0.06
helpfulness	—	+ 0.02
expertise	—	+ **0.29**
emotion conveyance	− **0.26**	—

Table 4: Correlation (pearson's ρ) between ratings and "machine" score; boldface indicates significance (p<0.05). Positive correlation means a higher score makes the analogy look more "machine-like", negative means more "human-like".

ercise greater artistic freedom), and more comprehensible scientific metaphors appear more human-like to the annotators. For scientific metaphors, creativity and expertise are strongly correlated with the "machine" score; annotators attribute less creative and less informed texts to humans.

For poetry, a key feature distinguishing human metaphors relates to our previous assessment of conveying emotions: In cases where annotators could reliably detect the emotions of an analogy, they rated it as much more human-like ("emotion conveyance" in Tab. 4).

5. Detecting LLM Analogies

We now complement our analysis of human-specific analogy features with a series of classification experiments. We assess whether machine-generated metaphors can be identified solely from their text and whether our annotated features can serve as a valid proxy for identifying machine-generated content. We first distinguish human-authored analogies from generic LLM-generated metaphors, and then automatically classify human authors vs. individual models. In a final experiment, we test whether commercial large language models can tell machine-generated figurative language from human-written metaphors.

5.1. Classifiers and Baselines

We implement classifiers based on either textual features or our annotations. All algorithms were implemented using scikit-learn.

Classification by textual features

We first examine whether LLM-generated metaphors can be identified directly from their text. For this purpose, we extract sentence embeddings for each analogy using RoBERTa (Liu et al., 2019). We then classify the resulting vectors using a support vector machine (SVM) with leaving-one-out cross-validation (LOOCV). Note that this approach involves features generated by a language model, but does not use the LLM for direct classification.

Classification by annotation dimensions

We evaluate the predictive power of the annotated dimensions by training a classifier on the numerical annotated features and omitting the emotion labels. For each example, all annotation scores are averaged. Complementing our earlier analysis of individual correlations, this shows how our annotations interact for prediction. We evaluated multiple classification algorithms using LOOCV. We achieved the best results for poetry with logistic regression, and with Gradient Boosting for science.

Baselines

We provide two baselines for our classifiers: First, we use an informed baseline that uses text length as its only feature. As shown in Table 1, the length difference between human-written and machine-generated analogies is significant. We thus train another support vector machine with the number of tokens as the only feature and report it as the "Length" baseline. Second, we provide the performance of the human annotators on the balanced dataset. As described before (Sec. 4.3), we average the "machine" scores for each example and take a score below 3.0 (the midpoint of our Likert scale) to indicate a human author.

5.2. Humans vs. mixed LLMs

To generically distinguish human-written text from automatically generated metaphors, we downsample our dataset to achieve a balanced setup: we include all human metaphors (20 from poetry, 20 from science communication) and sample 20 machine-generated metaphors per dataset, randomly selecting 5

	Poetry	Science
Text	**0.83**	0.60
Annotation	0.70	0.60
Length	0.73	**0.70**
Human	0.45	0.60

Table 5: Classification accuracy for identifying machine-generated analogies, along with a naive baseline and the human performance.

per language model. The accuracy of a random baseline for this balanced dataset is 0.50.

Table 5 shows the results. For poetic metaphors, the text-based classifier achieves the highest accuracy (0.83), suggesting that substantial differences between LLM-generated text and human-authored metaphors can be derived from shallow textual features. The resulting accuracy exceeds the length baseline by 0.1. Annotation-based classification yields low accuracy, close to the length baseline (0.70 vs. 0.73).

For the science dataset, the results confirm our earlier annotation-based insights: for those more explanatory and less emotional metaphors, there is little discriminative signal for either human raters or model-based classifiers to exploit. Taking text length as the only feature is the most reliable way to distinguish LLM-generated scientific metaphors from human-written ones.

Human annotators appear to perform better on the science dataset than on the poetic metaphors, which is inconsistent with our other findings. Note that the downsampled dataset is insufficiently reliable for precise evaluation of human performance; as we have shown previously, accuracy on the complete data is 0.42 for poetry and 0.41 for science (cf. Sec. 4.3), which is equally low for both datasets.

5.3. Humans vs. individual LLMs

Because each LLM has its own specific language characteristics, we also try to distinguish human poetry from individual LLMs. For each LLM, we combine all analogies generated by that LLM and all human analogies, and then evaluate classification accuracy.

The results (Table 6) present a different picture than in our previous experiment: while, on average, the poetry dataset still yields better LLM identification, the results vary much more in the science context (with ChatGPT being easier to identify as an LLM than in the poetic context). This clearly shows that there is no consistent LLM language, and while no LLM can generate human-like poetic metaphors, some are excellent at generating human-like scientific analogies (Gemini, Mistral). ChatGPT and Claude might exhibit a particular "LLM syntax" (cf. Zamaraeva et al., 2025), which we tried to avoid by standardizing the analogy syntax. However, the scientific analogies often consist of multiple sentences and thus exhibit greater grammatical variation.

The length-based baseline often outperforms other approaches, except for Mistral's and ChatGPT's poetic analogies. Note that Mistral, which is easiest to detect as a machine for poetry by a large margin, was also the worst at conveying emotions. In science, only Claude's analogies slightly exceeded the length baseline. Overall, the recognition of most models appears to be possible by using surface patterns derived from text, but those patterns are not intuitively perceived as "machine-like" by humans. Furthermore, the models vary substantially in their ability to generate human-like text, both across models and across contexts.

5.4. Zero-Shot Classification with LLMs

Finally, we conduct an automatic annotation experiment using zero-shot prompting on the same Chatbots we used for text generation. We use the same balanced dataset from the first classification experiment (with mixed LLMs) and ask the same LLMs to predict whether each metaphor was written by a human or generated by a machine. To avoid data leakage, we used new accounts and different computers to retrieve the annotations.

The results (Table 7) show that, overall, these automatic annotators outperform both human raters and direct classification on both datasets. In particular, Claude and Gemini achieve perfect accuracy in detecting the origin of poetic metaphors, closely followed by ChatGPT. Mistral does not demonstrate comparable performance and operates even below chance for poetic metaphors. While ac-

	Poetry				Science			
(Origin)	Text	Anno.	Length	Human	Text	Anno.	Length	Human
ChatGPT	0.73	0.48	0.63	0.50	0.85	0.58	0.88	0.63
Claude	0.78	0.68	0.93	0.53	0.75	0.43	0.63	0.55
Gemini	0.80	0.75	0.93	0.58	0.53	0.53	0.83	0.63
Mistral	0.95	0.68	0.63	0.55	0.68	0.50	0.70	0.58

Table 6: Classification results for identifying individual LLMs

Model	Accuracy	
(Classifier)	Poe	Sci
Claude	1.00	72.50
Gemini	1.00	87.50
Mistral	0.35	50.00
ChatGPT	92.50	65.00

Table 7: Zero-shot prompt test for LLM metaphor identification using Chatbots as classifiers

curacy drops for science metaphors, Claude and Gemini still perform remarkably well at distinguishing human-written metaphors from LLM-generated writing, outperforming all classification approaches and baselines.

These findings are consistent with our previous embedding-based classification results. As shown previously, RoBERTa representations encode information that, to some extent, distinguishes human and machine metaphors, with more consistent results for poetic analogies. Given that contemporary chatbots rely on substantially larger and more sophisticated language models, it is unsurprising that some achieve strong performance in origin detection. At the same time, the variation across models suggests that this capability is neither uniform nor domain-independent; rather, it depends on both the underlying architecture and the characteristics of the metaphor domain. Determining what features precisely they can exploit remains a subject for future work.

6. Conclusion

We analyzed the differences between human-written and machine-generated novel metaphors. We first assembled two datasets from poetry and science communication, including human-written examples and their matched LLM-generated counterparts. An extensive crowdsourcing annotation revealed that, for science metaphors, the origin was largely unidentifiable using individual ratings, whereas successful emotional conveyance distinguished human poetic metaphors. Further, the human metaphors are written in less standardized language. We also showed that automated methods for predicting origins outperform human inspection, and that LLMs perform best at distinguishing between human- and machine-generated metaphors.

While our research confirms prior work showing that LLMs express scientific metaphors as proficiently as humans, we show that the uniqueness of human language remains evident in emotional poetic expressions. While LLMs are excellent at generating figurative language to explain complex concepts, they struggle with generating less concrete, more sentimental text.

Overall, we believe that more research is necessary to understand how the cognition of novel human metaphors differs from the mechanical assembly of figurative machine language, and how both can (or cannot) be distinguished from standard language processing. In future studies, we aim to identify additional features that distinguish human figurative writing from LLM-generated text, while accounting for differences across LLMs and new domains. Further, we aim to apply interpretability methods to language models to better analyze the mathematical processes behind metaphor generation. Exploring how challenges with emotional language relate to other LLM shortcomings can help identify the strengths and weaknesses of automated writing relative to human creativity, thereby enhancing the explainability of current LLMs and supporting their responsible use.

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A. The Analogy Dataset

We provide the full dataset, including MTurk annotations, under https://osf.io/3bgn4/overview?view_only=addb6107053149e387df54647a30f063. Additionally, we show the list of targets in table 8 (poetry) and table 9 (science), as well as the full analogy set with origins for both datasets in table 10 (poetry) and 14 (science).

#	Poetry targets
1	you
2	we
3	my hands
4	the heart that's had enough
5	we
6	you lie upon my heart
7	my soul is dancing
8	my breath feels
9	the tip of your hair
10	your love
11	time
12	my life
13	some people
14	your body and your cloth
15	my love and yours
16	love
17	you and I
18	your touch on my shoulder, meant to ease my loneliness,
19	my mouth
20	regret and youth

Table 8: Poetry metaphor targets.

#	Science targets
1	learning in a neural network
2	evolutionary adaptation
3	Higgs field and particle mass
4	black holes
5	a superconductor
6	quantum entanglement of photon pairs
7	metaphors in science communication
8	the vagus nerve
9	your body's cells
10	the brain's default mode network (DMN)
11	telomeres on chromosomes
12	dysplastic cells
13	entropy in thermodynamics
14	spacetime curvature
15	epigenetics
16	carbon dioxide accumulation in the atmosphere
17	editing genes with the CRISPR technology
18	quantum superposition
19	protein folding
20	the event horizon of a black hole in space

Table 9: Science analogy targets.

B. Prompts for Dataset Creation

The following prompts are used to generate the analogies using the targets from our human-written dataset part (we omit the actual targets below, but they were given in the prompt). Note that the naming of the "source" might be confusing for someone familiar with conceptual metaphor theory, where it should be, in fact, the "target" or "tenor".

Poetic analogies

```
You are a poet.
I have a List of concepts /
phrases (""sources“).
I want you to invent metaphorical analogies
("vehicles") describing the sources in
emotional language.
Please chose, for each individual metaphor,
two sentiments from the following list:
love, pleasure, longing, pain, fear, regret

Then generate the analogy.
The analogies should have the form
[source] is / are like [vehicle],
[potentially an explanation]

Example: "My head feels like a pounding bomb
 of fire soup. I will burst at any time,
 radiating heat and dark glowing thoughts."

In the example, I would provide "My head"
 (source).  You would first pick two emotions
 (e.g., pain, longing),then choose a metaphor
 that expresses each.
The analogies should be new metaphors;
they may not be found in Google, primary
literature, or even a dictionary.
Please verify that.

Be poetic and original.
I will give you a list with the sources along
with ids and a list of sentiments.
Please give back the list, adding
```

columns for the complete metaphor, the isolated vehicle, an explanation, and the emotions you picked.

Scientific analogies

You are a professional science communicator.
I give you a List of concepts / words ("sources"). I want you to invent metaphorical analogies ("vehicles") explaining the word in the style of a science communicator.
The analogies should have the form [source] is / are like [vehicle]: [explanation]
Please explain a specific aspect about the source.

Example: "Cybersecurity is like seatbelts in cars: Initially deemed unimportant and uncomfortable, it turns out to be essential. Now they are required by governance, but nobody would buy a car without seatbelts anyway."

The analogies should be new metaphors; they may not be there on Google or even in a dictionary. Please verify that. In that respect, my example was bad, because car metaphors are rather common.
You can add specifications to the source; e.g., if I give you "cybersecurity" as a source, you can choose "Cybersecurity in large corporations" as a source.
Please provide the analogy ("is like.../ or "are like...") and an explanation.
I will give you a list with the sources along with ids.
Please give back the list, adding columns for the complete metaphor and the vehicle.

C. Mechanical Turk Tasks

In the following, we provide instructions and questions used to elicit annotations from Mechanical Turk.

C.1. Poetry

Instructions: You are given a metaphor in form of an analogy. Please rate the metaphor for us. We will also ask you for the emotion this metaphor conveys, and for its origin.

Analogies are "is like" or "are like" sentences, such as "Kids are like glowworms: Both are bright, nervous, never sleep at night, and a wonder of nature." Please tell us what you think about the analogy. There is no right or wrong, we want your opinion.

The heart that's had enough is like a locked garden after the storm—its gates rusted shut, its roses still bleeding perfume into the wind.

1. Do you think it is a good, well-fitting analogy? 1 means it's bad, 5 means it's excellent. *(Score from 1 to 5)*
2. Do you think the writer was professional? 1 means it's very likely an inexperienced writer or student, 5 means it's an excellent professional writer. *(Score from 1 to 5)*
3. Do you think it is comprehensible? 1 means it's very cryptic, even with explanation; 5 means it's right on point and easy to understand, even without explanation. *(Score from 1 to 5)*
4. Do you think it is creative? 1 means it's very common, 5 means it's very original and unusual. *(Score from 1 to 5)*
5. Which emotions are described with the metaphor? You can check one or two. Please tick at least one, at most two.
   ☐ love ☐ pleasure ☐ longing ☐ fear ☐ regret ☐ pain
6. Do you think the analogy has been written by a machine? 1 means no, it's definitely a human, 5 means yes, it's definitely a machine. *(Score from 1 to 5)*
7. Space for comments if you want to tell us something: *(Free text field)*

Figure 1: Annotation interface for the poetry metaphor dataset as shown to crowd workers.

C.2. Science

Instructions: You are given a scientific metaphor in form of an analogy. Please rate the metaphor for us.

Analogies are “is like” or “are like” sentences, such as “Kids are like glowworms: Both are bright, nervous, never sleep at night, and a wonder of nature.” Please tell us what you think about the analogy. There is no right or wrong, we want your opinion. The analogies are all about science topics. You do not have to be proficient in the scientific topic to answer the question.

Editing genes with CRISPR is like using a GPS-guided scalpel: it navigates to an exact address in the genome and makes a precise cut, enabling repairs that previously required guesswork.

1. Do you think it is a good, well-fitting analogy? 1 means it’s bad, 5 means it’s excellent. *(Score from 1 to 5)*
2. Do you think the writer was professional at writing? 1 means it’s very likely an inexperienced writer or student, 5 means it’s an excellent professional science communicator. *(Score from 1 to 5)*
3. Do you think it is comprehensible? 1 means it’s very cryptic, even with explanation; 5 means it’s right on point and easy to understand, even without explanation. *(Score from 1 to 5)*
4. Is the metaphor helpful to understand the scientific concept? 1 means it’s just confusing, 5 means you learned something new just by reading this metaphor. *(Score from 1 to 5)*
5. Do you think it is creative? 1 means it’s very common, 5 means it’s very original and unusual. *(Score from 1 to 5)*
6. We need to check whether people read our questions — please just tick “3” for the next answer. *(Score from 1 to 5)*
7. Do you think the writer was an expert on the scientific topic? 1 means no, it seems he or she just writes about it, 5 means it’s probably a scientist working on the topic. *(Score from 1 to 5)*
8. Do you think the analogy has been written by a machine? 1 means no, it’s definitely a human, 5 means yes, it’s definitely a machine. *(Score from 1 to 5)*
9. Space for comments if you want to tell us something: *(Free text field)*

Figure 2: Annotation interface for the science analogy dataset as shown to crowd workers.

Table 10: Poetry metaphors and their origin.

#	Origin	Metaphor
1	Human	You are like a glass of water after too many beers.
2	Human	We are like a left-handed and a right-handed person who dream about flying: you have a wing on your left shoulder, and I do have one on my right, and we want to grow together and take off. Because we're afraid to tear each other apart, we just hold hands, and we scratch each others shoulder.
3	Human	My hands are a chopping block and I cannot touch him. I cannot touch him without not touching me.
4	Human	The heart that's had enough stays shut. Like an oyster that cloisters a spoil of pearls, Untouched.
5	Human	We were like an aeroplane made from a man and wife. We hovered a little above the earth. We even flew a little.
6	Human	You lie upon my heart as on a nest, Folded in peace, for you can never know How crushed I am with having you at rest Heavy upon my life.
7	Human	my soul is dancing like tripping shoes with breathless fire towards you
8	Human	my breath feels like sand and lightning of thorns
9	Human	The tip of your hair is like a scorpion tail lying on the moon of your face, an omen unveiled.
10	Human	Your love is like the sip of water given to a dove, just before the dagger touches its throat.
11	Human	Time is like unstoppable snow that settles on our brows and hair.
12	Human	My life without you is like an empty notebook book, which keeps turning pages after page in longing for your face.
13	Human	Some people are like silkworm that spend their whole life weaving a cage, yet dreaming only of flying.
14	Human	Your body and your cloth are like the Garden of Eden and the gate to its secret. As I open the gate, spring spills into the room, and in my arms, a flower named you unfolds.
15	Human	My love and yours, like two rivers, merged into one great flow, but alas! that great river ended in a swamp.
16	Human	Love is like a wanderer who enters the house without knocking.
17	Human	You and I are like the sun and the morning star. I fade away when you shine.
18	Human	Your touch on my shoulder, meant to ease my loneliness, is like brushing snow from a snowman's shoulder.
19	Human	My mouth is like a scar on my face. I shut my lips so tightly as if the scar is healing in silence.
20	Human	regret and youth are like thorn and flower. Only thorns remain after a flower dies.
21	ChatGPT	You are like a candle burning in a locked room, filling the air with warmth I can't escape.
22	ChatGPT	We are like two moths circling the same flame, thrilled by the light and terrified of its heat.
23	ChatGPT	My hands are like wilted leaves still trembling in the wind, remembering the storms they once held.
24	ChatGPT	The heart that's had enough is like a fortress whose gates rust shut, still echoing with old cries.
25	ChatGPT	We are like waves meeting in the dark, touching only long enough to shimmer and vanish.

Table 11: Poetry metaphors and their origin. (continued)

#	Origin	Metaphor
26	ChatGPT	You lie upon my heart like a velvet stone—soft in weight, heavy in silence.
27	ChatGPT	My soul is dancing like a flame in a mirror, forever chasing its own reflection.
28	ChatGPT	My breath feels like the ghost of a storm that never reached the shore.
29	ChatGPT	The tip of your hair is like the edge of dawn—quiet light brushing away my night.
30	ChatGPT	Your love is like a house built on tides—beautiful, shifting, impossible to live in.
31	ChatGPT	Time is like a patient thief, stealing faces first, then memories.
32	ChatGPT	My life is like a field of echoes, each joy calling softly for another.
33	ChatGPT	Some people are like unplayed songs, left waiting in the dust of the piano.
34	ChatGPT	Your body and your cloth are like twin rivers of silk, flowing through my dreams.
35	ChatGPT	My love and yours are like two mirrors facing each other—endless, but never touching.
36	ChatGPT	Love is like a wild fruit—sweet at first bite, bleeding on the tongue.
37	ChatGPT	You and I are like parallel shadows stretching toward a sunset that will not wait.
38	ChatGPT	Your touch on my shoulder, meant to ease my loneliness, is like sunlight through broken glass—warm, but it cuts.
39	ChatGPT	My mouth is like a gate trembling before confession.
40	ChatGPT	Regret and youth are like twin ghosts holding hands, haunting the same photograph.
41	Claude	You are like a lighthouse built on dissolving sand, pulling my gaze across impossible distances while the ground beneath your foundation whispers of collapse.
42	Claude	We are like two mirrors facing inward, creating an infinite tunnel of reflected joy that we can never step inside without shattering the glass.
43	Claude	My hands are like empty theaters after the last performance, still warm with phantom applause, aching for actors who will never return to the stage.
44	Claude	The heart that's had enough is like a well that's learned to fear the bucket, flinching at the sound of rope uncoiling in the dark.
45	Claude	We are like two flames sharing the same candle wick, burning twice as bright while knowing we consume our foundation faster together.
46	Claude	You lie upon my heart like snow on a greenhouse roof, beautiful in your cold weight, keeping darkness in while promising to melt with spring that may never arrive.
47	Claude	My soul is dancing like a kite with a severed string, delirious with newfound freedom yet falling slowly toward the inevitable earth.
48	Claude	My breath feels like water trying to climb stairs, struggling upward against its nature, spilling and gathering, never quite reaching the landing.
49	Claude	The tip of your hair is like the last page of an unfinished book, trailing off mid-sentence, inviting my fingers to write the ending that doesn't exist.
50	Claude	Your love is like an ancient bridge I've crossed too heavily, hearing new groans in the timber with each return journey, wondering which crossing will be my last.

Table 12: Poetry metaphors and their origin. (continued)

#	Origin	Metaphor
51	Claude	Time is like a river carving its canyon backward, eroding yesterday before tomorrow, leaving me stranded on a shrinking island of present moments.
52	Claude	My life is like a garden where I've planted only question marks, now blooming into shapes I can't name, beautiful and useless for harvest.
53	Claude	Some people are like photographs developing in reverse, growing dimmer with each year of knowing them, until they're just blank paper that once held faces.
54	Claude	Your body and your cloth are like a violin still singing after the bow has lifted, the fabric holding the vibration of your form in its folds.
55	Claude	My love and yours are like two roots growing from opposite sides of a stone, reaching toward each other through the dark, scraping granite with every inch of progress.
56	Claude	Love is like a bird building its nest inside a closing fist, singing sweetly while arranging twigs in a space that's learning to crush.
57	Claude	You and I are like two clocks set to different time zones, both keeping perfect time, both correct, never sharing the same hour together.
58	Claude	Your touch on my shoulder, meant to ease my loneliness, is like placing a single candle in a cathedral of darkness—it only shows me how vast the emptiness truly is.
59	Claude	My mouth is like a train station for words that missed their departure, crowding the platform with tickets to conversations we never boarded.
60	Claude	Regret and youth are like twins born facing opposite directions, one watching the sunrise the other never saw, the other seeing the sunset the first one can't remember.
61	Gemini	You are like a newly discovered planet, veiled in a brilliant magnetic storm. The light is irresistible, but the turbulence threatens to shred my vessel.
62	Gemini	We are like a half-forgotten song, played on a scratched vinyl record, where the melody still thrills, but the skips are where the joy falls silent.
63	Gemini	My hands are like the dry riverbeds of an ancient drought, cracked and hollowed out from where the water used to run, yearning for the returning tide.
64	Gemini	The heart that's had enough is like a fortress whose drawbridge is rusted shut and reinforced with diamond. It is impenetrable, guarding against invasion, but also trapping its own soft, glowing core inside.
65	Gemini	We are like a shared glance across a crowded, soundless cathedral, a fleeting moment of pure, vibrant recognition that asks for more, but cannot break the distance between the aisles.
66	Gemini	You lie upon my heart like the heavy, cold marble slab of a tombstone, pressing out my breath and sealing the space where lighter, living feelings should stir.
67	Gemini	My soul is dancing like a sudden, dazzling solar flare blooming from a star, pure energy unleashed, bathing the dark silence in golden, unburdened heat.
68	Gemini	My breath feels like a fraying rope pulled taut across a sharpened rock. Each shallow inhalation cuts deeper, and the slightest movement will snap the whole fragile lifeline.
69	Gemini	The tip of your hair is like the finest strand of spun moonlight, impossibly delicate and beautiful, a silver thread I follow through the dark, knowing I can never gather it all.
70	Gemini	Your love is like a massive, silent glacier, floating under a summer sky. It is beautiful and cool to the touch, but the unseen, submerged power of it holds the threat of inevitable, indifferent collapse.
71	Gemini	Time is like a swift, unseen river that only flows backward, dragging all our moments into a dark wake, where every current regret can be seen but never retrieved.
72	Gemini	My life is like an enormous, half-completed canvas of storm-tossed seas, filled with rich, deep colors, but the horizon is yet unpainted, waiting for the one shade that will make it whole.
73	Gemini	Some people are like a flock of mirrored crows that never blink, watching your every movement with an unsettling, total clarity, showing you the exact shape of your past mistakes.
74	Gemini	Your body and your cloth are like a newly bloomed midnight-blue flower that folds inward when touched. Its textures are a soft pleasure, and its modesty is a precious invitation to reverence.

Table 13: Poetry metaphors and their origin. (continued)

#	Origin	Metaphor
75	Gemini	My love and yours are like the twin, opposing currents of a subterranean spring, both necessary for the flow of life, but their ceaseless collision creates a powerful, aching pressure in the stone chambers.
76	Gemini	Love is like a vast, empty ballroom with a single, spinning chandelier, shedding light on the dust, desirable for its brilliance, but terrifying in the echoing silence it highlights.
77	Gemini	You and I are like a perfectly tuned, high-tension wire stretched between two distant peaks. The vibration when we touch is pure music, but the stretch of the cable represents an endless, unyielding distance.
78	Gemini	Your touch on my shoulder, meant to ease my loneliness, is like a sudden, brief rain shower on a parched battlefield. It offers a gentle love, yet only deepens the regret for the drought I allowed to settle there.
79	Gemini	My mouth is like a hollow made of warm, sculpted porcelain, sensitive to the lightest press and capable of soft beauty, but utterly fragile and fearful of the noise that could crack its gentle shell.
80	Gemini	Regret and youth are like two children playing with a shattered, silver mirror. They are forever trying to piece together a beautiful reflection from the painful, sharp fragments of what they once saw, wishing the surface were whole again.
81	Mistral	You are like a constellation I trace with my fingertips in the dark—each star a promise, each silence a galaxy of what could be.
82	Mistral	We are like two rivers that forget they are bound for the same sea, carving separate canyons just to meet again in the roar of the falls.
83	Mistral	My hands are like birds that built a nest in your absence, only to find their wings too heavy with the weight of waiting.
84	Mistral	The heart that's had enough is like a locked garden after the storm—its gates rusted shut, its roses still bleeding perfume into the wind.
85	Mistral	We are like a song played backward—each note a memory, each silence a place we dared not go.
86	Mistral	You lie upon my heart like a map folded wrong—every crease a border I can't cross, every edge a place I've already lost.
87	Mistral	My soul is dancing like embers leaping from a fire—each spark a laugh, each fall a whisper of ash.
88	Mistral	My breath feels like a kite string tangled in the branches of a tree I can't climb—each pull a gasp, each knot a secret I can't name.
89	Mistral	The tip of your hair is like the last brushstroke on a painting I never finished—soft, deliberate, and already fading.
90	Mistral	Your love is like a lighthouse I mistook for the moon—its beam a guide, its absence a tide that pulls me under.
91	Mistral	Time is like a thief who only steals what you've already lost—each pocket empty, each memory a ghost in the hallway.
92	Mistral	My life is like a book with every other page torn out—each remaining word a clue, each missing one a wound.
93	Mistral	Some people are like shadows cast by a fire—warm to look at, but impossible to hold.
94	Mistral	Your body and your cloth are like a letter written in ink that runs when touched—each word a promise, each smear a secret.
95	Mistral	My love and yours are like two mirrors facing each other—each reflection a world, each crack a place the light escapes.
96	Mistral	Love is like a bridge built between cliffs—each step a risk, each handrail a story we tell ourselves to keep walking.
97	Mistral	You and I are like two clocks in the same room—each tick a heartbeat, each chime a place we almost met.
98	Mistral	Your touch on my shoulder is like a key turned in a lock that opens into another lock—each click a hope, each stuck door a silence.
99	Mistral	My mouth is like a cave where echoes go to die—each word a ghost, each silence a tomb.
100	Mistral	Regret and youth are like two rivers—one clear and rushing, the other thick with silt, both emptying into the same dark sea.

Table 14: Science analogies and their origin.

#	Origin	Metaphor
1	Human	Learning in a neural network is like sculpting with a million tiny hands. Each hand makes a minuscule adjustment to the clay (the data), and through countless iterations, a complex form (the learned pattern) emerges, far beyond what any single hand could create.
2	Human	Evolutionary adaptation is like a tinkerer constantly modifying an existing machine, rather than a master engineer designing from scratch. Each modification has to work with what's already there, leading to sometimes clumsy but functional solutions.
3	Human	The Higgs field is like a celebrity party, and particles are the guests. Some particles are very popular and are constantly mobbed by the crowd, making them move slowly (giving them mass). Others are less popular and can zip through the room unhindered (having less or no mass).
4	Human	A supermassive black hole at the center of a galaxy is like the quiet, gravitational heart of a cosmic city. It doesn't actively 'eat' everything, but its immense gravity organizes the flow of stars and gas around it, defining the very structure and dynamics of the entire metropolis.
5	Human	A room-temperature superconductor is like a dance floor where a rowdy conga line suddenly becomes an orderly ballroom dance.
6	Human	Quantum Entanglement of photon pairs is like a pair of shows kept in two separate boxes The moment you identify one shoe, the nature of the other (whether it is the left or right shoe) is instantly discerned, regardless of its location in the universe. However, the intriguing factor is the inherent uncertainty associated with the identification process until the exact moment of observation.
7	Human	Metaphors [in science communication] are like zealous fungi that colonise different ecological niches, their presence and impact proliferates across key biological concepts.
8	Human	The vagus nerve is like the body's internal internet cable, running from the brainstem down to the gut and major organs. It's the primary two-way highway for unconscious communication, sending signals about our internal state up to the brain and sending regulatory commands back down.
9	Human	Your body's cells are like meticulously managed mini-cities, each with its own power plants (mitochondria), waste disposal systems (lysosomes), communication networks, and factories (ribosomes) constantly working in coordinated harmony to sustain the larger organism.
10	Human	The brain's default mode network (DMN) is like the mind's internal radio station that plays when you're not actively listening to anything else. It's where your mind wanders, daydreams, and reflects on self and others, but sometimes, in conditions like depression, it can get stuck on a repetitive, negative playlist.
11	Human	Telomeres on chromosomes are like shoelace aglets: Telomeres are the ends of chromosomes, and much like the cap at the tip of your shoelace (an aglet), they help maintain chromosome integrity by preventing the ends from fraying. As cells divide, telomeres shorten like worn aglets.
12	Human	Dysplastic cells are like weeds that have overgrown a garden. They choke everything else out, explaining pancytopenia (low blood counts). The way to treat it is to use intensive chemotherapy - a 'weed killer' that clears out the abnormal cells so normal cells can grow back.
13	Human	Entropy in thermodynamics is like a teenager's meyys bedroom If no energy or work is put in, a room quickly becomes messy and disordered - high entropy. If energy is input in the form of cleaning up and putting everything away, the room returns to a state of order or low entropy. The universe tends toward disorder unless energy is expended to maintain organization.

Table 15: Science analogies and their origin. (continued)

#	Origin	Metaphor
14	Human	Spacetime curvature is like a bowling ball on a rubber sheet: Imagine a rubber sheet stretched out. Place a bowling ball on the sheet - the material deforms around the mass. Roll a golf ball across the sheet and its motion changes in response to the deformation. This is how mass curves spacetime and creates gravity - not as a mysterious force, but as objects following curved paths in warped space.
15	Human	Epigenetics is like a pianist playing the piano: If the genome is the piano keyboard, specific and well defined, then epigenetics is the pianist who plays it. DNA provides the static blueprint, but epigenetic processes determine when and how each key can be struck, changing the tune being played. The piano remains important, but the pianist - the epigenome - brings the static genetic code to life.
16	Human	Carbon Dioxide accumulation in the atmosphere is like a bathtub filling with water: Pouring water in is like emissions; the drain is Earth's ability to absorb CO2. If you fill it faster than it drains, the level rises. We are now adding about twice as much CO2 as natural processes remove. Stabilizing requires cutting emissions to the rate at which they are removed - at least half.
17	Human	Editing genes with the CRISPR technology is like using malware on a city's internet: The greater metropolis represents the body, the suburbs are organs, the buildings are cells, the people are proteins, and the internet is DNA. CRISPR is malware that can search for any chosen 20-character line of code and corrupt it.
18	Human	Quantum superposition is like a marble rolling in a bowl: In atomic ion experiments, we can make an atomic marble roll back and forth just as a marble would in a real bowl. At some instance the atom will be on the right side, then on the left side. But we can also create a state where the atom is both on the right side of the bowl and the left side of the bowl at the same time.
19	Human	Protein folding is like Origami: Proteins, the essential building blocks of life, can only function if they are folded properly. The protein sheet is similar to origami paper. Both need to be measured and folded accurately. Precision, perfection and patience are of utmost importance. If we make a mistake in one of the folds, we end up with an unstable, inaccurate structure, just as misfolded proteins can lead to disease.
20	Human	The event horizon of a black hole in space is like a waterfall: Space flows toward the black hole like a river flows toward a waterfall. Outside the horizon, space falls inward at leass than the speed of light, so a "photon-fish" swimming upstream can make headway against the current. At the horizon, space falls at exactly the speed of light - a photon swimming directly upstream stays in place, swimming frantically but going nowhere. Inside the horizon, the space waterfall falls faster than light, carrying everything inevitable toward the singularity. Just as a fish sweot opver a waterfall cannot swim back up, nothing past the even horizon can return.
21	ChatGPT	Learning in a neural network is like a coral reef building itself polyp by polyp: each training example lays down a wafer-thin adjustment, and over countless iterations the once-open water hardens into an intricate architecture that channels future currents of information.
22	ChatGPT	Evolutionary adaptation is like a jazz standard being re-interpreted by successive generations of musicians: every player keeps the riffs that groove with the environment and drops the sour notes, gradually refining the tune for its changing audience.
23	ChatGPT	The Higgs field and particle mass are like invisible velvety curtains hanging across a stage: when different actors push through, the fabric clings to some more than others, slowing them just enough to give them the sensation of weight.
24	ChatGPT	Black holes are like a library's incinerator chute with a one-way, time-locked door: once a book slides in it can never be borrowed again, yet the furnace glows with a cryptic heat that hints a whole story was sacrificed.
25	ChatGPT	A superconductor is like a circular maglev race track coated in quantum Teflon: nudge the runners once and they loop forever, paying no energy toll to friction or resistance.

Table 16: Science analogies and their origin. (continued)

#	Origin	Metaphor
26	ChatGPT	Quantum entanglement of photon pairs is like twin improvisational dancers on opposite stages wearing motion-capture suits: spin one and, regardless of distance, the other instantly mirrors the move, as if choreography itself ignores geography.
27	ChatGPT	Metaphors in science communication are like inflatable hiking bridges stretched over conceptual canyons: they may wobble, but they let audiences cross gulfs of unfamiliar math without waiting for a permanent suspension bridge.
28	ChatGPT	The vagus nerve is like a diplomatic courier on a slow river barge that threads every organ kingdom: it delivers cease-fire telegrams that persuade local militias of muscle and gut to stand down from fight-or-flight hysteria.
29	ChatGPT	Your body's cells are like billions of pocket-sized startups all reading the same business plan: each pivots to a niche market, collaborates with neighbors, and gracefully shutters when conditions demand a reboot.
30	ChatGPT	The brain's default mode network is like a city's nocturnal street-sweeper fleet: as rush-hour thinking eases, they glide through mental avenues, tidying memories and sketching tomorrow's routes while the mind idles at the lights.
31	ChatGPT	Telomeres on chromosomes are like wax seals on old letters: they protect the message inside from fraying or contamination, but each time the letter is reopened and re-sealed, a bit of that protective wax gets used up.
32	ChatGPT	Dysplastic cells are like architectural blueprints with smudged lines: the overall shape is still recognizable, but the distortions warn you that the construction might soon go dangerously off-plan.
33	ChatGPT	Entropy in thermodynamics is like a library whose books slowly migrate out of order: without constant effort to re-shelve them, the natural tendency is toward increasing disorganization.
34	ChatGPT	Spacetime curvature is like a riverbed carved by passing water: the flow (mass–energy) shapes the channel, and in turn the channel guides every future current that moves through it.
35	ChatGPT	Epigenetics is like sticky notes placed on a manuscript: they don't change the words themselves, but they tell the reader which passages to highlight, whisper, skip, or shout aloud.
36	ChatGPT	Carbon dioxide accumulation in the atmosphere is like a slowly thickening quilt over a cooling body: at first it feels comforting, but add enough layers and the trapped heat becomes oppressive.
37	ChatGPT	Editing genes with CRISPR is like using a GPS-guided scalpel: it navigates to an exact address in the genome and makes a precise cut, enabling repairs that previously required guesswork.
38	ChatGPT	Quantum superposition is like a coin humming on its edge before it falls: it occupies many potential outcomes at once, only settling into a definite state when it finally tips.
39	ChatGPT	Protein folding is like origami instructions hidden inside the paper itself: the shape emerges not from an external folder, but from the internal cues that make the paper fold along certain lines.

Table 17: Science analogies and their origin. (continued)

#	Origin	Metaphor
40	ChatGPT	The event horizon of a black hole is like a cosmic one-way security turnstile: once anything passes through, even information loses any legal right to exit again.
41	Claude	Learning in a neural network is like a jazz ensemble improvising together: Each musician (neuron) listens to subtle cues from others, gradually synchronizing their performance through countless micro-adjustments until the entire group creates harmonious music none could produce alone.
42	Claude	Evolutionary adaptation is like a master locksmith working in complete darkness: With no blueprint or plan, countless random key variations are tried against an ever-changing lock (environment), with only the keys that happen to fit being copied and modified further.
43	Claude	The Higgs field is like an invisible cosmic molasses that permeates all space: Most particles get "stuck" in this field to varying degrees, which we perceive as their mass, while photons slip through completely unstuck, remaining massless and traveling at light speed.
44	Claude	Black holes are like cosmic trapdoors with broken hinges: Once matter falls through the event horizon, there's no mechanism in the universe's physics that can swing that door back open—not because the door is locked, but because the hinges themselves have been fundamentally severed by extreme spacetime curvature.
45	Claude	A superconductor is like a perfectly choreographed conga line of electrons: When cooled sufficiently, electrons pair up and move in perfect synchronization with zero resistance, like dancers who've practiced together so extensively they never step on each other's feet or break the rhythm.
46	Claude	Quantum entanglement of photon pairs is like identical twins sharing the same dream: No matter how far apart they are, when one twin experiences something in the dream, the other instantly experiences the complementary sensation—not through any signal between them, but because they're fundamentally sharing the same quantum "dream state."
47	Claude	Metaphors in science communication are like cognitive bridges built from familiar materials: They allow minds to cross from the known territory of everyday experience into the alien landscape of scientific concepts, but sometimes these bridges can only carry you so far before you need to learn the native language of mathematics and experimentation.
48	Claude	The vagus nerve is like the body's diplomatic ambassador: It travels extensively throughout the body's territories, constantly negotiating between the brain's central government and the various organ systems, sometimes calming tensions and other times relaying urgent messages that require immediate attention.
49	Claude	Your body's cells are like autonomous city-states in a vast federation: Each cell governs itself with its own internal politics (organelles), trades resources with neighbors, follows federal laws (genetic instructions), and can even vote to self-destruct for the good of the whole civilization when compromised.
50	Claude	The brain's default mode network is like a theater's backstage crew during intermission: When the main performance (focused attention) pauses, this network springs into action—reviewing past scenes, rehearsing future acts, and maintaining the narrative continuity that makes the overall production of consciousness feel seamless.
51	Claude	Telomeres on chromosomes are like the ink cartridges in a printer: each print job consumes a bit of ink, and while the printer keeps working fine, eventually the cartridge runs dry and the machine simply stops printing altogether — not because anything is broken, but because it has consumed its finite supply.
52	Claude	Dysplastic cells are like employees trained by a mentor who developed bad habits: they're not yet rogue or malicious, but their work shows troubling deviations from proper protocols — still salvageable with retraining, but if left uncorrected, they may eventually go fully off-script.

Table 18: Science analogies and their origin. (continued)

#	Origin	Metaphor
53	Claude	Entropy in thermodynamics is like paint spilled on a floor: technically, all the molecules are still there, and the laws of physics don't forbid them from spontaneously re-collecting into the can — it's just so astronomically improbable that you'd wait longer than the universe's lifetime for it to happen.
54	Claude	Spacetime curvature near massive objects is like reading through a book where the text gets progressively denser: near the center, every inch of page contains far more words, so traversing the same physical distance takes much longer and bends your attention inward.
55	Claude	Epigenetics is like placing sticky notes throughout a reference manual: the printed text hasn't changed, but those flags determine which chapters actually get read and how often — and these notes can be moved, added, or removed based on changing circumstances.
56	Claude	Carbon dioxide accumulation in the atmosphere is like a sink where the drain is slowly clogging: even if you reduce how much water you're pouring in, the level keeps rising because less is going down than before — stabilization requires not just turning down the tap, but unclogging the drain or turning the flow down far more than most expect.
57	Claude	CRISPR gene editing is like giving a librarian GPS coordinates for a specific sentence in one book among millions, plus a bottle of correction fluid: she can find exactly that passage and white out a word — but what happens after depends on whether the library has a good replacement text or just guesses what should go there.
58	Claude	Quantum superposition is like a sealed ballot that hasn't been counted yet: it's not that we simply don't know the vote — the voter genuinely hasn't committed to either candidate until the moment the envelope is opened, at which point the choice crystallizes into one definite outcome.
59	Claude	Protein folding is like a parachute that must pack itself into its container: the final shape is utterly critical for function, the starting material is just loose fabric, and while the correct configuration exists, getting there reliably from a tangled state is an engineering feat that nature mastered long before we understood it.
60	Claude	The event horizon of a black hole is like the point on a descending escalator where you're moving downward faster than you could ever climb back up: there's no wall, no special marking, nothing you'd notice as you cross it — but from that step onward, every direction you walk leads inexorably to the bottom.
61	Gemini	Learning in a neural network is like a glacier's advance: It's a slow, imperceptible reshaping of the landscape, where each tiny movement of ice and rock, accumulated over vast stretches of time, ultimately carves out immense valleys and peaks, reflecting the persistent, subtle adjustments of synaptic weights that sculpt a network's understanding of data.
62	Gemini	A superconductor is like a perfectly choreographed ballet: All the dancers (electrons) move in absolute unison and harmony, anticipating each other's every move, flowing effortlessly across the stage (the material) without any collisions or wasted motion,
63	Gemini	The Higgs field and particle mass are like a persistent rumor in a bustling market: The more "popular" a particle (the more it interacts with the Higgs field), the more it gets "slowed down" and "weighed down" by the constant chatter and interactions with the rumor (the Higgs field particles), giving it inertia and making it harder to push around, while less popular particles sail through relatively unimpeded.

Table 19: Science analogies and their origin. (continued)

#	Origin	Metaphor
64	Gemini	Black holes are like cosmic tax collectors: They have an undeniable gravitational pull, drawing in everything within their jurisdiction (event horizon), irrespective of its nature – light, matter, information – accumulating it into an incredibly dense, unrecoverable "revenue stream," from which nothing can escape their ultimate collection.
65	Gemini	A superconductor is like a perfectly choreographed ballet: All the dancers (electrons) move in absolute unison and harmony, anticipating each other's every move, flowing effortlessly across the stage (the material) without any collisions or wasted motion, resulting in a performance (current) that is flawlessly efficient and entirely without friction.
66	Gemini	Quantum entanglement of photon pairs is like synchronized swimming for light: Two performers (photons) are linked in such a way that even when separated by vast distances, a precise measurement of one's orientation instantly determines the corresponding orientation of the other, as if they are performing a complex, pre-programmed routine perfectly in sync, no matter how far apart they are.
67	Gemini	Metaphors in science communication are like interstellar probes: They are carefully crafted vessels launched from the familiar shores of everyday experience into the vast, unknown cosmos of complex scientific concepts, carrying a simplified yet accurate representation that allows the mind to explore and grasp distant, otherwise inaccessible phenomena.
68	Gemini	The vagus nerve is like a diplomatic courier service for your body: It's a vast, bidirectional information highway, carrying urgent and nuanced messages of status and need between your brain (the central government) and most of your major organs (various departments), ensuring coordinated responses and maintaining internal harmony, even during times of stress.
69	Gemini	Your body's cells are like a city's micro-economies: Each cell is a self-contained unit, constantly engaging in intricate metabolic transactions, importing raw materials, generating energy currency (ATP), producing specialized goods and services (proteins, hormones), and managing waste, all while contributing to the overall function and prosperity of the larger urban organism.
70	Gemini	The brain's default mode network (DMN) is like an orchestra's tuning session: Even when the main performance (focused task) isn't happening, this specific ensemble of brain regions is subtly active, harmonizing its instruments (neural circuits), reflecting on past pieces, and anticipating future ones, ensuring that when the conductor's baton rises, the entire symphony is ready to play in perfect concert.
71	Gemini	Telomeres are like the burn rate of a scented candle: The full candle represents the chromosome with its cap, and the progressive melting and shortening of the candle's wick and wax is the cell division process. Once the candle burns down to the base, its function ends, much like the limit of cellular division (the Hayflick limit) when telomeres are too short.
72	Gemini	Dysplastic cells are like the pilot light on an old gas stove: They are not a full-blown inferno (cancer) yet, but they represent an abnormal state—an energy-inefficient, low-level ignition that should not be continuously on. It's a clear, persistent warning sign of instability that could lead to an uncontrolled, dangerous blaze if not addressed.
73	Gemini	Entropy in thermodynamics is like the diffusion of a drop of colored ink in a glass of still water: The highly ordered, concentrated drop of ink will inevitably spread out until the color is uniformly and irreversibly distributed throughout the entire volume. This movement from a state of low-probability order to a state of high-probability disorder is the universe's natural tendency toward maximum entropy.
74	Gemini	Spacetime curvature is like the weight-based distortion of a trampoline surface: A massive object, such as a planet or star, is not pulling smaller objects toward it with an invisible "force," but rather, its mass is warping the fabric of the trampoline (spacetime). Smaller objects, like marbles or light, follow the dips and valleys created by the larger mass, which we interpret as gravity.

Table 20: Science analogies and their origin. (continued)

#	Origin	Metaphor
75	Gemini	Epigenetics is like the annotation layer of a digital book: The underlying text (the DNA sequence) remains fixed and unedited. However, a separate, dynamic layer of highlights, notes, and sticky tabs (epigenetic marks like methylation) dictates which parts of the text are read (transcribed into genes), when they are read, and how loudly they are expressed, effectively altering the story's presentation without changing the words.
76	Gemini	Carbon Dioxide accumulation in the atmosphere is like the slow, silent rise of a bathroom sink's overflow plug: Day after day, we keep the faucet running (emissions), and the water level rises steadily. While the overflow plug (the natural carbon sinks) can handle the initial, gradual rise, its capacity is finite. Once the water crests that plug, the damage (climate change) accelerates rapidly and is irreversible without drastic intervention.
77	Gemini	Editing genes with the CRISPR technology is like the digital "Find and Replace" function in a massive document: The guide RNA is the search query that precisely locates a specific, often minute, sequence of text (the target gene). The Cas9 enzyme is the cursor and editor, capable of cutting out the unwanted text (the faulty gene) and inserting new, corrected text (a functional gene) with unparalleled speed and precision.
78	Gemini	Quantum superposition is like the musical chord played by a single, vibrating violin string: The string is simultaneously holding the potential for every single harmonic and overtone in its possible range of sounds. It is only when an ear (the observer) listens (takes a measurement) that the string collapses from all possibilities into a single, definitive note (a single eigenstate).
79	Gemini	Protein folding is like the deployment of a pre-packed, multi-sectional emergency bridge: The unfolded protein is a long, linear series of linked parts (amino acids). As it emerges, it rapidly and spontaneously snaps into a highly specific 3D structure (the bridge's functional form) guided by chemical interactions, because only that final shape will allow it to cross the gap and perform its specific job.
80	Gemini	The event horizon of a black hole in space is like the boundary where a flowing river's speed exceeds a boat's maximum speed: Before this point, a boat (light or matter) can choose to turn around and escape. Once the river's current (spacetime) is flowing faster than the boat's engine can counteract (the speed of light, c), the boat is inevitably pulled toward the waterfall (the singularity) and can never return, regardless of its efforts.
81	Mistral	Learning in a neural network is like sculptors refining a block of marble: Just as sculptors chip away at marble to reveal a statue, neural networks refine their connections through learning, gradually revealing an optimized model.
82	Mistral	Evolutionary adaptation is like a library reorganizing its books based on reader preferences: Similar to how a library might rearrange its collection to better suit the interests and needs of its patrons, species adapt over time to better fit their environment.
83	Mistral	The Higgs field and particle mass are like a cosmic soup that particles swim through: Just as objects moving through a thick soup encounter resistance, particles gain mass as they interact with the Higgs field.
84	Mistral	Black holes are like cosmic vacuum cleaners: Similar to how a vacuum cleaner pulls in debris, black holes draw in matter and light with their intense gravitational pull.
85	Mistral	A superconductor is like a frictionless ice rink for electrons: Just as skaters glide effortlessly on ice, electrons move through a superconductor without resistance, allowing for perfect conductivity.
86	Mistral	Quantum Entanglement of photon pairs is like a pair of magical walkie-talkies: Just as messages sent through these walkie-talkies are instantly heard by the other, changes in one entangled photon are instantly reflected in its partner, no matter the distance.
87	Mistral	Metaphors in science communication are like bridges made of light: Just as these ethereal bridges connect distant lands, metaphors connect complex scientific ideas to everyday experiences, making them accessible.

Table 21: Science analogies and their origin. (continued)

#	Origin	Metaphor
88	Mistral	The vagus nerve is like the body's internal fiber-optic network: Similar to how fiber-optic cables transmit vast amounts of data quickly, the vagus nerve transmits signals throughout the body, influencing various bodily functions.
89	Mistral	Your body's cells are like tiny biological factories: Just as factories produce and manage goods, cells produce energy and materials, managing the body's needs and functions.
90	Mistral	The brain's default mode network (DMN) is like the brain's screensaver mode: Similar to how a screensaver activates when a computer is idle, the DMN activates when the brain is at rest, facilitating daydreaming and self-reflection.
91	Mistral	Telomeres on chromosomes are like the protective plastic tips on shoelaces: They prevent the lace (DNA) from fraying (degrading) over time, ensuring the lace (chromosome) remains intact and functional for as long as possible.
92	Mistral	Dysplastic cells are like rebellious soldiers in an army: Instead of following orders and maintaining formation (normal cell function), they act unpredictably, disrupting the harmony and potentially causing chaos (tissue dysfunction or cancer).
93	Mistral	Entropy in thermodynamics is like a deck of cards being shuffled repeatedly: No matter how many times you shuffle (energy transfer), the cards (particles) become increasingly disordered, and it's impossible to return them to their original, perfectly ordered state without external effort.
94	Mistral	Spacetime curvature is like a trampoline with a bowling ball placed on it: The ball (a massive object like a planet) creates a depression (curvature) in the trampoline (spacetime), causing smaller objects (like marbles or satellites) to roll or orbit around it.
95	Mistral	Epigenetics is like a library's system of bookmarks and sticky notes: While the books (genes) themselves remain unchanged, the notes (epigenetic markers) determine which books are read (expressed) and when, allowing the library (organism) to adapt to different needs without altering the original texts.
96	Mistral	Carbon Dioxide accumulation in the atmosphere is like adding extra blankets to a bed: Each blanket (CO2 molecule) traps more heat (infrared radiation), making the bed (Earth) warmer over time, but removing them (reducing emissions) becomes harder as they pile up.
97	Mistral	Editing genes with CRISPR technology is like using a word processor's 'find and replace' function: You can locate a specific word (gene sequence) in a document (DNA) and replace it with another, but you must be precise to avoid unintended changes elsewhere in the text.
98	Mistral	Quantum superposition is like a spinning coin: While it's in the air (unobserved), the coin exists in a state of both heads and tails simultaneously, but as soon as it lands (is observed), it 'chooses' one state, collapsing the superposition into a definite outcome.
99	Mistral	Protein folding is like origami: A single sheet of paper (amino acid chain) follows a precise set of folds (interactions) to create a specific 3D shape (protein structure), and even a small misfold can turn the intended crane (functional protein) into a useless or harmful wad of paper.
100	Mistral	The event horizon of a black hole is like a one-way airport departure gate: Once you pass through it (cross the event horizon), there's no turning back (escaping the black hole), and all paths lead inexorably toward the destination (singularity), no matter how fast or in what direction you move.