

**The Black Hole Fed on the Star:
Conceptual Metaphors in Cosmology on Popular
Science YouTube Channels**

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1. Introduction

1.1. Historical Overview of Cosmic Understanding

Cosmology, the study of the universe's origin, structure, and evolution (Ryden, 2017), has intrigued the collective mind of humanity throughout history, captivating early thinkers, philosophers, and scientists alike. Long before the advent of language, humans have looked up to the night sky with a sense of curiosity since over 30,000 years (Eyres, 2016, p. 7). This is evidenced by cave drawings in Spain and France that depicted the Sun and, even possibly, the phases of the Moon (Kragh, 2007, p. 6). With rise of early civilizations, however, our efforts to understand the universe became more structured, taking shape through speculations from different cultures around the world, including those of Ancient Egypt, Sumer and Babylon, Ancient Greece, and many others (Blacker & Loewe, 1975). Though many of these cultures were completely diverse in terms of thought and philosophy, they shared a common goal: to make cosmic phenomena comprehensible in a way that aligns with their respective frameworks. Early civilizations approached this challenge by conceptualizing cosmic objects and phenomena as living entities with personalities and intentions (Jacobsen, 1975, p. 142). They lacked our present day understanding of how natural phenomena interacted and thus interpreted each as an independent power, believing that these powers could be influenced through ritualistic devotion (Lambert, 1975, p. 46). The sun and the moon are prime examples of this. Since they are the most prominent celestial bodies visible to the naked eye, many ancient cultures worshipped these heavenly objects as deities, attributing to them powers over life, death, and the cycles of nature (Eyres, 2016, p. 7). Early civilizations also fit such entities into mythological narratives as a means to understand the origins of the universe (Frankfort & Groenewegen-Frankfort, 1975; Campion, 2012). The Heliopolitan creation narrative in ancient Egypt, for instance, often began with the concept of Nun, the primordial waters from which the creator god Atum arose. Atum then proceeded to create the Ennead, a group of nine deities who represented various aspects of the material world (Plumley, 1975, p. 28-30; Van Dijk, 1995). This imagery of primordial waters was likely shaped by the Egyptians surrounding environment and geography, particularly the life-giving Nile, whose presence deeply influenced their worldview (Blacker & Loewe, 1975, p. 19).

We also find a similar, yet more turbulent environment in Mesopotamia, shaped by the seasonal floods of the Tigris and Euphrates rivers. The Babylonians and the Assyrians conceptualize the creation of the world in their epic, *Enūma Eliš*, or 'When in the Height' as a battle between the forces of chaos and order (King, 1999, p. 26). The story begins with the mingling of the waters of Apsû (representing sweet water) and Tiāmat (representing salt water),

which gave birth to younger gods (Kragh, 2007, p. 9). As the younger gods became disruptive, Apsû planned to destroy them, but was instead defeated by Ea, the god of wisdom and magic. Later, Tiāmat, angered by the death of Apsû, created monsters to wage war against the other gods. Marduk, the deity of Babylon, emerged as the hero who defeated Tiāmat. He then splits her body in half, using one half to create the sky and the other to form the earth, thus establishing the order of the universe (King, 1999, p. 32-49). A connection can be drawn between this epic and the geographical features of Mesopotamia. The Mesopotamians believed that their land was formed by the deposition of silt where fresh water from the rivers met the salt water of the Persian Gulf. This geological process seems to have served as the basis for their cosmological speculations, as reflected in *Enūma Eliš*. Marduk creating the sky and earth from the split body of Tiāmat also mirrors the Mesopotamians' understanding of their landscape. They observed that the sky appeared to be made of solid matter, similar to the earth, and they reasoned that it must have been formed through a process comparable to the deposition of silt and raised to its current position (Jacobsen, 1975, p. 187).

Throughout this early history, a pattern emerges in how humans developed frameworks for understanding abstract cosmic phenomena. When confronted with the incomprehensible vastness of the cosmos, civilizations consistently created explanatory frameworks using familiar concepts from their immediate experience. The emergence of monotheistic religions also introduced a new way of conceptualizing cosmic order through the idea of a single divine creator. Rather than multiple deities responsible for different cosmic phenomena, the concept of a single creator suggested an ordered universe operating under unified divine principles. Christian cosmology, for instance, centered on the concept of a creator God who brought the universe into existence *ex nihilo* in structured stages (Campion, 2012, p. 161). Islamic cosmology, on the other hand, offered a particularly comprehensive framework, with the Quran describing a universe where all existence, from the heavens and earth to everything between them, emerged from a single divine source (Jachimowicz, 1975, p. 145-146). Such monotheistic frameworks emphasized not only divine creation but ongoing divine governance of the cosmos.

1.2. The Evolution of Scientific Conceptualization

A significant shift in perspective emerged in Ancient Greece around the 6th and 5th centuries BC (Kragh, 2007, p. 13). The philosopher, who was mainly occupied with the study of the natural world, seemed to take on the pursuit of cosmic inquiry, but in a more systematic manner (Couprie, 2011, p. 22). The main instrument at his disposal at that time was employing rational thinking in an effort to grasp the universe. In Ancient Greece, the philosopher Anaximander

was the first to introduce “apeiron,” an indefinite, boundless substance that serves as the ultimate source and origin of all things in the universe (Theodossiou et al., 2011). This concept, or the fragment that remains of it, is notable in cosmological thought because it shifted the focus away from divine beings to the exploration of natural phenomena (Kragh, 2007, p. 14). Anaximander’s concept of the apeiron, along with the contributions of other pre-Socratic philosophers such as Thales and Anaximenes (Theodossiou et al., 2011), marked a departure from mythological interpretations and encouraged an empirical approach to understand and communicate cosmic phenomena through purely abstract principles rather than familiar physical analogies.

Another significant contribution to Greek thought emerged through the Pythagorean school in southern Italy during the 6th century BC (Ballif & Moran, 2005, p. 315). The Pythagoreans were the first to suggest that mathematics could explain material phenomena, laying early groundwork for the theoretical framework that would later develop into mathematical physics and cosmology (Kragh, 2007, p. 15). This observation emerged from their discovery of mathematical regularities in music, where they found that harmonic sounds corresponded to specific numerical ratios. This observation led them to a broader hypothesis: if musical harmony could be explained through numbers, perhaps the entire cosmos operated according to similar mathematical principles (Hetherington, 2023, p. 61-63). These mathematical approaches to understanding the cosmos influenced subsequent thinkers, including Plato and Aristotle, who continued to grapple with cosmological questions (Kragh, 2007, p. 19-23). Aristotle’s geocentric model, which placed a stationary Earth at the center of the universe with the Sun, Moon, planets, and stars revolving around it in perfect circular orbits, would come to dominate astronomical thought for nearly two millennia (Hetherington, 2023, p. 102-103).

Still maintaining Earth at the center, the Alexandrian mathematician and astronomer Claudius Ptolemy refined the geocentric model further in the 2nd century AD, through his work *Almagest* (Kragh, 2007, p. 28-29). This refined geocentric model remained the standard framework of cosmic phenomena until the 16th century, when Nicolaus Copernicus proposed a revolutionary alternative: a heliocentric model that placed the Sun, rather than Earth, at the center of the universe (Hetherington, 2023, p. 107; North, 1989, p. 405). This heliocentric model gained crucial empirical evidence in the early 17th century through Galileo Galilei’s telescopic observations. Galileo made several groundbreaking discoveries that challenged the traditional geocentric view (Eyres, 2017, p. 21-22; Kelley & Milone, 2011, p. 257). When Galileo pointed his telescope at Jupiter, he discovered four moons circling the planet. This simple but revolutionary observation proved, for the first time, that some celestial bodies

orbited something other than Earth. If these moons could orbit Jupiter, then the fundamental idea that everything in the universe must orbit Earth could no longer be true (Bussotti & Lotti, 2022, p. 79-81).

This paradigm shift was not merely a change in astronomical calculation; it required a complete reconceptualization of how humans understood their position within the universe. We encountered an unsettling truth: the universe was not structured around human existence. This decentralization required new ways of conceptualizing a universe that no longer placed Earth at its center (Eyres, 2017, p. 68-69; Hetherington, 2023, p. 229).

1.3. The Mathematical Approach in Cosmological Understanding

By the end of the 17th century, our scientific understanding of the cosmos changed drastically (Hetherington, 2023, p. 177). Johannes Kepler's discovery of elliptical planetary orbits showed that celestial motion could be precisely described through mathematical principles, while Isaac Newton's theory of universal gravitation provided a unified conceptual framework that explained both earthly and celestial phenomena through the same mathematical principles (Elizalde, 2021, p. 99; Hetherington, 2023, p. 235). These developments represented a crucial shift in how humans could conceptualize and explain cosmic phenomena, from relying on intuitive understanding to embracing abstract mathematical descriptions of reality. It was in this context that Immanuel Kant emerged as the last major philosopher to significantly engage with cosmological speculation. Through his transcendental turn in the *Critique of Pure Reason*, Kant examined not the universe itself, but the conditions that make knowledge of the universe possible, inadvertently setting philosophy on a path that would lead away from direct cosmological inquiry (Couprie, 2011, p. 22-23; Bussotti & Lotti, 2022, p. 302). This marked a decisive separation between philosophical speculation and scientific investigation of the cosmos (Couprie, 2011, p. 23; Hetherington, 2023, p. 556). The transformation of cosmology into an empirical science was accelerated by significant technological advances in the 20th century when improved telescopes and observational methods led to discoveries that would fundamentally reshape our understanding of the cosmos. In 1916, Einstein's theory of general relativity brought perhaps the most dramatic reconceptualization: rather than seeing gravity as a mysterious force acting across empty space, Einstein showed that space and time form a fabric that can be curved and warped by massive objects (Kragh, 2007, p. 125-126). This fundamentally changed how we conceptualize the relationship between space and time. A decade later, Edwin Hubble demonstrated that our Milky Way was not the entire universe, but just one galaxy among many. His observations revealed that the universe was vastly larger than

previously imagined, further diminishing Earth's cosmic significance (Elizalde, 2021, p. 84-90). These revolutionary discoveries laid the groundwork for modern cosmology (Hetherington, 2023, p. 412).

1.4. The Challenge of Communicating Black Holes

Einstein's theory not only changed how we understand gravity and space, but also predicted something extraordinary: if an object were massive and compact enough, its gravitational pull would be so strong that nothing, not even light, could escape from it (Blundell, 2015, p. 26). The evolution of terminology used to describe these objects reflects the ongoing struggle to conceptualize and communicate such abstract concepts. Originally coined around 1960 by physicist Robert Dicke, who drew an analogy to the notorious Black Hole of Calcutta prison, the term was officially introduced to scientific literature by American physicist John Wheeler in 1969 (Hawking, 2011, p. 78; Herdeiro & Lemos, 2018). Robert Dicke first drew the analogy from a small prison cell in Fort William where, in 1756, numerous East India Company soldiers were tragically confined in severely cramped conditions (Herdeiro & Lemos, 2018). This historical reference was apt: just as the prison represented a confined space from which escape was nearly impossible, these cosmic objects represented regions of space from which nothing, not even light, could escape. This pattern of using familiar concepts to explain the unfamiliar reflects a continuous effort to understand cosmic phenomena. Throughout history, from ancient mythological frameworks to modern scientific metaphors, humans have consistently sought ways to make the incomprehensible cosmos accessible through familiar reference points. Today, this challenge reaches its peak in explaining objects like black holes. The abstract and counter-intuitive nature of these mysterious regions of space makes them particularly challenging to explain. This challenge was dramatically illustrated in 2019 when the Event Horizon Telescope collaboration captured the first-ever image of a black hole, approximately 55 million light-years from Earth. The historic image revealed the black hole outlined by emission from hot gas swirling around it under the influence of strong gravity near its event horizon (NASA, 2019), making visible what was previously understood only through mathematical models and metaphorical explanations. Even with this groundbreaking visual evidence, scientists and educators continue to rely on metaphorical language to explain what highly scientific phenomena represents to the public (Koteyko & Atanasova, 2010, p. 296). This persistent pattern to explain abstract concepts through concrete, experiential domains aligns with the fundamental principles of conceptual metaphor theory (Lakoff & Johnson, 1980).

2. Theoretical Framework

This study draws on Conceptual Metaphor Theory (CMT) and research in science communication to examine how conceptual metaphors are employed to explain black holes in popular science YouTube channels. The theoretical framework integrates insights from cognitive linguistics, science communication studies, and educational research to provide a comprehensive lens for analyzing metaphorical explanations in online science communication.

2.1. Conceptual Metaphor Theory (CMT)

Conceptual metaphor theory, first systematically presented by George Lakoff and Mark Johnson (1980), provides the foundational framework for analyzing how abstract concepts are understood and communicated through metaphorical mapping. The theory presents a fundamental shift in understanding metaphor not as a mere linguistic device, but as a basic cognitive mechanism that structures how we think and reason about abstract concepts through more concrete experiential domains (Kövecses, 2016, p. 13; Lakoff, 2006, p. 185).

CMT differentiates between a ‘source domain’ and a ‘target domain.’ The source domain refers to a concrete, experiential field, while the target domain represents an abstract concept (Kövecses, 2010, p. 4). When a metaphorical mapping is applied, it aligns knowledge from a familiar source domain to structure understanding within a less accessible target domain. Such mappings are not arbitrary but grounded in physical and everyday experience (Lakoff, 2006). This becomes particularly relevant for understanding how complex physics concepts like black holes, which cannot be directly experienced, are made comprehensible through metaphorical mappings from more familiar domains.

2.2. The Importance of Effective Science Communication

Effective science communication goes beyond mere fact transmission, aiming to foster dialogues between scientists and the public (Fischhoff & Scheufele, 2013). This interactive approach is crucial, as the presentation of scientific concepts can significantly influence public understanding and perceptions of new discoveries (Nisbet & Scheufele, 2009). Gross (1996) presents two fundamental models of science communication that offer contrasting approaches to public understanding of science. The first, known as the deficit model, assumes a direct transmission of knowledge from scientific experts to a passive public presumed to lack scientific understanding. This approach suggests that increased provision of scientific

information would automatically result in enhanced public comprehension and acceptance of scientific concepts.

However, this view has been challenged by social scientists, leading to the emergence of the contextual model. This alternative framework conceptualizes science communication as an interactive process that recognizes public engagement and understanding as emerging from the combination of scientific and local knowledge (Gross, 1996). The contextual model emphasizes the importance of considering sociocultural factors in science communication, acknowledging that effective transmission of scientific concepts requires engagement with audiences' existing knowledge frameworks and cultural contexts (Koteyko & Atanasova, 2016, p. 296).

2.3. Metaphors in Science Communication

Metaphors in science can enhance both comprehension and engagement through what Grady (2016) identifies as key benefits: they make abstract concepts 'easier to think about,' create novel framings that help break through communication barriers, and aid memorability of complex scientific ideas. These factors can be considered especially relevant for digital science communication platforms like YouTube, where content creators must balance scientific accuracy with audience engagement and understanding. Kulgemeyer (2018, as cited in Kohler & Dietrich, 2021) identifies that successful science videos should maintain minimalist design, employ clear structure, and connect to viewers' prior knowledge. For metaphorical explanations of black holes, this suggests that effective communication requires not only apt metaphors but also careful consideration of how these metaphors are presented and contextualized within viewers' existing understanding.

As Ceroni (2014) notes, when explaining advanced scientific concepts to the public, communicators must rely on ordinary language and conceptual systems to generate meanings accessible to their audience. Drawing on conceptual metaphor theory, Ceroni argues that effective scientific metaphors must do more than simply highlight similarities between source and target domains, they must provide a coherent conceptual framework that allows audiences to construct meaningful understanding. McCool (2008) also notes, "much of this metaphorical work is used to satisfy the mind's insatiable appetite for concrete images" (p. 14). This observation aligns with the cognitive function of metaphor in science communication, particularly when explaining phenomena like black holes that cannot be directly visualized.

2.4. Educational Research on Physics Metaphors

Building on these insights about the cognitive role of metaphor in science communication, research has extensively examined how metaphorical understanding develops in educational settings, providing valuable insights into the learning process. Çetin's (2016) extensive study of high school students' metaphorical perceptions revealed that physics concepts are primarily understood through four key categories: content, function, affective characteristics, and cognitive characteristics. Smith et al. (2017) found that while metaphorical framings generate engagement, relevance-based explanations that connect phenomena to viewers' lives proved more effective at increasing motivation to learn than purely metaphorical comparisons. Corni et al. (2019) demonstrated how understanding of physical science concepts develops through perception-based schemas and metaphorical thinking, particularly in educational settings. These educational studies collectively suggest that effective metaphorical explanations of complex physics concepts must balance technical accuracy with experiential grounding while considering both cognitive and affective dimensions of understanding.

Similarly, Brookes and Etkina (2007) found that metaphorical language plays a crucial role in helping students grasp abstract concepts by mapping them onto more familiar domains. However, they also noted that metaphors can introduce potential misconceptions if the mapping between source and target domains is not carefully managed.

2.5. Black Hole Metaphors in Scientific Discourse

Kramar and Ilchenko (2021) offer a similar insight in their analysis of astrophysical and cosmological metaphors. They observe that metaphorical terms often become "enriched and elaborated" in a way that enhances audience engagement while potentially amplifying misconceptions. Kramar and Ilchenko (2021) specifically analyze the term 'black hole' as an example of metaphorical terminology that both illuminates and potentially misleads. They note that neither the 'black' nor 'hole' aspects of the metaphor accurately represent the phenomenon: it is not truly black (being invisible rather than dark-colored), nor is it actually a hole in space. Rather than being empty, as the hole metaphor might suggest, it is a region of extremely dense matter with intense gravitational effects. This metaphorical framing, they argue, has led to potentially problematic personification in popular discourse, where black holes are often described as "hungry monsters" that "feed" on or "gobble up" matter.

Tambor (2020) also examines how the black hole concept has evolved from its initial metaphorical introduction to become what he terms a "dead metaphor", one so established in scientific discourse that its metaphorical nature is often forgotten. Pulaczewska (2011)

demonstrates this further, explaining how the fundamental metaphor of a ‘hole’ in describing these cosmic phenomena emerged from observational limitations, the apparent void or hollow region in space where nothing can be detected. This linguistic choice reflects both the perceptual experience (an unobservable region) and the physical behavior (objects becoming imperceptible as they approach).

2.6. YouTube Science Communication Context

While these studies provide valuable insights into metaphor in science communication and cosmology, there remains a significant gap in understanding how metaphorical explanations function specifically in online science video platforms. Although research has examined science communication on YouTube more broadly and in different disciplines (Allgaier, 2020; Ilundáin & Anguiano, 2019; Llewellyn & Rose, 2021; Welbourne & Grant, 2016), and studies have investigated metaphorical terminology in cosmology (Kramar & Ilchenko, 2021; Pulaczewska, 2011; Tambor, 2020), there has been limited integration of these research areas. Particularly, there is a need to examine how conceptual metaphors for black holes are constructed and deployed in the unique communicative context of YouTube, where content must balance scientific accuracy with audience engagement.

This gap is especially significant given that science communication on YouTube differs markedly from traditional media, operating within what Burgess and Green (2009, as cited in Welbourne & Grant, 2016) term a “participatory culture,” where viewers shift from being passive consumers to active participants in the communication process. Understanding how metaphorical explanations function in this environment is crucial, as YouTube has become an increasingly important platform for science communication, with science and technology ranking as the third most popular content category (Ilundáin & Anguiano, 2019). This suggests a significant public appetite for scientific content when presented in accessible formats.

This study aims to address this gap by identifying the dominant conceptual metaphors used to explain black holes in popular science YouTube channels and examining how abstract cosmological concepts are mapped onto more familiar domains. In addition, this study seeks to understand not only what metaphors are used, but how they function within the specific context of YouTube science communication.

3. Methodology

3.1. Research Design

This study employs a qualitative approach to analyze conceptual metaphors used in explaining black holes in popular science YouTube videos. The analysis focuses on identifying, categorizing, and semantically analyzing metaphorical expressions and their underlying conceptual mappings.

3.2. Data Collection

3.2.1. Source Selection

The study examines videos from four prominent science communication channels on YouTube, selected for their significant reach, educational approach, and consistent production of physics-related content:

- **Veritasium**, created by Dr. Derek Muller, has established itself as a leading science education channel with 16.6 million subscribers (Veritasium, n.d.). Dr. Muller, who holds a PhD in physics education research from the University of Sydney and a degree in Engineering Physics from Queen's University, brings substantial academic credentials to his science communication work (About, n.d.). The channel's approach combines rigorous scientific explanation with engaging presentation formats.
- **Kurzgesagt – In a Nutshell**, founded by Philipp Dettmer, has attracted 23.2 million subscribers through its distinctive animated educational content (Kurzgesagt, n.d.). Dettmer's background in information design and history influences the channel's approach to explaining complex scientific concepts through detailed animations and infographics (Philipp Dettmer, n.d.). The channel is particularly noted for its "optimistic nihilism" perspective in addressing scientific topics.
- **TED-Ed**, with 20.6 million subscribers, represents TED's educational initiative. Operating under the broader TED organization, founded by Richard Saul Wurman, TED-Ed's mission focuses on celebrating and disseminating educational content globally (Ted, n.d.). The channel has produced over 2,000 videos, maintaining TED's commitment to accessible expert knowledge (Ted-ed, n.d.).
- **SciShow Space**, founded by science communicator Hank Green, reaches 1.43 million subscribers with focused content on space and astronomy (Hank Green, 2021; SciShow Space, n.d.). The channel specializes in concise explanations of cosmic phenomena,

from the early universe to contemporary space exploration, making it particularly relevant for this study's focus on black hole conceptualization.

- **Cool Worlds**, led by Professor David Kipping from Columbia University's Department of Astronomy, reaches 949,000 subscribers with specialized content focused on space science, particularly exoplanets and astrobiology (Cool Worlds, n.d.). The channel's scientific approach and academic affiliation make it particularly relevant for analyzing technical and specialized metaphorical framing of astronomical phenomena. Operating from within an active research lab environment, the channel provides authoritative astronomical content while making complex astrophysical concepts accessible to general audiences.

The selection of videos followed specific criteria to ensure relevance and focus. Primary videos were identified through a keyword search of 'black hole' in video titles across the selected channels. A total of 10 videos were selected for analysis, distributed across the channels as follows: three videos from Veritasium, three from Kurzgesagt – In a Nutshell, two from TED-Ed, one from SciShow Space, and one from Cool Worlds.

The selected videos varied in length from 5 minutes and 10 seconds to 32 minutes and 23 seconds, with a total combined duration of 117 minutes and 67 seconds. The videos also span from December 2015 to April 2024, capturing nearly a decade of science communication content about black holes across multiple popular science channels.

3.2.2. Data Processing

The data collection and processing employed a systematic approach to ensure both accuracy and comprehensive metaphor identification. The initial step involved extracting video captions using online caption extraction tools. To ensure transcript accuracy, each extracted text was manually verified against the original video content, with any discrepancies or errors in the automatic transcription being corrected. The transcripts were preserved in their entirety, with only promotional or advertisement segments being removed as they were not relevant to the scientific content (see **Appendix**).

3.3. Analytical Framework

Following transcript verification, the identification of metaphorical expressions began with a thorough reading of each transcript. A color-coding system was implemented to mark potential metaphorical expressions about black holes. The verified metaphorical expressions were then compiled and analyzed for patterns and relationships.

Through this process, expressions were grouped based on shared conceptual features and analyzed for their source and target domain relationships. This systematic analysis led to the identification of 21 distinct metaphorical expressions. These expressions cluster around three major conceptual frameworks: BLACK HOLE AS LIVING ENTITY, BLACK HOLE AS OBJECT, and BLACK HOLE AS CONTAINER. These major categories were further refined into specific subcategories based on recurring patterns in the metaphorical expressions. The data collection and analysis phase of this research was completed in November 2024.

4. Findings

The following findings reveal how popular science communicators systematically use concrete, experiential domains to make the abstract properties of black holes comprehensible to general audiences.

4.1. Black Hole as Living Entity

4.1.1. Conceptualization of black holes as cosmic monsters

- 1) As the star approached the side closest to the black hole, it experienced a much stronger gravitational pull than the other side, **ripping the star to shreds**. (Veritasium)

In this expression, the black hole is conceptualized as a violent, animate aggressor with physical agency. The conceptual metaphor HARM IS PHYSICAL INJURY structures this understanding, where gravitational interaction is understood through physical violence. The violent action schema involves a monster ‘the black hole’ that possesses intention and physical strength to destroy, performing an action ‘ripping’ on a victim ‘the star,’ resulting in complete disintegration ‘shreds.’

This emphasizes the thoroughness of destruction, the irreversible nature of the action, and the complete disintegration of the object into a state of extreme fragmentation. This metaphorical

expression makes the abstract concept of gravitational force comprehensible by mapping it onto familiar physical experiences of violent destruction.

- 2) Outer space has no shortage of forces that could wreak havoc on our tiny planet. But there's something in space that seems more terrifying than any of these – something [a black hole] that **wipes out everything** it comes near. (TED-Ed)

Here, the black hole is conceptualized as an all-powerful destroyer with absolute control over its environment. The primary conceptual metaphor HARM IS DESTRUCTION emphasizes complete elimination of affected objects. The spatial aspect 'comes near' draws on EVENT STRUCTURE metaphors where spatial relationships represent causal relationships. In this case, it can be understood as PROXIMITY IS DANGER, creating a comprehensive image of unstoppable destructive force.

The addition of 'more terrifying than' introduces an emotional evaluation, establishing a hierarchy of cosmic threats and attributing fear-inducing qualities to the black hole, ultimately asserting its supremacy in destructive capability. This metaphorical framework conveys both the physical power and the psychological impact of black holes.

- 3) black holes have **a dark side**, they have the power to consume everything around them. (SciShow Space)

In this expression, the black hole is conceptualized through the well-established metaphor GOODNESS IS LIGHT / BADNESS IS DARKNESS, which directly structures the understanding of 'dark side' as morally negative. This works in conjunction with PSYCHOLOGICAL FORCES ARE PHYSICAL FORCES to attribute agency and moral character to a physical phenomenon.

This metaphorical framework suggests a dualistic nature that implies both good and evil sides, with emphasis on hidden malevolent qualities and potential for harm. This metaphorical conceptualization also makes the abstract physical properties of black holes comprehensible by mapping them onto familiar moral and personal characteristics.

- 4) Anything that falls in can never come out, but that also raises a problem. They [black holes] seemingly **destroy information for breakfast**. (Cool Worlds)

This expression conceptualizes black holes as ravenous entities that casually consume information as a mundane daily activity, i.e., ‘for breakfast.’ The choice of the first meal of the day creates an image of routine destruction, suggesting this is a natural and regular behavior for black holes. The black hole is mapped as an active monster, information is portrayed as consumable matter ‘food’, and the process of information destruction is represented as eating.

Notably, the monster frame in this expression extends beyond physical matter to encompass abstract concepts like information. Therefore, the destruction here is not just of physical matter but of fundamental properties of the universe.

4.1.2. Conceptualization of black holes as a hungry, feeding entities that grow

- 5) black holes **eat everything** and then the universe dies. What an easygoing existence you’d have if you were just a black hole just exist and **eat** until the end of time. (SciShow Space)
- 6) black holes might be the **hungriest things** out there **consuming everything** that comes close enough to get sucked in. (SciShow Space)
- 7) a star came too close to a supermassive black hole with a mass millions of times that of our Sun and **it was eaten**. The black hole **fed on the star**. (Veritasium)

The black hole is conceptualized through the conceptual metaphor BLACK HOLE IS A HUNGRY CREATURE, where the source domain of a living, hungry creature is mapped onto the target domain of a black hole. The systematic mappings also include food mapping onto cosmic matter (stars, dust, gas) (6, 8), and hunger mapping onto gravitational pull (5).

The semantic components of these eating-related verbs portray the black hole as an active, intentional consumer rather than a passive physical phenomenon. The use of superlative ‘hungriest’ particularly emphasizes this characteristic, presenting the black hole as the most ravenous entity in the cosmos (5). The phrase ‘eat until the end of time’ further reinforces this conceptualization by suggesting eternal, purposeful consumption as the black hole’s primary characteristic and function (4).

- 8) Not only do stars eventually die, but even black holes one day perish. So, the fact that black holes die means that we cannot ignore the information that they **gobbled up**. (Cool Worlds)

The expression ‘gobbled up’ (8) adds a particular dimension to this metaphorical framework, emphasizing not just consumption but a hasty, eager form of eating that maps onto our understanding of black holes’ intense gravitational effects. This characterization of consumption appears within discussions of black hole mortality, where black holes are presented as living entities that both consume and eventually perish. The metaphorical mapping thus extends beyond simple consumption to include temporal aspects of existence, suggesting that while black holes’ consumption appears permanent, it exists within a larger cycle of cosmic processes.

- 9) black holes that **grow larger consume more** and spin faster than all the rest. (SciShow Space)
- 10) In this accretion disk there is dust and gas swirling around here very chaotically it's incredibly hot. It's this matter that the black hole **feeds off and gets bigger and bigger** over time. (Veritasium)

These expressions build on the HUNGRY CREATURE metaphor by incorporating additional mappings from the source domain of biological growth. The black hole is conceptualized as a growing organism where the mappings include food consumption onto matter absorption, physical growth onto increase in size, and growth rate onto rate of matter absorption (7).

In ‘feed off’ (8), the conceptualization is refined through the more specific metaphor BLACK HOLE IS A PREDATOR. The mappings include predator onto black hole, prey onto cosmic matter, feeding ground onto accretion disk, predatory behavior onto gravitational attraction, and sustenance extraction onto matter absorption. The black hole is portrayed specifically as a predatory entity that sustains itself by actively feeding off other cosmic material, suggesting a more aggressive or opportunistic form of consumption. The continuous feeding and growth aspects also seem to be structured by the conceptual metaphor EXISTENCE IS LIFE, where the black hole’s consumption ensures its continued existence and development.

These mappings work together to create a coherent conceptual framework where abstract phenomena are understood through familiar biological processes of feeding, hunger, and growth.

4.1.3. Conceptualization of black holes as an authoritarian power

- 11) Unfortunately, when an object enters a black hole, the black hole will completely **delete its past identity** – whether it's made of matter or of antimatter. (Kurzgesagt – In a Nutshell)
- 12) This **lack of a memory of its** [the object] **past**, means that a black hole has only three properties: their mass, spin, and electric charge. Everything else **is lost**. (Kurzgesagt – In a Nutshell)

In these expressions, the black hole is conceptualized through the conceptual metaphor BLACK HOLE IS AN AUTHORITARIAN, where the source domain of forceful elimination of identity and history is mapped onto the target domain of physical transformation of matter. The mappings include authoritarian power onto black hole, personal identity onto physical properties, and memory erasure onto transformation of matter.

Using 'delete' and 'lost' emphasizes complete and irreversible elimination, while the concept of 'identity' and 'memory' personifies the properties of matter as personal characteristics that can be erased. This metaphorical framework presents the black hole as a totalitarian force that destroys the fundamental characteristics or the 'identity' of whatever falls into it.

- 13) The space **under their** [the black holes] **control** is blocked by an invisible, one-way border called the event horizon. (Kurzgesagt – In a Nutshell)

This expression employs the conceptual metaphor BLACK HOLE IS A TERRITORIAL RULER, where the source domain of political or military control over territory is mapped onto the target domain of gravitational influence. The mappings include ruler onto black hole, territory onto space, and border control onto event horizon.

The expression 'under their control' draws on the established metaphor CONTROL IS UP, where the black hole occupies the dominant upper position while the controlled space is

conceptualized as being below and subject to its power. The addition of ‘one-way border’ contributes to the overall authoritarian conceptualization by suggesting strict control over movement, similar to restrictive border policies of authoritarian regimes. This portrays the black hole as an absolute ruler over its domain, with the event horizon serving as its strictly controlled border that allows entry but no exit.

4.1.4. Conceptualization of black holes as gatekeepers

- 14) Although black holes have been portrayed as the ultimate monsters of the universe, they may actually be the **heroes that keep us safe** from the madness of singularities. (Kurzgesagt – In a Nutshell)

In this expression, the black hole is conceptualized through the conceptual metaphor BLACK HOLE IS A PROTECTIVE ENTITY, where the source domain of a powerful guardian force is mapped onto the target domain of a black hole’s containment of singularities. This expression presents an intriguing reframing of the typical ‘black hole as a cosmic monster’ conceptualization, not by humanizing it but by recasting its monstrous qualities as beneficial.

4.2. Black Hole as Object

4.2.1. Conceptualization of black holes as cosmic vacuum cleaners

- 15) a black hole is like a **cosmic vacuum cleaner** with infinite capacity, **gobbling up** everything in its path, and letting nothing out. (SciShow Space)
- 16) just about everything else is eventually going into a black hole, fortunately it will take a while for black holes to **vacuum the universe**. (SciShow Space)

In these expressions, the black hole is conceptualized through the conceptual metaphor BLACK HOLE IS A VACUUM CLEANER, where the source domain of a common household cleaning device is mapped onto the target domain of a cosmic phenomenon. The mappings include vacuum cleaner onto black hole, dirt or debris onto cosmic matter, suction power onto gravitational pull, and cleaning process onto matter absorption.

The addition of ‘cosmic’ and ‘infinite capacity’ suggests this is no ordinary vacuum cleaner but one of unlimited power operating on a universal scale (13). The semantic components of ‘gobbling up’ add an element of eager consumption (13), bridging this metaphor with the hungry creature conceptualization mentioned earlier (4, 5, 6).

The expression ‘vacuum the universe’ extends this metaphor to a larger scale, presenting the ultimate fate of the universe as a cosmic cleaning process (14). This conceptualization makes the complex physics of gravitational attraction more relatable by comparing it to the familiar experience of vacuum cleaning, where objects are inevitably pulled in by suction force.

4.3. Black Hole as Container

4.3.1. Conceptualization of black holes as bounded spaces

- 17) Places [black holes] with so much mass that the universe formed a **‘no-go’ zone** where the rules change. (Kurzgesagt – In a Nutshell)
- 18) The **boundary** that stakes out the maximum **danger zone around any black hole** is its event horizon. (SciShow Space)
- 19) The event horizon is the **outer edge** of this **ultimate prison** [a black hole]. **Cross it**, and you’ll never be able to come back. (Kurzgesagt – In a Nutshell)

In these expressions, the black hole is conceptualized through the conceptual metaphor BLACK HOLE IS A BOUNDED SPACE, where the source domain of restricted access areas and imprisonment is mapped onto the target domain of a black hole’s gravitational influence. The semantic components of ‘no-go’ (15) and ‘danger’ (16) emphasize prohibited access and threat, while ‘prison’ explicitly reveals the property of confinement and inability to escape.

The spatial terms ‘boundary’ (16), ‘outer edge’ and ‘cross it’ (17) draw on the CONTAINER image schema, presenting the black hole as a bounded region with clearly defined limits. This conceptualization aligns with Robert Dicke’s original metaphorical mapping to the Black Hole of Calcutta prison, suggesting that crossing this boundary leads to permanent confinement.

- 20) They [black holes] are not really a thing, but rather **a region of spacetime** folded into an embrace so tight that even light is forever ensnared. (Cool Worlds)

- 21) If I throw a book into the black hole, then those words, that information, becomes trapped within **a region of spacetime** from which nothing can escape. (Cool Worlds)

These expressions extend further on the BOUNDED SPACE conceptualization. Both expressions emphasize the spatial rather than object-based nature of a black hole by describing it as ‘not really a thing’ (20). In (20), the bounded space is characterized through the physical manipulation of spacetime itself, described in terms of an intimate human experience, i.e., ‘folded into an embrace’ while in (21), the absoluteness of the spatial boundary is emphasized through the impossibility of escape. These expressions develop the spatial aspect of the conceptualization by presenting black holes not merely as confined spaces but as regions where the fabric of spacetime itself creates the boundary conditions.

5. Discussion

The analysis reveals several significant patterns in how black holes are conceptualized in popular science communication, demonstrating the complex interplay between scientific understanding and metaphorical thinking grounded in everyday experience. These conceptualizations can be examined through several key themes:

5.1. Black Holes as Cosmic Monsters

The predator/monster frame is particularly significant, transforming the basic physical concept of gravitational attraction into an intentional act of ‘hunting’ and ‘devouring.’ Jeffrey Andrew Weinstock’s (2017) analysis of monster theory provides crucial insight into why the monster frame resonates so powerfully with black holes. As he explains, monsters are never intrinsically monstrous, they are cultural constructions that embody specific societal fears and anxieties (p. 315). Black holes align perfectly with what Weinstock identifies as key characteristics of modern monsters: they are invisible until it’s too late to escape from their inescapable grip, they transgress fundamental laws and boundaries, and they represent uncontrollable forces that threaten established order. This captures the nature of black holes, which can only be detected through their gravitational influence on surrounding matter. The anxiety this creates, that a monster could be lurking unseen, may explain the persistent appeal of the predator frame.

In science communication, this monster/predator frame provides an accessible way to understand black hole behavior while also capturing something of their awesome and terrifying nature. This dual function, explaining while also evoking appropriate emotional responses, may explain the frame’s enduring appeal. However, as Kramar and Ilchenko (2021) pointed out,

while this frame makes black hole behavior more comprehensible, it may also reinforce misconceptions. DeCristofano (2017) highlights how news headlines and reports on black holes repeatedly employ verbs suggesting intentional predatory behavior, such as ‘feeding,’ ‘lurking,’ and ‘gobbling.’ This anthropomorphic language, she argues, creates a misleading representation of black holes as sentient, malevolent entities.

This ‘predator’ frame may stem from a psychological tendency to personify and find blame in threatening phenomena, creating a sense of control. This attribution of intent is particularly potent with black holes, as it enables individuals to categorize them within familiar, accessible narratives. While this framing may comfort audiences by casting black holes as ‘known dangers,’ it inadvertently distorts scientific reality by promoting the misconception that these cosmic entities act with purpose, rather than being governed by impersonal physical laws.

5.2. Black Holes as Powerful Agents

The attribution of agency and power to black holes reveals complex patterns in how humans conceptualize non-sentient cosmic forces. While they are attributed agency through metaphorical personification, this agency is peculiarly automatic and non-deliberative. They are portrayed as operating with a kind of mechanical inevitability, they must consume, they must grow, they cannot do otherwise. They are not portrayed as choosing to consume matter, but rather as being compelled by their very nature to do so. It seems that black holes occupy a unique conceptual space, neither purely mechanical objects nor fully personified agents, but something in between.

The idea that black holes hold the power to ‘delete’ identities also presents a fascinating paradox. This erasure manifests in a particularly striking way: while we can measure how much a black hole has consumed (its increase in mass), we cannot determine what it has consumed. The nature of the consumed matter, whether it’s dust, gases, or entire stars, becomes fundamentally unknown. This represents a unique form of information loss in physics, where qualitative information is irretrievably destroyed while quantitative information persists (Blundell, 2015, p. 84).

Therefore, black holes erase the identity of everything they consume, but they simultaneously maintain and strengthen their own identity through this consumption. The black hole grows stronger and more defined as an entity precisely by destroying the defining characteristics of other objects. This aspect of black holes challenges our normal conceptual frameworks for understanding identity and transformation, suggesting a form of existence that operates outside our usual categories of being and non-being.

However, this power of black holes is distinctively bounded. While they are portrayed as supremely powerful within their domain through metaphors like “cosmic monster” and “cosmic vacuum cleaner”, they are also constrained by physical laws (Thorne, 1995, p. 45). Hence, they cannot reach beyond their event horizons or escape their own gravitational imprisonment. The attribution of powerful but non-conscious agency helps capture something essential about their nature, they are active forces in the universe but operate according to physical law rather than will or intention. This framework allows us to think productively about their role in cosmic processes while avoiding oversimplified anthropomorphizing.

5.3. Black Holes as Moral Characters

A key question emerging from our analysis is whether black holes are predominantly conceptualized as ‘good’ or ‘bad’ entities. Lakoff and Johnson (1999) explain that our basic moral metaphors often stem from physical experiences of wellbeing. In this framework, we may consider things that threaten physical wellbeing are typically conceptualized as ‘bad’ or immoral. Black holes certainly fit this pattern in many ways as they destroy, consume, and represent ultimate physical annihilation. The common metaphorical framing black holes having a ‘dark side,’ directly invokes the established DARKNESS IS BAD metaphor.

However, as Weinstock (2017) demonstrates in his analysis of contemporary monster narratives, modern conceptualizations of threatening entities have become more nuanced, evolving beyond simple good-versus-evil dichotomies. The ‘dark side’ of black holes, their very destructive capacity, is reframed as accidentally beneficial. Like many monsters in literature, black holes remain fundamentally transgressive entities, breaking physical laws and destroying information. Their ‘heroism’ is impersonal and automatic, arising from their very nature as cosmic monsters rather than from any human-like moral choice or intention.

This connects to what Sharifian (2017) identifies as cultural schemas, collectively shared patterns of understanding that help cultures make sense of phenomena. The cultural schema for black holes appears to be shifting from a simple ‘cosmic monster’ to what might be called a ‘necessary monster,’ an entity whose very monstrosity serves a crucial function in maintaining cosmic order. This is reflected in scientific discourse about black holes as gatekeepers.

The moral conceptualization of black holes reveals a fundamental contrast in human understanding of these cosmic phenomena. The first and more prevalent perspective focuses solely on their destructive capacity. This view, dominant in popular discourse and media representations, emphasizes black holes’ role as cosmic destroyers, entities that consume and

obliterate everything in their path. Such a perspective naturally leads to their characterization as threatening or ‘evil’ forces in the universe.

However, a more nuanced perspective emerges primarily within the scientific community, particularly among astrophysicists and cosmologists who possess deeper understanding of black hole physics. These experts, through their comprehensive knowledge of black holes’ role in the universe, conceptualize them as boundary entities between comprehensible and incomprehensible physics. From this scientifically informed viewpoint, black holes serve not merely as physical boundaries but as protective barriers between our comprehensible universe and this ‘other world’ that defies human conceptualization.

This stark contrast between public and expert conceptualization demonstrates how scientific literacy and specialized knowledge can fundamentally alter the moral framing of cosmic phenomena. The fact that the function of black holes transcends human sensory and conceptual frameworks, it paradoxically makes them essential protectors of the physical reality we can comprehend, a perspective that appears to emerge only through advanced scientific understanding.

5.4. Implications for Science Communication

The case of black holes reveals profound insights about how humans conceptualize and communicate about phenomena that exist at the boundaries of human comprehension. The intense mystery surrounding black holes naturally evokes fear and anxiety, leading to their widespread characterization as threatening cosmic entities. This fear response to the unknown appears to operate on two distinct levels in human conceptualization.

The first level concerns black holes themselves as visible threats, cosmic destroyers that consume matter, light, and even intangible constructs, such as information. However, a deeper and more existential fear emerges when considering what lies beyond black holes. Their interior represents an even more profound source of cosmic anxiety, leading to speculations about the chaos within, one that is incomprehensible to human understanding and potentially hostile to our own universe’s existence.

In this context, black holes become conceptualized as crucial defensive barriers, protecting our comprehensible universe from an incomprehensible ‘other.’ This protective function transforms them from pure threats into necessary guardians of cosmic order. Such a reconceptualization suggests that science communication about black holes must engage not only with their physical properties but also with their deeper symbolic significance as boundary keepers between the known and the unknowable in our universe.

6. Conclusion

This study has examined how popular science communicators on YouTube employ conceptual metaphors to explain black holes, revealing complex patterns in how these enigmatic cosmic objects are conceptualized and communicated to general audiences. The analysis of 21 metaphorical expressions across prominent science communication channels demonstrates a systematic reliance on three primary conceptual frameworks: BLACK HOLE AS LIVING ENTITY, BLACK HOLE AS OBJECT, and BLACK HOLE AS CONTAINER. These frameworks reflect both historical patterns in cosmic understanding and contemporary challenges in science communication.

The findings reveal a fascinating continuity in human approaches to understanding cosmic phenomena. Just as ancient civilizations used familiar frameworks to comprehend celestial bodies, modern science communicators employ experiential domains to make abstract physics concepts accessible. However, black holes present a unique challenge, pushing the boundaries of both human comprehension and metaphorical thinking. Their nature as objects that exist at the limits of known physics requires particularly sophisticated metaphorical frameworks that can bridge the gap between mathematical abstraction and public understanding.

The dominance of biological and anthropomorphic metaphors, particularly the ‘cosmic monster’ framework, suggests that science communicators tend to favor metaphors that not only explain physical properties but also capture the emotional and psychological impact of these cosmic phenomena. This dual function of metaphors, explaining while evoking appropriate emotional responses, appears crucial in digital science communication, where engagement must balance with educational content.

However, this study also highlights potential tensions in science communication. While metaphorical frameworks make abstract concepts more accessible, they can simultaneously introduce misconceptions (Kramar & Ilchenko, 2021), particularly when attributing intentionality or moral characteristics to physical phenomena. This suggests that effective science communication must carefully balance accessibility with scientific accuracy, perhaps by explicitly acknowledging the limitations of metaphorical explanations.

These findings have significant implications for science communication practice and research. They suggest that effective communication of complex physics concepts requires not only apt metaphorical frameworks but also careful consideration of how these frameworks interact with audience understanding and platform-specific demands. Future research might

examine how different audiences interpret these metaphorical frameworks and how they influence long-term understanding of physics concepts.

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