METAPHOR IN SCIENCE: A JOURNEY INTO THE BLACK HOLE

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Abstract

'Black hole' is a metaphor used to describe a particular area of space. The purpose of this article is to show how such metaphors are used by science writers to explain the incomprehensible in terms of the comprehensible. Knowledge about black holes is outside of ordinary experience, hence the metaphor is theory-constitutive (Boyd 1993) it is part of the technical vocabulary of science itself. By using metaphor, scientists enable the layperson to relate vast concepts of time and space to something in everyday experience, so that we may begin to learn about - if never fully understand – these phenomena. The article looks at a range of structural, image-schematic and ontological metaphors, based on a corpus of 10 articles from the *New Scientist* magazine, published between December 2017 - October 2018. Black holes are personified and talked about in terms of human actions: they 'eat', 'devour' and 'spew' matter. Spatially, they are containers from which hardly anything ever escapes.

Black hole: 'the perfect metaphor for a bottomless well in space' (Jones 1983, 5).

JONES' USE OF a metaphor to describe a metaphor neatly pinpoints the difficulty of conceptualising the true nature of a black hole. Ten articles from *The New Scientist*, dated December 2017 to October 2018 (corpus), reveal the metaphors used to conceptualise black holes.[1] The articles show that Lakoff and Johnson's 1980 cognitive theory of metaphor is correct, for without the use of metaphors, the ability to conceptualise a black hole would be limited.

[1] All unreferenced quotations come from this corpus.

Lakoff and Johnson's cognitive theory of metaphor is not about 'mere words' (1980b, 6) for the meanings of the words of a metaphor are not the same as the meanings of those words when used in a non-metaphorical sense (McGlone 2007, 110). Metaphor is also about 'thought processes' as metaphor involves the transfer of meaning from one domain to another, the conceptualisation of something in terms of something else (Lakoff and Johnson 1980b, 6). If we see something in a certain way, we will act towards it in that way, for metaphor is important in how we define reality (3).

Lakoff and Johnson identify three main types of metaphor: structural, where 'one concept is metaphorically structured in terms of another'; orientational, which 'organises a whole system of concepts with respect to one another'; physical: the 'projection of entity or substance status upon something that does not have that status inherently' (Lakoff and Johnson 1980b, 14, 461, 14). 'Black hole' is a physical or ontological metaphor used to give physical presence to a region of space-time. It could also be seen as orientational, as a conceptual domain (space) is mapped onto an image schema that we are familiar with, that of containers.

Boyd (1993) describes two types of metaphor: pedagogic and theory-constitutive. The first of these teaches theory in a way which could be replaced by another method; the second teaches theory in a way in which there is no other way for it to be taught, for which 'no adequate literal phrase is known' (Boyd 1993, 486). 'Black hole' can be seen as a theory-constitutive metaphor because it represents scientific ideas and terminology that cannot be expressed, nor understood, in any other way.

A black hole is formed by a collapsing star, a star of such gravitational strength that it causes part of space to curve and form an area that is completely separated from the rest of space. This is known as the event horizon, so called because 'nothing happening inside can be communicated to the outside' but everything is attracted to and can enter it (Taylor 1974, 53). Here we see that black hole is a container metaphor, it has an inside that matter can be in and an outside that matter comes from: 'information' and 'stuff' can fall into black holes and 'when matter falls into a black hole, information is destroyed,' 'they [black holes] seemed to be destroying information contained in the matter that fell into them.'

The event horizon is not a place that can be seen, but a metaphorical boundary. It 'contains the information needed to tell us about what has fallen into the black hole.' The event horizon is the 'black hole's point of no return,' 'the black hole's boundary of no return,' 'the boundary beyond which nothing can escape.' Humans, according to Lakoff and Johnson (1980), conceptualise themselves as containers and subsequently see everything else as a container. Container metaphors are image-schematic. The use of these container metaphors allows the imposition of boundaries, the sizing and quantifying of what is in the container. This can aid in the conceptualisation of what a black hole is. This pedagogic and theory-constitutive metaphor (Boyd, 1993) that is used to explain the concept of a black hole educates by attributing physical properties to the black hole that it does not in reality have: there are no physical boundaries to a black hole.

A further container metaphor emerges beyond the event horizon, for black holes 'contain another boundary within the event horizon called the Cauchy horizon.' A picture is built up of containers within containers, expressing the depth of the black hole, giving something that we can quantify and measure and relate to. There is a further container metaphor, for 'the Cauchy horizon should become a singularity.' Singularity, in non-metaphorical terms, is defined as 'the state, fact or quality of being singular,' i.e. having the properties of being 'remarkable, exceptional, extraordinary' (Makins 1994, 1443). In astronomy, this abstract noun is used as a concrete noun to describe something that cannot actually be seen or touched. Singularities have no physical presence in space; they have no physical location, but are said to 'arise out of Einstein's general relativity' and occur 'where Einstein's equations cease to make any sense,' 'where the warping of space-time simply goes off the scale,' 'at a black hole's centre.'

It is thought that 'the big bang is a singularity, too,' and 'the structure of the singularity inside black holes is not very different from the one at the big bang.' The theory-constitutive metaphor 'big bang' attempts to explain one theory of how this universe was created in a comprehensible manner. From everyday experience we can understand the explosion and scattering of matter into space and thus it could also be said to be image-schematic.

Ontological metaphors (personifications) are frequently found in the corpus. Personification is used to describe the black hole as having the 'motivations, characteristics, and activities' (Lakoff and Johnson 1980b, 33) of humans or to label them as physical entities such as 'truly gargantuan monsters,' 'gravitational mini-monsters' and 'supermassive creatures.' By labelling black holes as such, their incomprehensible massiveness is reduced to a conceptually comprehensible size whilst maintaining the sense of size of a black hole in relation to the human.

The actions of a black hole are described in terms of sucking or spewing, ingesting substances, eating. These are from the conceptual domain of human actions. We do these things and we are familiar with everyday objects that do these things. Lexical choices are important, for the more senses a metaphor appeals to the more effective the transference from one conceptual domain to another will be. These metaphors are worth listing in their entirety, for they build up a picture of a greedy, ever-hungry physical entity that devours everything in its surroundings:

> An enormous black hole sits at the centre of a galaxy gobbling up gas and dust.
>
> Do black holes eat information?
>
> Its immense gravity slurps up dust, gas and light.
>
> The more a black hole eats, the more massive it gets and the stronger its pull becomes.
>
> Black-hole voracity.
>
> It would have to have eaten about nine sun-sized stars.
>
> They could be devouring incredibly massive stars.
>
> That would give them time to hoover up stars.
>
> Their influence on nearby matter as they suck in gas and dust and stars.
>
> Could be sucked into a neutron star and cause a collapse that would spew out FRBs.
>
> Mirror opposites to black holes that spew matter instead of sucking it in.

> Transforms the black hole into a white hole that spews out everything its predecessor consumed.
>
> They suggest these are magnetic fields from black holes in the previous aeon that have spewed Hawking radiation.

The black hole is seen as something that 'sits,' can grow 'more massive'; it has a 'pull' which can get 'stronger.' It can 'hoover up stars.' All of these are human actions, used to personify the black hole and make it comprehensible in terms that can be related to. They 'have no hair' - a reference to Wheeler who used this metaphor to describe how black holes have no distinguishing features (Chown, 2008).

Bekenstein 'showed that the entropy of a black hole - which depends on the black hole's microscopic quantum structure - is proportional to its surface area.' This discovery led to the use of 'entanglement' as an ontological metaphor. Humans have everyday experiences of things that can become entangled; 'our experiences with physical objects,' can be applied to the conceptualisation of a complex scientific theory (Lakoff and Johnson 1980b, 25). The amount of entanglement can be measured and quantified; something can also emerge from it: 'the area of certain surfaces within such a volume is related to the amount of quantum entanglement between different regions in the quantum field theory. Two regions are entangled if the state of one cannot be described independently of the other'; 'changing the amount of entanglement between different surface regions can create or destroy space-time in the volume, suggesting that it emerges from entanglement.'

The mathematical concept Hilbert Space, used in theoretical physics, 'can be split into different tiny parts' and 'there is entanglement between these little parts says Carroll. A lot of entanglement between some, and very little between others.' Entanglement can be related 'to geometry by further assuming that the greater the entanglement between two parts, the closer they are' and 'the dynamics of entanglement are similar to Einstein's equations of general relativity. In other words, space-time and gravity emerge from entanglement.' However far apart the particles are, they will always be connected with each other. Entanglement could be seen as an image-schematic metaphor (the 'entanglement' can be visually represented), as well as a structural metaphor because it maps the domain of particle physics onto the everyday experience of working with materials that can become entangled, for example threads or wool.

As Graur argues, 'making sense of our world cannot take place without metaphor' (2015, 108): making sense of black holes would be impossible without the use of metaphor. By creating the term 'black hole,' John Wheeler has provided a way for scientists to discuss theoretical aspects of space, to describe and elucidate what black holes are and do (Chown, 2008). Lakoff and Johnson's theory of cognitive metaphor (1980) is significant to how we understand the mental relationships of concepts because it enables the representation of the unfamiliar, in this case black holes, as something that can be understood. The open-ended nature of black hole as a theory-constitutive metaphor, and its associated metaphors, is useful as new information can be added as knowledge of black holes grows. The metaphors are then 'capable of further refinement and disambiguation' (Boyd 1993, 495).

Metaphors such as black hole are ‘designed to wrap our heads around big ideas’ (McCool 2008, 14) and to escape from ‘the power of the inexpressible’ (Graur 2015, 116). The success of ‘black hole’ as a metaphor rests on the ability of it to fit in with an individual’s everyday experience of life (Lakoff and Johnson 1980a, 465). ‘Black hole’ takes something from the conceptual domain of space and astro-physics and successfully transfers it to another: ordinary human experience - so that we may start to understand the often-complicated concepts and theories of space exploration.

The success of the metaphors ‘black hole’ and ‘singularity’ has led to them being used in everyday language, but not only as they were intended. Lost items are now said to have disappeared down a black hole and ‘singularity’ is used to denote the time when computer understanding outstrips human understanding. This change in use would appear to be inevitable - such is the nature of language change – but it is to be hoped that this change does not detract from the power of the metaphors to aid in the conceptualisation of scientific theories.

Black holes are hard to understand, which is why metaphor is important. Metaphors can also be beautiful, as in the following depiction of the creation of a black hole:

> Enigmatically indifferent to its surroundings, it is a kind of cosmic Cheshire cat. When the gravity and density become sufficiently high, the black hole winks out and disappears from our universe (Sagan 1980, 241).

Carl Sagan's use of an ontological metaphor to describe the creation of a black hole helps us to conceptualise and comprehend what we cannot perceive, but it may be its beauty that helps us to remember what we have learned.

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