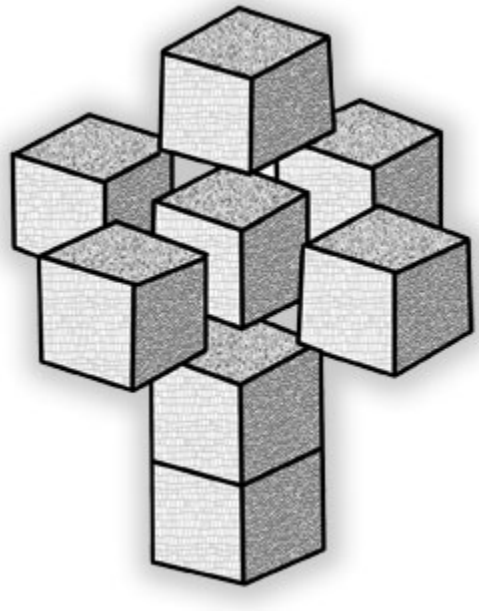
3, 4 or More?



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Thoughts of space and time have occupied human consciousness ever since our early ancestors first turned their eyes to the stars. For millennia, people have conjectured about the nature of space and the shape of our universe. Countless humans have looked toward the heavens and asked, "Where does space end? Is there something more?" The beauty of these questions is that no human has a monopoly on the correct answers. Despite an explosion of scientific knowledge, meaningful answers to even the simplest space-time questions still elude us. There is even a specialized branch of physics, known as "cosmology," that devotes itself to studying these concepts. Cosmologists have an impressive array of mathematical and scientific tools at their disposal, yet no cosmologist can answer with certainty when asked the simplest of questions about our universe. The question of dimensionality is one of those.

Most people are aware that we live in a three dimensional world. Physical things have width, height and depth. Movement can be right/left, up/down or forward/backward. This is all a result of the three-dimensional nature of the space within which we live. "Is there a fourth dimension?" No one knows. This is one of those simple, yet unanswerable questions that have plagued existential thinkers for thousands of years. In fact, the answer to this question has been a source of acrimony between philosophers and mathematicians for as long as these disciplines have existed. Sadly, discussions about the physical reality of a fourth dimension have so divided mathematicians and philosophers that each has a history of belittling the position of the other. More often than not, this discord has served only to stymie intelligent debate and has proven nothing. Nonetheless, examining the

positions of each of these disciplines is a good place to start in developing our own ideas about the true nature of 4D space.

Philosophers typically subscribe to the idea that a fourth dimension exists and that it has a physical reality. To them, it is more than just a mathematical construct. Many philosophers espouse the idea that our entire 3D universe is just a tiny portion of an infinitely larger 4D space into which our 3D universe is expanding. They often draw upon the expanding universe concepts of cosmology to support their position. One group of philosophers describes time as a 'flow of consciousness'. Time is viewed as nothing more than a side effect; what we experience as our consciousness moves though their hypothesized four-dimensional 'reality'. In some instances, philosophers even co-opt mathematical concepts such as Minkowskian space-time or Riemann space, to support their hypotheses. According to one philosophical concept, all time is "now". For adherents to this idea, words like "yesterday" or "tomorrow" are geographic descriptions of where events happen in 4D space rather than when they occur along a traditional 3D timeline. At the extreme end of the philosophical spectrum, spiritualists and other believers in the paranormal have claimed that a host of events, from the existence of ghosts to the disappearance of socks in the dryer (really!), can be explained as an interaction of 3D space with a larger four dimensional universe. As most people will appreciate, such extreme claims draw only ridicule, or at best apathy, from mathematicians and cosmologists.

Mathematicians, on the other hand, avoid answering questions about whether or not a fourth dimension has any basis in reality. In fact, they do not even ask themselves that question; at least not in their professional capacity. They are quick to point out that mathematical equations do not necessarily have any relation to the physical world around us. They are equally quick to describe the ease with which they can create equations that represent a four dimensional mathematical universe. In fact, they talk about how easy it is to create equations that can represent a universe with an unlimited number of dimensions. Complex mathematical concepts such as "string theory" are pushing the limits of understanding multi-dimensional spaces. String theory, for example, involves 10 or more dimensions and it is sometimes claimed to be the foundation upon which a "theory of everything" will be built. In their study of four dimensions, mathematicians easily describe the shape of 4D objects that are analogous to common 3D shapes, including the cube and sphere. They even have names for them. The 4D analogue of a 3D cube is known as a tesseract and the 4D direction known as "ana/kata" is the extra-dimensional extension of right/left, up/down and forward/backward. But despite their fluency with equations, even the best mathematicians cannot say if the fourth dimension, whose equations they know so well, has any basis in physical reality.

So where does that leave us? If you are like me, it leaves you confused. Yet among my confusion, an intriguing challenge has arisen. Paradoxically, this challenge stems from a point of agreement, rather than disagreement, between the philosophers and mathematicians. With a few exceptions, both disciplines claim that the human mind is incapable of envisioning a four-dimensional space, or even a 3D object embedded in 4D space. Perhaps it is just me, but I rebel at the notion that the human mind has any bounds as to what mental pictures it can conjure up. Setting aside the question of whether or not the fourth dimension has any physical reality, I am convinced that the human mind has the ability to do what so many

mathematicians and philosophers claim that it cannot do. That is, I believe that the human mind possesses the ability to create a mental picture of 4D space and manipulate mental images of 3D and 4D objects within that mental picture. But doing so is not easy.

After some research and a bit of analytical thought, most people can comprehend that a tesseract has 8 'sides', each of which is a 3D cube. I know that I can understand this, yet I am still unable to create a mental picture of a tesseract embedded within 4D space. Developing the ability to 'see' and 'rotate' such objects in one's mind takes practice. Perhaps some day I will be able to do it and prove the naysayers wrong. For now, I am still trying.

If you want to join the attempt, consider these suggestions. First, do lots of reading. In 1884, Edwin Abbot wrote a famous book, "Flatland", that describes life in a 2 dimensional plane. Most students of the fourth dimension have at one time or another read Abbot's book. They use it to understand how 2 dimensional 'people' would see 3 dimensional things and then extrapolate that knowledge to understand how 3 dimensional humans would see 4 dimensional objects. "The Fourth Dimension Simply Explained", edited by Henry P. Manning, is another recommended read. Published in 1910, it contains a series of essays on four-dimensional space that originally appeared in the 1909 Scientific American magazine.

A second recommendation is to start simple. Many essays on visualizing the fourth dimension jump directly to a discussion of visualizing a tesseract. This is way too complicated for a starting point. Begin by trying to create a mind's-eye picture of a 3 dimensional hollow cube. An object of this type is an empty cardboard box with square sides. It is composed of 6 equally sized, 2 dimensional surfaces. These surfaces separate the 3 dimensional space inside the box from the 3 dimensional space outside the box. Most people can easily form a mental picture of such box. The difficult part is creating a mental picture of what one would see when looking at the same box from a point in 4 dimensional space, when the 4D line-of-sight passes through the centre of the box and is perpendicular to the 3D space containing the box. This is not an easy concept to grasp; especially the notion of a line being perpendicular to a 3D space. Anyone who is able to create this mental image would simultaneously 'see' all 6 surfaces and both the space inside and outside the box. Not only that, but the box would appear infinitely 'thin' in the direction of the fourth dimension . If you are unable to visualize such a thing, you are not alone. If you can conjure up such a picture, then you are probably the first human being to have ever done so. Good luck!

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"Flatland: a romance of many dimensions", by Edwin Abbott, is available at:
http://www.gutenberg.org/etext/201.html.utf8
"The Fourth Dimension Simply Explained", edited by Henry P. Manning, is available at: http://etext.lib.virginia.edu/toc/modeng/public/ManFour.html