

Introduction

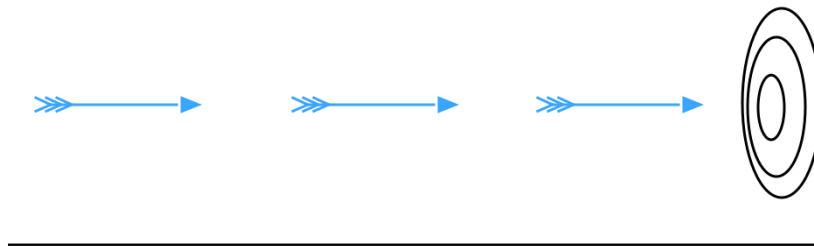
Recall again Zeno's overall argument against the existence of motion:

1. Space is infinitely divisible or not infinitely divisible.
2. If space is infinitely divisible, motion is impossible.
3. If space is not infinitely divisible, motion is impossible.
4. Therefore, motion is impossible (from 1–3).

The conclusion is false; we all do move. Since the argument is valid—the premises do entail the conclusion—at least one of the premises is false. Zeno argues for premise 3 with what is called the Arrow Paradox. Our goal is to try solve that paradox. Zeno first asks us to assume that space is finitely divisible. He subsequently argues that motion is impossible under this assumption. There are various presentations of the paradox:

The third is ... that the flying arrow is at rest, which result follows from the assumption that time is composed of moments he says that if everything when it occupies an equal space is at rest, and if that which is in locomotion is always in a now, the flying arrow is therefore motionless (Aristotle, *Physics*, 239b30).

Zeno abolishes motion, saying "What is in motion moves neither in the place it is nor in one in which it is not" (Diogenes Laertius, *Lives of Famous Philosophers*, ix.72).



Consider a moving arrow; it moves during some duration of time. What is happening to that arrow at any particular instant of that duration? Zeno claims that it is not moving at all during all of particular instant because, at each instant, it occupies a space equal to itself. This is a reasonable assumption. Suppose that the arrow did not occupy a space equal to itself for the whole instant.

Perhaps you think it began the instant in one location and ended the instant at a different location. If you think this, then the relevant instant is not really an instant; an instant is supposed to be the smallest measure of time. So what is happening to the arrow at a true instant? It cannot be in motion for all of it because that would require the instant to be divisible into smaller parts. Since the entire period of the arrow's motion contains only instants, all of which contain an arrow at rest, Zeno concludes that the the arrow does not move at all.

Outline of the Paradox

Assume that space is finitely divisible. Assume also that time is finitely divisible. There are two ways to present the argument:

Version 1:

1. If the arrow moves throughout the period of its flight, then it moves at each instant of that period.
2. The arrow occupies a space equal to its own volume at each instant.
3. If the arrow occupies a space equal to its own volume at an instant, then it is not in motion at that instant.
4. The arrow is not in motion at any instant of that period (from 2–3).
5. The arrow does not move throughout the period of its flight (from 1 & 4).

Version 2:

1. If the arrow moves throughout the period of its flight, then, when it moves, it moves in the present.
2. The arrow is not in motion in the present.
3. The arrow does not move throughout the period of its flight (from 1 & 2).

The first version assumes that time is finitely divisible. The second does not; all it requires us to accept is that nothing moves during the present.

The Standard Solution

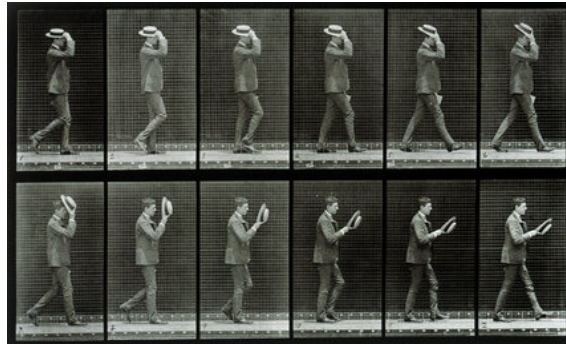
Motion does exist. To defend its existence, we must either find a solution to the Arrow Paradox (if we believe space is finitely divisible). Here I will discuss the Standard Solution, which charges Zeno with committing the fallacy of composition. This fallacy has the following form:

1. An object, O, has parts, P1, P2, P3 ... Pn.

2. None of $P_1, P_2, P_3 \dots P_n$ has property F .
3. O does not have property F ...(from 1–2).

This argument commits a fallacy. Some wholes have the properties of their parts, but some do not. A whole green flag has the properties of its parts, e.g., its parts are green and it is green. But a whole car does not have the properties of all its parts, e.g., the car does not have the property of being an engine, but obviously it has a part that has that property. The Standard Solution to the Arrow Paradox claims Zeno makes a similar mistake:

- An arrow does not move for parts of its flight.
- An arrow moves for the whole of its flight.

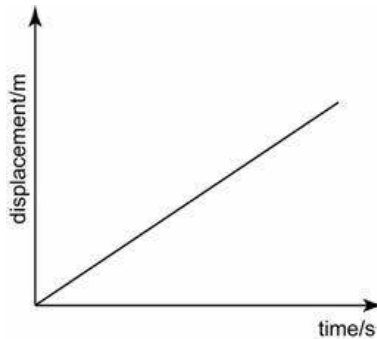


Defending this solution requires explaining how both claims could be true together. One way of doing this is by using the *at-at* theory of motion, which claims that being in motion involves being at different places at different times. All it means for an arrow to move is for it to occupy different locations at different times. The at-at theory then asks us distinguish between being in **motion during an instant** and being in **motion at an instant**. The former is impossible, while the latter is not. Here is a simple summary:

1. An object is in **motion during a period of time** if and only if the object occupies different locations at every instant of that period.
2. An object is in **motion at an instant** if and only if it occupies different locations immediately before and after that instant.
3. An object is at **rest at an instant** if and only if it is at the same location immediately before and after that instant.

The at-at theory accepts that the arrow cannot **move during an instant**, but claims that the arrow can still **move at an instant**. It does so by occupying different locations before and after that instant. If correct, the difference between rest and motion has to do with what is happening at nearby moments and has

nothing to do with what is happening during a moment. The arrow counts as moving at an instant because it occupies different locations before and after that instant. The arrow counts as being at rest at an instant because it is not located at different locations before and after that instant.



A Response to the Standard Solution

The Standard Solution rescues motion by claiming that the arrow is moving at an instant because it will be at a different location in the next instant. This assumes that facts about the arrow's future location determine what is happening to the arrow in the present; it assumes that the future fixes what is happening now. This has caused many to reject the Standard Solution. Surely it is what is happening to the arrow now that determines what happens to it in the future, and not the other way round. One way to press the worry is to suppose that God exists. Now suppose that God were to wipe the arrow out of existence completely one instant after it has moved. Does the arrow move at the instant before it was annihilated?

1. The arrow occupies location 1, l_1 , at instant 1, t_1 .
2. The arrow is moving at t_1 if and only if the arrow occupies a different location, l_2 , at a later instant, t_2 .
3. If God destroys the arrow at t_2 , then the arrow does not occupy l_2 at t_2 .
4. If God destroys the arrow at t_2 , then the arrow is not moving at t_1 (from 1–2, & 3).
5. If God does not destroy the arrow at t_2 , then the arrow does occupy l_2 at t_2 .
6. If God does not destroy the arrow at t_2 , then the arrow is moving at t_1 (from 1–2, & 5).
7. Whether the arrow is moving at t_1 depends upon whether God destroys it at t_2 (from 4 & 6).