Atoms, Components and Structures

Abstract

It is argued that whenever component parts are assembled into an integrated whole, some of the properties defining the qualitative identities of the components are lost, and therefore the components as such have ceased to exist, at least temporarily. They have been replaced by a structure, which has different properties and behaviour from its components. In the process of creating a structure some properties are lost and others are gained, so rather than saying "a whole is more than the sum of its parts" it would be more accurate to say "a whole is instead of its parts". It is suggested that the visual perception of components continuing to exist intact within solid structures is illusory, a result of the way our perceptual and cognitive processes habitually operate. The relation between physical structures and consciousness is briefly discussed, in the context of the physical universe conceived as one continuous structure uniting all individual physical entities.

"Everything around us is entirely composed of atoms: the paper of the book you are reading, the table in front of you, your house, the trees - yourself, and the very air you breathe. Everything is composed of those absolutely invisible, extremely small particles."
(Heinz Haber, 1956, Our Friend the Atom)

"Dust you are, to dust you shall return."
(Genesis 3.19, New English Bible)

"In the case of all things which have several parts and in which the totality is not, as it were, a mere heap, but the whole is something besides the parts, there is a cause; for even in bodies contact is the cause of unity in some cases, and in others viscosity or some other such quality."
(Aristotle, Metaphysics Book VIII, 1045a.8–10, trans. W. D. Ross)

A raindrop falls into a flower and is split into several droplets. None of these, each able to move independently of the others, and with its own enclosing surface smaller than that of the raindrop, can reasonably be said to have existed previously as a discrete entity within the raindrop. Some of the droplets run down inside the flower and merge into a larger globule of water forming in the base. These droplets, as discrete entities, have now ceased to exist.

If a glass or ceramic vase falls to the ground and is broken into fragments, those particular fragments, now separated and with sharp exposed edges, did not exist as such in the intact vase. It might perhaps be argued that the intact vase comprised all the possible sets of fragments, existing simultaneously, but this would be true only in the sense that the fragments had the potential to come into existence, along with properties such as sharp exposed edges. Again, any number of different statues could potentially be made out of a particular block of marble, but none of these can reasonably be said to physically exist unless and until given being and form by the sculptor.

In the case of the water droplets merging into a globule, it may be said that although the droplets have ceased to exist, their constituent water molecules have not, and that these molecules, each comprising one oxygen and two hydrogen atoms, have existed all along, within the raindrop, the droplets, and the globule, also in the cloud where the raindrop was formed, and probably for very much longer. The hydrogen and oxygen atoms, or their nuclei, will have existed for much longer still. But do the water molecules making up a mass of liquid (or frozen) water really exist as discrete entities, with the same properties and

behaviour as when they are isolated as water vapour? Do the atoms bound together in a water molecule show the same properties and behaviour as when they are free and separate? The answer to both these questions is no. The molecules in liquid or frozen water are held together by hydrogen bonds, which result from and in turn modify the uneven distribution of electric charge around the outside of each molecule, and make the molecules much less mobile than in water vapour at the same temperature. The hydrogen atoms in a water molecule each share two electrons with the oxygen atom, and this gives water very different physical and chemical properties from monatomic hydrogen and oxygen, or indeed hydrogen gas (H_2), oxygen gas (O_2) or ozone (O_3).

Raindrops, ice crystals, water molecules and hydrogen and oxygen atoms are all examples of structures, as are books, tables, houses, trees, and human bodies. A structure may be defined as a unified combination or assembly formed from the coupling or merging together of other entities or structures. Structures range in duration from extremely transient (nanoseconds or less) to very long-lasting (billions of years), and in size from sub-atomic to intergalactic, and have seemingly unlimited scope for internal complexity, as in advanced living organisms.

Two or more entities have formed a structure if their spatial positions, or the respective values of any other of their properties, have become correlated, and causally connected in a way that tends to maintain the correlation and thus the integrity of the structure. A structure is an integrated whole. It is not a mere juxtaposition of mutually independent, non-interacting component parts, nor is it a set of interacting components each maintaining its own individual integrity and identity. Due to their relative coherence, structures can transport and deliver quantities of matter, momentum and energy to the same destination all at once, in a way in which their uncoordinated separate components could not. The unified mass of a structure also gives it greater inertia than its separated components. Structures are formed because physical entities interact with one another. Any entity which could not participate in such interactions would be unknown to science, since it would not interact with any measuring instruments or detectors, including human senses, nor affect the observed properties or behaviour of any other physical entities.

Whenever two or more entities merge or combine, they create a structure. When a structure merges or combines with one or more other entities or structures, this creates a new, more inclusive structure. Each new structure is a new whole, in principle separable again into its previous parts, or into different parts. When separate parts become a unified whole, as when hydrogen and oxygen atoms form a water molecule, some properties are lost and others are gained. Rather than saying "a whole is more than the sum of its parts" it would be more accurate to say "a whole is instead of its parts". Whenever a structure is formed, there no longer exist objects qualitatively identical (in properties and behaviour), and spatio-temporally continuous, with any of the components which came together to form the new structure. That is to say, the individual entities/structures which were the separate component parts of the new structure, have, for the time being, ceased to exist.

In the case of some structures made from solid components, like a mechanical clock, it might be objected that the components, including those of the mechanism, are still individually visible, even while the structure is complete and functioning, and therefore they have not ceased to exist. This appearance is, I think, an illusion arising from the way our perceptual and cognitive processes habitually operate. Wherever the components of a clock come into contact, they are necessarily to some extent changed and joined together, by the electromagnetic interactions underlying mechanical friction, and therefore they no longer exist as individual, independent entities, despite still being discernible as such through our visual and cognitive processes. The habitual mental construction of a whole existing simultaneously with its parts is somewhat like the perception of the ambiguous duck/rabbit

figure which fascinated the philosopher Ludwig Wittgenstein, but occurs at a more abstract cognitive level, producing complementary interpretations but not alternations of mutually exclusive perceptions.

The mental images of a complete whole, and of its barely separated parts, become merged into a single, ambiguous construct comprising the features which the unmerged images (of the whole and of the set of parts) had in common. As with the duck and rabbit, the whole and its parts can co-exist in the merged image/construct but not in the physical world. An alternative account, perhaps closer to the actual cognitive processes, is that the merged mental construct of whole and parts is a compression, or projection, into a single simultaneous state, of the remembered or imagined temporal sequence of the barely separated parts coming together to form the whole, or starting to separate away from it. This projection process would be analogous to the creation, by an artist or camera, of a two-dimensional perspective image of a three-dimensional scene. The merged mental construct of whole and parts may be compared to that of a digital photograph known to be made up of pixels: the pixels correspond to individual parts into which one can imagine the image being separated, or as having been composed from. The pixels, all the same shape and size and each entirely of a single colour, exist in the image but not in the photographed object in the physical world. This comparison is particularly apposite if the parts of a structure are envisaged to be individual physical atoms or sub-atomic particles, all of which of the same type are conceived as being qualitatively identical. Atoms and sub-atomic particles, unlike pixels, do exist in the physical world, but, also unlike pixels, they do not maintain their discrete intact identities when assembled into structures such as molecules, crystals or living organisms. We human beings may have come from dust and atoms, and return again to dust and atoms, but within our structures the dust and atoms have, temporarily, ceased to exist.

Some structures are in a constant state of flux, with components separating and joining, while the structure maintains its continuity in space and time. The internal architecture of liquid water is continually changing, with molecules separating from and joining the multi-molecular structure as hydrogen bonds are broken by the energy of thermal motion and new hydrogen bonds are formed. The structures of living organisms are likewise in a state of dynamic turnover. Molecules and atoms of many different types and sizes, neutral or as electrically charged ions, are constantly being incorporated into, and separating from, all living structures, while the structures themselves continue to retain their identities.

The idea that a physical structure always, at least temporarily, ceases to exist when participating in a more inclusive structure, might seem to be inconsistent with the observation that one physical structure may apparently be associated with more than one conscious being. Examples include a baby in the womb, conjoined twins, a child in its mother's arms, people holding hands. Does the continuing existence of different conscious beings require the continuing existence of their individual associated physical structures when these participate in a more inclusive physical structure? Not necessarily as regards actual, as opposed to

potential, existence. Although each conscious being is apparently associated with one particular living and functioning brain, spatially separate from every other brain, this does not preclude retention of those particular properties relevant to individual consciousness when a brain, within its supporting body structure, is also within another, more inclusive structure incorporating other bodies and brains, when some other properties of the individual bodies are absent or temporarily lost.

All entities in the physical universe are ultimately interconnected by or in space-time, through gravitational, electromagnetic and other fields, thus constituting a single over-arching physical structure, in principle representable as a single comprehensive quantum-mechanical wave function. Individual physical entities are like the individual inner surfaces of a collection of air bubbles in water or glass, each inner surface describable as a self-contained whole, isolated from all the others, but all in fact connected by and belonging to the single matrix in which they are embedded, without which they can have no existence. In this wider view, the whole physical universe is the body of each and every embodied sentient being. The different streams of consciousness are centred on the different spatio-temporal regions occupied by the different brains, and may be imagined (like particular durations within any single stream of consciousness) as being arranged along a non-physical dimension analogous to physical time.

Even though the concept of a perfectly self-contained discrete entity, other than the whole universe, may be an abstract Platonic ideal, not to be found anywhere in concrete reality, it is nonetheless true that conceptual schemes involving such discrete entities are, fortunately, very useful approximations to reality for most human practical purposes, including scientific prediction. Like a digital photograph made of discrete, self-contained pixels, a scientific theory based on discrete entities, related through appropriate mathematical constructs, can provide a good approximation to the appearance of the connected, continuous reality it represents.