Ontological Realization of Individuality in Experimental Sciences

Short abstract

This paper discusses the *ontological realization of individuality* – the production of individuals predicted by scientific theories. *Ontological realization* refers to the processes by which scientists produce new phenomena, entities, and individuals by means of experimental techniques and instruments. Experimental production of individuals implies a conception of individuality that is different from those found in the metaphysical literature, a conception that is ripe for philosophical development and analysis. I address two main questions: (1) What counts as an individual in experimental sciences? and (2) Under what conditions can scientists be said to realize the individuality of an object? By examining the creation of Bose-Einstein Condensates in experimental physics and the modification of genes in genetic engineering, I will suggest a conception of *manipulative individuality* in experimental science and identify its three realization conditions: *manipulability*, *separability*, and *maintenance of structural unity*. Ontological realization is complementary to the "ontological commitment" that is traditionally regarded as a core element of general metaphysics. Experimental realizations provide the strongest evidence for the theoretical commitments that scientists have to the ontological structure of world because theories themselves may be mistaken. Ontological realization via manipulative individuality has far-reaching ramifications for metaphysical discussions of individuality.

Words count: 196

Long abstract

This paper discusses the *ontological realization of individuality* – the production of individuals predicted by scientific theories. I address two main questions: (1) What counts as an individual in experimental science? and (2) Under what conditions can scientists be said to realize the individuality of an object? By examining the creation of the Bose-Einstein Condensate in experimental physics and the modification of genes in genetic engineering, I will suggest a conception of *manipulative individuality* in experimental science and identify its three realization conditions: *manipulability*, *separability*, and *maintenance of structural unity*.

Individual is seen as a fundamental category of the "furniture" of the world. In order to answer the question of what counts as an individual, metaphysicians often propose definitions and attendant criteria of individuality based on conceptual analysis of the ways that we use "individual," say with respect to a dog or a stone. Naturalism-oriented philosophers of physics insist that philosophical accounts of criteria of individuality are to be developed from the conceptions of individuality that they take to be implicit in the best current theories of the physical science (e.g., the theories of relativity and quantum mechanics) (Ladyman and Ross 2007). Similarly, philosophers of biology tend to think that the problem of biological individuality is best approached through evolutionary

theory (Hull 1980; Millstein 2009). Some philosophers argue that theories from more narrowly circumscribed biological disciples (e.g., physiology and immunology) also provide important insights (Pradeu 2012). We can see then that metaphysicians and philosophers of science tend to approach the concept of individuality via theories – metaphysical, physical, and biological.

Theories, both philosophical and scientific, can be wrong. Indeed by nature they must remain open to testing, revision, and rejection. Given the fallible nature of theories, we might want other ways of generating criteria of individuality *for the practice of experimental science.* A natural place to seek these criteria is in the conception of individuality already at work in experimental science. Criteria developed in this way would have the advantage of being robust to changes in theory, as well as being more closely tied to what scientists actually do. The conception and criteria of individuality implied by the use of certain experimental techniques provides us with an alternative way to ground philosophical accounts of individuality for the practice of experimental science (Braillard, Guey, Imbert and Pradeu 2011). I propose the conception of *manipulative individuality* and three attendant conditions of realization as capturing the conception of individuality that is already at work in experimental science.

In 1925, Satyendra Nath Bose and Albert Einstein predicted a new state of matter into which dilute gases of bosons would enter when the gases were cooled to temperatures very near absolute zero. The atoms of the cooled gases were predicted to enter the same quantum state and become "cloudy" with the wave property. Seventy years later, Eric Cornell and Carl Wieman used sophisticated new instruments and techniques (laser cooling and magnetic-optical trapping) to create the Bose-Einstein Condensate which consisted of about 2000 indistinguishable rubidium atoms and existed for approximately ten seconds. What are philosophical significances of this experimental realization? One result is empirical confirmation that bosons, theoretical entities, violate Leibniz's principle of identity of indiscernibles (French and Redhead 1988). The feature that I want to draw attention to, however, is that the experiment created a new individual. Cornell and Wieman claimed that they "caused the atoms to lose for a few seconds their individual identities and behave as though they were a *single* 'superatom'." (Cornell and Wieman 1998) This statement hints at a conception of individuality

Experimental manipulation of genes provides another philosophically interesting case study. The commitment to the existence of genes within organisms' cells has a long history. Although Hunt Morgan's team located many genes on the four chromosomes of *Drosophila* (Waters 2004), the referent of "gene" was contested. The discovery of the double helical structure of DNA in 1953 did not solve "the gene problem," but instead cast doubt on earlier gene conceptions. Philosophers of biology have argued that the referent of "gene" cannot be segments of DNA (Kitcher 1984, Rosenberg 1985), but there has to date not been a very successful positive account of just what a gene is. The development of genetic engineering has important implications for this question. Genetic modification provides the strongest evidence for the ontological commitment to genes as individuals. The ability to locate, isolate, target, insert, and knock out genes implies a conception of individuality on the part of the genetic research community.

Important features of this conception are shared with the conception implicit in the language describing the experimental production of the Bose-Einstein Condensate. From the two cases, we can extract *manipulability* in experimental contexts as an important condition for realization of the individuality of entities (Hacking 1983). More precisely, if one can control and use an object to investigate other phenomena, the object's being as an individual is thereby demonstrated. Thus manipulability is a plausible condition of the realization of individuals in experimental contexts. One can show the individuality of an object if she is able to in some sense separate it from other objects. This suggests that *separability* is a second important realization condition. Finally, one can separate a given individual only if she does not destroy its structural unity in the process. Thus I include *the maintenance of structural unity* as the third realization condition.

Clearly in the creation of the Bose-Einstein Condensate, Cornell and Wieman manipulated the condensate by using a magnetic trap to separate it from other free atoms while maintaining the condensate's structural unity in terms of quantum state homogeneity. In the case of genetic modification, scientists create an organism with a novel phenotype by isolating an exogenous gene to replace an endogenous gene without destroying the structural unity of the exogenous gene as evidenced by its successful function within the context of the new genome. These case studies will demonstrate how the three realization conditions of manipulative individuality characterize a unique conception of individuality grounded in scientific practice.

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