PARTICULARS, SUBSTRATA, AND THE IDENTITY OF INDISCERNIBLES*

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This paper examines the view that ordinary particulars are complexes of universals. Russell's attempt to develop such a theory is articulated and defended against some common misinterpretations and unfounded criticisms in Section I. The next two sections address an argument which is standardly cited as the primary problem confronting the theory: (1) it is committed to the necessary truth of the principle of the identity of indiscernibles; (2) the principle is not necessarily true. It is argued in Section II that a proponent of the theory need not accept (1) and an argument against (2) is presented in Section III. The final section attempts to show that Russell's theory ultimately fails because of inadequacies in its treatment of space and time. The paper closes with a suggestion for remedying this difficulty.

One traditional view of ordinary particulars is that they are complex entities consisting of two more fundamental kinds of entities: universals and a substratum. This view has been challenged on two grounds. On the one hand, philosophers in the empirical tradition have been suspicious of theories invoking substrata ever since Berkeley's celebrated criticism of Locke. It appears difficult, if not impossible, to justify belief in the existence of substrata within the confines of an empiricist epistemology. On the other hand, the view that the properties of a particular are universals has also been subject to extensive criticism. Indeed, one motivation for denying that properties are universals is that the need for substrata appears to vanish.[1] The primary purpose of this paper is to examine the issue of whether a realist—i.e., one who regards properties as universals—must also introduce substrata in order to provide a satisfactory account of ordinary particulars.

I

The classical statement and defense of the view that particulars are complex entities consisting of universals and a substratum is found in

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[1]This seems to be one of G. F. Stout's (1971, pp. 157–58) primary reasons for arguing that the properties of ordinary particulars are abstract particulars rather than universals. Keith Campbell (1976, pp. 214–6) also invokes this argument in support of his claim that the properties of ordinary particulars are tropes rather than universals.

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Bertrand Russell (1971). Among more recent philosophers, the view is most closely associated with the work of Gustav Bergmann (1967, Chapter Two). Since the argument Bergmann and his followers offer in support of substrata parallels the one originally offered by Russell, I shall consider only the latter. The argument can be stated as follows:

(1) It is possible for two particulars to have all qualities (i.e., monadic properties) in common.
(2) Relations (i.e., nonmonadic properties) cannot individuate particulars.
(3) Therefore, substrata must be admitted to individuate particulars.[2]

Russell (1940, 1948, 1959), however, later rejected this argument for substrata. There appear to have been three major reasons for this change. First, although he had taken for granted in his earlier work that perceptual space is relational rather than absolute, he later rejected this view. Second, Russell also came to believe that there are complexes of universals, *complete complexes of compresence,* no two of which have all qualities in common. Finally, he later regarded it as a *contingent* truth that there are no substrata. Although there are possible worlds in which particulars are not complexes of universals, the particulars of the actual world are *in fact* such complexes.

How do these points bear on the original argument? The argument is invalid. Its premises support at most only the weaker conclusion:

(3*) Therefore, *it is possible that* substrata must be admitted to individuate particulars.

For, if *in fact* no two particulars have all qualities in common, then there is no need to admit substrata in order to individuate them. (3*), however, is compatible with the claim that it is contingently true that there are no substrata. Therefore, (1) must be replaced with

(1*) There are *in fact* particulars which have all qualities in common

in order to support the claim that there are *in fact* substrata.

In the case of particulars in the visual field, (1*) can be rejected as false. For if perceptual space is absolute, particulars in the visual field do not have their position or location by virtue of their relations to other particulars in the field. Instead, according to Russell (1948, pp. 298–9), their position or location is determined by *monadic* positional properties. For example, a particular occupying the center of a visual field has the

[2]Russell actually concludes that "instances of universals" must be admitted. An instance of a universal might be either (a) an abstract particular, or (b) the exemplification of a universal by a substratum. I have chosen the latter interpretation since it is the view which the later Russell regards himself as rejecting.

quality of *centrality*.[3] If the account is correct, it follows that any two objects in the same visual field differ from one another at least in their positional qualities. This account, however, cannot be extended to particulars in physical space-time. For Russell did not think such particulars are reducible to phenomenal particulars. Furthermore, since he also held that position or location in physical space-time is to be analyzed relationally, there are no positional qualities of physical particulars. Consequently, some critics have drawn the conclusion that the theory is at best incomplete. M. J. Loux, for example, complains of "Russell's rather cavalier dismissal of ontological problems as they arise within the context of the physical world" (1978, p. 135).

Russell, however, was well aware of the limitations of his account of phenomenal particulars and offers a more sophisticated theory of physical particulars. The underlying idea is to combine the plausible thesis that particulars are individuated by their spatio-temporal location with his claim that relations cannot individuate. This is accomplished by introducing a basic relation, called *compresence*. This relation manifests itself in two different ways. In psychology, it is equivalent to "simultaneity in one experience", while, in physics, it is equivalent to "overlapping in spacetime". Russell then constructs complexes of qualities, called *complete complexes of compresence,* which have the following characteristics: 1) all members of the complex are compresent; 2) given anything not a member of the complex, there is at least one member of the complex with which it is not compresent. Finally, he maintains that it is a well established *empirical generalization* that no two complete complexes have all qualities in common. It is logically possible, although exceedingly improbable, that two complete complexes have all qualities in common. Therefore, Russell's theory of physical particulars is based on the following thesis:

(4) No two complete complexes of compresence *in fact* have all qualities in common.

This move has led many critics to draw the conclusion that Russell analyzes ordinary particulars as complete complexes of compresence, a view which would leave him open to serious criticism.[4] This conclusion, however, is incorrect.

Russell goes on to analyze space-time point-instants as complete complexes of compresence and holds that it is such complexes which are the

[3]For a defense of positional qualities see Goodmann (1977, pp. 139–40). Bergmann (1967, Chapter Two) rejects this approach. Bergmann's position is critically discussed by L. N. Oaklander (1977).

[4]See, for example, D. M. Armstrong's (1978, Chapter 9) discussion of Russell. Armstrong's views are critically discussed in Casullo (1981).

primary terms in spatio-temporal relations. Spatio-temporal ordering requires that there be at least some spatio-temporal relations which are transitive and asymmetric. Complete complexes can serve as the terms of such relations since it is a well established empirical generalization that no complete complex precedes itself or is west of itself. Although complete complexes stand in asymmetric spatio-temporal relations, they are not individuated by these relations. They are individuated by virtue of differences in their monadic properties. Russell regards an ordinary particular as a series of events and events are analyzed as incomplete complexes of compresence. Since incomplete complexes are individuated by virtue of their membership in complete complexes, it follows that ordinary particulars are individuated in the same manner. In other words, they are individuated by their spatio-temporal location. Therefore, if (4) is true, then one can consistently hold (1*) and (2) while rejecting (3).

We are now in a position to consider another objection to the theory. M. J. Loux (1978, pp. 136–7) has charged that Russell's account of phenomenal particulars is unsatisfactory. For although positional qualities may individuate particulars within a visual field, they cannot individuate the visual fields themselves. Therefore, the account does not preclude the existence of two visual fields with all qualities in common. Furthermore, even if one grants that any two particulars in the *same* visual field differ in their positional qualities, it remains open that there exist two phenomenal particulars with all qualities in common, including positional qualities, provided that they occur in *different* visual fields. Russell's treatment of phenomenal particulars parallels his account of physical particulars at this point. As was mentioned earlier, he held that the relation of *compresence* appears in psychology as well as physics. In psychology, it appears as *simultaneity in one experience*. Complete complexes of compresence formed by the relation of *simultaneity in one experience* take the place of what we would ordinarily call a total momentary experience. Russell believes that there is good empirical evidence to support the claim that no two momentary experiences (of the same person or different people) have all qualities in common. Since no two total momentary experiences have all qualities in common, both phenomenal particulars and visual fields are ultimately individuated by their membership in these larger complexes. Therefore the claim that no two complete complexes have all qualities in common forms the basis of Russell's account of the individuation of phenomenal as well as physical particulars.

II

The standard objection to the view that particulars are nothing but complexes of universals consists of the following pair of claims: (i) the theory is committed to the necessary truth of the principle of the identity of

indiscernibles (PII); (ii) the PII is not necessarily true. As we saw in the previous section, one leading thesis of Russell's later view is that it is a *contingent* truth that particulars are complexes of universals. Therefore, the theory is committed only to the contingent truth of the PII.

Although Russell's critics are often willing to grant the contingent truth of the PII, they nevertheless maintain that his theory does not circumvent the problems generated by the fact that it is not a necessary truth. They have argued that although it may very well be true that no two particulars in the actual world have all properties in common, this is a fortuitous feature of our world which is of little ontological significance. This fact, if it is a fact, is not sufficient to sustain the ontological thesis that particulars in the actual world are nothing but complexes of universals. M. J. Loux, for example, argues that Russell's

> proposal to treat the bundle theory as a merely contingent truth only puts off the evil day when he must confront the dilemma of individuation; for while it may be true that no two objects in our world are qualitatively indiscernible, this remains a possibility. . . . [T]here are possible worlds where diverse substances agree in all their pure properties; and the bundle theorist has to provide us with an account of the ontological structure of substances in those worlds; . . . In those worlds, substances are diverse yet indiscernible in their properties and so cannot be characterized in bundle theoretic terms; the only way of explaining their structure is by appealing to bare individuators . . . (1978, pp. 156–7).

Several objections can be raised. First, it is not clear why the bundle theorist is obliged to provide some account of particulars in worlds other than the actual world. Loux appears to view possible particulars—i.e., particulars in worlds other than the actual world—as a peculiar species of actual particulars so that a theorist whose account of the actual world omits consideration of such particulars has provided an incomplete theory. But Loux provides no reason for believing that talk about possible worlds and possible particulars needs to be taken seriously from an ontological point of view.[5] But suppose we grant that talk about possible particulars needs to be taken with ontological seriousness. Furthermore, let us also grant that there are some possible worlds in which it is necessary to introduce substrata, or bare individuators, in order to provide a satisfactory account of the individuation of particulars in those worlds. Does it follow that Russell is wrong in contending that one need not introduce substrata to individuate particulars in the actual world? Then denial of Russell's claim follows only if one grants the following Witt-

[5]For a discussion of this issue, see Mondadori and Morton (1976) and Haack (1977).

gensteinian premise:

(*W*) The basic ontological constituents of all possible worlds are the same.

Without this key premise the connection between what is true of possible worlds different from the actual world and what is true of the actual world remains obscure. Although (*W*) may be defensible, it is certainly not self-evidently true. Furthermore, much of the recent work in metaphysics indicates that it is not generally accepted. For most, if not all, contemporary materialists are willing to grant that it is *logically possible* that irreducible minds or mental states exist. Nevertheless, they maintain that this is *in fact* false. Their opponents, on the other hand, do not reject this position simply on the grounds that since there are possible worlds in which minds or mental states exist, it follows that they also exist in the actual world. Therefore, in the absence of further support, Loux's argument falls short of its mark.

One might attempt to establish the relevance of considerations about possible worlds somewhat differently. One might argue that what these considerations show is that two particulars could be numerically different even if they did not differ qualitatively. Since they could be numerically different even if they did not differ qualitatively, it follows (or, more cautiously, there is reason to believe) that the actual occurrence of qualitative difference is irrelevant to numerical difference. Qualitative difference merely accompanies numerical difference but does not account for it. This argument, however, establishes at best that it is not a *necessary truth* that qualities individuate; it establishes that there are possible worlds in which there is numerical difference without qualitative difference. From this it follows only that qualitative difference *need* not account for numerical difference. But it does *not* follow that qualitative difference *cannot* or *does not* account for such difference. The latter conclusion can be derived only if one adds a premise very similar in spirit to (*W*):

(*W**) If qualitative difference does not individuate particulars in some possible world, then it does not individuate particulars in any possible world.

But (*W**) is not more plausible than (*W*).

One final attempt to show that the mere contingent fact that no two particulars have all qualities in common cannot account for their numerical difference will be considered. Suppose there exist two balls with all qualities in common except one—color, for example. It appears perfectly possible that someone could come along and paint one of the balls the same shade of color as the other. According to the theory in question, however, the "balls" would now be one instead of two. But, it is ex-

tremely implausible to maintain that one could destroy a ball simply by painting it a certain color. Therefore, the theory should be rejected. This argument can be interpreted in two ways. It might be calling attention to the fact that there are possible worlds in which there are distinct particulars with all qualities in common. But, as we argued earlier, this does not tell against the theory. On the other hand, it might be interpreted as pointing out that it is highly unlikely that no two particulars in the actual world have all qualities in common. But, on this interpretation, there is no disagreement with the claim that the contingent truth of the PII is all that the theory requires. The disagreement is over whether the empirical evidence sufficiently supports the claim that the PII is in fact true. The disagreement is epistemological rather than ontological.

III

It was argued in the previous section that a theory such as Russell's which holds that particulars in the actual world are complexes of universals, need not be committed to the necessary truth of the PII. However, the claim that the PII is not a necessary truth has been left unchallenged. The arguments offered in support of this claim typically consist in pointing out the possibility of radially symmetrical universes whose occupants have all qualities in common. Max Black's (1970) two-sphere universe is the most widely discussed of the alleged counterexamples to the PII. Since the status of the PII is of fundamental ontological importance, the counterexample merits careful scrutiny.

One might be tempted to reject Black's alleged counterexample by arguing that even in symmetrical universes diverse objects must differ in their spatio-temporal location and, hence, in either their spatial or temporal relations. Suppose, for example, we introduce '*a*' as the name of one of the spheres. It appears that the defender of the PII can now maintain that although one sphere has the property of *being some distance from a,* the other does not. Black, however, objects that he does not "know how to identify one of the two spheres supposed to be alone in space and so symmetrically placed with respect to each other that neither has any quality or character the other does not also have" (1970, p. 208). What is the force of this objection? Even if it is true that one has no way of identifying sphere *a*, this would establish only that one did not *know* which sphere is at a distance from *a* and which is not. It would not establish that it is not the case that one sphere has this property while the other does not.

Although this response is plausible, it is not a viable one in the present context. Since Russell held that relations cannot individuate particulars, he would contend that a satisfactory defense of the necessary truth of the PII would have to uncover some *qualitative* difference between the two

spheres. Furthermore, the individuating property which has been invoked appears to make an ineliminable reference to a particular. Consequently, a proponent of the view that particulars are nothing but complexes of universals cannot appeal to such properties without rendering his account circular.

There is, however, a different approach to Black's argument. The argument rests on the claim that a certain state of affairs is possible. A defender of the necessary truth of the PII will, of course, maintain that the state of affairs in question is not possible. Therefore, a satisfactory resolution of the issue requires an investigation into the important question of how one determines the possibility of a state of affairs. Such an investigation will indicate that Black's counterexample is only apparent.

Speaking very generally, there have been two important traditions regarding this issue. The logico-linguistic tradition maintains that questions about the possibility of a state of affairs must ultimately be answered by reference to the law of noncontradiction. The psychologistic tradition, on the other hand, maintains that in order to answer such questions one must ultimately appeal to considerations about what one finds conceivable. Black concludes his discussion of the PII with the following remarks:

> I tried to support my contention that it was logically possible for two things to have all of their properties in common by giving an illustrative description. . . . It was for you to show that my description concealed some hidden contradiction. And you haven't done so (1970, p. 216).

Thus Black's defense of the cogency of his counterexample appeals to the logico-linguistic theory.

The logico-linguistic theory typically involves the following claims: (1) a proposition p is necessarily true just in case not-p is self-contradictory; (2) p is necessarily false just in case p is self-contradictory; and, finally, (3) p describes a possible state of affairs just in case p is not necessarily false. Some propositions are explicit contradictions and, hence, no special procedure is required to establish that they describe impossible states of affairs other than to notice that they are of the form 'p and not-p'. There are, however, necessarily false propositions which are not explicit contradictions. In the case of such propositions, it must be established by demonstration that they are self-contradictory. The standard procedure is to derive an explicit contradiction from the proposition in question using only principles of inference which are necessary truths. This procedure, however, cannot be incorporated into the explication of the logico-linguistic theory. For, according to the theory, p is necessarily true just in case not-p is self-contradictory. But once this is unpacked to take account of implicit contradictions, it will read: p is necessarily true

just in case either (1) not-p is an explicit contradiction; or (2) an explicit contradiction can be derived from not-p using only necessary truths. This explication of the theory clearly results in circularity. The usual way of circumventing this problem is to hold that p is necessarily true just in case either (1) not-p is an explicit contradiction; or (2) an explicit contradiction can be derived from not-p using only logical truths and definitions. Although this explication of the logico-linguistic theory avoids circularity, it has a notable shortcoming. It cannot be significantly applied to logical truths which constitute an important class of necessary truths. Therefore, in order to employ the logico-linguistic theory to determine whether a given proposition is a necessary truth, one must know antecedently, and on independent grounds, which propositions are logical truths.[6]

Black's rejection of the necessary truth of the PII is based entirely on the claim that one cannot derive a contradiction from his description of a universe consisting of two spheres with all qualities in common. The cogency of this claim turns on what propositions one admits as logical truths. A proponent of the necessary truth of the PII is likely to regard it as a truth of second order logic.[7] Patently, if it is admitted as a logical truth, then a contradiction can be straightforwardly derived from Black's description of his universe. One might argue that to include the PII among the laws of logic is question-begging. But, of course, it is no more question-begging than the failure to include it. The fundamental point that must be recognized is that the appeal to the logico-linguistic theory cannot resolve the difficulty since it cannot be used to determine whether a proposition of logic is a necessary truth. Consequently, the question of whether the PII is a necessary truth can be resolved only if one appeals to a broader criterion of necessity which does not have this limitation. The only available alternative appears to be the psychologistic theory.

If one appeals to the Humeian criterion of conceivability, the necessary truth of the PII may still appear to be rather dubious. For, according to this account, whatever is conceivable is possible and it is quite easy to conceive of a world consisting of only two qualitatively identical spheres. The primary difficulty in assessing the latter claim is that the concept of conceivability is notoriously obscure. This, of course, is the primary reason why many have rejected the Humeian criterion. I want to suggest

[6]I am indebted here to Arthur Pap's (1958, pp. 7–13) discussion of the logico-linguistic theory. For a more recent criticism of the theory, see Butchvarov (1970, pp. 105–24).

[7]Baruch Brody (1980, pp. 6–7), the latest defender of the necessary truth of the PII, suggests that "$(x)(y)[(F)(Fx \equiv Fy) \supset x = y]$" be treated as an axiom of second-order logic. The formula "$x = y \equiv \cdot F(x) \equiv_F F(y)$" is a theorem of Church's (1956, p. 302) system F_2^2. Whitehead and Russell (1970, p. 57) make the following remarks about the PII: "Thus we cannot, without the help of an axiom, be sure that x and y are identical if they have the same predicates. Leibniz's identity of indiscernibles supplied this axiom."

that the clearest sense of conceiving a state of affairs, as well as the sense relevant to determining the possibility of a state of affairs, is to imagine or visualize it.[8] Although the more limited concept of visualizing presents difficulties of its own, there is one relatively uncontroversial feature of it. Whenever one visualizes a group of objects, one visualizes them in some spatial configuration. For example, when one visualizes two objects, one might be to the left of the other, or behind the other, or on top of the other. Consequently, whenever more than one object is visualized, each occupies a different position in the visual field. But if Russell's account of the spatial structure of the visual field is correct, objects in the visual field occupy different positions in virtue of differences in their positional qualities. The implications for Black's alleged counterexamples are clear. In order to visualize two spheres, one must visualize them as occupying two different positions in the visual field. But if they occupy different positions in the visual field, then they differ in their positional qualities and, hence, do not have all qualities in common. Black's claim that we can imagine two spheres with all qualities in common is mistaken because of his failure to notice the difference in positional qualities. Black, of course, could reject the Humeian criterion of possibility. This move, however, is not sufficient to vindicate his position. For, as we saw earlier, the logico-linguistic criterion cannot resolve the issue. So, on either alternative, Black's counterexample is far from convincing.

IV

It has been argued that Russell's theory is not open to objections based on the PII. Most of these objections fail because they overlook the central role played by Russell's account of space and time. I shall conclude by arguing that if the theory ultimately fails it is because of inadequacies in its treatment of space and time.

The basic idea of Russell's treatment of physical space-time is to analyze space-time point-instants as complete complexes of compresence. Prior to his account of space-time in modern physics, Russell also discusses space and time as it appears in classical physics. There he proposes to analyze instants as classes of events having the following two properties: (1) all the events in the class overlap; (2) no event outside the class overlaps with every member of the class (1948, p. 271). This analysis is strikingly similar to the analysis of space-time point-instants. Although it initially appears that each analysis employs a different basic relation, a look at the ostensive definitions provided for each indicates otherwise.

[8]This view is endorsed in traditional as well as more recent accounts of the theory. See, for example, J. S. Mill (1973, p. 269), C. I. Lewis (1946, p. 152), and A. Pap (1956, pp. 216–18). For a defense of the psychologistic theory, see Casullo (1979).

Russell offers the following observations about *overlap:*

> There are two observable temporal relations among events: they may overlap, as when I hear a clock striking while I see its hands pointing to twelve o'clock; or one may precede another, as when I still remember the previous stroke of the clock while I am hearing the present stroke (1948, p. 276).

In the case of *compresence,* he maintains that:

> If I see something and at the same time hear something else, my visual and auditory experiences have a relation which I call "compresence" (1948, p. 294).

These passages strongly suggest that "overlap" and "compresence" designate the same relation. Furthermore, since an event is later analyzed as an incomplete complex of compresence, a maximal class of overlapping events is, upon analysis, a complete complex of compresence. Therefore, it appears that Russell has taken the instants of classical physics and made them the space-time point-instants of modern physics. The fact that the instants of classical physics are spatially extended while space-time point-instants are not suggests that the theory will encounter difficulties in its treatment of spatial relations.

This suspicion is confirmed when one tries to work out the relationship between the spatial features of perceptual experience and those of the physical world. Russell is emphatic in maintaining that the relation of *compresence* appears both in psychology and in physics. It appears in psychology as "simultaneity in one experience" and in physics as "overlapping in space-time". On the other hand, he also holds that phenomenal complete complexes of compresence (i.e., those formed by the relation of *simultaneity in one experience*) often contain smaller complexes of qualities standing in asymmetric spatial relations.[9] But if physical complete complexes of compresence (i.e., those formed by the relation of *overlapping in space-time*) are space-time point-instants, they cannot contain smaller complexes which stand in asymmetric spatial relations. For all the constituent complexes of such a complete complex occupy the same space-time point. Therefore, Russell is committed to holding that although phenomenal complete complexes often have an internal spatial structure, physical complete complexes do not.

Russell seems to recognize this point. In discussing the spatial complexity of complete complexes of compresence, he states that "private compresence [i.e., the relation which forms smaller complexes of qualities within a complete complex] of percepts is a necessary but not suf-

[9]See, for example, Russell (1948, p. 300), and Russell (1940, p. 338).

ficient condition for public compresence of the corresponding physical objects'' (1948, p. 306). The upshot of this remark is that the public qualities corresponding to those in a phenomenal complete complex of compresence do not typically overlap in space-time. For most private complexes of compresence contain smaller complexes of privately compresent qualities standing in spatial relations. In the case of such complete complexes, the public qualities corresponding to each smaller complex of privately compresent qualities belong to a different space-time point-instant.

This account appears to reconcile the spatial complexity of phenomenal complete complexes of compresence with the absence of such complexity in the case of physical complete complexes. However, it also raises a new problem. Although experience may provide evidence that phenomenal complete complexes do not recur, it certainly provides ample evidence that incomplete complexes formed by the relation of *private compresence* do recur. Since physical complete complexes correspond to incomplete complexes of compresence formed by the relation of *private compresence,* Russell is no longer in the position to support the key claim that physical complete complexes do not recur. Consequently, the theory is faced with a dilemma. Do physical complete complexes contain smaller complexes standing in spatial relations? If they do contain such complexes, then they cannot be space-time point-instants. For the complexes standing in a spatial relation cannot occupy the same space-time point. If they do not contain smaller complexes standing in spatial relations, then they do not correspond to phenomenal complete complexes and there is no reason to suppose that they do not recur. The truth of either consequent is sufficient reason for rejecting the theory.

The conclusion at which we have arrived is that Russell's attempt to reduce particulars to complexes of universals ultimately fails because of inadequacies in its account of space-time. In light of this failure, one might be tempted to draw the further conclusion that the prospects for such a reduction are not very promising. This conclusion, however, would be premature. For Russell holds that relations cannot individuate complexes of qualities. Consequently, he must maintain that no two complete complexes of compresence have all qualities in common. The second horn of the dilemma posed above establishes that this fundamental principle cannot be defended. But if it were to be shown that relations can individuate complexes of qualities, then the reduction of particulars would not require a defense of this principle. There are cogent reasons for believing that this can be shown and, consequently, that particulars can be reduced to complexes of universals. The defense of this claim, however, goes beyond the scope of the present paper.

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