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Problems for the Nuclear Theory of Substance

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TROPES AND DEPENDENCY PROFILES: PROBLEMS FOR THE NUCLEAR THEORY OF SUBSTANCE

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In this article I examine the compatibility of a leading trope bundle theory of substance, so-called Nuclear Theory, with trope theory more generally. Peter Simons (1994) originally proposed *Nuclear Theory* (NT), and continues to develop (1998, 2000) and maintain (2002–2003) the view.[1] Recently, building on Simons's theory, Markku Keinänen (2011) has proposed what he calls the *Strong Nuclear Theory* (SNT). Although the latter is supposed to shore up some of NT's weaknesses, it continues to maintain NT's central tenet, the premise that tropes are variously existentially interdependent. I argue that the central tenet of NT frustrates several important aims of trope theory. If my arguments go through, they also implicate SNT. Because of this, I largely set aside other aspects of NT and SNT and focus on their shared central tenet.

I begin by outlining NT's strategy for meeting two challenges a trope bundle theory faces in accounting for the hallmark features of substance. Crucial to the strategy is NT's central tenet that tropes are variously existentially interdependent. In the second section, I argue that, given NT's central tenet, a trope has what I call a dependency profile. In the third and fourth sections, I argue for a principle I call Inheritance—that two tropes are exactly similar only if their dependency profiles are exactly similar. In the fifth section, I argue that, given Inheritance, NT jeopardizes several important aims of trope theory.

I. Nuclear Theory and Its Central Tenet

As a *bundle theory*, NT holds that every substance (or every simple substance) is a bundle of properties and only properties; there are no bare particulars or substrata.[2] As a *trope* bundle theory, NT works within the framework of trope theory, the general view that properties exist but are particular, rather than universal. Such "particularized" properties, or "tropes," are variously understood to be "non-shareable," "non-multiply-instantiable," "non-multiply-locatable," and so forth. Accordingly, as a trope bundle theory, NT takes a substance to be a bundle constituted entirely by tropes.[3] What makes NT *unique* is its strategy for overcoming challenges that confront trope bundle theory.

Nuclear Theory aims to overcome two challenges concerning hallmark features of substance. According to a traditional view, the features that distinguish substances include *being an independent entity*, and *having both essential and accidental properties*. These characteristics provide distinct desiderata for a metaphysical theory of substance and significant challenges for trope bundle theory.

After describing these challenges, I will outline NT's strategy for overcoming them.

Nuclear Theory is essentially and explicitly predicated on the conviction that each trope is a dependent entity, incapable of existing by itself and existing only when suitably bundled with other distinct tropes. This *dependence thesis* is not held by all trope bundle theorists, but those who accept it face a difficultly concerning independence.[4] The worry is that "no amount of collecting or tying together of dependent entities will result in anything but a dependent entity, or a collection of dependent entities" (Simons 1994, p. 562). Thus, given the dependence thesis, it would seem that "tropes are too insubstantial to give rise to substantial individuals by bundling" (Simons 1994, p. 558). This presents a challenge concerning independence: if tropes are dependent entities, how can they go together to form a bundle that is itself independent?

The next challenge concerns the "stock objection" that bundle theory is unable to distinguish between essential and accidental properties (Molnar 2003, p. 50). The problem stems from egalitarianism about the properties in a bundle: all the properties in a bundle stand in the same kind of part-whole relation to the bundle. That is, there is only one way for a trope to belong to a bundle. As a result, there is no principled way to distinguish between properties had essentially and properties had accidentally. Either all of a bundle's properties are had essentially or all of them are had accidentally. This threatens the view with both excessive essentialism and excessive anti-essentialism (Simons 1998, p. 243). Thus arises the second challenge: how can the bundling of tropes be understood so as to allow for a bundle to have some properties essentially and some accidentally? (Simons 1994, p. 561).

Nuclear Theory was designed to meet these challenges. Crucial to its strategy is what I will call its *central tenet*, the proposal that tropes are variously existentially interdependent. More precisely, tropes are such that each "by its nature requires" the existence of distinct token tropes and/or types of tropes (Simons 2000, p. 153). As intimated by the "and/or," a dependence relation between two tropes will be either *rigid* or *generic*. (Both are cases of *strong* dependence, in that if x strongly depends on y, then y is neither x nor a part of x [Simons 1998, p. 236]. For simplicity, I will suppress this qualification in what follows.)

In a case of *rigid dependence*, the existence of a trope depends upon the existence of a distinct *token* trope. If x is rigidly dependent on y, then necessarily, x exists only if y does. For example, suppose m_1 is a 0.511 MeV/c^2 mass trope and c_1 is a -e charge trope. If m_1 rigidly depends on c_1, then necessarily, m_1 exists only if c_1 exists. The subscripts help to show that this type of dependence holds at the *token* level. That is, not just *any* -e charge trope will satisfy the existence needs of m_1. Indeed, even if c_1 and some distinct trope c_2 are exactly similar, m_1's existence requirements cannot be satisfied by c_2. Rather, m_1 exists if and only if c_1 exists.

In a case of *generic dependence*, the existence of a trope depends upon the existence of a distinct *type* of trope. If x is generically dependent on y and y is of determinable kind K, then necessarily, x exists only if some trope of kind K exists. Again, suppose m_1 is a 0.511 MeV/c^2 mass trope and c_1 is a -e charge trope. If c_1 generically depends on m_1, then necessarily, c_1 exists only if a mass trope exists. That is, the existence of *any* mass trope will satisfy the existence needs of c_1. By means of the formal relations of rigid and generic dependence, NT is able to construct substances from tropes while meeting the above challenges (Keinänen 2011, p. 431). In meeting the first challenge, NT appeals to the following independence principle: "[I]f a whole is composed of a collection of parts each of which has its existential needs (of whatever strength) met within the collection, then the collection and therewith the whole it composes requires nothing outside it, and is thereby independent" (Simons 1998, pp. 243–244). On the basis of this principle, NT's answer to the first challenge is this: "Substances are independent existents because the 'existential needs' (i.e., rigid and generic dependencies) of tropes are met by the tropes constituting a substance" (Keinänen 2011, p. 431). According to NT, a "substance is a particular *whole under dependence closure*" (Simons 2000, p. 148). For example, suppose B is a bundle of two or more tropes such that (i) every trope in B is rigidly dependent on every other trope in B, either directly or by the transitivity of necessary dependence (Simons 1994, p. 568), and (ii) no trope in B is rigidly or generically dependent on a trope not in B. Given the independence principle, B enjoys the emergent or gestalt property of being independent. In this example, a substance is constructed by means of only (mutual) rigid dependence. To use a term I gloss below, such a substance is "all nucleus." Nuclear Theory, however, is a flexible theory of substance. It also allows for an "all halo" substance, one constructed by means of only generic dependence relations, as well as for a "two-tiered" substance, one constructed by means of both rigid and generic dependence relations. Nuclear Theory takes advantage of this flexibility to meet the second challenge.

The second challenge is to account for the distinction between essential and accidental properties. Nuclear Theory meets this by way of the two-tiered substance. More specifically, on NT it is possible for a substance to be constituted by two collections of tropes: a *nucleus* and a *halo*. A nucleus consists of mutually rigidly dependent tropes. In a two-tiered substance, one or more nuclear tropes (and so the nucleus, by transitivity) has *generic* requirements not met by nuclear tropes. All the generic requirements of the nuclear tropes are met by halo tropes. Halo tropes, in turn, are rigidly (but one-sidedly) dependent only on their nucleus (Simons 1998, p. 243). Together, a nucleus and halo constitute a collection such that each trope in the collection has its existential needs (rigid or generic) met within the collection. Thus, given the above independence principle, the two-tiered collection is an independent entity, a substance. Moreover, the two-tiered substance provides NT with the resources to underwrite a distinction between essential and accidental properties: the essential properties of the substance reside in its nucleus, and the accidental properties reside in its halo. When the substance undergoes accidental change, for example, one halo is replaced by another. Thus, the nucleus persists through accidental change, whereas any given halo does not.

II. Dependency Profiles

As just indicated, crucial to meeting the above challenges is NT's central tenet that tropes stand in various existential dependence relations. Tropes in a nucleus, for example, are mutually rigidly dependent. Because of this, each trope has what I will call a *dependency profile*. A trope *t*'s dependency profile specifies all the distinct token and/or types of tropes on which *t* is (rigidly or generically) dependent. For example, if a 0.511 MeV/c^2 mass trope (m_1), a -e charge trope (c_1), and a 1/2 spin trope (s_1) belong to the same nucleus, then m_1's dependency profile involves both charge (c_1) and spin (s_1). Thus, on NT, dependency profiles have *qualitative content*. (As I am using the term, a dependency profile does not include self-dependence.[5])

By way of contrast, consider the kind of dependency profiles we find on the following substance-attribute ontology, on which (i) the fundamental entities include both tropes and substrata, (ii) tropes are non-transferable: if trope *t* belongs to (is borne by, etc.) substratum *S*, then it is impossible for *t* to exist and belong to a substratum non-identical with *S*, and (iii) substrata are transferable: if substratum *S* has trope *t*, it is possible that *S* exist and not have *t*.[6] On this view, tropes are not mutually rigidly dependent, but each trope is rigidly dependent on a specific substratum. In themselves, however, substrata are supposed to be non-qualitative entities. The intrinsic difference between *any* two substrata is only numerical—a difference one might describe as one of mere thisness and not suchness. Thus, because a substratum is a non-qualitative entity, a trope's being non-transferable (with respect to a substratum) does not itself add any qualitative content to the trope's dependency profile. Its dependency profile does not put any specific qualitative demands on the world. For example, if trope *t* is rigidly dependent on substratum *S*, then the existence of *t* requires the existence of a distinct numerically specific entity (*S*), but *t*'s existence does *not* require the existence of a distinct *qualitatively* specific entity (i.e., another trope or type of trope). Thus, on this view there are no qualitative differences between the dependency profiles of non-transferable tropes. For *any* tropes *t* and *t**, where *t* and *t** are non-transferable with respect to distinct substrata, the dependency profiles of *t* and *t** are merely numerically different. Because their dependency profiles involve no qualitative content, their dependency profiles put no qualitative demands on the world.

In contrast, on NT, a trope *is* existentially dependent on distinct qualitative entities—other tropes. As a result, a trope's dependency profile involves qualitative content; it puts qualitative demands on the world. Presumably, however, there are (and NT should allow for) substances that are only partially similar (i.e., similar but not exactly similar) with respect to their internally grounded qualitative character—that is, with respect to the character they have in virtue of their constituent tropes. If so, then there will be tropes whose dependency profiles admit of qualitative differences and similarities.

To illustrate, consider the following three nuclei. The first two (N_1 and N_2) represent electrons and the third (N_3) represents a muon. N_1 contains tropes m_1, c_1, and s_1 (a 0.511 MeV/c^2 mass trope, -e charge trope, and 1/2 spin trope, respectively). N_2 contains tropes m_2, c_2, and s_2 (a 0.511 MeV/c^2 mass trope, -e charge trope, and 1/2 spin trope, respectively). N_3 contains tropes m_3, c_3, and s_3 (a 105.7 MeV/c^2 mass trope, -e charge trope, and 1/2 spin trope, respectively).

Consider s_1 and s_2, the 1/2 spin tropes that belong to the electrons. Although each of these tropes is existentially dependent on its own token 0.511 MeV/c^2 mass trope and its own token -e charge trope, the dependency profiles of s_1 and s_2 are qualitatively exactly similar. That is, their dependency profiles are only numerically different and put exactly similar qualitative demands on the world.

Now compare s_1 and s_3, the 1/2 spin trope of the first electron with the 1/2 spin trope of the muon. Unlike s_1, which requires only a 0.511 MeV/c^2 mass trope, s_3 exists only if a 105.7 MeV/c^2 mass trope exists. Thus, the dependency profile of s_3 requires about two hundred times more mass than does the profile of s_1. Here, the difference between the dependency profiles is more than merely *numerical*. Rather, because the dependency profiles of s_1 and s_3 have different qualitative content, it is not the case that their dependency profiles are qualitatively exactly similar.

The point of the illustration is this. Given NT's central tenet, it is not the case that NT's dependency profiles are merely numerically distinct. Rather, NT's dependency profiles admit of qualitative differences and similarities in virtue of their respective qualitative content.

This section has three upshots. First, on NT, tropes have dependency profiles. Second, dependency profiles have qualitative content. And third, in virtue of having qualitative content, dependency profiles admit of qualitative similarities and differences. In the next two sections, I argue that the latter upshot suggests that the qualitative differences and similarities between dependency profiles are inherited, so to speak, by the tropes that have those profiles—that tropes with qualitatively different dependency profiles are qualitatively different tropes. More specifically, I argue for the following principle:

> **Inheritance:** For any tropes *t* and *t**, if *t* and *t** have dependency profiles that are not qualitatively exactly similar, then it is not the case that *t* and *t** are exactly similar.

In section 5, I argue that in virtue of Inheritance, NT frustrates several important aims of trope theory.

III. First Argument for Inheritance

In order to illustrate the plausibility of Inheritance, let's return to the above example. Compare s_1 and s_3, the 1/2 spin trope of the first electron and the 1/2 spin trope of the muon. As we've seen, the dependency profiles of s_1 and s_3 are qualitatively different: s_1's dependency profile involves a 0.511 MeV/c^2 mass trope, whereas s_3's does not. In virtue of their respective dependency profiles, s_1 and s_3 are different in several ways. First, these 1/2 spin tropes put different qualitative demands on the world. Although both require the world to contain mass, the existence of s_3 requires the world to contain about two hundred times more mass than does the existence of s_1. Second, s_1 and s_3 differ with respect to the kinds of nuclear tropes with which each is incompossible: Because a nucleus is a collection of rigidly mutually dependent tropes, a nucleus cannot change with respect to its constituent tropes. Thus, unlike s_3, s_1 cannot be part of a nucleus that contains a 105.7 MeV/c^2 mass trope; and unlike s_1, s_3 cannot be part of a nucleus that contains a 0.511 MeV/c^2 mass trope. Third, s_1's being a part of a nucleus and s_3's being a part of a (distinct) nucleus is sufficient to make it *impossible* that their nuclei are exactly similar. Altogether, these differences suggest that the difference between the 1/2 spin tropes *themselves*—s_1 and s_3—is a *qualitative* difference and not merely a numerical one. That is, in virtue of having qualitatively different dependency profiles, it is false that the 1/2 spin tropes (s_1 and s_3) are qualitatively exactly similar.

This conclusion is further supported by comparing the differences and similarities between s_1 and s_2, on the one hand, and s_1 and s_3, on the other. On the one hand, s_1 and s_2 have exactly similar dependency profiles: each requires a 0.511 MeV/c^2 mass trope and a -e charge trope. On the other hand, s_1 and s_3 do not have exactly similar dependency profiles: s_1 requires a 0.511 MeV/c^2 mass trope, whereas s_3 requires a 105.7 MeV/c^2 mass trope. Thus, in virtue of their respective dependency profiles, s_1 is more similar to s_2 than to s_3. That is, there is less similarity between s_1 and s_3 than there is between s_1 and s_2. However, the following general rule seems unimpeachable: if the similarity between tropes *t* and *t** is less than the similarity between tropes *t* and *t***, then it is not the case that *t* and *t** are exactly similar. Thus, with respect to the case at hand, it is not the case that s_1 and s_3 are exactly similar. Again, this is because of the dissimilarity between their respective dependency profiles.

Of course, there is nothing special about the above case. That is, s_1 and s_3 represent any two tropes with qualitatively different dependency profiles. Thus, we get the general conclusion that for any tropes *t* and *t** that have dependency profiles, *t* and *t** are exactly similar only if their dependency profiles are exactly similar. This is the Inheritance principle.

IV. Second Argument for Inheritance

The second argument for Inheritance concerns the ontological status of a trope's dependency profile. On NT, a trope's dependency profile is essential to that trope. This is not an optional part of the theory. For example, if trope *t*'s dependency profile were not essential to *t*, then *t* could exist without the distinct token and/or types of tropes specified in that profile. If this were possible, then, where t is a nuclear trope, t could exist without the other token tropes in t's nucleus. But the central strategy of nuclear theory is to secure the existential interdependence of tropes. Thus, a trope must essentially have its dependency profile. This is not news for the Nuclear Theorist. As Keinänen says, the existence of a trope "fixes" its formal relations of existential dependence; for example, if two tropes are mutually rigidly dependent, the existence of either *entails* that this is the case (2011, p. 441). Similarly, Simons says that a nuclear trope "by its nature requires" the existence of other tropes (2000, p. 153). In other words, a dependency profile is part of the nature of a trope. Thus, if two tropes have qualitatively different dependency profiles, this must be so in virtue of those tropes having qualitatively different natures. That is, tropes with qualitatively different dependency profiles have qualitatively different natures.

But tropes with qualitatively different natures are not exactly similar tropes. This is because similarity supervenes on the natures of tropes. Keinänen speaks for many trope theorists when he says that exactly similar tropes are exactly similar "due to being the tropes they are" (Keinänen 2011, p. 429). In other words, if t and t^* are exactly similar, they are so in virtue of t's having the nature it does and t^*'s having the nature it does. Thus, if two tropes have qualitatively different natures, then they are not exactly similar tropes. As noted above, however, tropes with qualitatively different dependency profiles have qualitatively different natures. Thus, we arrive at Inheritance: if two tropes have qualitatively different dependency profiles, then they are not exactly similar.[7]

To resist this argument, one might be tempted to adopt the following:

> **Proposal:** Take a trope's dependency profile to itself be a further, numerically distinct trope. In other words, where trope t has a dependency profile, there is a trope d such that $t \neq d$, t has d, and d is a dependency profile. With this distinction between a trope's nature and dependency profile, one might plausibly hold that tropes t and t^* are in themselves exactly similar even if their dependency profiles, d and d^*, are qualitatively different.

Unfortunately, the Proposal leads to trouble. Suppose we adopt the Proposal's general principle that a trope's dependency profile is itself a numerically distinct trope. Thus, where t_1 and t_2 are mutually rigidly dependent tropes, they are so, in part, in virtue of there being a dependency profile trope d_1, such that $d_1 \neq t_1$, $d_1 \neq t_2$, t_1 has d_1, and t_1 is rigidly dependent on t_2 in virtue of t_1's having d_1. In this case, there are two ways to think about the relationship between t_1 and d_1. Either (A) t_1 is neither rigidly dependent nor generically dependent on d_1, or (B) t_1 is either rigidly dependent or generically dependent on d_1. These options represent a problematic dilemma for the Proposal.

On the one hand, suppose (A), that t_1 is neither rigidly dependent nor generically dependent on d_1. In this case, t_1's existence requires neither d_1 nor a dependency profile trope of the same type as d_1, where the relevant type is the type that requires its bearer—t_1—to be rigidly dependent on t_2. In other words, t_1 does not have to have a dependency profile on which t_1 exists only if t_2 does. This contradicts the working assumption that t_1 and t_2 are mutually rigidly dependent tropes. So option (A) is at odds with NT's central strategy.

On the other hand, suppose (B), that t_1 is either rigidly dependent or generically dependent on d_1. Thus, either (B1) t_1 exists only if t_1 has d_1, or (B2) t_1 exists only if t_1 has a dependency profile trope of the same type as d_1 (i.e., a type that requires t_1 to be rigidly dependent on t_2). In either case, t_1 must have a dependency profile that t_1 has prior to t_1's having d_1. But according to the Proposal, the dependency profile which t_1 has *prior* to t_1's having d_1 must *also* be a further trope. That is, there must be a dependency profile trope d_2, such that (i) $d_2 \neq t_1$ and $d_2 \neq d_1$, (ii) t_1 has d_2, and (iii) it is in virtue of t_1's having d_2 that t_1 is either rigidly or generically dependent on d_1. Of course, this leads to a regress. Given our assumption, (B), either t_1 is rigidly dependent or generically dependent on d_2. In either case, the Proposal requires a further dependency profile trope, d_3, and so on. The regress here is clearly unattractive and seemingly vicious. Thus, option (B) is unavailable.

More generally, the Proposal—taking a dependency profile to itself be a trope—only leads to trouble. It is either at odds with the central strategy of nuclear bundle theory (on A) or gives rise to regress problems (on B). It does not resist the above argument for Inheritance.

So Inheritance looks plausible. In the next section, I will argue that NT, by way of Inheritance, jeopardizes three important goals of trope theory.

V. The Havoc Wreaked by Inheritance

Primitive exact similarity plays an important role on almost every prominent trope theory, including NT.[8] In fact, exact similarity plays a role in tropist strategies for solving the One Over Many problem, constructing natural kinds, and accounting for causal laws. Inheritance frustrates these strategies.

First, exact similarity plays a crucial role in trope theory's solution to the so-called One Over Many problem. The aim here is to explain what it is for distinct objects to share a perfectly natural property, or accounting for "Moorean facts of apparent sameness of type" (Lewis 1983, p. 351). Trope theory offers the following basic analysis: Objects O and O* share a perfectly natural property iff (and because) O has a trope *t* and O* has a trope *t** such that *t* and *t** are numerically distinct but exactly similar. Thus, two particles P and P* share the property of being negatively charged only if there is a pair of exactly similar tropes such that P has one and P* has the other. On NT, however, there will be negatively charged particles that fail to satisfy this condition. In the previous example we considered c_1 and c_3, the -e charge tropes of an electron (N_1) and a muon (N_3), respectively. We saw that c_1 and c_3 have qualitatively different dependency profiles. Thus, given Inheritance, it turns out that the -e charge tropes of the electron and the muon are not themselves exactly similar. (In fact, given Inheritance, it turns out that *no* trope in N_1 is exactly similar to a trope in N_3. The 1/2 spin tropes, s_1 and s_3, have qualitatively different dependency profiles and so, by Inheritance, are dissimilar tropes. And the mass tropes, m_1 and m_3, are dissimilar independently of their dependency profiles.) Thus, by way of Inheritance, NT wreaks havoc with the tropist strategy of using exact similarity to account for what it is for objects to share a perfectly natural property.

Second, for similar reasons, NT jeopardizes the tropist strategy of using exactly similarity to construct determinate kinds. On this view, a determinate kind is supposed to be a class of tropes closed under exact resemblance—a so-called "property class." The theoretical aim is to divide the whole field of tropes "into mutually exclusive classes, each of which is an exact resemblance class, a class with the highest degree of natural unity" (Armstrong 1989, p. 121). This strategy succeeds only if there is an exact resemblance class containing all and only -e charge tropes. But as noted above, given Inheritance, there are -e charge tropes that fail to exactly resemble. Thus, a suitable property-class cannot be constructed for negative elementary charge.

The third way in which NT thwarts the aims of trope theory concerns trope theory's account of causal laws. A standard objection to trope theory is that taking properties to be tropes, rather than universals, saddles the view with a significant disadvantage when it comes to establishing a link between causes and laws.[9] For example, suppose that trope *f* causes trope *g*. Now consider *f**, which is exactly similar to *f*. Why should we think that *f** will cause a trope that is exactly similar to *g*? A philosopher who takes properties to be universals will identify *f* and *f**, and so she may answer this question by appealing to the meta-law that "*identicals cause identicals*." Of course, the trope theorist cannot give this answer. She will have to appeal to a meta-law that "*like causes like*." As Sophie Gibb explains, the idea is that "exactly resembling tropes will play an exactly resembling causal role in exactly the same circumstances" (Gibb, "Tropes and the Generality of Laws"). Unfortunately, while this strategy might work on other trope theories, it does not seem to work on NT. As before, the trouble stems from Inheritance.

Consider again the -e charge tropes that belong to the electron (N_1) and muon (N_3). The "like causes like" meta-law cannot guarantee that these tropes will have exactly similar effects. This is because Inheritance implies that c_1 and c_3 are not themselves exactly similar. Furthermore, in virtue of their respective dependency profiles, c_1 must be coinstantiated with a 0.511 MeV/c^2 mass trope and (thus) cannot be coinstantiated with a 105.7 MeV/c^2 mass trope, whereas c_3 must be coinstantiated with a 105.7 MeV/c^2 mass trope and (thus) cannot be coinstantiated with a 0.511 MeV/c^2 mass trope. Thus, because their respective *bundles*—their nuclei—cannot be exactly similar, c_1 and c_3 cannot obtain under exactly similar circumstances. Indeed, as already noted, the immediate circumstance in which c_3 obtains must involve about two hundred times more mass than the circumstance in which c_1 obtains. There is, then, no guarantee that their obtainings will bring about exactly similar effects. In this way, NT exacerbates what is already a contentious strategy for linking causes and laws.

VI. Conclusion

Trope bundle theory faces significant challenges with respect to accounting for two hallmark traits of substance—independence and changeability. Nuclear Theory attempts to overcome these challenges by its central tenet that tropes stand in various existential dependence relations, especially mutual rigid dependence. As a result, tropes have dependency profiles and thereby are subject to the Inheritance principle. That is, the qualitative differences between dependency profiles are inherited by the tropes that have those profiles. Unfortunately, this ultimately sabotages trope theory's standard strategies for solving the One Over Many problem, constructing natural kinds, and accounting for causal laws.

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NOTES

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1. For discussion of NT, see Bacon (2010); Denkel (1997); Ehring (2011); Hoffman and Rosenkrantz (1994); Maurin (2002); and Molnar (2003).

2. I discuss bare particulars in "Bare Particulars and Constituent Ontology" (forthcoming). For a general critical discussion of bundle theory, see my "Bundle Theory's Black Box: Gap Challenges for the Bundle Theory of Substance" (forthcoming); and Loux (2006), pp. 90ff. The flexibility of bundle theory is especially apparent in the versions developed and/or critiqued in Casulo (1988); Denkel (1997); Robb (2005); Rodriguez-Pereyra (2004); Simons (1994); and Van Cleve (1985).

3. Versions of trope bundle theory have been defended by several contemporary philosophers, including Campbell (1990); Denkel (1996, 1997); Ehring (2011); Keinänen (2011); Maurin (2002); Robb (2005); Simons (1994, 1998, 2000); and Williams (1953).

4. Among trope bundle theorists, those affirming the dependence thesis include Denkel (1997); and Keinänen (2011); those rejecting it include Campbell (1990); and Williams (1953). For discussion, see especially Schaffer (2003).

5. Although the stipulation is appropriate, nothing substantial hangs on it. It seems appropriate because the relevant dependencies are strong rigid and strong generic dependencies. In Simons's terminology, x strongly depends on y only if $x \neq y$. Thus, because a trope's dependency profile specifies the trope's strong rigid or strong generic dependencies, self-dependence should be excluded. In Keinänen's discussion of rigid and generic dependence, he explicitly excludes self-dependence (2011, p. 20n46, p. 21n49). More importantly, for this paper, excluding self-dependency highlights NT's unique implications for dependency profiles. If we *include* self-dependence, then for any trope t, t's dependency profile would involve t, and thus (because t is a qualitative entity) t's dependency profile would have qualitative content. Furthermore, it would follow that tropes have dependency profiles with qualitative content on *every* version of trope theory. Excluding self-dependence helps clarify the qualitative content that dependency profiles have in virtue of NT's central tenet.

6. This is consistent with it being necessary that S have *some* trope or other.

7. This argument also goes through on the plausible doctrine that, strictly speaking, a trope does not *have* a nature but rather *is* a ("particularized") nature. In this case, a dependency profile is part of a nature to which a trope is identical.

8. A notable exception is the *natural class trope nominalism* developed by Ehring (2011). On his view, two tropes are similar in virtue of their various respective memberships in primitively natural classes. It would be interesting to consider the prospects of developing a version of NT within the framework of natural class trope nominalism. Call such a view NT*. Although NT* may not be subject to the specific problems I raise here, Inheritance would still be true on NT*, and this would seem to saddle NT* with some puzzles. For example, supposing that there is a primitively natural class whose members are all and only -e charge tropes, Inheritance would imply that there are members of this class that are not exactly similar. More generally, one puzzling feature of NT* would be that there are natural classes of tropes whose members fail to be exactly similar.

9. See Armstrong (1997, 2004). For a reply see Gibb, "Tropes and the Generality of Laws."

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