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Weak Discernibility, Quantum Mechanics and the Generalist Picture*

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Introduction

It is commonly held that in quantum mechanics (QM), unlike in classical mechanics (CM), particles violate the *Principle of the Identity of the Indiscernibles*, according to which

$$\forall x \forall y (\forall P (Px \leftrightarrow Py) \rightarrow (x = y)) \qquad \text{(PII)}$$

(P stands for a property, and the lowercase variables for individuals).

As a consequence, there seems to be an inevitable alternative between two mutually exclusive options as regards the ontological interpretation of quantum entities. That is:

a) Sticking with the Principle of the Identity of the Indiscernibles (PII) as a criterion of individuality and object-hood, and consequently holding that quantum particles are not individual objects;
b) Endorsing the idea that individuality is a primitive and non-further-analysable metaphysical fact of self-identity and numerical distinctness from other entities (the terms 'primitive thisness', 'transcendental individuality' and 'haecceity' have been variously used) which cannot be captured in terms of properties, and consequently demands the abandonment of PII.[1]

The possibility of avoiding the choice altogether, at least for certain particles, has been suggested by Saunders ((2003), (2006)). He attempts to obtain the best of both worlds by arguing that a version of PII capable of 'testing for' so-called *weak* discernibility shows *fermions* to be individual

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1 See Post (1963) and Adams (1979). As is well-known in the metaphysics literature, this is incompatible with the first alternative because PII cannot take primitive properties of self-identity and numerical distinctness into account, as this would trivialize it as a criterion of individuation.

objects. In this paper, I analyse Saunders' argument in favour of this conclusion in detail.[2]

In section 1, I introduce the 'generalist' perspective endorsed by Saunders and consider its possible justification and philosophical basis; and then look at the Quinean notion of weak discernibility he appeals to. Next, I move on to a consideration of quantum mechanics. First, in section 2, I summarize the established understanding of the way things stand as regards quantum particles and PII; then, in section 3, I evaluate the way in which Saunders intends to employ the concept of weak discernibility with a view to providing an alternative picture for fermions. There, I expand on the criticisms formulated by Hawley (2006) and Dieks and Veerstegh (2008) by explaining in detail what I take to be the basic problem, not entirely made explicit in these papers: that the properties invoked by Saunders cannot be pointed to as 'individuators' of otherwise indiscernible (and thus numerically identical) entities because their ontological status remains *underdetermined* by the evidence and the established interpretation of the theory. In addition to this, in section 4 I contend that, even if he is granted his conclusions as regards fermions, Saunders does not deal adequately with bosons, and cannot do so *because* he subscribes to PII and the generalist picture. Section 5 contains a critical examination of the widespread claim (or at least implicit assumption) that the generalist picture should be regarded as obviously compelling by the modern-day empiricist.

1. The generalist picture, weak discernibility, and Black's universe

In his (2003), Saunders endorses what, following O'Leary-Hawthorne and Cover (1996), he calls the 'generalist picture'. This view is

> a distinctive and uncompromising form of realism, a commitment to the adequacy of purely descriptive concepts (Saunders 2003, pp. 289–290).[3]

2 Saunders' ideas have been elaborated in more detail and applied more generally by Muller and Saunders (2008). Since the considerations made in this paper apply to the more general framework as well, however, I will only consider Saunders' original paper here.

3 This is intimately connected to the 'semantic universalism' developed by Van Fraassen ((1977–8), (1991)). That is, the thesis that all factual descriptions can be given completely in terms of general propositions making no reference to individuals. See also Hintikka's remark that "[e]ach possible world contains a number of individuals with certain properties and with certain relations to each other. We have to use these properties and relations to decide which member (if any) of a given possible world is identical with a given member of another possible world. Individuals do not carry their names on their foreheads; they do not identify themselves" (1970, p. 410).

The generalist picture is based on the Quine-Hilbert-Bernays[4] view of the identity relation as definable in terms of the conjunction of all the formulas (not involving the identity sign) satisfied in a given first-order language with a finite lexicon; and on the subsequent subscription to PII as a valid criterion for the identification of individual objects.[5]

Against such a 'reductionist' understanding of identity, it has been often demurred that it renders identity relative to the predicates appearing in the language, while identity seems to be an 'absolute' notion. In support of the idea that the suggested reduction is consequently unacceptable, various allegedly paradoxical results—obtaining in aptly constructed languages—have been presented.[6] However, it seems that the generalist can respond with some degree of *prima facie* plausibility that the notion of identity as indiscernibility is very reasonable once the *richest* available language is considered. In the case of material objects, this is usually taken to mean that the non-logical vocabulary defined in the light of our best empirical knowledge of the world, i.e., the knowledge expressed by physical theory, gives support to the generalist picture.

But why does this latter claim (which is what we will be concerned with in this paper) appear plausible? A philosophical argument for endorsing the generalist position may legitimately be asked.

It seems clear that the generalist picture is an expression of the empiricist emphasis on verifiability and epistemic accessibility. The idea is that the reduction of identity to the conjunction of formulas satisfied in the relevant language is justified by the use of the vocabulary of physical theory because the latter i) expresses all the available knowledge we have of the material world, and ii) is exclusively concerned with things' qualities. If this is correct, then the best (if not the only) way to formulate a justification of the generalist picture is by subscribing to a 'refurbished' version of a well-known criterion first advocated by Russell in his early writings ((1912, esp. chapter 5), (1917)) as setting the correct empiricist constraints on reasonable beliefs: the *Principle of Acquaintance* (PA). It is indeed PA that, in some form, lies at the roots of the empiricist stance on metaphysics.

4 See Quine (1960) and Hilbert and Bernays (1934).

5 If identity is *defined* as the conjunction of satisfied qualitative formulas, then the conditional (equality of properties)→(identity) must be true, provided that sameness of satisfied formulas entails equality of properties (which appears a sensible thing to say). However, it is important to emphasise that the generalist subscribes to the *bi-conditional* (equality of properties)↔(identity).

6 See, for instance, Wallace (1964) and Williamson (2006).

After distinguishing *knowledge by acquaintance* (direct, non-inferential knowledge) and *knowledge by description* (knowledge that is mediated, inferred from the direct knowledge of something else), Russell claimed that one can refer determinately and with certainty only to things that one knows by acquaintance. According to Russell, the only knowledge by acquaintance that we have is that of *sense-data.* Everything else is known by description: a middle-sized physical object, a table for example, is only known indirectly for, in order to say that we know it, we need to rely on propositions such as 'the table is the cause of such-and-such sense data', which do not refer to something we are directly acquainted with. The result is that only demonstratives pointing to sense-data can be taken at face value, and not doubted (Russell calls the expressions referring to these *logically proper names*).

Of course, contemporary empiricists do not subscribe to the letter of Russell's ideas on acquaintance. They typically argue that Russell's limitation of knowledge by acquaintance to sense-data is too restrictive, and that PA should be relaxed so as to include mind-independent properties of middle-sized physical objects in the range of what is known with certainty.[7] Those who support PII as a criterion of individuation *of material objects* (and not of bundles of perceptual contents) are indeed committed to such a move from *phenomenalism* to (partial) *direct realism* about such objects. Moreover, the range of what can be taken as warranted on the basis of a criterion of acquaintance must, in the present context, include scientific claims: for, as we have seen, the generalist (rightly) considers science as the best candidate for the definition of the relevant non-logical vocabulary.

The essential point for present purposes is that the 'renewed PA', exactly as Russell's original PA, presses one to avoid commitment to the existence of things that are not known (or know*able*) directly, and to subscribe only to claims secured by either direct non-mediated knowledge (and/or our best available scientific theories). The key claim, then, seems to be that we are (can be) acquainted with the qualities that things possess and nothing else, and so we should explain everything about what surrounds us in terms of properties; and suspend our judgment whenever this is not possible. PII should consequently be regarded as the 'best we can get' as far as criteria of individuation are concerned: given the characteristics of our epistemic access to reality, that is, the reduction of facts of identity and individuality to qualitative facts is *not only plausible, but inevitable.*

7 See, for example, Brewer (2001, esp. pp. 251–255).

The further step that may be made (and in fact appears to be implicitly made in the literature) is to then give an ontological basis to this perspective by endorsing the so-called *bundle theory* of entity constitution. According to the bundle theory, every object is a bundle of universal-instances, and every instance of a universal is numerically identical to all the others; hence, two numerically distinct bundles must have at least one property (i. e., universal-instance) not in common.

I will come back to a discussion of these issues later. For the time being, let us assume this sort of empiricist justification for the generalist picture, and move on to an assessment of its application to quantum mechanics by Saunders.

Saunders first introduces Quine's (1976) distinction between *absolutely*, *relatively* and *weakly* discernible entities. Entities are absolutely discernible if there is in the language a formula in one free variable that applies to one of them only. They are relatively discernible if there is a formula in two free variables which applies to them in one order only. And they are weakly discernible if they satisfy an *irreflexive* formula in two free variables; that is, if a formula is satisfied by the two of them together but not by one of them and itself. With some degree of simplification with respect to Quine's original proposal (which, at any rate, does not affect the point being made) this can be translated in terms of properties as follows: *weak discernibility consists of the fact that an irreflexive relation R holds.* Since, by definition, for any such relation it is true that $\forall x(\neg R(x,x))$, there must exist two distinct entities x and y such that $x \neq y$ and R(x,y) whenever R is instantiated. Therefore, one has an individuating *qualitative* fact based on neither a monadic nor a relational property of a single entity.[8]

According to Saunders, weak discernibility can be reconstructed in scenarios that are normally presented as violating PII: on the one hand, Black's (1952) classic (putative) counterexample to PII; on the other, certain quantum physical systems involving fermions. In the thought-

8 PII as it is commonly formulated consequently becomes the more complex expression $\forall x \forall y((\forall P(Px \leftrightarrow Py) \wedge \forall R \neg(R(x,y) \wedge \forall z \neg(R(z,z)))) \rightarrow (x=y))$. French and Krause (2006, pp. 167–168) claim that Saunders is in fact subscribing to a different principle, the 'Principle of the Identity of the Indiscriminables', stating that that $x=y$ *if and only if*, for all unary predicates A, binary predicates B, and so on, the predicates apply equally to x and y. Once one points out that the generalist *equates* identity and indiscernibility, and consequently subscribes to a *bi-conditional* stronger than PII as traditionally intended, this does not make a relevant difference in the context of the present discussion; therefore, I will continue taking Saunders as endorsing a form of PII, *which is what he suggests in his papers.*

experimental case devised by Black, one has two qualitatively identical spheres and nothing else; while Black presents them as indiscernible and yet numerically distinct (so allegedly contradicting PII), says Saunders, the spheres are in fact made distinct by an irreflexive *distance* relation that holds among them: *each* sphere is at some distance from *another* sphere, but not from itself.[9] What about the quantum case?

2. Quantum mechanics and the violation of the Identity of the Indiscernibles

In classical mechanics, an assumption of impenetrability holds. This suffices to make PII a valid criterion of individuation once it is formulated in what is known as its *weak* version; namely, with its universal quantifier over properties ranging over spatial locations too. For of course, two numerically distinct things, if impenetrable, will differ qualitatively at least in their locations.

Impenetrability is not, however, presupposed in quantum mechanics (QM).[10] This, it has been claimed, entails the violation of PII. Let us briefly look at the argument usually given in favour of this conclusion.

Properties of physical systems are represented in the quantum formalism as Hermitian operators in Hilbert space. The eigenvectors of these operators represent the possible values of the observable quantity represented by the operator. QM gives us the probabilities that these values be detected upon measurement. In a seminal paper, French and Redhead (1988) follow a widely accepted interpretation of the theory and *identify* the properties of quantum entities with these probabilities. A consequence of this is that in order to test PII against the evidence of QM one must *compare probabilities* regarding the observables of identical particles (i.e., particles with the same state-independent properties). French and Redhead consider two-particle systems of identical particles and an arbitrary observable O with eigenvalues x and y; and analyse

9 This of course excludes Hacking's (1975) suggested interpretation of Black's universe—as a non-Euclidean curved and closed universe with only one sphere at some distance from itself—as irrelevant. The same seems to apply to O'Leary-Hawthorne's (1995) suggestion that Black's world is one with numerically the same entity instantiated twice in different places.

10 It is important to emphasise that the most well-established version of QM, namely the 'orthodox' interpretation based upon the formalisation given by Von Neumann and on the idea of 'collapse' of the wave-function, is assumed here as in the relevant literature. According to such an interpretation, the position observable can have the same values for (supposedly) distinct particles.

both *monadic* properties of the form Prob $(x)_{Oi}^{|\Psi>}$ —that is, those expressed by the probability that in the state Ψ observable *O* 'actualises' upon measurement with value *x* for particle *i*; and *relational* properties of the form Prob $((x)_{O1}|(y)_{O2})^{|\Psi>}$ —that is, those properties that correspond to the conditional probabilities of one value being actualised for *O* in one particle, *conditional on* the actualisation of the other value for the same observable in the other particle.

Making use of a *permutation operator* exchanging particles in the same system—let us name it $Perm_{1,2}$—and applying the *Indistinguishability Postulate*, French and Redhead show that for any arbitrary monadic property one obtains

$$\text{Prob}\,(x)_{O1}^{|\Psi>} = <\Psi|P^{O1}{}_{x}|\Psi> = <\Psi|Perm_{1,2}{}^{\dagger}\,P^{O2}{}_{x}\,Perm_{1,2}|\Psi> = <Perm_{1,2}\Psi|\,P^{O2}{}_{x}\,Perm_{1,2}|\Psi> = <\Psi|P^{O2}{}_{x}|\Psi> = \text{Prob}\,(x)_{O2}^{|\Psi>}$$

For relational properties, they prove that

$$\text{Prob}\,((x)_{O1}|(y)_{O2})^{|\Psi>} = \text{Prob}\,((x)_{O2}|(y)_{O1})^{|\Psi>}$$

as follows.

By a fundamental property of probabilities[11], the above equality is the same as

$$\text{Prob}\,((x)_{O1}\&(y)_{O2})^{|\Psi>}/\text{Prob}\,(y)_{O2}^{|\Psi>} = \text{Prob}\,((x)_{O2}\&(y)_{O1})^{|\Psi>}/\text{Prob}\,(y)_{O1}^{|\Psi>}$$

The denominators have been shown to be equal. As for the numerators, they are also equal. For,

$$\text{Prob}\,((x)_{O1}\&(y)_{O2})^{|\Psi>} = <\Psi|P^{O1}{}_{x}\,P^{O2}{}_{y}|\Psi> = <\Psi|Perm_{1,2}{}^{\dagger}\,P^{O2}{}_{x}\,(Perm_{1,2})^{2}\,P^{O1}{}_{y}\,Perm_{1,2}|\Psi> = <\Psi|Perm_{1,2}\,P^{O2}{}_{x}\,P^{O1}{}_{y}\,Perm_{1,2}|\Psi> = <\Psi|\,P^{O2}{}_{x}\,P^{O1}{}_{y}\,|\Psi> = \text{Prob}\,((x)_{O2}\,\&\,(y)_{O1})^{|\Psi>}$$

Consequently, the relational properties of identical quantum particles in the same system are also equal.

French and Redhead conclude that, for both fermions and bosons, identical particles in the same system

> do in fact have the same monadic properties and the same relational properties one to another, so the weakest form of PII which we can formulate[,] which involves both monadic and relational properties, is violated (Ib., p. 241).[12]

11 According to which Prob(A|B)=Prob(A&B)/Prob(B).

12 Of course, the use of the word 'weakest' is in need of an important qualification, which will be made in the next section. French and Redhead also show that systems of three indistinguishable paraparticles (still undetected—but see (Camino, Zhou

These results are not absolutely uncontroversial. In particular, unlike classical entities, for which a maximally specific state description is always available, quantum entities lack such a description when entangled. And if one identifies state-dependent properties with maximally specific state descriptions, this means that there are no state-dependent properties to be 'plugged into' PII for at least some quantum systems. French and Redhead assume that the state-dependent properties of entangled quantum particles are those described by their mixed state[13], a move which they regard as justified by the fact that pure states and mixed states cannot be distinguished by means of observations made on one of the particles alone.[14] However, if one were to stick to the Eigenstate-Eigenvalue Link (EEL), there would be ground for rejecting the attribution of any state-dependent property whatsoever to entangled particles.

French and Redhead's presupposition is usually accepted as unproblematic in the literature, but it is important to ask why this is the case. It seems to me that the reason for this is that the assumption does not affect the conclusion: identical particles have all the same properties when they partake in the same system, *even if the larger set of properties, including the state-dependent properties encoded in the particles' mixed states, is 'extracted from theory'*. In other words, the assumption is regarded as non-problematic because PII turns out to be violated anyway. This will be of some relevance later on.

The possibility has been contemplated (see, for instance, the exchange between Cortes (1976) and Barnette (1978)) of employing particle histories

and Goldman 2005)—particles that are neither fermions nor bosons and obey different types of symmetry and statistics) are such that two particles differ from the third with respect to some property but have all the same monadic properties and all the same relational properties as each other. French and Redhead's results have been later improved upon in terms of generality by Butterfield (1993), who extended their proofs regarding relational properties to properties of two particles involving their relation to a third entity; and by Huggett (2003), who gave a general proof of violations of PII for any number of particles and any number of observables. As for paraparticles, Huggett's results show that for systems of n identical paraparticles only a number $m<n$ (determined by the type of particle) of them is such that they are indiscernible (Huggett also proved that the m indiscernible paraparticles are (anti-)symmetrized).

13 It must be stressed that the theory (*via* the so-called *Axiom of Reduction*) *always* allows one uniquely to identify separate mixed states for the component particles. The point is whether these states denote real physical features of well-defined objects.

14 Massimi (2001) comments that one is prevented from attributing monadic properties to entangled particles, as the latter are not in separable states; and that, consequently, PII applies to such particles only if these are considered as possessing state-dependent relational properties *only*.

for individuation. Two considerations seem to lead to the immediate rejection of this option. On the one hand, histories do not appear in our theories. One may follow Van Fraassen (1991, p. 432) and insist that the fact that they are 'empirically superfluous' cannot lead one to exclude histories from the range of genuine properties. French and Krause point out, though, that this appears in conflict with the empiricist stance underpinning PII, essentially based on a rejection of in principle undetectable factors determining things' identities (2006, pp. 165–166). Be this as it may, on the other hand, it looks as though the postulation of a property corresponding to the history of *a* particle in fact presupposes *that* particle's identity, as it can only denote the evolution of *the* particle as *the same individual* in time. It could be objected that histories *determine* rather than *depend on* the particles' identities. But, how can particle histories exist 'floating', as it were, until there are other properties they can be bundled with? Are they not necessarily properties that express facts about the existence in time of *already individuated* bundles? It appears indeed sensible to exclude particle histories from the discussion.

3. Weak discernibility to the rescue?

In spite of the correctness of French and Redhead's argument, there might be more to say, at least as regards some quantum particles.

The *Exclusion Principle* (EP) has been referred to in the past (for example, by Weyl (1949)) as a vindication of PII for *fermions*. Because EP bans two indistinguishable fermions from having all the same quantum numbers, it seems to entail their discernibility. However, as first pointed out by Margenau (1944), EP represents a constraint only on future experimental outcomes, and fermions in the same physical system indeed have the same values for all their observables (provided, of course, that properties are identified with pre-measurement probabilities in the way described in the previous section).

Still, it is a fact that identical fermions in the same system have all the same properties but we also know *with certainty* that, starting from a condition of *entanglement*, they will give rise to opposite results when measured. Does this not point towards an actual fact of the matter—concerning a *relation* among the particles—that is sufficient for individuation even before measurement?

Saunders' claim that PII is vindicated for fermions, as the latter are weakly discernible in Quine's sense, goes along exactly these lines. Fermions in the *singlet* state of spin, Saunders claims, are weakly discernible because they are in an irreflexive relation expressed by

> the symmetric but irreflexive predicate '… has opposite ↑-spin component of spin to…' (2006, p. 59).

Saunders exploits the fact that, although the component particles are in mixed states, the composite system—represented in the Hilbert space which is the tensor product of the Hilbert spaces representing the component particles—is in a pure state which is an eigenstate for the spin observable with eigenvalue 0. Given EEL, the composite system constituted by two entangled fermions can therefore *always* be said to *actually* possess spin 0.

This latter fact, though, appears directly to lead one to regard the *correlation* between the entangled fermions as equally real. For, the total spin state of a system of two entangled fermions 1 and 2—which we just took as an actual property of an entangled system—is represented by the following expression:

$$1/\sqrt{2}(|\uparrow>_1|\downarrow>_2 - |\downarrow>_1|\uparrow>_2)$$

But the above conveys the information that, in spite of the fact that they have equal monadic and relational spin properties (in particular, they are both in the mixed state $1/2|\uparrow>+1/2|\downarrow>$), fermions 1 and 2 *necessarily* have opposite spin values. This is easily shown by recalling the canonical statistical algorithm used to define quantum probabilities in terms of inner products between vectors in Hilbert space, and noticing that

$$<\Psi|P^O{}_i|\Psi>=|c_i|^2$$

and thus

$$\text{Prob}\,(o_i)_O^{|\Psi>}=|c_i|^2$$

With reference to the singlet state, it follows that (with *S* denoting the observable corresponding to the chosen component of spin),

$$\text{Prob}(\uparrow_1|\downarrow_2)_S^{|\Psi>}=\text{Prob}(\downarrow_1|\uparrow_2)_S^{|\Psi>}=1/2$$

and

$$\text{Prob}(\uparrow_1|\uparrow_2)_S^{|\Psi>}=\text{Prob}(\downarrow_1|\downarrow_2)_S^{|\Psi>}=0$$

But this, Saunders maintains, points to the holding of a discerning *irreflexive relation*: the conveyed information is about an actual property; it has to do with what is true *of the two particles together*; it is not equivalent to two properties possessed by each particle separately; and it holds regardless of the order in which we consider the particles.

Whence, it looks as though fermions can be individuated by PII even when they are indistinguishable in the sense intended by physicists, and are neither strongly nor moderately discernible.

This result is interesting. Nonetheless, it can be questioned on three grounds.

3.1 Relations and relata

The *first* reason for perplexity is quite general, and in fact widely acknowledged. The basic claim Saunders makes regarding fermions is that they are *exclusively* individuated by relations, and that if spin correlations did not make them weakly discernible, then fermions would be absolutely indiscernible (and consequently identical). Therefore, Saunders is in effect subscribing to the view that relations can be independent of their relata, and actually be prior to them in the sense that they determine the relata's numerical distinctness. This is obviously not inconsistent, and actually squares well with the structuralist ideas that Saunders explicitly underwrites.[15] On the other hand, such a view is certainly open to discussion.

Metaphysically speaking, that relations have the power to individuate surely is a controversial claim. Russell, for one, argued (against Moore) that particulars must exist over and above universals because there are certain relations entities cannot have to themselves (1911, p. 118) and presuppose relata. In the 1960s, Allaire ((1963) and (1965)) argued similarly for the existence of bare particulars, while others (Chappell (1964), Meiland (1966)) objected that relations can individuate and so there is no need to postulate anything over and above the qualitative aspects of things. Similar problems arise in the more specific domains considered in recent debates about structuralism. Burgess (1999) and Keränen (2001), for instance, object to structuralism about mathematics that if objects are to be individuated on the basis of inter-structural relations, then objects occupying structurally indiscernible positions should be deemed identical; but entities that we take as uncontroversially distinct, such as any complex number and its conjugate, are structurally indiscernible. Ladyman (2005) invokes the notion of weak discernibility to maintain that this is not actually the case, as each complex number is related to its conjugate by an irreflexive relation. Ketland replies that identity is in fact presupposed; and that, at any rate, counterexamples can be found to the claim that all structures are such that distinct

15 In particular, Saunders endorses a form of structural realism about physical theory.

individuals are at least weakly discernible (see his 'dumb-bell' structure (2006, pp. 309–310)). Ketland consequently claims that the existence of what he calls 'non-Quinian' structures shows that a reductionist analysis of identity is "mathematically unworkable" (Ib., p. 312).[16] The obvious question therefore is: Why should we exclude the possibility of non-Quinian structures, for which the reduction of identity to individuality is impossible, in the domain of material objects?

Looking at the physics side of the matter, the following may additionally be relevant: there are results showing that the correlations between the subsystems of individual isolated composite quantum systems cannot be taken to be objective local properties of that system, with 'objective' being taken to mean of a property P of system S that 'P is such that it cannot change in immediate response to what is done to a system not interacting with S'.[17] Seevinck (2006), in particular, takes certain relatively simple proofs to be sufficient for saying that the correlation between entangled particles is not ontologically 'robust', the latter qualification being taken to encompass impossibility, without interaction, of i) creation, ii) elimination via mixing, iii) flow into some environment upon mixing. It is certainly an interesting question whether or not a strong structuralist-like understanding of relations of the sort Saunders suggests requires ontological robustness so defined. If relations are ontologically prior their relata, one may ask, how can they fail to be objective local elements of reality? If they change non-locally, are they capable of individuating in an unambiguous way? These appear to be important questions that the generalist must deal with.

I will not delve into this further here, however, as I take another fact to count decisively against Saunders' attempt.

3.2 Ontological underdetermination

Hawley (2006) attacks Saunders on two counts. On the one hand, she argues, PII *permits*, rather than *compels*, one to take fermions as distinct objects, and it is instead Leibniz's Law (the Indiscernibility of the Identicals) that *requires* one to posit distinct objects in cases of qualitative

16 See also Bermudez's critique of Ketland (2007) and Ketland's reply (2007).

17 Cabello (1999), Jordan (1999) and Seevinck (2006) argue, in different but related ways, that if one assumes that the correlations among entangled quantum particles are objective local properties of the composite systems these particles give rise to, then Bell-like inequalities for pairs of correlated pairs of particles can readily be formulated and shown to be violated by quantum systems.

difference. On the other hand, adds Hawley, the relations Saunders points to do not allow for the different treatment of fermions and bosons.

As regards the first criticism, it is true that PII tells us that indiscernible entities are identical, not that discernible entities are distinct objects; and that it is only Leibniz's Law that allows one to infer numerical distinctness from discernibility. We have already seen, however, that Saunders follows Quine in *defining* identity as indiscernibility. This entails that he endorses a bi-conditional claim that absorbs *both* PII and Leibniz's Law. It follows that his general perspective on identity and individuality does in fact constitute a sufficient criterion for attributing numerical distinctness in the case at hand.

As for the point about relations and the different treatment of fermions and bosons, Hawley says that

> Saunders argues that an entangled-fermion system has proper parts, while an entangled-boson system does not. For him, an entangled-boson system is just irreducibly symmetric. Then why not say that an entangled fermion system is just irreducibly anti-symmetric? Neither symmetry nor antisymmetry has a better or worse claim to ontological basicness. We know that if entangled fermions did exist, the being-of-opposite-spin relation between them would not supervene upon their other properties. The same goes for the being-of-the-same-spin relation between putative bosons [...] The difference between antisymmetry and symmetry doesn't give us positive grounds for recognizing fermions but not bosons (Ib., pp. 301–302).

This is unclear. Saunders exploits the fact that only particles that give rise to anti-symmetric systems, *since they obey EP*, have opposite spin necessarily. That is, his claim is that only in the case of fermions does one necessarily have irreflexive relations. It is for these latter relations, though, that he puts forward a claim of 'ontological basicness'. Of course, then, it is the ontological status of the (alleged) irreflexive relations that one must discuss, not that of antisymmetry as opposed to symmetry.

With respect to irreflexivity and its consequences, Hawley argues that the notion of weak discernibility is unappealing because

> [f]irst, it incites us to divide an object with, say, four units of mass into a three unit part and a one-unit part. Second, it conflicts with the modest, empiricist stance which makes PII attractive in the first place. PII tells us to restrict our ontology to the minimum required by Leibniz's Law, to choose a single object over two indiscernibles any time. The present principle tells us to make work for Leibniz's Law, to choose mereological complexity over simplicity whenever we can (Ib., p. 302).

This methodological criticism appears weak. First, there is no need for the generalist employing the notion of weak discernibility to make such unequal divisions as those suggested by Hawley. According to the generalist, an object's parts can, to the contrary, be equal as regards their intrinsic properties, including mass, provided that they enter into irreflexive relations. If they do not, the very existence of distinct parts can be put into doubt, and so there is no need to divide at all.

As for empiricism and simplicity, it is hard to see why a 'modest empiricist' should ignore the (entirely qualitative) differences determined by irreflexive relations. Indeed, *independently of whether or not one is an empiricist*, it is difficult to deny that whenever a dyadic irreflexive relation holds there must be two numerically distinct relata.

The real issue regards the ontological status of the relations being pinpointed. Hawley considers it only in passing, when she says that

> [w]e can treat each [both the relation holding between identical fermions and that connecting identical bosons in the same system] as either an irreducible property of the system or else as a non-supervenient relation amongst the parts (Ib.).

But this requires much more in-depth discussion.

That quantum systems exhibit holistic features is commonly acknowledged. Entangled systems, in particular, are exemplar of the holistic claim that 'the whole is more than the sum of the parts': as shown above, there is more information encoded in them than in their (supposed) parts considered together. Some form of *property holism* (some properties of the whole are not supervenient on properties of component parts, but subsystems exist in spite of the non-separability of the corresponding *states*) might appear more plausible on an ontologically 'conservative'[18] understanding of the theory. However, a stronger form of holism such as *system* non-separability, determining that the system simply *has no component parts* (this is what is meant by 'ontological holism'), might also be true. *In both cases*, I wish to argue, the generalist cannot be sure that the system exhibits the genuine irreflexive relations required for weak discernibility.

The issue of holism is relevant for the evaluation of the results related to EPR-like correlations and the violations of Bell's inequalities. Many authors (most notably, Teller—see his (1989)) indeed claim that the observed correlations are to be explained in terms of property holism.[19] And some others, discussing the same issues, rule out ontological holism as not being

> a tenable scientific doctrine, much less an explanatory one (Dickson, 1998, p. 156).

18 With respect to the ontology of the classical world, that is.

19 More specifically, of violations of outcome dependence due to the fact that the measurement causally affects the whole by affecting the non-supervenient correlation and not the systems at the two wings separately.

However, ontological holism has also been presented as the most plausible explanation of the observed evidence. Recently, for example, Lange (2002)[20] suggested that in an entangled state

> the whole particle pair isn't anything more than the sum of its parts [… and…] the wave-function collapse occurs over both wings because there aren't separate physical objects on the left and right until after the measurement has taken place, so locality is satisfied (Ib., p. 294).

According to Lange, seeing the 'disentangling' measurement as a non-spatially continuous event transforming a whole into two of those subsystems that we call particles is the *only* way to account for the evidence in agreement with locality (see Ib., ch. 9, esp. pp. 292–297)). Could this suggestion—and similar ones—not be taken as a reason to take ontological holism seriously, so indirectly settling the issue about individuality too (since, obviously enough, if there are no component parts, *a fortiori* there are no relations making them discernible)?

Dieks and Versteegh (2008) suggest that one has to apply a 'symmetry-breaking' test in order to see whether a physical system truly has parts or not. The test amounts to breaking the symmetry of a configuration of putative objects by introducing a reference object, gauge or standard and checking whether the alleged distinct objects become distinguishable with respect to the introduced element. Indeed, Dieks and Versteegh argue, our mind's eye, or a fictional observer, sees Black's spheres as distinct; or two oppositely directed classical arrows as distinct with respect to a conventionally fixed 'up' direction. This must correspond to the physical possibility of creating asymmetries that confirm the numerical distinctness of the objects. However, the quantum case is different in that adding a gauge system to the original system without any disturbance (which is the only way to break the symmetry *physically* there) does not give rise to distinguishable objects. Dieks and Veerstegh conclude that

> [a]s far as standard quantum mechanics goes, there are no separate individual fermions and the question of whether they are weakly discernible does not even arise. Conventional wisdom, saying that systems of identical quantum particles are best considered as one whole, like an amount of money in a bank account, appears to be eminently defensible even in the face of weak discernibility (Ib., p. 934).

20 The suggestion that quantum entangled systems may exemplify ontological holism is also present in Howard (1989). There, Howard says that "maybe we can opt for radical ontological holism and still do some physics"([Ib., p. 252) and, even more strongly, that "the universe is 'really' one, but once we put a specific question to it, it falls apart quite naturally into apparent parts" (Ib., p. 253).

This conclusion is surely consistent with a broadly understood 'operationalist' approach to determining one's ontological commitments. However, one may ask why exactly should it not be possible to have a system of distinct individuals that can only enter in 'non-perturbative' physical relations with other systems such that each component of the initial system remains indistinguishable from the others. Faced with such a system, a hypothetical observer (perhaps God-like, in the sense of being able to look at the particles without interfering with them) could still experience many distinct objects (recall that indistinguishable particles are always determinately countable, and appear to each possess its own instances of basic state-independent properties such as mass and charge). In other words, even though it is correct to claim that

> it is sometimes possible and even usual to employ properties or relations *talk* in situations in which there are no different objects at all (Ib., italics mine),

contrary to Dieks and Versteegh a more careful stance appears advisable. The reason for this is that not only could Dieks and Veerstegh's criterion be considered not compelling; one could also insist that facts of countability and numerical distinctness are basic in quantum mechanics, and so ontological holism is not so natural an interpretation of the evidence.[21]

In what follows, I will therefore adopt the abovementioned more careful stance towards ontological holism, and consequently consider property holism as the 'default position'. Nevertheless, I will argue in some detail for the existence of an essential *underdetermination* as regards the metaphysical nature of the relevant properties that undermines Saunders' attempt all the same.[22]

Let us first move one step back, to Saunders' justification for his claims. Saunders' argument, as mentioned, is based on an *analogy* between entangled systems of identical particles and Black's universe. As

21 Not surprisingly, an assumption to the effect that countability is fundamental is explicitly made by Saunders in later work on the subject (see Muller and Saunders (2008, p. 530)).

22 Van Fraassen and Peschard (2008) appear to follow a similar line. On the one hand, they urge that an examination of the 'conditions of the possibility of being' be connected to an analysis of the 'conditions of the possibility of knowledge', which in practice amounts to individuating the 'experimental support' for one's metaphysical claims. On the other hand, they conclude that this neo-Kantian approach to metaphysics shows that the practical circumstances in which we can ascertain that an irreflexive relation exists are incompatible with those that lead to the identification of distinct and discernible particles, and so the metaphysics is left undecided (Ib., pp. 33–34).

Saunders puts it, Black's thought experimental scenario fails to count as a counterexample to the 'Quinean version' of PII because the fact that two individuals stand in a mutual spatial relation (that of being at a non-zero distance from) by no means entails

> that they each have a *particular* position in space (2006, p. 59, italics mine).

Consequently, a condition for weak discernibility (non-zero distance) may hold, and *in fact holds*, in spite of the fact that conditions necessary for stronger forms of discernibility (in this case, distinct space-time locations defined in non-relational terms) do not.

This shows that the possibility and relevance of weak discernibility is based upon the *non-supervenience* of an (allegedly) discerning *relation*.[23] If the overall situation exhibits a non-supervenient spatial relation that is enough to individuate two spheres in Black's universe, claims Saunders, then it must also be accepted that the total state determines a non-supervenient spin correlation that is sufficient for individuation in the quantum case.

However, while the claim of non-supervenience cannot be disputed in either case, the analogy is far from straightforward, and so the consequent of the above implication far from clearly true. A crucial ambiguity lies in the meaning that is to be attributed to the word 'particular'. In the case of spatial relations, it seems that Saunders can only be correct if by 'particular' he means 'absolute', or 'specific'; not if he means 'actual'. For, obviously two things can be at some distance from each other independently of what position each one of them occupies, and also *independently of whether or not such a position is individuated in an absolute space-time*. But, surely—at least in the classical domain—each thing must occupy *a* location *at the moment of the holding of the relation*. In Black's case, the essential fact is exactly that we can be sure that (at least in a Euclidean space-time!—see Hacking (1975)), if there exists a (non-zero) distance relation R at time t_1, then necessarily there also exist two distinct objects *at* t_1, namely, those connected by R as existing at some distance from each other at that time.

In the quantum case, however, this is not so. Despite Saunders' talk of entangled fermions *having* opposite spins, as we have seen when looking at French and Redhead's seminal paper, at most such particles can be attributed *equal probabilities* regarding their spins on the basis of their

23 If the discerning relations were supervenient on *particular* properties of the relata, the latter would be sufficient for discernibility too. But this means that monadic and/or relational properties of the relata would be different, and so one would in fact have absolute or moderate discernibility.

equal mixed states. Given orthodox quantum theory, the correlation holding among entangled fermions cannot but express what will happen to them *at a future time*, that is, *it refers to measurement outcomes only*. This means that despite the fact that we know with certainty at time t_1 that there exists an actual property within an entangled system, on the basis of such a property we can only say that *at a later time t_2*, that is, after measurement, there will be two distinct physical systems. This, though, leaves it completely open whether

a) What is a single system (without component particles) at t_1 will split into two at t_2, or
b) Two sub-systems already existing at t_1 will come into possession of such-and-such anti-correlated properties at t_2 thanks to a genuine irreflexive relation holding between them at t_1, or
c) Two subsystems already existing at t_1 will come into possession of such-and-such properties thanks to a monadic property of the whole and the way the whole is disposed to behave according to physical laws.

It is immediately obvious that, even if one rules out a), that is, ontological holism, it is by no means the case that weak discernibility can be reconstructed on the basis of the evidence. In other words, unlike in Black's case, the conclusion that the *correlation* in question is a *relation* and, as such, it holds among numerically distinct individuals, is far from obvious *in the quantum case*.

Saunders might maintain that he does not need to get into a detailed discussion of quantum states, as he is only taking QM at face value, so effectively assuming, *à la* Quine, that what is being described is a domain of individuals and what appears to be a relation is indeed a relation. However, Quine's aim was to provide a recipe for 'reconstructing' the identities of already given individuals in an identity-free language. But the generalist cannot do the same, as s/he must *entirely* reduce individuals to qualities. For him/her, that is, ontology is not given at the outset, and is in fact exactly what must be defined. Certainly, therefore, it cannot be the tensor product formalism of quantum mechanics (which *requires* that the total state be described in terms of parts) alone that tells us how the properties in question should be understood.

French and Krause argue that Saunders

> is working with a relational conception of the quantum state here and this specific irreflexive relation is simply a manifestation of the anti-symmetric state itself: since they are in such a state, the electrons must have opposite spin. Furthermore, to insist that we can only talk about two entities in such a state if they can be said to

> possess separable states—which they obviously cannot—is equivalent to insisting that only such states, corresponding to monadic properties, allow us to distinguish and hence individuate the entities. But now the question begging has been turned, since it is precisely this latter insistence that Saunders wants to move away from (2006, p. 170).

What I am suggesting here is that the legitimate claim that we should do away with the naive assumption that distinct individuals must be in separable states is not enough for believing that the 'additional information' about them present in the entangled system is contained in a relation. An explicit argument is needed if one is to claim that the anticorrelation corresponds to a genuine relation and not to a monadic property of the whole, and therefore one has distinct weakly discernible objects. It is this additional element that is missing in Saunders' argument.

The weakness of generalism as applied to QM becomes, it seems to me, even clearer when considered in connection with an additional, and final, difficulty that will be presented in the next section. This difficulty extends beyond Saunders' specific version of generalism, and must be dealt with by all those who, independently of whether or not they have recourse to weak discernibility, try to stick to PII as a valid criterion of individuation and to generalism *at the cost of radical ontological re-description*.

4. Bosons and the denial of objecthood

Having argued that fermions are genuine individuals, Saunders considers bosons. Indistinguishable bosons, as mentioned earlier, cannot be individuated via weak discernibility, because they *can* be irreflexively correlated in the same way as fermions but, since EP does not hold for them, such discernibility is not warranted in all cases.[24] In the light of this, Saunders concludes that:

> The only cases in which the status of quantum particles as objects is seriously in question are therefore elementary bosons [...; with respect to these, w]e went wrong in thinking the excitation numbers of the mode, because differing by integers, represented a count of things; the real things are the modes (2006, p. 60).

Saunders' use of the concept of 'mode' indicates that he has in mind the quantum-field-theoretic description of reality. But the latter is in effect

24 Sticking to the spin example, two identical bosons can be found in states that attribute either spin up or spin down to both of them.

informed by ontological holism, which immediately gives rise to a problem.[25]

For, if Saunders truly claims that, since they are not made discernible by PII, the natural interpretation of bosons is the field-theoretic one according to which they are just epiphenomenal manifestations of the bosonic field as a whole, then we have the following situation: according to Saunders, fermions are individuated by PII *provided* that ontological holism is excluded; and bosons are instead interpreted according to ontological holism *because* they violate PII. It seems clear, though, that with this Saunders applies a sort of 'double standard', and circularity subsequently arises as regards PII and the ontological interpretation of the relevant physical systems.

This goes to support the claim that the generalist is faced with an ontological underdetermination in the quantum domain that s/he cannot break by only having recourse to the tools at his/her disposal. Either s/he first independently settles the question regarding the plausibility of ontological holism, or s/he must acknowledge that spin correlations cannot be employed for individuation and, consequently, fermions and bosons cannot be treated differently (and must both be regarded as non-objects from his/her perspective).[26]

Is there a way for the generalist to avoid these difficulties?

One could interpret Saunders as claiming that bosons are non-individuals, intended as entities which are numerically distinct but only cardinally countable. This would allow him to avoid a holistic understanding of bosonic systems, as bosons would not 'dissolve' into unitary fields, but rather constitute 'aggregates' of countable non-individual entities. On the other hand, fermions could be regarded[27] as distinct objects that also prove to be individuals (in virtue of EP and the irreflexive relations holding among them).

In this case, though, it is obvious that an apt definition of non-individuality must be provided. For, the intuition that gave rise to the literature being considered here (see Cortes (1976)) is that if one starts from the Leibnizian idea that no two substances differ *solo numero*, and uses it to *define*, *à la* Quine, individuality as the relational property of

25 In particular, although it is possible to interpret quantum field theory as a theory about individual particles, the usual interpretation is that particles are mere 'epiphenomena' with respect to underlying unitary fields.

26 It is only at this point, it seems to me, that it is possible to make sense of Hawley's vague remarks about the lack of relevant differences from the generalist perspective between fermions and bosons.

27 Of course, provided that an answer to the objections raised in the previous section is given.

discernibility from all other entities, then quantum mechanics provides a straightforward refutation of the Leibniz-Quine position. And if the generalist claims that PII is only violated by non-individuals and then translates this into the claim that PII is only violated by indiscernibles, this hardly represents a valid answer to Cortes!

A truly informative difference between individuals and non-individuals inside the broader class of particulars (i. e., objects), however, can only be meaningfully established with respect to identity conditions. And it can easily be seen that *there is no way to do this within the generalist perspective.* To see this, consider the following options.

In their discussion of quantum vagueness[28], French and Krause (1995) put forward the idea that the peculiarities of quantum particles could be due to the fact that the concept of identity simply does not apply to them. In particular, that for these entities it is not true that each one of them is identical to itself. Logics in which the expression $x=y$ is not a well-formed formula have indeed been developed in support of such scenarios. The most fully worked out examples are the formalisms based on the notion of a 'quasi-set', introduced, for instance, in Krause (1992) and in Da Costa and Krause (1997). The basic idea is to posit as basic *Urelemente* so called *m*-atoms that are completely indiscernible and can be counted only cardinally. For such elements, French and Krause explain,

> identity, as it is usually understood, lacks sense; in other words, these entities are linked only by a weaker relation (≡) [indistinguishability], which mirrors an equivalence relation, but the language does not allow us to talk about either the identity or the diversity of the m-atoms (1995, p. 23).[29]

However, recall that the supporter of the generalist account of identity and individuality *defines* identity on the basis of the conjunction of the formulas satisfied in the (first-order and finite) language. That is, s/he assumes that identity and uniqueness of description are *the same thing* and one has a true *bi-conditional* of the form identity ↔ indiscernibility). This entails that, from the Quinean-Leibnizian perspective, a thing's identity conditions are fixed as soon as it is determined which properties the thing possesses. But the latter *are indeed determined for all quantum*

28 Essentially aiming to expand on Lowe's (1994) reply to Evans' famous paper against the idea of vague objects (1978).

29 Moving along similar lines, Dalla Chiara and Toraldo di Francia (1993), point out that quantum particles cannot be uniquely labelled and propose to regard them as 'intensional-like entities', where the intensions—much in the spirit of Quine's conception of identity—are represented by conjunctions of intrinsic properties. On this construal, the extensions of the relevant natural kinds are collections of indistinguishable elements, called 'quasets'.

particles. Therefore, it cannot be suggested from the generalist perspective that quantum particles are non-individuals intended as entities to which the notion of identity does not apply.

One might try to resist this conclusion by claiming that non-individuals have *indeterminate* self-identity. Translating again in Quinean terms, this would mean that it can be indeterminate whether an entity satisfies the same predicative formulas as itself. It might be argued that this is possible, because properties can be 'indeterminately exemplified' by things. In the cases in which this happens, the argument might continue, one has entities that satisfy conjunctions of predicative formulas indeterminately, and so possess indeterminate self-identity. However, even allowing for the possibility that properties (and conjunctions thereof) can be vaguely (i. e., not determinately) possessed by particulars, and that this is what happens in QM, on a closer look this suggestion turns out to be untenable as well, because based on a fallacy. The indeterminacy of property-exemplification only causes the conjunctions of properties to be indeterminately exemplified; it does not entail that it is indeterminate whether a given individual has the same properties as itself.[30] Hence, the notion of non-individual object cannot be employed to defend Saunders' proposal.

Generalizing, is also clear that those generalists who do not employ the notion of weak discernibility cannot account for many-particle system of indistinguishable quantum particles either. Because even though they avoid making problematic assumptions with respect to the properties of entangled systems, for them too it is the case that the principle they employ for determining what distinct objects exist cannot be made consistent with the available evidence, and yet the required ontological re-description does not mesh well with the basic principles and assumptions of both generalism and quantum theory.

It is important to point out that some authors (for instance, French (2006)) *assume* that the distinction between individuals and non-individuals is meaningful, and *then* claim that the issue of whether PII holds is simply obviated for non-individuals (and this is a valid explanation of the violations of PII by quantum particles). Although one may think that more needs to be said by way of justification of the

30 It is worth pointing out that a) the above reasoning applies even if no property whatsoever is attributed to an entity (for in that case the identity of that entity is defined by an empty conjunction of qualitative formulas); and b) even if it is accepted that quantum mechanics does not attribute properties determinately (which, I suggested, is at any rate insufficient to argue for lack of identity), state-independent properties are nonetheless possessed by particles determinately.

assumption being made, this position is in itself consistent. From a Quinean-Leibnizian perspective, however, PII is to be regarded as a principle of general applicability, for it directly follows from the basic definition of identity. Therefore, whenever it applies, but is violated, as in the case of bosons, an explanation must be provided. Such an explanation, I argued, is not available to the generalist.

5. Empiricism, acquaintance and primitive identity

Even if one concedes that the concept of weak discernibility sheds new light on the actual strength of Black's traditional (alleged) counterexample to PII, therefore, Saunders' application of Quine's ideas to quantum particles is not successful. On the one hand, the ontological underdetermination concerning quantum correlations, only hinted at by Hawley, can be defined in detail and shown to undermine Saunders' analogy between quantum entangled systems and Black's universe. On the other, the underdetermination can be considered relevant 'as it is', without the need to put into practice additional strategies such as, for instance, Dieks and Veerstegh's symmetry breaking.

The question arises at this point concerning why exactly the Quinean-Leibnizian generalist perspective should be, and in fact often is, seen as more natural and intuitively appealing than the competing view based upon identity and individuality as primitives. And why, consequently, in the light of the conflict between PII and the evidence, a 'peaceful coexistence' should be sought by sacrificing the idea that our physical theories describe objects rather than PII itself, which has not been justified on grounds other than the fact that it worked so far and is not violated by classical entities.

In the introduction, I suggested that the most plausible philosophical justification for this approach can be given in empiricist terms, on the basis of a modern version of Russell's Principle of Acquaintance, supported by a bundle-theoretic ontological view. I now want to contend that such a justification is insufficient for radically revising our ontology in light of quantum physics.

First, it is arguable whether only qualities are known by acquaintance. Allaire (1963), for example, suggests that property-less particulars are also known by acquaintance as the source of the numerical distinctness of things. He claims that

> [w]hen presented together [two qualitatively identical objects…] are presented as numerically different [and *t]hat difference* is presented as is their sameness with respect to shape, (shade of) color, and so on. [And thus…] something other than a

> character must also be presented. That something is what proponents of the realistic analysis call a bare particular (p. 4).

Allaire concludes that

> [bare] individuals are the carriers of numerical difference as directly presented to us (p. 8).

Clearly, science could equally be taken to deal with numerical identities directly: just consider the role of particle 'labels' in quantum theory. True, it might be objected (Chappell (1964)) that Allaire's reasoning is not entirely based on phenomenological description, and should consequently be rejected if one is to uphold the plausible empiricist criterion of acquaintance. This may appear correct. However, at the same time, such a reply points to a key distinction that ultimately undermines the generalist interpretation of Russell's ideas.

Suppose one perceives ('is presented with') a green spot. Surely, because of this, s/he can say that s/he is acquainted with a green object. However, the experience in itself does not allow him/her to say *anything* about the ontological categories that underlie such an experience. For instance, it does not allow one to conclude—as Allaire does—that a bare particular exists as what exemplifies 'green-ness' there and then. To claim this would be to *add* something to what we know from direct experience: namely, that a bare individuator exists. But, *equally*, nothing can be said on the basis of experience alone about the 'greenness' of the object: whether 'green' is a universal, and our observer consequently experiences a property-instance which is numerically identical to all other instances which it exactly resembles to; or the perceived green is an unrepeatable particular, remains entirely open. But, crucially, as pointed out in the introduction, *only the former alternative can ground PII ontologically as a criterion of individuation:* it is a well-known fact in the metaphysics literature that PII is true only in the context of the bundle theory[31], while it is false in other ontologies, most notably in a trope-theoretic one *exclusively* based on properties, but in which every property is a particular.

Upon analysis, therefore, we discovered two unwarranted assumptions underpinning the generalist picture: that only qualities are known directly, and that qualities are instances of universals. And even accepting the former, the latter appears particularly problematic. It could be objected, along with the early Russell, that whenever we are acquainted with a property of something we are *ipso facto* acquainted with a universal, and

31 Although there are arguments—see Rodriguez-Pereyra (2004)—to the effect that it is not even necessarily true within the bundle theory.

nothing else is ever known by acquaintance; and that, consequently, there are grounds to exclude alternatives to the bundle theory on the basis of experience. But it is to say the least unclear why this should be the case. And, more particularly, why this should be accepted once an analogous claim has been rejected for bare particulars as the (directly perceived) cause of our experiences regarding number. It seems to me much more sensible to acknowledge that, in general, an ontological view can only be arrived at by *analysis*; and that, while what is being experienced directly can (perhaps) be straightforwardly be identified, what sort of ontological categories underlie our experience is not obvious and does not immediately follow from perception in any case (as, after all, should be inferred from the general lack of agreement in this respect). A crucial differentiation, that is, must be drawn between empirical and metaphysical facts; between one's *object of acquaintance* and *what exists* at the ontological level.

In other words, it seems to me correct to claim, along with Clatterbaugh (1965) and Hochberg (1966), that the *Principle of Acquaintance cannot be employed to establish any ontological view.* Of course, it does so indirectly, as an ontological explanation must not contradict the evidence obtained via perceptual experience and best science. However, an ontological account can never be shown to be true or false by *only* making reference to experience (and science), and instead requires conceptual analysis.

Recalling Hawley's comments to Saunders' view, one could suggest that the motivation behind generalism has to do with economy and simplicity; that is, with the idea that when formulating our claims about identity and individuality we should commit ourselves to the minimum number of entities required to explain the available evidence. In a 'naturalist' spirit, that is, the generalist might reject indiscernibles because they are not empirically relevant and give rise to (so-called 'haecceitistic') purely numerical differences between worlds that are scientifically meaningless. However, 1) it is clear that indiscernibles make an empirical difference within a world (as a system of many indistinguishable particles can simply not be redescribed as a system with only one particle with the same property instances as each one of the allegedly distinct particles); and 2) a connection between primitive identities in a world and haecceitism (which is based on primitive *trans-world* identities) can be consistently denied (for example, by endorsing counterpart theory).

If the foregoing is correct, then the claim must be accepted that the generalist offers just one among several available ontological explanations of the facts we experience: one that can only be formulated on the basis of a specific metaphysical hypothesis as regards the nature of properties and the constitution of complex material particulars, and *is far from obviously preferable from an empiricist perspective.* Of course, Saunders can claim that he is only articulating a possible perspective, alternative to the views that posit individuality as a primitive, without ever denying that it is possible to take other facts, rather than qualitative ones, as fundamental. This granted, it is important to emphasise that the generalist picture, although it may perhaps be consistent in itself as an ontological framework, is not obviously rooted in the nature of our experience as many think it is. As a consequence, it does not have the advantage of being more plausible than the alternatives from the empiricist point of view aiming to provide a solid epistemological basis to our metaphysics. And of course its very consistency appears in danger given the analysis of its application to quantum mechanics provided in this paper.[32]

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32 It is barely worth pointing out that what has been said in this section by no means amounts to a rejection of the basic tenets of empiricism. It appears indeed sensible to require metaphysical hypotheses (once they are accepted as meaningful) to stem from, and agree with, the available evidence.

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