On recognizing an object with a partition

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Abstract

Smith and Brogaard ('A unified theory of truth and reference' *Logique et Analyse* 43 (2000) 49-93) proposed a resolution of the problem of referential ambiguity based on the use of mereotopological partitions. It is shown that this proposed resolution is circular if viewed ontologically and intractable if viewed epistemologically.

Keywords: Boundaries, Consistent Histories, Mereotopology, Ontology, Referential ambiguity, Truthmakers

1 Introduction

Quine (1960, 1969) can be interpreted as holding that nothing connects a word to an object beyond the speaker's assumption - shared one hopes by at least some listeners - that the word can be understood to refer to that object. Smith and Brogaard (2000) propose to do better than this, even in the presence of referential vagueness, by appealing to the mereotopological notion of a *partition* that "recognizes" not just a particular singular object John but "*all* of the aggregates f_i that are almost identical to John" (p. 79; emphasis in original). This sense of recognition is formalized in terms of the "location" of an object x within a partition A:

$$x \in A =_{def} \exists z(L_A(x, z)), \tag{1}$$

where $x \in A$ indicates "x is recognized by A" and $L_A(x, z)$ indicates "x is located in cell z of A." Smith and Brogaard consider objects to be *bona fide* real, objective entities[1] that exist "independently of any acts of human fiat and independently of our efforts to understand (them) theoretically" while partitions and the cells that they comprise are "artefact(s) of our judging, classifying, theorizing, or mapping activity" (p. 74); they claim, however, that "once a given partition exists, it is ... an objective matter whether or not that object is located in that cell" (p. 76). Recognition of an object by a partition, therefore, resolves the "mystery of reference" *objectively* for Smith and Brogaard.

I show here that any objective reading of the notion of recognizing an object with a partition is either circular or intractable. Briefly, the notion is circular if viewed ontologically, as the definition (1) of recognition implicitly assumes that the stipulated "fiat" partition A corresponds exactly to the objective mereotopology of the "aggregates" f_i that are to be recognized; A therefore accomplishes nothing not already done by the assumed objective mereotopology. The notion is intractable if viewed epistemologically, as the finite but arbitrary number of the f_i render it impossible to determine using finite means whether (1) is satisfied for a given object and a given partition. The idea of a "consistent history" of partitions that Smith and Brogaard (2002) develop to account for the possibility of consistently referring to an object that endures through time depends on the notion of recognition and is, therefore, also either circular or intractable. As Smith and Brogaard adapt this idea of a consistent history from its application to the interpretation of quantum mechanics[2], I comment briefly on an explicitly quantum-mechanical formulation of recognition with a partition, and show that this formulation, like that of Smith and Brogaard, in fact provides no advance over the Quinean position that shared terms must simply be assumed to refer to their target objects.

2 Partitions as truthmakers

Smith and Brogaard introduce partitions into natural-language semantics in order to cope with the well-known problem of referential vagueness: a term such as "Mont Blanc" can refer to many different circumscriptions of the world, some of which contain the rabbits living on the slopes of the famous mountain, while others do not. Uses of the term "Mont Blanc" all, however, occur in particular contexts that render relevant different aspects

[1]Smith and Brogaard (2000) give Quine his due by allowing that reality may be "intrinsically undifferentiated as far as metaphysical distinctions and categories are concerned" (p. 87). However, they appeal to "bona fide boundaries and relations in reality" (p. 90) and use terms like "Mont Blanc" and "rabbits" throughout with the assumption that such things have real boundaries that objectively differentiate them from the other furniture of the universe. Smith and Brogaard (2002) and Grenon and Smith (2008) include explicit statements of the common-sense realism about ordinary objects that is implicit throughout Smith and Brogaard (2000).

[2]Smith and Brogaard (2000) cite the "Consistent Histories" interpretation of Omnès (1994) as an inspiration for their notion of an object's "location" within a cell; Smith and Brogaard (2002) provide a more explicit review of the origin of their idea of a "history" in the quantum mechanics literature. See Griffiths (2011) for a recent exposition of this approach within quantum theory.

of these various circumscriptions; the resident rabbits are irrelevant when Mont Blanc is pointed out from afar, but are relevant if its ecology is being discussed. Whether the rabbits are relevant depends on the *granularity* of the context: its demand for details, and its concommittant provision of the opportunities and technologies needed to observe the demanded details[3]. Partitions control granularity by enforcing a finite limit on the size or scope of each cell; only the objects that are *recognized* as being in a cell z of a partition A by the relevant location function L_A need be considered when evaluating the truth of sentences referring to the object(s) in z. A partition that only recognizes mountain-sized things, for example, will recognize Mont Blanc, but will not recognize the rabbits whether they are resident on the mountain or not. Associating a partition with a context of discourse blocks mereotopological regresses and hence blocks inferences such as:

> John sees Mont Blanc.
>
> Mont Blanc includes numerous rabbits.
>
> ∴ John sees numerous rabbits.

Hence while *reality*, even from the perspective defined by a given context, does not make all intuitively true sentences true and false sentences false, reality plus a contextually-appropriate partition does. By limiting the scope of discourse in any given context, partitions become truthmaking overlays on reality.

Thrusting partitions into the role of truthmakers clearly raises two questions. The first is ontological: even if we acknowledge that they are fiat entities created for the purpose by us, do the "right" partitions to do the job of truthmaking exist? The second question is epistemological: is it possible, in a given context, to know that a given partition will do the needed truthmaking job? Smith and Brogaard allow that in some cases the right partitions to support truthmaking have not been and perhaps cannot be constructed; they note, for example, that as no partition of the waters of Lake Constance between the neighboring countries of Germany, Austria and Switzerland has been officially specified, legal claims about the ownership of particular, bounded volumes of Lake Constance water have no truthmaker. The explanatory project undertaken by Smith and Brogaard is, however, based on the assumption that in many if not most contexts, an appropriate partition can be either found or stipulated to serve as a truthmaker, as an appropriate international agreement would in fact serve in the case of ownership claims about the waters of Lake Constance. If it is "an objective matter" whether such a proferred partition provides a truthmaker in its intended context, then this is an assumption that *fiat* can, at least in many if not most contexts, be matched with *physics*, that is, with the actual mereotopology of the real world. For Smith and Brogaard, this matching of fiat to physics is the goal of science: "Elite things and classes are in our terms the things and classes captured by those

[3]Smith and Brogaard (2000) introduce granularity as a spatial concept; however, they employ it as a general term for distinguishing larger from smaller scopings of relevant facts independently of the dimensions along which "scope" is defined.

partitions which track bona fide boundaries and relations in reality. It is the job of science to move us in the direction of partitions of this sort" (2000, p. 90). The "bona fide boundaries and relations in reality" can be taken to define the actual mereotopology of the real world, a mereotopology yet to be discovered, but perhaps at least approximated by current science. The "elite things" are in this case also yet to be discovered, but are perhaps approximated by microscopic entities such as molecules, atoms or elementary particles.

Addressing the ontological question requires returning to the problem that partitions are meant to resolve, the problem of ambiguous reference. In the actual mereology of the real world, the macroscopic objects of ordinary experience are complex entities comprising vast numbers of parts: hunks of ice and rock in the case of Mont Blanc, living cells in the case of the rabbits, and assuming that current science *does* provide an approximate accounting of the "elite things," molecules, atoms and elementary particles in the case of all material objects. Taking the boundaries of such macroscopic objects of ordinary experience into account extends this actual mereology of parts to an actual mereotopology[4]. Under ordinary circumstances, reference is ambiguous because a precise accounting of parts - especially microscopic parts - and boundaries is neither demanded nor made; context shifts are significant because they can introduce both requirements to account for parts and boundaries and technologies that enable doing so. To employ an example of Smith and Brogaard's, whether a water glass is empty has a different answer for a pathologist with a microscope than it has for someone who has just drained it of water. A typical, macroscopic enduring object of reference x, then, is not a simple, but is rather a bounded aggregate of parts at various scales, currently definable, at least in principle, down to the scale of atoms or even Standard Model elementary particles.

Smith and Brogaard trace the ambiguity of reference to the fact that a typical, macroscopic enduring object of reference x is not identical at all times to a single, specific aggregate of parts f_k, but is rather identical, if quantum-mechanical effects are ignored, to different aggregates $f_1, f_2, ..., f_n$ from moment to moment as ice forms and evaporates, cells are born and die, and atoms drift off and are re-captured. These various aggregates f_i are all mutually "almost identical" and all equally referenceable by the term 'x'; 'John' refers to John, for example, regardless of the details of John's physical composition at the molecular scale, details which change with every breath. Collecting the aggregates that are almost identical to x into some single cell z of a partition A allows 'x' to refer to *whatever* is recognized as contained within z; the small differences between the aggregates are sequestered in z and can safely be ignored. If the partition A is to recognize x as a well-defined and enduring object of reference, it clearly must recognize within the same cell z *all* of the aggregates f_i that are from time to time almost identical to x as Smith and Brogaard require; the collection $\{f_i\}$ must, as Grenon and Smith (2008) require explicitly, be an equivalence class for $L_A(x, z)$.

Capturing all of the almost identical aggregates f_i in a single cell z is, however, insufficient to assure the fidelity of reference. As noted above, the partitions of interest are stipulated

[4]Ontologies can be constructed in which such part-hood relations and boundaries are discounted; that of Cartwright (1999) is a case in point.

by fiat, but whether a given object is a contained within a given cell is not a matter of stipulation, but rather an objective matter of fact. A cell z large enough to contain all of the aggregates f_i that are almost identical to x may, as an objective matter of fact, also contain some aggregate g that is *not* almost identical to x. For example, a cell large enough to contain all the aggregates almost identical to Mont Blanc may also contain some aggregates almost identical to rabbits. In such a case, if A is to serve as a referentially-transparent truthmaker for judgments regarding x, the recognition relation L_A must be such that $L_A(x, z)$ but $\neg L_A(g, z)$, i.e. it must be the case that A recognizes x as being in z but does not recognize g as being in z. If A is to serve as a truthmaker, in other words, the definition (1) of recognition leaves unstated an important restriction on L_A. Explicitly ruling out the recognition of unwanted g's requires the stronger definition:

$$x \in A =_{def} \exists z(L_A(x, z) \wedge \forall y \nsim x, (y \notin A \vee \neg L_A(y, z))), \tag{2}$$

where '$y \nsim x$' indicates that y is not "almost identical to" x in the sense employed by Smith and Brogaard. Unlike (1), this stronger definition forces whatever is recognized by the partition A as being in the cell z to actually be (almost) identical to x; hence 'x' can safely be taken to refer to *whatever* is recognized as being in z. Hence if the resident rabbits are not as an objective matter of fact given the "bona fide boundaries and relations in reality" - as indeed Smith and Brogaard claim they are not - part of Mont Blanc, any partition that recognizes the rabbits must put them in a different cell from Mont Blanc.

It is this requirement that completeness be combined with exclusivity that renders problematic the notion that a fiat partition can be an objectively correct truthmaker. Consider, for example, a partition z that contains all the aggregates almost identical to John, but also contains a proper subaggregate g almost identical to John's right thumb. The intuition that 'John' refers to John but not to John's right thumb can be preserved by defining $L_A(x, z)$ as non-distributative over g, i.e. as such that:

$$(L_A(x, z) \wedge g < x) \Longrightarrow \neg L_A(g, z), \tag{3}$$

where '$<$' indicates proper mereological containment (cf. Smith and Brogaard (2000) p. 78-79). It is tempting to generalize (3) to rule out recognition of *all* proper subaggregates, i.e. to require:

$$\forall y(L_A(x, z) \wedge y < x) \Longrightarrow \neg L_A(y, z). \tag{4}$$

It is clear, however, that (4) is too strong. John without a hair is still John; indeed John without his right thumb is still John[5]. Similarly, Mont Blanc without a particular block of ice is still Mont Blanc. These are, moreover, for Smith and Brogaard *matters of fact* about the "bona fide boundaries and relations in reality," i.e. about the actual mereotopology of the real world. Hence the application of (4) must be limited to proper subaggregates y that

[5] These claims about identity over time for persons are taken to be non-controversial; see Scholl (2007) or Nichols and Bruno (2010) for recent discussions.

are not *as a matter of fact* almost identical to x and hence themselves members of the set $\{f_i\}$ of aggregates that the cell z is designed to isolate.

One can now ask, what partitions A *guarantee* that (2) holds for all $y \nsim x$, given that (4) cannot be applied to rule out proper subaggregates across the board? One partition clearly satisfies this requirement: the "natural" partition N that exactly captures the "bona fide boundaries and relations in reality" and hence corresponds exactly to the actual mereotopology of the real world. The natural partition "carves nature at its joints" at every level of granularity; if $g \notin \{f_i\}$ and hence is not almost identical to x as a matter of fact, N either puts g in a different cell than x, or does not recognize g at all. The natural partition is, moreover, the only partition with this property; if some partition A satisfies (2) at some fixed level of granularity for every object x and for every aggregate g that is never as a matter of fact almost identical to that x, then $A = N$ at the chosen level of granularity.

A fiat partition $A \neq N$ can be arbitrarily close to N but still fail as a truthmaker due to referential ambiguity. Suppose, for example, that $A \neq N$ is a partition that successfully locates in a cell z all members of the set $\{f_i\}$ of aggregates that are as a matter of fact almost identical to Mont Blanc, but that A also locates in z an aggregate $g \notin \{f_i\}$ such that $g = f_k \oplus \zeta$, where $f_k \in \{f_i\}$ and ζ is a nearby cubic centimeter of air. Provided that it is a *matter of fact* that the set $\{f_i\}$ contains *all* of the aggregates that are almost identical to Mont Blanc - provided, in other words, that there really are "bona fide boundaries and relations in reality" and hence that the natural partition N exists - such a g must also exist. To claim otherwise is to claim that all elements f_k within $\{f_i\}$ are such that no ζ can be found for which the mereological sum $g = f_k \oplus \zeta$ can be constructed; Mont Blanc is large, but surely it is not mereologically maximal in this way. Because the chosen ζ is small, the constructed g exists at the same level of granularity as any of the f_i, and because $L_A(g, z)$, $g \in A$ by definition; hence (2) fails for A. The partition A *looks like* a truthmaker for sentences such as "that over there is Mont Blanc" - who cares about an extra cubic centimeter of air - but it is not: at least one of the objects, g that it recognizes as being within z and hence allows as a referent of 'that' is as a matter of fact never almost identical to Mont Blanc. Any number of entities such as g can be constructed; hence the partition A fails due to potentially arbitrary referential ambiguity.

The object g in the above example is clearly an artificial construction, but it serves to illustrate the fundamental problem with (2) as a criterion. The point of introducing fiat partitions is to resolve problems with referential ambiguity independently of N; scientific investigation of the world is not complete, so N is as a matter of fact unknown. The requirement that the second clause of (2) holds "$\forall y \nsim x$," however, introduces an implicit dependence on N; as the example shows, whether some proferred y is ever almost identical to some given x is a question about what parts are included *as a matter of fact* in what aggregates, and such questions can only be answered by appeal to N. This implicit dependence on N turns (2) into a circularity: the fiat partition A does no work in (2) that is not already accomplished by N. The natural partition is, however, *not* established by fiat; it is established by the laws of nature. Once appeal is made to (2) to specify what each cell of a truthmaking partition must recognize, the entire apparatus of fiat partitions as truthmakers is rendered redundant. If N is available, then reality itself is the truthmaker. If N is not available - as it presently is not - then except in cases such as the ownership of Lake Constance where there is no natural fact of the matter, the potential for referential ambiguity is unavoidable.

The above argument turns, clearly, on Smith and Brogaard's insistence that whether two things are "almost identical" is a matter of objective fact. By capturing the "bona fide boundaries and relations in reality," the assumed natural partition N captures such matters of objective fact. What has been shown here is that if this notion of "almost identity" is objective, it cannot be captured by a fiat partition A unless A is, again as a matter of objective fact, identical to N. Unless by lucky chance $A = N$, two things may *seem* "almost identical" to us, using A, without them *being* "almost identical" in fact, i.e. according to N. There is, moreover, no way for us to determine whether what seems "almost identical" actually is "almost identical"; we have no way to *demonstrate* that $A = N$. This is shown in the next section.

3 Identifying a truthmaking partition

Let us set aside the question of whether N exists - Smith and Brogaard clearly assume that it does - and suppose that some partition A has been put forward as a truthmaker for judgments about x in some context. Is it possible to determine whether A is in fact a truthmaker for such judgments in that context, i.e. is it possible to determine the "objective matter (of) whether or not that object is located in that cell" of A? From the reasoning above, this is clearly the question of whether it is possible to determine whether some cell z of A contains all of the f_i corresponding to the object of reference x and contains no non-x's that are recognized by A.

If one thinks of A as a "theory" of x, then the question above becomes the question of empirical theory confirmation, a question with a well-known negative answer. This can be made precise as follows. Consider a finite sequence of non-destructive observations of x made at times t_i, for simplicity keeping the context and means of observation fixed. Neglecting quantum-mechanical effects as above, x can be considered to be identical to some f_k at t_k, in which case x can be considered to be a classical finite state machine that executes state transitions $...f_i \rightarrow f_j \rightarrow f_k...$ in the intervals between the observation times $...t_i, t_j, t_k..$[6]. Theorem 2 of Moore (1956) shows that no finite sequence of observations of a classical finite state machine suffices to establish the identity of the machine, i.e. no finite sequence of observations suffices to fully specify the complete "machine table" of possible states and state transitions that defines the possible behaviors of the machine. Moore's proof of this theorem is disarmingly simple: for any machine table derived from a finite sequence of observations of x, Moore produces a larger machine table that includes all of the observed states and transitions, but also includes states and hence transitions that could

[6]For definitions and examples see Ashby (1956) or Hopcroft and Ullman (1979). Ashby (1956) proves a result essentially identical to Moore's. Fields (2013a) extends this result to the quantum-mechanical case.

be, but so far have not been observed. Moore's theorem thus demonstrates that no finite sequence of non-destructive observations is sufficient to put an upper limit on the potential behavioral complexity of a physical device, a result with which software debuggers and reverse engineers are all too familiar.

In the case of ordinary, macroscopic objects of reference, "state transitions" are just the inevitable transitions in identity from one aggregate of microscopic parts to another. Moore's theorem shows that no finite sequence of observations of x is sufficient to determine the number of distinct aggregates f_i to which x may be from time to time identical; hence no finite sequence of observations of x is sufficient to determine whether any specified cell z of a partition A captures the entire set $\{f_i\}$ of almost identical aggregates to which x may be from time to time identical. Clearly it is similarly impossible to establish with a finite sequence of observations that a given cell z captures nothing but the f_i. Partitions are in this sense like theories: their sufficiency as truthmakers cannot be demonstrated empirically.

4 Consistent histories

Intuitively, the sequence of particular aggregates f_i to which an object of reference x can be regarded as identical at a sequence of observation times t_i corresponds to a "history" of x at the granularity of the t_i. Smith and Brogaard (2002) formalize this intuition using changes in spatial location as a metaphor for changes in observation context or in the values returned by some ancillary measurement carried out on x at each of the t_i. They consider a partition A with cells corresponding to locations (in their motivating example, airports), observation contexts or measurement outcomes, and define a *history* of x as a sequence of cells of A indexed by time, and hence a sequence of propositions $L_i(x, z_i)$ where the index i ranges over observation times (Smith and Brogaard (2002); p. 4). As x is, as an objective matter of fact described by N, identical to some aggregate f_i at every t_i, this definition adds to the intuition above only the extra "dimensions" of location, context, or measurement outcome. A history is *consistent* if its component sentences $L_i(x, z_i)$ are all mutually consistent. Consistency obtains on this model, clearly, whenever x avoids occupying two distinct cells at the same time.

Smith and Brogaard introduce consistent histories in order to provide an "extension of the mereotopological ontology to deal with change and becoming" (Smith and Brogaard (2002) p. 8) that treats macroscopic objects as enduring aggregate entities and maintains the intuitive, qualitative distinction between space and time. While their account of partitions as truthmakers does not explicitly rely on this notion of historical consistency, by treating objects such as Mont Blanc or its rabbits and actions such as John kissing Mary in a straightforward, ordinary-language way it does so implicitly. The notion of a consistent history depends, conversely, on the ability of partitions to function as truthmakers, i.e. on the ability of '$L_i(x, z_i)$' to fully and unambiguously capture x within z_i at t_i. By basing both on the ability to recognize an object with a partition, Smith and Brogaard render a straightforward ontology of enduring bounded objects and a straightforward semantics of true sentences referring to such objects co-dependent.

The ontological and epistemological arguments rehearsed above apply, *mutatis mutandis*, to the concept of a consistent history. The ontological argument shows that this concept is circular: the only history that assures consistency is a history generated by extending N to encompass not only all objects but all locations, contexts and measurements within an assumed actual mereotopology of the real world. Only this history assures that x, in its many manifestations as particular aggregates, never occupies two locations simultaneously, and only this history assures that distinct objects x and y never occupy the same location. If this N-based history is assumed, however, the construction of further histories is pointless; any fiat history based on a fiat partition A does only some of the work of the N-based history, and does it only as a mereotopological approximation. Such approximations are clearly valuable as practical science, but they cut no ice as *ontology*. The epistemological argument simply reinforces this point, by showing that the consistency of a proferred fiat history based on a fiat partition A can never be empirically demonstrated.

5 A note on quantum-mechanical partitions

The foregoing has explicitly neglected quantum-mechanical effects; the assumption that an observed system x can be regarded as identical at t_i to a *particular* aggregate f_i of elementary parts is, in particular, inconsistent with the superposition principle of quantum mechanics, which requires that any linear combination of states of x is itself a state x[7]. Smith and Brogaard (2002) borrow the formal notion of a consistent history from quantum mechanics; they title their paper 'Quantum mereotopology'. The point of consistent histories within quantum mechanics is to provide an "interpretation" of the formalism that solves the problem of the "emergence" of a classical world of well-defined objects that can be observed in well-defined states[8]. Might a purely quantum-mechanical process provide the underlying ontological basis for N, and hence for a theoretical solution to the problems outlined above?

In quantum mechanics, a consistent history is a sequence of mutually-commuting measurements to which a well-defined probability can be assigned[9]. Measurements are operators defined on the Hilbert space of a quantum system; traditionally measurements were taken to correspond to orthonormal sets of projection operators, one associated with each distinct possible outcome, while more recently the orthogonality requirement has been dropped and

[7] The superposition principle motivates the choice of vectors in Hilbert space as the mathematical representation of physical states and is typically considered as axiomatic in quantum mechanics. See http://en.wikipedia.org/wiki/Quantum_mechanics or for a briefer, more axiomatic introduction http://plato.stanford.edu/entries/qm/.

[8] The traditional "measurement problem" is a special case of the general problem of the emergence of classicality in a fundamentally quantum world. Schlosshauer (2007) provides a textbook-length introduction; Landsman (2007) or Wallace (2008) are good general reviews.

[9] See Griffiths (2002) Ch. 10, Griffiths (2011) or relevant references in Smith and Brogaard (2002).

any positive operator-valued measure (POVM), i.e. any normalized set of positive semi-definite operators on the Hilbert space, where again each operator is associated with an outcome, is regarded as a measurement[10]. A consistent history of a system x as it evolves through time can, then, be thought of as a sequence of outcomes, each associated with some time t_i, of operations with components of some POVM on the Hilbert space of x. Defining such a sequence clearly requires specifying the Hilbert space of x, i.e. it requires specifying a partition that distinguishes the degrees of freedom of x from the degrees of freedom of the rest of the universe. A consistent history in quantum mechanics thus requires a quantum-mechanical partition of (universal) Hilbert space, just as a classical consistent history requires N.

Quantum mechanical systems can be isolated, and hence partitioned from the rest of the universe, "for all practical purposes" in the laboratory. *Ontologically* isolating a quantum system, however, involves violating the superposition principle as applied to the quantum state of the universe as a whole[11]. Griffiths (2011) avoids this problem by building Hilbert-space partitions into the mutually-incompatible "frameworks" within which consistent quantum-mechanical statements can be formulated. As no framework allows all true statements to be formulated, this solution effectively rejects "the quantum state of the universe" as meaningless. Not having a meaningful quantum state, however, means not having a meaningful Hilbert space, i.e. not having a meaningful collection of degrees of freedom. Griffith's solution, therefore, rejects the idea that there is a actual mereotopology of the real world; hence it rejects the self-consistency of N.

6 Conclusion

By providing an adjustable level of granularity with a natural mereotopological interpretation, the formal notion of a partition offers an attractive approach to the problem of referential ambiguity. What has been shown here is that this approach cannot be pushed to the limit of full objectivity. Any fiat partition that is overlaid onto the world is itself referentially ambiguous in a way that cannot be repaired without appeal to an hypothesized "natural" mereotopology N, and cannot be demonstrated to be repaired even if N is assumed. Hence fiat partitions cannot serve as *objective* truthmakers, however useful they may be as "for all practical purposes" truthmakers.

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[10]For an introduction to POVMs, see Nielsen and Chaung (2000) Ch. 2. That the POVM formalism can be consistently applied in a mereologically-nihilist context is shown in Fields (2012).

[11]Indeed as shown in Fields (2013b), any system-distinguishing boundaries drawn not just in physical but even in Hilbert space require the assumption that the distinguished systems do not interact, and hence yield a trivial physics at best.

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