Formalised Elementary Formal Ontology

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Abstract

Formal ontology, as the science of the formal relations that structure reality as a whole, aims at a theory of categories corresponding to the most general features of possible objects, whether existing or non-existing. The present paper is an attempt to summarise and extend recent research in analytical metaphysics in a formalised theory of objects. Existence is characterised as a formal property, suggesting that the use of quantifiers alone does not involve any existential assumptions about the objects quantified over. However, the only non-existing objects allowed for in the present account are *real* or *objective* possibilities. *De re* modalities as well as ontological dependence are defined on the basis of a counterpart-theoretic specification of possibilia. The present framework allows for necessary and non-relative identity as well as for a granular parthood relationship satisfying the thesis of composition as partial identity. The paper culminates in the formalisation of an Aristotelian four-category ontology allowing for universals and particulars, substances and particularised properties; in this context, the redundance of higher-order material universals as well as moderate haecceitism is argued for. After a short analysis of relationality and extrinsicness, a theory of spatial and temporal objects is sketched and a temporal counterpart theory is proposed as a solution to the problem of temporary intrinsics. The paper concludes with some general remarks on the relation between ontology and the theory of subjectivity, defending a modal approach to consciousness and a counterpart theoretic analysis of intentionality.

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1 Introduction

The present paper outlines a formalisation of elementary formal ontology. In contradistinction to a *material* ontology, *formal* ontology is concerned, not with the specification of the constituents (individuals, properties and relations) in a particular domain or region of the world, but with the axiomatisation of the most general, pervading categories that partition and shape reality as a whole ([50], pp. 1-2).

As Barry Smith has pointed out ([108], fn. 11), the use of the qualifier "formal" is liable to give rise to a fundamental misunderstanding: *formal* ontology is not merely the application of formal-logical methods to the study of metaphysics (as e.g. in Cochiarella [24], p. 640ff or Meixner [74]). Rather, the very success of mathematical logic has led to a "running together of the *formal* and *formal logical*" ([113], p. 73), and ultimately to a confusion of ontology with logic and with the study of the structure and semantics of artificial languages, at least as far as much philosophy in the analytic tradition is concerned. Only fairly recently, in an influential collection of studies in the philosophy of Brentano, Husserl and their followers (Smith et al. [112]) was there triggered a revival of a scientific metaphysics in the Aristotelian tradition that is not a mere appendix to predicate logic and set theory.

Indeed, the *formal/material* distinction has a wider range than just the specialist area of mathematical logic; it reflects the general opposition between form and matter in the realm of things as well as in the realm of truths. Just as formal logic studies the abstract relations between propositions, so formal ontology is concerned with the formal relations between entities ([113], p. 73; [119], p. 19). Formal-ontological constants are like formal-logical ones insofar as their meaning can be characterised purely in terms of operations and transformation

rules ([113], p. 74; [110], pp. 48-50; [111], pp. 87-88). Formal relations (such as parthood, dependence, but also identity and instantiation) are not mediated by ties (accidents, moments) of any sort, in contrast to material relations (such as "being a parent of", "being the moon of", and so on), but hold directly of their relata ([110], pp. 50-51). Formal properties and relations can therefore be instantiated by objects in all material domains or spheres of being ([119], ibid.). That is why formal ontology as the study of formal categories can justifiably be claimed to be the most general possible theory about the world.

Thus it should not come as a surprise that formal ontology is *realist* rather than *conceptualist*, inasmuch as it is an inquiry into the general features, the real aspects of the denizens of the world *out there* ([50], p. 2), and not into the basic characteristics of the conceptual framework which we happen to be equipped with as members of the human species or a particular ethnic group (as e.g. in Strawson [124], p. 9, and [125], p. 24). Formal ontology is *conservative* or "descriptive" instead of *revolutionary* or "revisionary", insofar it takes - *salva consistentia* - our everyday ways of speaking about the world at face value as the most detailed and corroborated description of reality available ([124], p. 9ff), but proceeds to theoretical revisions of so-called commonsense if required for the sake of coherence and, above all, scientific adequacy.

Formal ontology is *adequatist* rather than *reductionist*, trying to be as faithful as possible to reality in all its complexity and at all levels of granularity, embracing the actual multiplicity of categorial distinctions, instead of pruning the latter through reductive analysis to a paucity of types hallowed by fashion and ideological prejudice (cf. [122]). Hence I opt for a rich realism that acknowledges both existents and non-existents, parts and wholes, particulars and universals, substances and accidents, continuants as well as occurrents. I

wholeheartedly agree with Barry Smith [108] in the fact that in ontology, expressivity should be preferred to terminological economy and that the quality of a metaphysical account has to be evaluated in terms of the subtleness and wealth of distinctions it provides for, not to speak of its truth.

The formalisation attempted here aims merely at a minimal axiomatic characterisation of the basic formal properties of, and interconnections between, the categories and relations in the ontology; by no means can it wholly specify the meanings of the constants used to represent them. Indeed, any formalisation has to rely on underlying ontological intuitions shared by author and recipient(s), since what formal ontology deals with is reality itself and not a mere calculus.

2 Existence, Essence and Dependence

2.1 Existence as a Property

A central tenet of mainstream analytic philosophy is the expendability of existence as a first-order property ([88], p. 1). Indeed, Quine has established the now common opinion that existence is trivially instantiated by everything ([88], p. 2), thus turning the proposition that something exists into a tautology ([94], p. 1; [98], pp. 151-152). According to the orthodox view, nonentities are too evasive to bear any identity ([94], p. 4; [88], p. 27). Alleged reference to them should be avoided by following Russell's [99] proposal to paraphrase names and definite descriptions using the existential quantifier and identifyingly characterising properties ([94], p. 6). Indeed, in Quine's account, quantifiers are conceived of as being existentially loaded ([98], p. 154), and instead of names, it is bound variables that bear the burden of ontological commitment; it is their use that commits us to the existence of things in their range ([94], p. 12).

However, it has been pointed out that the program of quantificationally paraphrasing all singular references using names has never actually been carried out ([86], p. 652; [88], p. 37). Nor could its alleged success have the same force as a direct ontological argument against a view of existence as an attribute ([73], p. 23). The underlying presumption that existence is not a first-order property, but a second-order attribute consisting in the instantiation of properties by entities ([73], p. 19) runs into an infinite, though not necessarily vicious, regress as it makes perfectly sense to question the existence of each property itself ([73], p. 24). Quantificational paraphrases of singular references involve, as a first step, the replacement of names by definite descriptions – a step possible only if everything instantiates properties that identify it, which is a hazardous metaphysical claim ([73], pp.28-30), as it presupposes the controversial principle of the Identity of Indiscernibles (cf. below).

Bencivenga observed that neither a logical system nor its set-theoretic interpretation can by themselves involve the user in any kind of metaphysical commitment. In fact, every formalism or formal semantics can be said to be devoid of existential assumptions ([11], p. 374). It is the assumptions underlying the use of the formalism that commit one to a certain ontology. However, neither a linguistic nor a pragmatic choice as to the design of our basic theories can increase or decrease in any way what there is in reality. (Cf. [98], pp. 153, 174.)

Thus, in particular, quantifying expressions have no existential import whatsoever ([73], pp. 32, 34; [98], pp. 151–152, 168); indeed, existential assumptions about objects have to be made explicit using an existence predicate. Quantifiers like “most”, “every” or “some” indicate merely the quantity or proportion of objects satisfying the propositional functions having the former as prefixes ([73], pp. 34). So to exist is most certainly not only to be the value of a bound

variable ([73], p. 34). According to Bencivenga, quantifiers without existential import and classical logic can actually go very well together ([11], pp. 376–377), and the common way to allow for an ontologically neutral interpretation within Tarskian semantics is to admit non-existing as well as existing objects in the domain and thus in the range of the quantifiers ([11], p. 379; [73], p. 33).

In order to avoid contradictions - in a classical system at least - it is mandatory (pace Parsons [88], p. 31) to ban *impossibilia*, that is objects instantiating incompatible properties, from the domain of quantification ([97], p. 259; [103], p. 261). Then the apparent paradoxicality of non-existence can be allayed by introducing the formal property of *mere being* or *subsistence*, defined as follows: an object x *subsists* iff there is something identical to it.

Df 2.1 $\mathcal{B}x \equiv \exists y\,(\,y = x\,)$

Since there are no impossibilia in the universe of discourse, everything is identical to itself *salva consistentia*, and so nothing in the domain can fail to subsist. Hence all the variables in elementary formal ontology range over subsisting objects, forcing a Meinongian or possibilist reading of quantifiers. Hence the distinction between *existence* and *non-existence* is to be understood as the dichotomy of *actual* vs. *non-actual subsistence* (concurring with Meixner [74], p. 271ff and disagreeing with McGinn [73], p. 39ff).

A Meinongian reading of quantifiers, as well as admitting singular reference to entities and non-entities alike, allows the introduction of "existence" as an (undefined) predicate constant ([88], pp. 155-156), thus turning classical first order logic into a calculus very similar to the system R* described by Routley in [97], pp. 254ff. In such a system the assertion that everything exists is not analytic, but synthetic and - false ([97], p. 255). This corresponds to the natural intuition that existence is a perfectly meaningful predicate ([78], p. 126; [73],

p. 17; [97], p. 251) that makes a distinction between objects since it ascribes a property that things can fail to have ([73], p. 15).

Indeed, there are things that do not exist ([98], p. 151; [86], p. 649), though everything necessarily subsists. Identity and distinctness hold indifferently of existing and non-existing things ([88], p. 28; [98], pp. 156-158) and identity conditions can be formulated for entities and non-entities alike ([98], pp. 158, 166). Though indeterminacy of identity is a concern for non-existing things, it is not more so than for existing ones, where convention might be just as needed to precisify boundaries ([98], p. 164-165). For further arguments against the absurdity of non-existing objects, the reader is referred to the literature on this subject (eg. Routley [97, 98] and Parsons [85, 86, 87, 88]).

It is a completely different question whether or not non-existents are essentially dependent on intentions/minds or on conventions ([73], p. 37ff). The present approach allows for non-entities only insofar as to make sense not only of the possible non-existence of actually subsisting beings, but also of the possible variations of their so-being, the facts of essence. I sustain that all non-entities are *real*, *objective* possibilities that have to be clearly distinguished from fictions, be they scientific, literary or legendary. Indeed, I would claim that merely fictional objects such as legendary or literary figures like Pegasus or Sherlock Holmes, should not be regarded as non-entities, but rather as existing "moments", i.e. dependent actual objects; the reader is referred to an interesting approach of Amie Thomason conceiving them as "abstract artifacts" that are historically dependent on the creative activity of humans ([126], pp. 35-42). I learn from Barry Smith [109] that a similar view has been uphold by the Polish phenomenologist Roman Ingarden, a view that Smith contrasts favourably to the Meinong/Parson's [88] approach to fictional objects. There may be no phys-

ical object referred to by "Holy Grail", but the latter denotes a perfectly regular literary denizen of reality. It is sensible to preclude mere fictions from being "possibilia", since there is no way how a fictitious being can be a real possibility. However, this does not mean that fictional objects cannot depict possibilities, even past realities, as e.g. the London of Sherlock Holmes. Nonetheless we have a good overall feeling, made ever more acute through scientific progress, which objects are the creation of our imagination and which things are objective in the sense of real individual possibilities.

In the next section I will show how the realm of objects can effectively and plausibly be delineated through formal restrictions in counterpart theory. Meanwhile I make the not very earth-shattering, though nonetheless significant assumption that some things exist and others do not ([88], p. 157):

Ax 2.1 $\exists x\, \mathcal{E}!x \wedge \exists x \neg \mathcal{E}!x$

It is clear that existence must be a formal property, holding of objects without any mediating ties (Parsons speaks of existence as an extranuclear property, [88], pp. 23, 156). Indeed, such ties would have to exist too, which would lead to an infinite regress. Existence seems so fundamental to ontology and logic that one has to accept the corresponding predicate as an ontological primitive. The meaning of this primitive will have to be constrained by further propositions relating it to other basic ontological functors, such as parthood.

2.2 Essence and Necessity

Once having got hold of the property of existence, one is easily tempted to conceive essentiality in terms of the latter: "it is essential to x that ϕ" would mean nothing other than "necessarily, if x exists, than ϕ"; in particular, a property F would be essential to an individual iff the existence of x would necessarily imply

that F holds of x ([73], p. 47; [103], p. 260). This and similar modal accounts, irrespective of whether they are *de re* or not, have come under sharp criticism, especially from the side of Kit Fine, who regards them as "fundamentally misguided" ([31], p. 3).

In fact, Fine argues that facts of essentiality simply do not supervene on facts of mere metaphysical necessity: it would be "possible to agree on all of the modal facts and yet disagree on the essentialist facts" ([31], p. 8). There are obvious counter-examples to the link between essence and necessitation by existence. For example, while it is a tautologically true for every object x that necessarily, if x exists, then x exists (cf. [103], p. 258), we would not say of every individual that its existence is essential to it ([31], p. 6). Necessary truths, e.g. those of mathematics, would be such as to be part of the essence of every ordinary concrete being ([31], p. 5). These examples suffice to show a fundamental asymmetry between necessity and essentiality (cf. ibid.).

Now there would seem to be ways to tackle counter-examples as those above. One possibility could be to integrate constraints as to the relevance for the object in question into the modal account; however, such relevance can only be determined in terms of essence ([31], p. 7). Another, much cherished, option consists in rejecting certain kinds of properties or truths as being "improper" candidates for essentiality. Now, this is an ad hoc – and unsuccessful – measure ([31], p. 7) which is far too restrictive, as we would like to speak, for instance, about the essentiality of necessary features, as in "four is essentially a number". We are far from being exhaustive here and the reader is referred to Fine's paper [31] for further arguments.

If it is essential for a particular flower to have a certain DNA code, than this is necessarily so. That same flower's having a metabolism based on photosynthesis

is a necessary feature of it, based on general facts about plants; however it is not essential for that particular rose - any arbitrarily chosen plant satisfies such a necessary condition. In general, facts of essence are also facts of necessity, but not vice versa: indeed, if it is essential for an object that ϕ, than it is necessary that ϕ, too, but not the other way round ([31], p. 4). Nevertheless this should not be understood as meaning that essentiality is just a special case of metaphysical necessity. Essential truths hold in virtue of the particular nature of the things involved ([31], pp. 8-9).

Instead of trying to understand essentiality in terms of necessity, it may be more fruitful to account for necessity in terms of essentiality. For each object there is a class of essential truths that hold owing to its nature, e.g. a particular flower having a specific DNA. Domain-specific necessities supervene on basic truths of essence determined by the natures of the things in the domain, e.g. that each organism has a DNA. Metaphysical necessity, then, should be regarded as a supervening necessity whose domain is the whole universe: the truth that each spatial object has necessarily a boundary is grounded in each individual spatial object having essentially its specific boundary .

Fine sets out an account of essentiality in terms of the real-definition of objects through others ([31], p. 13-14); however, I take the liberty not to follow him on this controversial path. For it is obvious that, pace Fine, essentiality can indeed be dealt with in a multi-modal approach, i.e. an account relying on an infinite number of specific modalities. Each particular nature actually determines a basic relative necessity; just as there is a multiplicity of relative epistemic modalities, each indexed by a specific knowing subject, so there is a plethora of relative essentialist modalities, each indexed by a specific essence/object. Given a particular rose r or a particular table l, one would have the essentiality-for-r

or the essentiality-for-l, such that it is essential-for-r that r has a particular smell s or essential-for-l that l has a specific scratch on one of its legs.

The underlying semantics of the corresponding modal operators parallels that of the epistemic ones: ultimately it is based on specific accessibility relations between worlds, or as I prefer and will explain below, counterpart relations between objects that represent the relevance of facts to the nature of a particular individual. (In [32], Fine de facto also opts for a multi-modal approach.)

The obvious question is whether these relative modalities are restrictive enough to convey essential relevance. My claim that this is indeed the case can be supported by a comparison with epistemic modalities. For instance, Goldbach's conjecture has been unknown to Socrates, that is irrelevant to his knowledge about the external world. Likewise, the mathematical fact expressed by this conjecture fails to be essential, that is relevant to the essence of Socrates. While *de re* metaphysical necessity is too generic to imply a link to the nature of the object concerned, the essentiality relative to that very individual is not: metaphysical necessity concerns every possible object whereas the essentiality for a particular thing matters for that thing alone.

Consequently one could introduce infinitely many essentiality operators indexed by singular expressions denoting individual objects (written "ε_x") as further undefined primitives in formal ontology. However, I opt for giving an ontological account of these essentialist modalities by defining them in terms of indexed counterpart relations between objects, adapting the well-known proposal of David Lewis ([57, 61]). Indeed, model-theoretic semantics is only meant to provide a basis for meta-mathematical enquiries into the consistency and completeness of formal languages, irrespective of their relation to the world, and cannot offer any ontological elucidation ([116], p. 650).

There are various respectable alternatives to counterpart theory that account for modality in terms of possible worlds, fictional or contrafactual situations (Kripke [55], p.15ff, p.44ff), alternative states of affairs constructed from elements (particulars and properties) of the real world (Armstrong [6], chap. 10, at p.160) or maximal states of affairs (Platinga [91], chap. 4, pp. 44-45; Meixner [74], chap. I.10, p.73ff), and the like. The main reason why I do not consider these approaches is that the ontological nature of the constructs they use is far from being clarified; I will return to states of affairs later, when discussing instances of universals. Counterpart theory has the advantage that it does not introduce kinds of objects in the universe of discourse which we have not adopted earlier: recognising existence as a predicate has already obliged us to allow for both existing and non-existing objects.

Another benefit is that under this analysis of modality, intensional or referentially opaque contexts disappear and thus an extensionalist reading of modal phrases is possible throughout ([88], pp. 45, 48). Also in terms of ontological economy and transparency, counterpart theory pays off, since any discourse using intentional terms such as "thought", "idea" or "sense" can be avoided in favour of a robust referentialist metaphysics. From a formal-logical point of view, counterpart theory brings a huge simplification of semantics and proof-theory, as the only rules needed for interpretation and inference are those of (classical) first-order predicate calculus ([57], p. 110).

It is not the case that by opting for counterpart theory one has to pay the price of modal realism, i.e. to believe Lewis' idea that possibilia enjoy existence in possible worlds as parallel realities ([61], pp. 1-5). One can very well reject the reproach that "actualism", the claim that only what is actual exists, is just another error from ontological perspective ([61], pp. 92-96) and stick to the

empirical evidence that there is just one reality. Any counterparts of actually subsisting objects, besides these objects themselves, simply do not exist, but merely subsist. Hence there is nothing mysterious about the ontological status of possibilia. My somewhat unorthodox actualist variant of counterpart theory may require the quantification over merely subsisting objects, but it characterises the latter as objective possibilities. Furthermore, it should be pointed out that this does not prejudice any actualist reconstructions of *possibilia* as powers or dispositions inhering in existing substances.

Every reference to possible worlds can be dropped, since under plausible conditions, counterpart relations between individuals can perform all jobs thought to be performed by accessibility relations between worlds. Indeed, in [57], counterpart relations have to be complemented by the formal property of *being in a certain world* to account for what in a Kripkean interpretation would be the variability or constancy of the domain ([57], p. 122). Instead of quantifying over such problematic objects as possible worlds, fictional or not, one can simply assume a further relation between counterparts, namely *compossibility*. Leaving out any mention of worlds collapses accessibility and counterpart relations onto each other.

Furthermore, different types of accessibility relations are used to account for different kinds of modality - however, this can also be done by differentiating between various sorts of counterpart relations [58]. Now, I would rather not be as generous as Lewis, for whom practically any kind of similarity relation between possibilia, any way of comparing them, conventional or not, already represents a counterpart relation and thus defines a kind of modality ([61], p. 252). I would claim that only few relations between objects qualify as counterpart relations and, in particular, that material relations of similarity or (conventional) com-

parison determine what would be better called "quasi-modalities" that may be relevant for natural language analysis, but not for formal ontology.

I agree with Lewis that all possibilia are individual possibilities ([61], p. 230), though I would like to regard them as real potentialities. First I assume that everything has to be the counterpart of something else.

Ax 2.2 $\exists y\, CP^{\varepsilon}_{z} xy$

Second, every object is the index of a non-empty counterpart relation.

Ax 2.3 $\exists yz\, CP^{\varepsilon}_{x} yz$

However, it is not plausible that every object has to be the counterpart of an entity. Imagine the following situation: Smith has a particular patch on the skin of his left forarm that could, according to the dermatologist, develop sooner or later in a melanoma, a malignous skin cancer. By removing this patch surgically, Smith's dermatologist prevents a skin cancer to develop. But though the melanoma never comes into existence, it nevertheless represents a real possibility, a real risk that has motivated a prompt surgical intervention. Thus one has to allow for objects that are not counterparts of existing things:

Ax 2.4 $\exists y \forall x \neg \exists z\, (\, \mathcal{E}!z \wedge CP^{\varepsilon}_{x} yz\,)$

The question is, then, how one can constrain the realm of objects otherwise in such a way as to exclude purely fantastic possibilities like golden mountains, chimaerae or round squares. Obviously such restrictions cannot be delivered by counterpart theory alone. The outline of an answer to this concern runs as follows: in order to delimit the domain of possibilia, axioms about mereotopology and naïve physics are required that hold for existents and non-existents alike. The constraints on what is admissable as a real possibility can only be given

by a full-fledged basic ontology of physical objects. Unfortunately, this is much more as one can deal with in the space of a single paper, so I have to remain ruefully vague on that important subject.

Each essentialist counterpart relation is supposed to be reflexive, symmetric and transitive, founding the full strength of S5 ([57], pp. 121-122).

Ax 2.5 $CP^{\varepsilon}_{y}xx$

Ax 2.6 $CP^{\varepsilon}_{z}xy \rightarrow CP^{\varepsilon}_{z}yx$

Ax 2.7 $CP^{\varepsilon}_{w}xy \wedge CP^{\varepsilon}_{w}yz \rightarrow CP^{\varepsilon}_{w}xz$

As an equivalence relation, counterparthood partitions the realm of objects in disjoint sets.

Now, counterpart relations alone do not suffice to define essentialist modalities. Counterparthood has to be complemented by compossibility, an equivalence relation partitioning the domain of objects that plays the same role in my account as the property of *being in a particular world* in Lewis' approach.

Ax 2.8 $CM^{\varepsilon}xx$

Ax 2.9 $CM^{\varepsilon}xy \rightarrow CM^{\varepsilon}yx$

Ax 2.10 $CM^{\varepsilon}xy \wedge CM^{\varepsilon}yz \rightarrow CM^{\varepsilon}xz$

An obvious assumption is that any two existing objects are compossible:

Ax 2.11 $\mathcal{E}!x \wedge \mathcal{E}!y \rightarrow CM^{\varepsilon}xy$

The combination of counterparthood and compossibility allows the definition of different brands of quantified modal logic. For essentialist counterparthood, I stipulate that any two possibilia x and y are identical iff for any counterpart relation, any compossible counterparts of x and y under that relation are identical. This is the principle of *Invariance of Identity under Counterparthood*.

Ax 2.12 $x = y \leftrightarrow (\, CP_z^{\varepsilon} wx \wedge CP_z^{\varepsilon} vy \wedge CM^{\varepsilon} wv \rightarrow w = v \,)$

This postulate corresponds to a generalisation, over multiple counterpart relations, of those conditions in Lewis' framework under which the Barcan formula and the necessity of identity hold ([57], p. 122).

Individual essentialist modalities can be defined in terms of corresponding counterpart and compossibility relations. Thus, it is essential for an object x that a property ϕ holds of objects $y_1 \ldots y_n$ iff ϕ holds for all compossible x-indexed counterparts of these objects:

Df 2.2 $\varepsilon_x \phi(y_1 \ldots y_n) \equiv$

$\forall z_1 \ldots z_n \, (\, CP_x^{\varepsilon} z_1 y_1 \wedge \ldots \wedge CP_x^{\varepsilon} z_n y_n \wedge CM^{\varepsilon} z_1 z_2 \wedge \ldots \wedge CM^{\varepsilon} z_{n-1} z_n \rightarrow \phi(z_1 \ldots z_n))$

If there is only one counterpart to consider, that is if ϕ is monadic, than any mention of compossibility can be dropped, since "$CM^{\varepsilon} xx$" holds trivially.

Any truth ϕ is (metaphysically) necessary iff it is essential for any object x that ϕ holds:

Df 2.3 $\Box \phi \;\equiv\; \forall x \varepsilon_x \phi$

The weaker modalities *(essential) compatibility* as well as *(metaphysical) possibility* are defined as usual:

Df 2.4 $\kappa_x \phi \;\equiv\; \neg \varepsilon_x \neg \phi$

Df 2.5 $\Diamond \phi \;\equiv\; \neg \Box \neg \phi$

Essential implication corresponds to the strong implication of modal logic.

Df 2.6 $\phi \rightharpoonup_x \psi \equiv \varepsilon_x \, (\, \phi \rightarrow \psi \,)$

We are now able to formulate some very general axioms relating essentiality (necessity) and existence. While it is true that everything is the counterpart

of something, not everything is the counterpart of an existing object. Thus, trivially some objects possibly exist and others do not.

Th 2.1 $\exists x \Diamond \mathcal{E}!x$

Th 2.2 $\exists x \Diamond \neg \mathcal{E}!x$

One has to distinguish between *being possible* and *being possibly existent or actual*. Strictly speaking, all objects satisfying the axioms of elementary formal ontology (including mereotopology and naïve physics) are possibilia, since they are counterparts. However, not everything that subsists is *ipso facto* also possibly existing. For the sake of clarity, it is preferable to avoid the term *impossibilia* while speaking about things that have no existing counterparts.

Furthermore I assume that there are things that necessarily exist (universals, for example):

Ax 2.13 $\exists x \Box \mathcal{E}!x$

Possibilia are either *necessary* or *contingent* objects (the latter being possibly existent or not).

Df 2.7 $\mathcal{N}x \equiv \Box \mathcal{E}!x$

Df 2.8 $\mathcal{C}x \equiv \neg \mathcal{N}x$

All necessary, and some contingent things exist (the former is a trivial theorem, the latter an assumption).

Th 2.3 $\mathcal{N}x \rightarrow \mathcal{E}!x$

Ax 2.14 $\exists x \, (\, \mathcal{C}x \wedge \mathcal{E}!x \,)$

There is something remarkable about necessary objects in this framework which is worth pointing out. Indeed, translating the definiendum of "necessary object" into the language of counterpart theory, one obtains the following:

Th 2.4 $\mathcal{N}x \rightarrow \forall y \forall z \, (\, CP_z^{\varepsilon} yx \rightarrow \mathcal{E}!y \,)$

Under the stipulation that no two existing objects can be counterparts of each other, it follows that necessary objects have no counterparts besides themselves:

Th 2.5 $\mathcal{N}x \rightarrow \forall y \forall z \, (\, CP_z^{\varepsilon} yx \rightarrow y = x \,)$

And this is exactly what one would predict about necessary beings: that there is no other way they could be. Indeed, counterparts are nothing else than alternative individual ways of being - thus it is quite intutive that necessary objects have no counterparts except themselves. As a direct consequence, one can also predict that properties or relations holding of necessary objects hold necessarily of them:

Th 2.6 $\mathcal{N}x_1 \wedge \ldots \wedge \mathcal{N}x_n \rightarrow (\, \phi(x_1, \ldots, x_n) \rightarrow \Box \phi(x_1, \ldots, x_n) \,)$

McGinn argues that every attempt to reduce or eliminate modality by a quantification over possibilia already has to presuppose it ([73], pp. 70-74). Indeed, I define essential modalities on the basis of other categories which themselves have already to be regarded as modal. I therefore go along with McGinn in considering modality as an ontological category of its own ([73], p. 89). Counterpart relations are ontological primitives, since they cannot be defined, but at most be elucidated through any non-modal ontological category.

It has already been mentioned that the only counterpart relations we consider are formal relations, in the sense of relations immediately holding of their relata. I will claim that they supervene on their relata and are thus to be regarded as internal relations.

2.3 Dependence as Essential Inclusion

In *Categories*, Aristotle introduces a notion of *being in* another entity which is distinct from that of parthood; indeed it is the formal relation something bears to an entity without whose existence it could not subsist ([3], 1 a 20-25). This formal relation is commonly called *ontological dependence*. Ontologically dependent entities, that is *accidents* or *moments*, are not self-sufficient and require the existence of another entity in order to exist. They come in a wide variety, which ranges from individualised qualities (the being-red of the rose, the pitch of a tone) over boundaries (the edge of a cube, the coast-line of Britain) to occurrences (Anne's smile, Mary's giving-a-rose-to-Anne).

Besides the work of Strawson (cf. [124], p. 17), there are not any detailed enquiries on dependence in the recent analytic literature, except the writings of philosophers associated with or influenced by the so-called "Manchester School" (cf. [112]). Historical surveys of the survival or revival of the philosophical interest in moments, mainly through the phenomenology of Brentano and Husserl, can be found in [111] as well as [81], pp. 290-295. I will discuss primarily the Mancunian contributions to the subject.

There are two common approaches to characterising the formal relation of ontological dependence:

1. non-modal accounts (Fine and Smith [30, 34] as well as the survey in Simons [103], pp. 310-318), and
2. modal accounts (Simons [102], [103], pp. 294-304).

Non-modal approaches treat the dependence relation as a quasi-mereological primitive whose formal properties are specified by axioms. However, as Simons has justly observed, the axiomatisations proposed by Fine and Null cannot rule out non-intended interpretations that are merely topological ([103], p. 316).

The only way to exclude them would be to embed the non-modal theory in a modal one ([103], pp. 316-317). In a modal approach, by contrast, the ontological dependence of an entity x on an entity y is defined as the necessitation of the existence of y by that of x. This definition may seem to be much more in harmony both with our common-sense intuitions as well as with philosophical tradition; indeed, it echoes Aristotle's definition of ontological priority in *Categories* ([3],16 b 10-15). Nevertheless, Kit Fine argues that modal construals of dependence are fundamentally flawed, since existence is either too weak, because there is much more to a thing than its mere being (actual or not), or too strong, as the nature of a thing may not involve its existence ([33], p. 274).

As a matter of fact, if modal existential construals are taken at face value, just every object depends on necessary beings: the existence of Socrates may well necessarily imply the existence of the number 2, but one may not want to claim for that reason that Socrates depends on 2 ([33], p. 271). Excluding such problematic cases by banning necessary objects from the range of the dependence relation, as Simons proposes ([103], pp. 295 & 297), is an inadequate measure, as one may want to say that the singleton $\{2\}$ is dependent on the number 2 ([33], p. 272). Trivial dependencies cannot be avoided even by shifting to essentialist modalities and essential implication ([33], p. 272-274).

In an actualist account of modality, at least as far as the present approach to counterpart theory is concerned, necessitation of existence cannot really be thematised, since modal reasoning about existence is rather restricted. Indeed, an object is possibly existent only if it has an existing counterpart. First, there are objects that do not possibly exist, that is, which have no existing counterparts. Second, existing objects have no actually subsisting counterparts, which also means that necessary objects have no counterparts besides themselves.

I agree with Fine's observation that dependence should not be conceived of as necessitation of existence ([33], p. 274). He proposes a stronger "existentially neutral account" of dependence ([33], p. 280), derived from his definitional conception of essence developed in [31], according to which a thing is dependent on any object which is a definitory constituent of its essence ([33], p. 275). Fine sketches a specification of dependence in terms of "consequential" instead of "constitutive" essence, whereby an object x depends on an object y iff y cannot be "generalised out" of the essence of x. In other words, x depends on y iff there is a property F such that y is the unique object whose being-F is implied by the properties constitutive of the essence of x ([33], pp. 276-279).

Having fine-grained individualised essentialist modalities at one's disposal, one can reformulate the idea that the dependence of x on y is in some sense the inclusion of the essence of y in that of x. One can say simply that, for all facts ϕ, ϕ's being essential for y (essentially) implies its being essential for x. In other words, the set of facts essential for y is (essentially) included in the set of facts essential for x. However, ϕ cannot be any property whatsoever - for sure, existence, at least, has to be out of the modal picture. Instead I follow Simons [102, 103], and distinguish between two variants of essential dependence, according to whether particulars and/or types of particulars are involved.

In order to give a precise definition, I have to anticipate some distinctions which will be discussed in more detail in section 4. Indeed, I suppose that the domain of possibilia is partitioned into the set of *particulars* ("$\mathcal{P}x$" meaning "x is a particular") and the set of *universals* ("$\mathcal{U}x$" meaning "x is a universal"). Universals are species, kinds *instantiated* by particulars; the relation of instantiation is written "::". Kinds are supposed to be *material* in contradistinction to the *formal* properties dealt with in formal ontology; they are also regarded

as sparse, in the sense that not every partition of reality and not every linguistic predicate corresponds to a kind or natural species. Thus, one can exclude formal properties and relations (such as identity, parthood and dependence itself) as well as gerrymandered material kinds (as "apples or pears").

The basic kinds of essential dependence are those involving only particulars, while essential dependencies between universals can be regarded to supervene on essential dependencies between particulars. A particular x is *essentially* or *strictly dependent* on a particular y iff for all universals z, it is essential for x that y instantiates z, provided it is essential for y that y instantiates z.

Df 2.9 $D^{\mathcal{P}}xy \;\equiv_{\mathcal{P}x,\mathcal{P}y}\; \forall z\,(\,\varepsilon_y y :: z \;\rightharpoonup_x\; \varepsilon_x y :: z\,)$

Let us call provisionally *substrate* the object a particular moment is dependent on. Now, every attribution of a kind (*flower*) to the substrate (a particular rose) which is essential for the substrate must also be essential for the moment (e.g. the color of the rose). Take for example the boundary of a sphere in Euclidian space: if it is essential to the sphere to be a three-dimensional geometrical object, than it must also be essential to its boundary that the sphere instantiates this mathematical kind, and likewise for every other species provided it is essentially instantiated by the sphere.

A universal x is essentially or strictly dependent on a universal y iff for every particular z instantiating x there is a particular w instantiating y such that x is essentially dependent on w:

Df 2.10 $D^{\mathcal{U}}xy \;\equiv_{\mathcal{U}x,\mathcal{U}y}\; \forall z\,(\,z :: x \;\rightharpoonup_z\; \exists w\,(\,w :: y \wedge D^{\mathcal{P}}zw\,)\,)$

The kind *human being* can be assumed to be strictly dependent on the kind *brain*, as each individual human being is strictly dependent on its particular brain.

Strict dependence has to be distinguished from two weaker relations of dependence, namely *notional* and *generic* dependence. These relations will not be used in this paper and are mentioned only for the sake of completeness. A particular x is *notionally dependent* on a universal y iff it is essential for x that y be instantiated; a universal x is notionally dependent on another universal y iff all the instances of x are notionally dependent on y.

Df 2.11 $ND^{\mathcal{P}}xy \equiv_{\mathcal{P}x,\mathcal{U}y} \varepsilon_x\exists z\,(\,z :: y\,)$

Df 2.12 $ND^{\mathcal{U}}xy \equiv_{\mathcal{U}x,\mathcal{U}y} \forall z\,(\,z :: x \rightharpoonup_z ND^{\mathcal{P}}zy\,)$

Every organism is notionally dependent on the kind *water*, and hence also the universal *organism*.

Generic dependence is actually a subcase of notional dependence which involves also existence. A particular x is *generically dependent* on a universal y iff it is essential for x that y has *existent* instances; a universal x is generically dependent on another universal y iff all the instances of x are generically dependent on y.

Df 2.13 $GD^{\mathcal{P}}xy \equiv_{\mathcal{P}x,\mathcal{U}y} \varepsilon_x\exists z\,(\,\mathcal{E}!z \wedge z :: y\,)$

Df 2.14 $GD^{\mathcal{U}}xy \equiv_{\mathcal{U}x,\mathcal{U}y} \forall z\,(\,z :: x \rightharpoonup_z GD^{\mathcal{P}}zy\,)$

Incidentally, every organism is also generically dependent on water and so is the kind *organism*. It is actually quite difficult to find real-world examples of notional dependencies that are not also generic. For instance, as the past has fortunately taught us, the kind *nuclear defense system* is merely notionally dependent on the occurrence-type *nuclear strike*.

3 Identity and Parthood

3.1 Identity: simple, indivisible, absolute

Identity is a sweeping, universal property: nothing can in any circumstances fail to be identical with itself, whether it be existing or not ([73], p. 9; [61], pp. 192-193). Identity is an equivalence relation, being trivially reflexive, symmetric and transitive:

Ax 3.1 $x = x$

Ax 3.2 $x = y \ \rightarrow \ y = x$

Ax 3.3 $x = y \ \wedge \ y = z \ \rightarrow \ x = z$

Identity is also the tightest relation a thing can have to itself; indeed, it is *essential* for every object that it be identical with itself, since all its counterparts are identical to themselves:

Th 3.1 $\varepsilon_x x = x$

Thus there is indeed an essential property that is exclusively instantiated by each particular object a and nothing else, namely the property of being (essentially) identical to a, which Plantinga calls a's *haecceity* ([90], p. 473ff). However it is important to note that a haecceity is a *formal*, not a material property.

As all counterparts of an object are self-identical under any essential counterpart relation whatever, it follows that self-identity is not only essential, but also metaphysically necessary:

Th 3.2 $\Box x = x$

The main defining axiom of identity is the Principle of the Indiscernability of Identicals, according to which identity implies congruence of properties (Wiggins

[132], pp. 50-51). According to whether one considers particulars or universals, its formulation will be different. For particulars, identity implies co-instantiation of all material kinds.

Ax 3.4 $x = y \rightarrow_{\mathcal{P}x,\mathcal{P}y} \forall z\,(\,x :: z \leftrightarrow y :: z\,)$

For universals (kinds), identity implies having the same instances.

Ax 3.5 $x = y \rightarrow_{\mathcal{U}x,\mathcal{U}y} \forall z\,(\,z :: x \leftrightarrow z :: y\,)$

The converse, however, is not true; unlike sets, universals are not extensional.

Note that this axiom does not imply that identity is nothing else than congruence of properties. For this to hold, the converse of the previous axiom, namely the Principle of the Identity of Indiscernibles, would also have to be true. Now, this assumption is far from being uncontroversial. Indeed, Wittgenstein already rejected it as unsatisfactory in his *Tractatus* ([133], 5.5302). Strong arguments against the Identity of Indiscernibles have been formulated on the basis of the logical possibility of contrafactual worlds in which it does not hold ([5], pp. 64-70). Max Black ([13], p. 156ff) has demonstrated that the hypothesis of a possible world whose only denizens are two qualitatively undistinguishable spheres is non-contradictory. Robert Adams ([1], p. 14) has strengthened the case against the Identity of Indiscernibles via a counterexample consisting in an infinite series, without beginning and end, of world-epochs that are qualitatively absolutely alike.

Now, it may be claimed that all arguments against the Identity of Indiscernibles beg the question: they already presuppose the assumption that non-identicals may be indiscernible. Furthermore these examples seem to pertain to the Identity of Indiscernibles for *particulars* rather than *universals*. However, the non-exensionality of universals is uncontroversally part of their definition.

As far as particulars are concerned, it seems to be reasonable to reject the Identity of Indiscernibles, at least if one formalises it as the converse of the axiom stated above concerning the indiscernibility of identical particulars. Co-instantiation of material kinds is undubitably too weak to hold identity. If one considered the congruence of *formal* properties, too, the principle of the Identity of Indiscernible particulars would be trivial, since one of the formal properties is (self-)identity itself.

Note that without the Principle of the Identity of Indiscernibles, there is scarcely any rationale for the assumption of identity criteria and an account of sortals or natural kinds in terms of identity conditions for particulars, an account defended by Wiggins ([132], chaps. 2 & 3) and Lowe ([69], chap. 2).

Both Marcus [8] and Kripke ([55], p. 3) have to be given credit for the principle that all identities are necessary, that there are no "contingent identities". This principle holds in any case under the *Invariance of Identity under Counterparthood* adopted in the theory of modality adopted above.

Th 3.3 $x = y \rightarrow \Box x = y$

With Wiggins ([132], chap. 1) and McGinn ([73], p. 4–5) I maintain that identity is not relative to material kinds, but is absolute and unitary. Indeed, according to the thesis that identity is sortal-dependent, it could be possible for two objects x and y to be identical under a kind a, but diverse under another kind b. E.g. x and y could be identical as lumps of clay, but distinct as statues. A way to implement relative identities in a counterpart theoretic framework would be to adopt multiple types of counterpart relations as ways of comparing or viewing objects and to define, for each of these counterpart relations, a particular identity relation. While this approach is consistent, it does not seem to me to make much ontological sense. I have already argued against the position

that every material way of comparing possibilia should be considered a valid counterparthood, since it may reflect conventions rather than the essences of the objects compared. Likewise, what is called "relative identities" should be better regarded as similarities; indeed, their link with identity is more or less tenuous. Another argument against identities relative to counterpart relations is that it would become difficult, if not impossible, to speak about an object independently of a certain view or way of comparing it to other objects. This would give rise to the uncomfortable question which role objects would have besides founding the unity of the different views.

Pace Wittgenstein ([133], 5.5301), identity is indeed a relation, though not a material one: there are no mediating identity-accidents. In other words, identity is a formal relation which holds immediately of its relata ([73], p. 13). Furthermore, identity is not supervenient on any other property or relation, whether material or formal ([132], pp. 183-188). Indeed, it is so basic that it underlies the very laws of logic and ontology ([73], p. 11). One is thus entitled to regard identity as an irreducible primitive.

3.2 Composition as Partial Identity

The paradigmatic cases of one object *being in* another are mereological relations. It would be spurious to look for an all-embracing formalisation of part-whole relationships; instead, one has to recognise the varieties of parthood. First, as in the case of dependence, I distinguish part-whole relations between particulars from part-whole relations between universals. Second, there are at least two kinds of parthood for particulars: an unconstrained, though non-extensional, variant, and a granular, but extensional variant allowing for levels of composition. Third, some part-whole relations between universals supervene on

mereological relations between particulars, just as strict dependence between universals supervenes on strict dependence between particulars; however, as we shall see, there is one variant of parthood between universals that does not merely reflect parthood relationships between particulars.

Granularity means that each portion of a world can be viewed at various resolutions, corresponding to levels of composition. So we can say that an animal is constituted by an organism composed of body parts and organs, that are themselves composed of tissues. Body tissues are composed of cells that are composed of cell organs like mitochondria, nuclei, and so on. In a certain sense cells are parts of an organism, but it is its organs that are its direct components. It is irrelevant for an organism which cells compose the tissues of its organs; cells are permanently created and eliminated without affecting the overall structure of an organism. However, exchange of organs does raise questions about the identity of an organism through time or though possible worlds.

Nevertheless it would be unintuitive to adopt only granular parthood in formal ontology, as one would like to speak about parts that are not direct granular components of a particular. Even though the cells of the skin covering your forehead are not direct components of your body and can be lost without affecting your body as a whole, one would nevertheless say that they are parts of your body. So I distinguish a weak, non-extensional parthood relationship from a granular one, which I will call *strict parthood* or *composition*; it is only the latter that qualifies as partial identity in the sense that the identity of particulars implies that they are strict parts or components of each other. The formalisation of parthood and strict parthood for particulars is based on the standard account as presented in Casati & Varzi [19], chap. 3, and in Simons [103], chap. 1.

Parthood only satisfies the axioms of so-called *Minimal Mereology*, i.e. the axioms of reflexivity, antisymmetry, transitivity as well as the Weak Supplementation Principle. In addition, I assume that there are maximal particulars containing all elements of an equivalence class under the relation of compossibility, so-called *worlds*.

First, parthood is a relation between *compossible particulars*.

Df 3.1 $CM^{\varepsilon}_{\mathcal{P}}xy \equiv CM^{\varepsilon}xy \wedge \mathcal{P}x \wedge \mathcal{P}y$

Ax 3.6 $Pxy \rightarrow CM^{\varepsilon}_{\mathcal{P}}xy$

Reflexivity, antisymmetry and transitivity of parthood constitute the backbone of so-called *Ground Mereology* ([19], p. 33 & 36):

Ax 3.7 $CM^{\varepsilon}_{\mathcal{P}}xx \rightarrow Pxx$

Ax 3.8 $Pxy \wedge Pyx \rightarrow x = y$

Ax 3.9 $Pxy \wedge Pyz \rightarrow Pxz$

Taking parthood as a basic notion, one can define the formal relations of *proper part* and *overlap* ([19], p. 36).

Df 3.2 $PPxy \equiv Pxy \wedge \neg Pyx$

Df 3.3 $Oxy \equiv \exists z\,(\,Pzx \wedge Pzy\,)$

Ground Mereology can be extended to Minimal Mereology by adopting the Weak Supplementation Principle ([19], p. 39):

Ax 3.10 $PPxy \rightarrow \exists z\,(\,Pzy \wedge \neg Ozx\,)$

The present framework allows for *worlds* as maximal particulars that contain all particulars compossible with them.

Df 3.4 $\mathcal{W}x \equiv_{\mathcal{P}x} \forall y\,(\,\mathcal{P}y \wedge CM^{\varepsilon}_{\mathcal{P}}yx \rightarrow Pyx\,)$

For each particular, there is exactly one world that it is part of.

Ax 3.11 $\mathcal{P}x \rightarrow \exists!y\,(\,\mathcal{W}y \wedge Pxy\,)$

Worlds have nothing to do with those abstract constructs that are called *possible worlds* in certain accounts of modality, such as situations, maximally consistent states of affairs or propositions. Being concrete particulars, "my" worlds correspond to those of Lewis [61]. Furthermore, they should be regarded as ontological free lunch in that they supervene upon, i.e. are nothing above or besides the possibilia that are their parts. Likewise accessibility relations between worlds supervene on counterpart relations between possibilia; a world w_1 is accessible from a world w_2 iff some part of w_1 is the counterpart of some part of w_2.

Something like Closure Mereology holds for existing objects that are compossible with each other and thus form a unique world, namely *reality*:

Df 3.5 $w_r \equiv \iota x \forall y\,(\,\mathcal{P}y \wedge \mathcal{E}!y \rightarrow Pyx\,)$

Th 3.4 $\mathcal{W}w_r$

Weak non-extensional parthood is poorly axiomatised and has to be restricted by links to other formal relations, such as (strict) dependence and existence. The axiom relating mereology to the theory of dependence asserts that a whole is strictly dependent on its parts ([103], p. 317; [34], p. 470):

Ax 3.12 $Pxy \rightarrow D^{\mathcal{P}}yx$

Furthermore, a whole exists only if its parts exist.

Ax 3.13 $\exists y\,Pyx \wedge \forall y\,(\,Pyx \rightarrow \mathcal{E}!y\,) \rightarrow \mathcal{E}!x$

Strict parthood or *Composition* is a non-transitive parthood relation that generates levels of granularity. It presupposes another undefined formal relation, that of *cogranularity*, which is an equivalence relation partitioning the realm of particulars. Intuitively, two particulars are cogranular if they are visible under a given resolution.

Ax 3.14 $CGxy \rightarrow \mathcal{P}x \wedge \mathcal{P}y$

Ax 3.15 $\mathcal{P}x \rightarrow CGxx$

Ax 3.16 $CGxy \rightarrow CGyx$

Ax 3.17 $CGxy \wedge CGyz \rightarrow CGxz$

Formally, one can put three constraints on cogranularity. First, cogranular particulars cannot be proper parts of each other (even though they may overlap):

Ax 3.18 $CGxy \rightarrow \neg PPxy \wedge \neg PPyx$

Second, if a particular is a counterpart of another particular, then they are cogranular:

Ax 3.19 $CP_z^\varepsilon xy \rightarrow CGxy$

Third, all instances of a given universal are cogranular; in other words, universals are bound to levels of granularity:

Ax 3.20 $x :: z \wedge y :: z \rightarrow CGxy$

Strict parthood implies parthood; thus the restrictions on parthood, namely particularity and compossibility of the relata, have to be satisfied by composition too. Furthermore, strict parthood has the same links with strict dependence and existence as parthood.

Ax 3.21 $P!xy \rightarrow Pxy$

The most important axioms about strict parthood are the following two. First, if a particular is a strict part of another particular, then they cannot be cogranular.

Ax 3.22 $P!xy \rightarrow \neg CGxy$

Since each particular is cogranular with itself, one can conclude by modus tollens that strict parthood is irreflexive.

Th 3.5 $\neg P!xx$

Second, if x is a strict part of y, there is no z such that x is a strict part of z and z is a strict part of y.

Ax 3.23 $P!xy \rightarrow \neg\exists z\,(\,P!xz \wedge P!zy\,)$

It is immediately evident that strict parthood is intransitive. However, if x is a a strict part of y and y is a strict part of z, than x is nevertheless a part of z. This axiom holds the two particularist mereological relations of parthood and strict parthood together.

Ax 3.24 $P!xy \wedge P!yz \rightarrow Pxz$

Also I suppose that strict parthood is antisymmetrical, which means that if two particulars are strict parts of each other, then they are identical.

Ax 3.25 $P!xy \wedge P!yx \rightarrow x = y$

The converse, namely that identity of particulars implies their being strict parts of each other, establishes a semantical link between identity and composition.

Ax 3.26 $x = y \rightarrow_{\mathcal{P}x,\mathcal{P}y} P!xy \wedge P!yx$

Indeed, even though one might shrink from defining identity through strict parthood and prefer to have them both as primitives ([19], p. 38), it makes sense to say that a whole is nothing over and above its strict parts ([19], p. 44; [62], p. 81). This is the so-called Thesis of *Composition as Identity*, according to which the "*are* of composition is, so to speak, the plural form of the *is* of identity", to use Lewis' words ([62], p. 82). Following Armstrong, one can actually conceive strict parthood as partial identity ([5], p. 17).

As a next step, I introduce the formal relations of *strict proper part*, *strict overlap* and *strict underlap* respectively ([19], p. 36).

Df 3.6 $PP!xy \equiv P!xy \wedge \neg P!yx$

Df 3.7 $O!xy \equiv \exists z\,(\,P!zx \wedge P!zy\,)$

Df 3.8 $U!xy \equiv \exists z\,(\,P!xz \wedge P!yz\,)$

Strict parthood satisfies the Strong Supplementation Principle ([19], pp. 39-40):

Ax 3.27 $\neg P!xy \rightarrow \exists z\,(\,P!zy \wedge \neg O!zx\,)$

Hence, strict parthood is extensional; it satisfies the theorem that non-atomic particulars that have all strict proper parts in common are identical ([19], p. 40).

Th 3.6 $(\,\exists z\,PP!zx \vee \exists z\,PP!zy\,) \rightarrow (\,\forall z\,(\,PP!zx \leftrightarrow PP!zy\,) \rightarrow x = y\,)$

Extensional mereology has been exposed to many criticisms ([19], pp. 40-42; [103], pp. 112-121); most of them are either related to the problem of identity through mereological change ([19], pp. 41-42; [103], pp. 117-121), or to the existence of objects that only differ as to the arrangement of parts ([19], pp. 40-41). Strict parthood is at least to some extent a reply to the problem of mereological change. Indeed, not every loss or gain of a part actually affects the identity of

a particular; only strict parts may be essential to their whole. However, since one can make temporal statements about strict parthood, too, a satisfactory answer to problems related to identity through change can only be provided by an adequate theory of continuants, which will be exposed later in this paper. As to problems concerning different arrangements of the same parts, they can easily be solved as soon as one admits relation-instances as ordinary particulars that can enter in mereological composition with other particulars. Indeed, counterexamples relying on objects that differ only with respect to the structure unifying their parts should be reconstructed taking into account as distinguishing constituents the relational moments that together with the very same parts form different structured wholes.

Extensional Closure Mereology results from Extensional Mereology by assuming that the sum (or product) of two strictly underlapping (or strictly overlapping) objects is defined ([19], pp. 43-45).

Df 3.9 $x + y \equiv \iota z \forall w \, (\, O!wz \leftrightarrow (\, O!wx \wedge O!wy \,) \,)$

Df 3.10 $x \times y \equiv \iota z \forall w \, (\, P!wz \leftrightarrow (\, P!wx \wedge P!wy \,) \,)$

Ax 3.28 $U!xy \rightarrow \exists z \, (\, z = x + y \,)$

Ax 3.29 $O!xy \rightarrow \exists z \, (\, z = x \times y \,)$

There is no unique upper bound for strict parthood. Instead, *levels of granularity* can be defined as as maximal particulars that contain all particulars cogranular with them.

Df 3.11 $\mathcal{G}x \equiv_{\mathcal{P}x} \forall y \, (\, CGyx \rightarrow Pyx \,)$

Every particular is part of exactly one level of cogranularity:

Ax 3.30 $\mathcal{P}x \rightarrow \exists! y \, (\, \mathcal{G}y \wedge Pxy \,)$

Extensional Closure Mereology only allows for finitary closure conditions; the passage to infinitary mereological operations is not trivial and results in *General* or *Classical Extensional Mereology*. However, I opt for restricted general fusions ("$\sigma_y x$") and products ("$\pi_y x$") of particulars under a given universal x and, acknowledging the bounds of compossibility, relative to worlds y. As the instances of each universal have to be cogranular, an explicit restriction of infinite sums to levels of granularity is not necessary.

Df 3.12 $\sigma_y x \equiv_{\mathcal{U}x,\mathcal{W}y} \iota z \forall w \, (\, Pzy \wedge Pwy \wedge O!wz \rightarrow \exists v \, (\, Pvy \wedge v :: x \wedge O!wv \,) \,)$

Df 3.13 $\pi_y x \equiv_{\mathcal{U}x,\mathcal{W}y} \iota z \forall w \, (\, Pzy \wedge Pwy \wedge P!wz \rightarrow \exists v \, (\, Pvy \wedge v :: x \wedge P!wv \,) \,)$

Thus, *Restricted General Extensional Mereology* only assumes that for any instantiated universal, there is the fusion and the product of its instances in a certain world:

Ax 3.31 $\exists y \, (\, y :: x \wedge Pyz \,) \rightarrow_{\mathcal{U}x,\mathcal{W}z} \exists w \, (\, w = \sigma_z x \,)$

Ax 3.32 $\exists y \, (\, y :: x \wedge Pyz \,) \wedge \exists w \forall y \, (\, Pwz \wedge (\, y :: x \wedge Pyz \rightarrow Pwy \,) \,) \rightarrow_{\mathcal{U}x,\mathcal{W}z}$
$\exists v \, (\, v = \pi_z x \,)$

As mentioned above, parthood between particulars and parthood between universals have to be strictly distinguished, as it is the case for dependence. There are genuine mereological relations between universals, some supervening on parthood relations between particulars, and at least one that does not.

Parthood relations between universals that supervene on those between particulars are *generic parthood* and *generic strict parthood*. A universal x is a generic (strict) part of a universal y iff all instances of x are (strict) parts of instances of y.

Df 3.14 $GPxy \equiv_{\mathcal{U}x,\mathcal{U}y} \forall z \, \exists w \, (\, z :: x \wedge w :: y \rightharpoonup_z Pzw \,)$

Df 3.15 $GP!xy \equiv_{\mathcal{U}x,\mathcal{U}y} \forall z\, \exists w\, (\, z :: x \wedge w :: y \rightharpoonup_z P!zw\,)$

These relations seem to be a little trifle, but are, in fact, used in computing science, particularly in conceptual modelling, where they are called *aggregation*: for instance, aggregation may hold between a class *Car* and classes *Engine*, *Wheel*, *Seat*, and so on.

A parthood relation particular to universals is *subsumption*. A universal x *subsumes* a universal y iff for every particular z it is essential for z that if z instantiates y then z instantiates x:

Df 3.16 $x \supseteq y \equiv_{\mathcal{U}x,\mathcal{U}y} \forall z\, (\, z :: y \rightharpoonup_z z :: x\,)$

Subsumption relations between universals are of relevance especially for the study of taxonomies, which is important for computational applications of formal ontology.

4 A Four-Category Ontology

4.1 Universals and Particulars

Like Lowe ([70], pp. 203-209) and Smith ([81], p.291, & [117]), I adopt a four-category ontology based on Chapter 2 of Aristotle's *Categories* ([3], 1a, 20 ff), which classifies possibilia according to whether they are:

1. said of or attributed to a subject or not, i.e. universals and particulars, and
2. inhering in a subject or not, i.e. accidents and substances.

I follow Lowe's usage of calling accidents *modes* ([70], p. 203); these do not only comprise qualities, states, powers, and so on, but also occurrents, i.e. events or processes. Modes are strictly dependent either on substances or on other modes,

that is, there can be modes of modes, like the shade of a colour or the velocity of a movement.

All possibilia are either particulars or universals:

Ax 4.1 $\mathcal{P}x \vee \mathcal{U}x$

Ax 4.2 $\neg(\, \mathcal{P}x \wedge \mathcal{U}x \,)$

There are existent as well as non-existent particulars. It is certainly a controversial claim whether universals are necessary entities.

Ax 4.3 $\exists x \,(\, \mathcal{P}x \wedge \mathcal{E}!x \,)$

Ax 4.4 $\mathcal{U}x \rightarrow \mathcal{N}x$

Wolterstorff amongst others has remarked that the debate between realism and nominalism is "pointless" and only decidable by "arbitrary fiat" ([134], p. 186). The bipartite scheme of universals and particulars (as defended by Armstrong [6], Lowe [70], Chisholm [23] and others) is heavily contested by the defenders of trope theory (such as Campbell [17] and Bacon [7]), who claim that talk about instantiation of universals by particulars can be eliminated in favour of talk about similarity relations between modes (which nominalists prefer to call *tropes*). However it is not obvious whether the overall theoretical balance between realism and trope nominalism is in favour of the former or the latter. I cannot go into the details of the philosophical debate about the pros and cons of realism. I just remark that realism has certainly the advantage of taking not only the view of common sense, but also that of science and technology at face value; even in such mundane disciplines as software engineering talk about universals (as in "data types" or "classes") is common practice.

The asymmetrical relation of instantiation holding between particulars and universals has already been introduced in an earlier section.

Ax 4.5 $x :: y \rightarrow \mathcal{P}x \wedge \mathcal{U}y$

The type restriction on the arguments of instantiation preclude the possibility that universals can instantiate other universals. This is indeed a position I will defend later in this paper: if one admits modes of modes, then a hierarchy of modes can do all the jobs a hierarchy of universals is presumed to do.

Instantiation is yet another way how an object can *be in* another object; here we say that a universal *is present* in a particular. However, I believe that instantiation is non-mereological, just as dependence is. In particular, with Armstrong I reject the view of particulars as bundles of universals ([5], chap. 4), a position that in any case would have to rely on the problematic principle of the Identity of Indiscernibles ([5], pp. 64-65). For the same reasons I believe that Meixner's Leibnizian conception of individuals as maximally consistent properties ([74], chap. II.2, p. 137) is equally inadequate.

The relation between kind and instance is that between type and token. The nearest (and most dangerous) analogy is the relation between a class and its members; however, sets are completely characterised by their extension, while this is notoriously not the case for kinds (cf. Wolterstorff [135], p. 240; [136], pp. 212-213). The gap between kinds and classes cannot be closed, even if one considers, like Lewis [59], necessary co-membership in classes, because this move fails to account for the difference of necessarily co-extensional kinds like "triangular figure" and "trilateral figure" ([5], pp.25-26).

An important argument for universals is their explanatory value ([70], p. 203; [59]). According to a "sparse" theory of universals as defended by Lewis and Armstrong ([6], p. 111; [59]), all kinds together should provide a minimal basis for a complete specification of how there is what there is. To adopt, with Lewis and Armstrong, the words of Plato in *Phaedros*: universals cut reality at its

joints; they provide the partitions of reality. Universals unify the objects that instantiate them and are the law-like structure of the world. Since it is essential for universals to be distinctive, there are, for each universal, particulars that possibly instantiate them and other that possibly do not.

Ax 4.6 $\mathcal{U}x \rightarrow \exists y\, \kappa_y\, y :: x \wedge \exists y\, \kappa_y \neg\, y :: x$

In a sparse theory of universals, not to every linguistic predicate there corresponds a kind of being. What universals there are is a problem to be settled by empirical science, not by ontology; with Armstrong, I opt for an *a posteriori* realism ([5], p. 87; [6], p. 25). But not only is there no one-to-one correspondence between kinds and predicates, but also no Boolean combinations of predicates denoting universals correspond themselves to universals; in this sense, Grossmann [39] is right in ruling out complex properties that are in part accepted by Armstrong ([6], p.31ff, 51ff).

Certainly there are no negative universals, as the latter would contribute nothing to the characterisation of reality ([5], p. 83; [6], p. 27). So for every universal x, there is no kind y such that it is essential, for each particular z, that z instantiates y iff z does not instantiate x.

Ax 4.7 $\mathcal{U}x \rightarrow \neg\exists y \forall z\, \varepsilon_y(\, z :: y \leftrightarrow \neg z :: x\,)$

Furthermore, as a general rule, no disjunction of kinds constitutes itself a universal ([5], pp. 82-83; [6], p. 27); indeed, as Armstrong observes, a disjunctive universal would apply to a particular already if the latter instantiated just one of the disjuncts.

Ax 4.8 $\mathcal{U}x_1 \wedge \ldots \wedge \mathcal{U}x_n \rightarrow \neg\exists y \forall z\, \varepsilon_z(\, z :: y \leftrightarrow z :: x_1 \vee \ldots \vee z :: x_n\,)$

Armstrong claims that nevertheless conjunctions of kinds are also universals as they combine specifications and refine the partition of reality ([5], p. 84; [6],

p. 28). However, Grossmann rightly rejects this view: for example, though there is a universal *winged animal* and a universal *horse*, there is no kind *winged horse* ([39], pp. 160-161). Hence, also conjunctions of universals have to be ruled out:

Ax 4.9 $\mathcal{U}x_1 \wedge \ldots \wedge \mathcal{U}x_n \rightarrow \neg\exists y \forall z \, \varepsilon_z(\, z :: y \leftrightarrow z :: x_1 \wedge \ldots \wedge z :: x_n \,)$

Since instantiation characterises both particulars and universals, Armstrong correctly assumes that uninstantiated universals do not exist ([5], pp. 75-82; [6], p. 38ff), no more than particulars without properties, so-called "bare particulars" ([5], p. 94). Note that in a Meinongian scheme, the *Principle of Instantiation* translates strictly speaking as the thesis that every universal has *existent* instances.

Ax 4.10 $\mathcal{U}x \rightarrow \exists y(\, \mathcal{E}!y \wedge y :: x \,)$

The Principle of Instantiation is the formalisation of the Aristotelian thesis of *universalia in rebus* ([5], p. 77; [6], p. 38ff), the thesis that universals are wholly present in their existing instances and have no existence outside the latter.

4.2 Inherence

The second axis of the four-category ontology is the distinction between substances and accidents or *modes*; the latter can be spatial objects like qualities, dispositions, relations, but also temporal objects like processes and events. Modes are characterised by the fact that they *inhere* in other particulars that can be themselves modes of other particulars, and so on. Lest there be an infinite regress, there must be particulars that do not inhere in any other particulars; these I will call *substances*. The object a mode inheres in, whether it be itself a substance or another mode, will be called *substrate*; as already mentioned , not every substrate is a substance. The formal definition of mode, substrate and

substance will be provided in a later section; for now I will concentrate on the characterisation of inherence.

Inherence is an irreflexive, asymmetric and intransitive relation between particulars:

Ax 4.11 $x \multimap y \rightarrow \mathcal{P}x \wedge \mathcal{P}y$

Ax 4.12 $\neg x \multimap x$

Ax 4.13 $x \multimap y \rightarrow \neg y \multimap x$

Ax 4.14 $x \multimap y \wedge y \multimap z \rightarrow \neg x \multimap z$

Furthermore, inherence is a kind of strict dependence; in contrast to Campbell ([17], p. 21), I agree with Armstrong ([5], pp. 114-115) and Lowe ([70], p. 206) that modes cannot be conceived of independently of the particulars they inhere in. The converse, namely that dependent objects are modes, is not true: the temperature of a volume of gas depends on, but is not a mode of its pressure.

Ax 4.15 $x \multimap y \rightarrow D^{\mathcal{P}}xy$

Since modes strictly depend on their substrates, the latter cannot be mere bundles of their modes, unlike what Simons [104], Campbell ([17], pp. 20-21) and Bacon ([7], p. 20) believe. With Armstrong ([5], p. 115) and Lowe ([70], p. 209), I prefer Martin's [72] "substrate-attribute" account. Inherence is stronger than mere dependence, as a mode inheres in just one substrate (I will defend the view that this holds for relational modes too). According to the scholastic principle of *non migratio*, modes cannot be swapped between particulars, they are non-transferable (Martin, as reported in Armstrong [5], p. 117 and [6], p. 115).

Ax 4.16 $x \multimap y \wedge x \multimap z \rightarrow y = z$

There seems to be solid evidence for modes, both from an analysis of the content of perception ([70], p. 205; [81], p. 304-308) and from a realist account of truth-making ([81], p. 295-304). Indeed, colours, sounds, runs, laughter and singings are the immediate objects of everyday perception, while the idea of modes as truthmakers underlies a standard event-based approach to natural language semantics, as initiated by Davidson ([25], pp. 118-119) and Parsons ([89], chaps. 1-3).

Nonetheless an ontology allowing both for universals and modes is widely regarded as somehow inconsequent. Indeed, Armstrong ([5], pp. 17 & 132), Grossmann ([40], p. 35) and Bacon ([7], pp. 85-86) believe that kinds and modes render each other redundant, so that they define a genuine ontological choice. Furthermore, Armstrong ([5], p. 133; [6], p. 115) and Moreland ([80], pp. 15-16, 98-100) argue that in a realist approach "apparent" references to modes can be analysed as references to states-of-affairs, complex entities constituted by universals and instantiating particulars. As a consequence, Künne ([56], p. 424) confesses to remaining unconvinced of the analytical utility the very notion of a particularised quality could have.

The reason why I have the cake and eat it too, is the structural opacity of states-of-affairs. Since different states-of-affairs can have the same constituents, e.g. "John's-loving-Mary" and "Mary's-loving-John", which obviously contradicts the laws of classical mereology ([5], p. 90; [6], p. 120), Armstrong decides that the mode of composition for atomic states-of-affairs must be non-mereological ([6], p. 122). However, he does not give us any hint as to the formal properties of the particular constitution he has in mind. As the how of the composition of states-of-affairs remains unclear, one had better sticking to modes, disregarding Moreland's verdict that the very adoption of such enti-

ties constitutes a slide towards (moderate) nominalism ([80], pp. 14 & 82-83). Furthermore, I reject Armstrong's proposal to view universals and (thick) particulars as (types of) states-of-affairs ([6], pp. 28-29; p. 125), which is - to some extent - shared by Johansson ([50], pp. 33-34).

4.3 Exemplification and Characterisation

To complete the Aristotelian square, there are universals of modes as well as universals of substances. In contrast to Lowe ([70], pp. 180-181), I regard mode-universals and substance-universals equally as kinds instantiated by particulars ([81], p. 295; [135], p. 260; [136], p. 228).

Wolterstorff refers to substance-kinds as *predicables* in contradistinction to mode-kinds which he calls *non-predicables* ([135], pp. 249, 256 and [136], p. 208). This dichotomy echoes Aristotle's distinction between *predication in the category of substance* (as in "Kathy is a woman") and *predication in the category of accident* (as in "Kathy is tall" or "Kathy is laughing"). This linguistic difference is a reflection of an ontological one; indeed, we say for example that Kathy instantiates the substance-kind *woman*, but *exemplifies* the mode-kind *tallness* or *laughing*. Thus, besides instantiation, there is another formal relation between particulars and universals, namely that of *exemplification* which relates a particular to a kind of one of its modes.

Df 4.1 $x.y \equiv_{\mathcal{P}x,\mathcal{U}y} \exists z\,(\,z \multimap x \wedge z :: y\,)$

Note that, as there can be modes of modes, exemplification clearly is not constrained to substances and mode-kinds, but holds also between modes and universals instantiated by meta-modes. For example, Kathy's laughter may exemplify the mode-kind *frankness*.

It has been mentioned several times that, pace Armstrong ([6], pp. 65-68), all universals are *kinds*. *Properties* are derived roles of kinds; indeed, a universal is a *property* of a particular iff it is a kind instantiated by one of the particular's modes, or, to put it differently, iff it is a kind exemplified by the particular. Instantiation is prior to exemplification; the fixation on exemplification, the diagonal of the Aristotelian square, is the mark of a wide-spread logic-induced state-of-mind that one may call, after Smith [117], "fantology".

The last formal relation to mention with respect to the Aristotelian square holds between mode-universals and other universals, be they substance-kinds or mode-kinds. Indeed, as a mode inheres in its substrate, so a mode-kind *characterises* [71] a kind of substrates. Let me illustrate this with some examples. The universal *man* is characterised by the mode-kinds *rational*, *animal*, *bipede*, *mammal*, and so on. The mode-universal *magenta* is characterised by the mode-universals *red*, *colour*, *sensory quality*, and so on. Characterisation reflects, on the level of universals, the relation of inherence: as modes are features of their substrates, so mode-kinds are features of the kind they characterise. A kind x *characterises* a kind y iff for every instance z of y, there is an instance w of x such that w inheres in z.

Df 4.2 $x \rightsquigarrow y \equiv_{\mathcal{U}x,\mathcal{U}y} \forall z(\, z :: x \rightarrow \exists w\,(\, w :: y \wedge z \multimap w\,)\,)$

I call *attribute* of a universal a mode-kind that characterises it. It can be supposed that each universal has at least one attribute.

Ax 4.17 $\mathcal{U}x \rightarrow \exists y\,(\, y \rightsquigarrow x\,)$

Now, an important assumption regarding modes is that at least and at most one of the mode-kinds they instantiate characterises a kind instantiated by their substrate.

Ax 4.18 $x \multimap y \rightarrow \exists! z \exists w \, (\, x :: z \wedge y :: w \wedge z \rightsquigarrow w \,)$

For sure, modes can be instances of many diverse kinds, but the claim is that for every mode there is exactly one kind which it instantiates that fully specifies it, in the sense that one refers to a mode as an individual redness, acuteness, roundness, craving, running, and so on. In other words, each substrate has exactly as many modes as there are kinds characterising kinds instantiated by the substrate. For example, if Kathy is a human being and the substance-kind *human being* is characterised by the mode-kinds *animality*, *rationality*, *bipedity*, and so on, then Kathy necessarily has exactly one animality-mode, one rationality-mode, one bipedity-mode, and so on.

In some cases, a mode-kind x characterises another kind y in such a way that no particular z is an instance of y unless there is an instance of x that inheres in z; in this case, I say that x *strongly characterises* y:

Df 4.3 $x! \rightsquigarrow y \equiv_{\mathcal{U}x, \mathcal{U}y} x \rightsquigarrow y \wedge \forall z (\, z :: y \rightarrow \exists w \, (\, w :: x \wedge z \multimap w \,) \,)$

When an attribute x of a kind y strongly characterises y, then x mirrors y in the sense that the instances of x are particular cases of being-of-kind-y. For example, the kinds *liver*, *bone* or *blood of group A* would be strongly characterised by the attributes *being a liver*, *being a bone*, or *being blood of group A*. Natural language reflects this fact by the many adjectivisations of nouns or nounphrases in normal usage, for example *man/human*, *planet/planetary*, *circle/circular*, *animal/animal*, and so on. Now, I assume that each universal is strongly characterised by exactly one other universal.

Ax 4.19 $\mathcal{U}x \rightarrow \exists! y \, (\, y! \rightsquigarrow x \,)$

Thus, to every universal x there corresponds exactly one universal y whose exemplification by a particular z reflects z's instantiating x. This is exactly

the difference between formal categories and material kinds: the truthmakers of statements about the instantiation of (material) kinds x by particulars y are modes of y that are instances of attributes which strongly characterise x. The statement that a particular organ instantiates the kind *liver* is made true by the particular being-a-liver of the organ. Not so for formal properties or relations: what makes statements about, for example, existence or inherence true are not particular modes of existence or inherence, but the relata themselves. To put it differently, formal categories are *internal* properties and relations, that is, properties and relations supervening on their terms, since they are nothing outside or above the objects they hold of.

It has already been pointed out that in the present account, instantiation holds between particulars and universals, but not between universals and universals. This is not to say that there are not any predicates of predicates, or classes of classes; my stance against universals of universals does not pertain to predicate logic or set theory, but to ontology. Furthermore, *formal* properties and relations like *universal* or *instantiation* are in fact higher-order universals. What is contested here is merely the necessity of allowing for material universals instantiating other material universals. Hierarchies of universals are not hierarchies of instantiation, but, as we shall see by examples, of *(strong) characterisation* and/or *subsumption*. The thesis that there are no higher-order universals (a thesis which I restrict on *material* properties and relations) is called *elementarism* and has been defended for instance by Bergmann [12].

The most common presumed examples of higher-order universals are determinables, like *colour*, *pitch*, *tonality*, and so on. For example, *colour* is presumed to be a universal instantiated by the substance-kinds *red thing*, *green thing*, *blue thing*, and so on; similarly, *tonality* is seen as a universal whose instances are the

kinds *C minor*, *G major*, etc.. However, if one admits modes or even modes of modes, then these examples can be reinterpreted in such a way as to avoid any talk about universals instantiating universals. Indeed, *red*, *green*, *blue*, and so on are kinds of optical modes and are *subsumed* by the mode-kind *colour*. Similarly, *C minor*, *G major*, and so on are kinds instantiated by sounds; according to our assumptions about strong characterisation, each sound exemplifies the mode-kinds *being in C minor*, *being in G major*, et cetera. *Tonality* can be regarded, not as a universal of universals of sounds, but a universal instantiated by particular modes of *being in C-minor*, *being in G major*, and so on.

A four-category ontology allowing both for properties in the category of universal (that is, kinds), properties in the category of particular (that is, qualities), as well as occurrences, quite naturally leads to a trope nominalism about *material* higher-order properties. Admitting particularised properties and events does not to do away with first-order universals, i.e. kinds instantiated by particulars, but avoids reference to (material) higher-order universals. Instantiations of universals by universals can be reinterpreted as characterisations (sometimes subsumptions) of universals by other universals. Thus, there is just one level of instantiation (or exemplification), as all hierarchies of kinds are seen as chains of characterisation (or subsumption) and not of instantiation.

Of course, not all higher-order universals are eliminated in this way; in fact, those universals of universals that still are with us are *formal* properties and relations, such as *existence*, *universal*, *particular*, *dependence*, *identity*, *parthood*, *inherence*, *instantiation* and so on.

These considerations are not the first attempt to draft a scheme for instantiation, exemplification and qualification; indeed, similar ideas have been suggested by Wolterstorff ([135], p. 258; [136], p. 228), Simons [105] and Lowe [71].

4.4 Substances and Modes

In the previous sections I have gathered all the necessary elements to give precise definitions of the formal categories *substance* and *mode*. As already mentioned above, a mode can be generally characterised by the fact that there is a particular it inheres in.

Df 4.4 $\mathcal{M}x \equiv_{\mathcal{P}x} \exists y\,(\,x \multimap y\,)$

In a possibilist scheme, the existence of tropes has to be explicitly assumed:

Ax 4.20 $\exists x(\,\mathcal{M}x \wedge \mathcal{E}!x\,)$

The particular that a mode inheres in is called its *substrate*.

Df 4.5 $sb(x) \equiv_{\mathcal{M}x} \iota y\,(\,x \multimap y\,)$

Furthermore, every mode instantiates exactly one universal that characterises a kind instantiated by its substrate; this particular mode-kind is called its *form*.

Df 4.6 $fm(x) \equiv_{\mathcal{M}x} \iota y \exists z\,(\,x :: y \wedge sb(x) :: z \wedge y \rightsquigarrow z\,)$

For example, a particular instantiating the kind *human* has at least modes whose forms are, respectively, *animality*, *rationality*, *bipedity*, and so on.

As discussed earlier on, the notion of substrate is relative, as modes can be substrates of other modes. Now lest there be an infinite regress there must be least elements in this ordering, particulars that do not inhere in any other object. Thus, it is possible to introduce an absolute notion of *substance* defined as the complement of the category *mode*.

Df 4.7 $\mathcal{S}x \equiv_{\mathcal{P}x} \neg\mathcal{M}x$

Again, I have to assume explicitly that there are existent substances.

Ax 4.21 $\exists x(\, \mathcal{S}x \wedge \mathcal{E}!x\,)$

My notion of substance is rather abstract and does not prejudice any of the possible ontological choices related to persistence in time. In particular, it is not inconsistent with a three-dimensionalist or endurantist conception of substances as continuants, objects that have no temporal parts and are wholly present at each moment of their existence. Indeed, this is a position I will defend later in this paper.

In adopting an abstract specification of substance in terms of inherence, I follow Aristotle who advocated this approach in *Categories* ([3], ibid.) and, at least partially, in *Metaphysics* ([4], 1017b). As a consequence, I do not see the point of restricting the notion to everyday middle-sized objects of the so-called *mesoscopic* common-sense reality as envisaged by Aristotle himself ([4], ibid.). As far as I am concerned, quarks, probabilistic particle-waves, international trusts and the Milky Way are just as regular substances as horses, plums, garden fences and persons.

It is clear that this general definition of substance has to be refined in order to be of practical use in applied formal ontology. Mereotopological characterisations as those proposed by Chisholm ([23], p. 3) and Smith [117, 118, 119], but also functional and causal specifications as those suggested by Smith [119, 121] can be the basis for the case-bound task of distinguishing types of substances, as Simons remarked in *Parts* ([103], chap. 9). In all, I do not feel, like Simons in one of his latest essays [106], the need for a leave-taking from substance, be it as differentiated as it may.

If one accepts the distinction between substances and modes, one can formally classify universals as to whether they are instantiated either by substances or modes, that is in *substantial* and *non-substantial kinds*.

Df 4.8 $\mathcal{U}^{\mathcal{S}}x \equiv_{\mathcal{U}x} \forall y\,(\,y :: x \rightarrow \mathcal{S}y\,)$

Df 4.9 $\mathcal{U}^{\mathcal{M}}x \equiv_{\mathcal{U}x} \forall y\,(\,y :: x \rightarrow \mathcal{M}y\,)$

Substantial kinds are distinguished by the fact that they are not exemplified by any particular.

Th 4.1 $\mathcal{U}^{\mathcal{S}}x \rightarrow \neg\exists y\,(\,y.x\,)$

Non-substantial kinds, however, are exemplified by particulars.

Th 4.2 $\mathcal{U}^{\mathcal{M}}x \rightarrow \exists y\,(\,y.x\,)$

Non-substantial kinds are the only properties in the category of universal to be recognised in formal ontology.

Like Armstrong ([5], p. 94) I consider it obvious that we need to exclude *bare particulars*, that is, particulars instantiating no universals. The distinction between substances and modes however implies, in the words of Armstrong ([5], p. 95; [6], pp. 109-110), the existence of a thin particular that is distinct from its modes, though it cannot be separated from them. This account is not empirically absurd, as the possibility of a purely indexical reference to items in the perceived environment indicates ([6], pp. 110-111). The idea of non-qualitative thisnesses or haecceities distinct from qualitative suchnesses has been revived by Robert Adams [1]; it has been mainly motivated by doubts concerning the Principle of Identity of Indiscernibles, as well as by semantical considerations regarding the direct rigid reference of proper names, as in the work of Saul Kripke [55].

Now Adams has pointed out that a merely contingent association between thisnesses and suchnesses, i.e. between the thin particular and its modes, would

have the absurd consequence that every particular could instantiate every universal whatsoever ([1], p. 24). Adams has suggested that there must be suchnesses a thisness is necessarily associated with, though the necessity involved could not be analytical, considering the irreducibility of thisnesses on suchnesses. The necessity of the link between thisnesses and (some) suchnesses, thin particulars and their modes, has to be synthetic: it is a brute fact that the Queen of England is not a broom stick. Adams calls *Moderate Haecceitism* the thesis that thisnesses are necessarily, though not analytically, but synthetically, connected to suchnesses.

How should one formalise this principle? Well, one can first adopt the following obvious definitions of *essential kind* and *essential mode*:

Df 4.10 $x ::_{\varepsilon} y \equiv \varepsilon_x x :: y$

Df 4.11 $x \multimap_{\varepsilon} y \equiv \varepsilon_x x \multimap y$

Moderate Haecceitism asserts that for each particular x there are essential kinds or modes of x:

Ax 4.22 $\mathcal{P}x \rightarrow \exists y\, x ::_{\varepsilon} y$

Ax 4.23 $\mathcal{P}x \rightarrow \exists y\, x \multimap_{\varepsilon} y$

Moderate haecceitism is also presupposed by a Kripkean scheme of direct reference of singular terms (cf. Kripke [55], pp. 52-53). Indeed, when we fix the reference of a name to a particular, we implicitly single out kinds essentially instantiated by that object. Though these essential kinds are not necessarily identifying, they are mandatory for determining in which circumstances a name keeps its reference. Fixing reference involves fixing (if necessary by *fiat*) stable properties that ground synthetic a priori statements about particulars. Otherwise it does not make sense to say, in Kripke's ([55], p. 113-114) example, that

this table (referring to a particular object in a lecture room at Princeton) is wooden and could under no circumstances be made of painted ice.

4.5 Relations and Extrinsicness

The present formal-ontological framework allows for single instantiation and exemplification only. Now, many authors, for example Armstrong ([6], chap. 6), regard relations as polyadic universals multiply instantiated by particulars. In a certain sense, I will advocate a form of *monadism*, the thesis that there is no multiple instantiation. Monadism does not imply that relational truths can be eliminated, as Campbell ([17], pp.99-100) rightly observed. It only asserts that the formal-ontological account of relations is not fundamentally different from that of any other kind.

Before entering into the details, let me review shortly a fundamental distinction among relations. Following Moore [76], Armstrong differentiates between *internal* and *external* relations, where the former supervene on their terms (they are, as Armstrong would say, "ontological free lunch"), while the latter do not. All formal relations like identity, parthood, dependence, are uncontroversially internal. Now, Campbell ([17], p. 101ff) and Fisk [35] have defended the position that material relations are internal, too, that is, that they, too, supervene on the nature of their terms, a thesis which is called "foundationalism". However, I would agree with Moore (ibid.) and Armstrong (ibid.) that this claim is exaggerated: material relations are external and involve mediating ties.

Another important distinction has to be made between relations in the category of universal, that is *relational kinds*, and relations in the category of particular, which I call *relational modes*. I claim that material relations (like *being a parent of*, *being the capital of*, *being a child of A and of B*) as univer-

sals are not multiply instantiated by their relata, but are, like any other kinds, singly instantiated by relational modes that bind the relata together. Relational modes, that is individual cases of *being in love with* or *being the currency in*, however do not bind the relata together by multiple inherence, but by multiple dependence.

So first of all, material relations as universals are just ordinary monadic kinds, however of modes, not substances. This means that there are no relation-kinds in the category of substance. Second, speaking of relations as particulars one thinks of a tie or link between the terms rather than of an ordered collection or a tuple constituted by the terms. The idea that there are relational modes has already been defended by Simons [105], Smith and Mulligan [82], as well as Bacon ([7], p. 8 & chap. 2).

In particular, Simons, Smith and Mulligan regard relational modes as multiply dependent moments. Since multiple dependence does not imply any order of the substrates, I propose that a relational mode is not uniformly dependent on its terms. I will concentrate on the dyadic case, as the n-adic case can be reconstructed by composition. A dyadic relational mode is strictly dependent on both terms, but *inheres* only in one of them. The particular loving of Mary by John inheres in John and is strictly dependent on Mary. Relational modes are always asymmetrical. Symmetry only appears at the level of relations as universals, when all their instances appear in correlated pairs, as for example in the case of the relation-kind *being married to*, where to each being-married of a particular x to a particular y corresponds a being-married of y to x.

If relational modes only inhere in one substrate and relation-kinds hence characterise at most one universal, what distinguishes them from what is traditionally called "relational properties", which are basically dependent modes or

mode-kinds like *being a spouse*, *being a capital*, and so on ? In a sense, I adopt the monadist thesis that relations are nothing else than relational properties, as had been believed by Aristotle ([4], 1020a-1021b; [3], 6a, 35 - 8b, 25) and his medieval followers (cf. Henninger [48]). *Relation* and *relational property* are just two ways of referring to the same formal category, just as in the case of *kind* and *property*.

I will speak of *relational properties* as *extrinsic properties*. Roughly, a property, whether mode or mode-kind, is extrinsic iff an object cannot have it provided the existence of another entity. An extrinsic property presupposes accompaniment and is incompatible with loneliness, as Lewis ([60], p. 113) put it. Formally, a mode is *extrinsic* iff it depends on some other particular than its substrate. A mode-kind is *extrinsic* iff all its exemplifications are extrinsic.

Df 4.12 $\mathcal{M}^{Ex}x \equiv_{\mathcal{M}x} \exists y\,(\,\neg y = sb(x) \wedge D^{\mathcal{P}}xy\,)$

Df 4.13 $\mathcal{U}^{Ex}x \equiv_{\mathcal{U}x} \forall y\,(\,y :: x \rightarrow \mathcal{M}^{Ex}y\,)$

Examples of extrinsic mode-kinds are *being a capital*, *being a spouse*, and so on. Accordingly, a mode is *intrinsic* iff it is not extrinsic. A mode-universal is intrinsic iff all its exemplifications are intrinsic. *Being a lump of gold* or *human* are both intrinsic.

Df 4.14 $\mathcal{M}^{In}x \equiv_{\mathcal{M}x} \neg\mathcal{M}^{Ex}x$

Df 4.15 $\mathcal{U}^{In}x \equiv_{\mathcal{U}x} \forall y\,(\,y :: x \rightarrow \mathcal{M}^{In}y\,)$

This is an approximation to the so-called non-qualitative account of intrinsicness proposed by Dunn [29] after Moore ([77], p. 187), an account that, by the way, has been reformulated and contested by Lewis ([60], p. 113) in a reply to Kim [53] (cf. Humberstone [49] for an overview over the debate).

From the formal-ontological point of view, relations are just extrinsic mode-kinds. Indeed, all that is needed to connect the relata (like capitals and countries or husbands and wifes) are extrinsic modes like the particular cases of *being a spouse* or *being a capital*. It is only in predicate calculus that an absolute distinction between polyadic relations and monadic relational properties has to be drawn, but ontology is not logic, nor is it set theory. *Being a planet* and *being a planet of* or *being a cell* and *being a cell of* are just two ways to speak about the same universal respectively. However, we have also the intution that extrinsicness alone does not make a universal relational. The additional requirement is that a relation-kind be *typed*, that is, that its relata be from given kinds; for example *being the capital of* relates instances of the kinds *city* and *country*. Also, an extrinsic mode is relational iff it instantiates a relational kind.

This gives us all the indications needed for a formal-ontological account of relationality. First I define what it means for a mode to (dyadically) link two particulars, or to link its substrate with some other particular.

Df 4.16 $x \infty y z \equiv_{\mathcal{P}x,\mathcal{P}y,\mathcal{P}z,\neg x=z,\neg y=z} sb(x) = y \wedge D^{\mathcal{P}} x z$

N-adic linking can be defined as a composition of n-1 dyadic linkings. An n-adic linking mode x is the mereological sum of dyadic modes that constitute a chain whose first term is also the substrate of x.

Df 4.17 $x \rho y_1 \ldots y_n \equiv_{\mathcal{P}x,\mathcal{P}y_1,\ldots,\mathcal{P}y_n} sb(x) = y_1 \wedge$
$\exists z_1 \ldots z_{n-1} (x = z_1 + \ldots + z_{n-1} \wedge \forall i (i < n \rightarrow z_i \infty y_i y_{i+1}))$

As an example take a particular mode consisting in Mary's *being a daughter of* John *and* Joanne; indeed, we can regard this mode as being composed of Mary's being a daughter of John and John's being the husband of Joanne.

A universal x *relates* other universals $y_1 \ldots y_n$ iff for all instances $z_1 \ldots z_n$ of y_1 to y_n, there is exactly one mode w instantiating x such that w links $z_1 \ldots z_n$.

Df 4.18 $x\mathcal{R}y_1 \ldots y_n \equiv_{\mathcal{U}x,\mathcal{U}y_1,\ldots,\mathcal{U}y_n} \forall z_1 \ldots z_n \exists! w \, (\, z_1 :: y_1 \wedge \ldots \wedge z_n :: y_n \wedge w :: x \rightarrow w\rho z_1 \ldots z_n \,)$

A universal is an *(n-ary) relation* iff it relates other universals.

Df 4.19 $\mathcal{U}^{\mathcal{R}}_n x \equiv_{\mathcal{U}x} \exists y_1 \ldots y_n \, (\, x\mathcal{R}y_1 \ldots y_n \,)$

Df 4.20 $\mathcal{U}^{\mathcal{R}} x \equiv_{\mathcal{U}x} \exists n \mathcal{U}^{\mathcal{R}}_n x$

A mode is *(n-ary) relational* iff it links other particulars, provided it instantiates a relation. Linking alone does not constitute the relational character of a mode.

Df 4.21 $\mathcal{M}^{\mathcal{R}}_n x \equiv_{\mathcal{M}x} \exists y_1 \ldots y_n \, (\, x\rho y_1 \ldots y_n \,) \wedge \exists y \, (\, \mathcal{U}^{\mathcal{R}}_n y \wedge x :: y)$

Df 4.22 $\mathcal{M}^{\mathcal{R}} x \equiv_{\mathcal{M}x} \exists n \mathcal{M}^{\mathcal{R}}_n x$

Non-relational universals or *non-relational modes* are intrinsic and vice versa.

Df 4.23 $\mathcal{U}^{\neg\mathcal{R}} x \equiv_{\mathcal{U}x} \neg \mathcal{U}^{\mathcal{R}} x$

Df 4.24 $\mathcal{M}^{\neg\mathcal{R}} x \equiv_{\mathcal{M}x} \neg \mathcal{M}^{\mathcal{R}} x$

5 Time and Temporal Modality

5.1 Spatial and Temporal Objects

In the previous sections I have defined substances as the least elements in the chains of inherence. Further refinements of the notion of substance, especially through mereotopological or causal characterisations, are possible. In particular, I want to defend in this section a rather traditional account of (contingent) substances as *continuants*, or spatial objects.

In a nowadays almost mythical passage of his *On the Plurality of Worlds* ([61], p. 202), Lewis distinguishes between two ways of persisting, i.e. existing in time, namely *endurance* and *perdurance*. A perduring object persists by having a different temporal part at each time, while an enduring object is wholly present at each instant of its existence. It is less known that this distinction had been anticipated by Zemach [137], who described four types of ontologies of space and time, of which the first (the ontology of *events*) contains objects that have have both spatial and temporal parts (ibid., pp. 233-234), while the second (the ontology of *things*) embraces individuals that have only spatial parts and continue in time (ibid., pp. 234-236). In quasi-popular terms, the ideology that all substances are perdurants is often called "four-dimensionalism", while the more conservative view that there exist enduring substances is frequently branded as "three-dimensionalism", despite the fact that this terminology is far from being scientifically correct, as physicists recently have told us that we unwittlingly live in a world of ten spatial and one temporal dimension. For my part, I prefer the neologisms "perdurantism" and "endurantism", even though I will occasionally slip back into popular slang.

It seems that perdurantism is quite wide-spread in the faculties of philosophy. For once agreeing with Lewis ([61], p. 203), Armstrong is convinced that temporal parts are the best explanation for persistence ([6], pp. 99-103). Perdurantism has been advocated by Quine ([93], p. 171; [95], pp. 65-66), devotedly followed by Heller ([46], chap. 1; [47]), who both claim that each filled region of Minkowski spacetime constitutes a substance, and most recently by Sider ([101], pp. 1-10, pp. 188-208) and Hawley ([45], chap. 2), who both prefer to regard only *stages*, that is the contents of filled non-overlapping (instantaneous?) space-time regions, as the basic ontological category. Even Peter Simons, who

firmly defended endurantism with respect to substances in *Parts* ([103], pp. 129 and chap. 5), has recently drifted towards a position that does not completely embrace perdurantism, but does allow for substances to supervene on events as "invariants under ... [suitable] equivalence" relations ([107], pp. 428, 432).

For a number of reasons, endurantism seems both problematic and outdated to many ontologists. One issue advanced in the case against endurantism I will not extensively discuss here is *coincidence*. Some researchers (e.g. Heller [46], pp. 30-32 and Sider [101], chap. 5, pp. 141-142) seem to regard the idea that two different enduring objects could be temporarily spatially co-located as scandalous; examples based e.g. on the spatial overlap of artifacts or organisms and the stuff they are made of, or on undetached parts (after whose removal the host object collapses with the remainder) are commonly put forward as puzzles.

Besides the fact that endurantists can more or less elegantly deal with these puzzles by temporalising the involved formal properties of parthood and identity (e.g. Simons [103], chap. 5), it is quite known that cases of coincidence can also be cited with respect to fourdimensional objects (cf. Simons [103], pp. 121-122 and Van Inwagen [129], pp. 118-120). To borrow an example of Alan Gibbard [38], just consider the space-time worms of a statue and the material, say clay, it is made of and suppose that both come and go out of existence at the same time. Obviously they are spatio-temporally coincident, though they are non-identical as they have divergent modal features: the statue could survive a replacement of a piece of clay, while the lump of clay could not. One can dismiss such examples by waving the argument that artefacts actually are purely conventional, as Heller ([46], p. 39ff) proposes for any object besides the brute contents of spatio-temporal regions. Leaving aside all reservations regarding such reductionism, one is free to doubt whether this line of argumentation is

adequate in the case of natural objects such as organisms and the materials they are made of.

Anyway, I do not intend to address the so-called puzzles of coincidence as I am convinced that they have nothing to do with time whatsoever, but are the logical consequence of the thesis that identity is both absolute and necessary. This has been shown by Saul Kripke ([55], pp. 144-155) and is conceded by Lewis [57] and Sider ([101], pp. 223-224), who both prefer to go down the slippery road of identities under multiple counterpart relations (which in the present paper is avoided by invoking the principle of the invariance of identity under counterparthood). I believe that the simplicity and transparence of absolute identity outweighs any considerations of ontological parsimony and that relations of similarity should not, for the sake of intellectual honesty, be camouflaged as relative identities. If modal variability suffices to entail diversity under spatial and temporal co-location, so be it. Scruples regarding coincidence are induced by a fixation on spacetime together with a mistaken belief in identity criteria. Furthermore I believe that the non-transitive mereological relation of strict parthood that allows one to distinguish levels of aggregation and granularity *inside* a given ontological view, is an adequate way to formalise philosophical intuitions about constitution and coincidence.

One issue related to endurantism which will be fully addressed in this paper is the problem of temporary intrinsics that has been first formulated by Lewis ([61], pp. 202-204). This is the question whether temporalisation, which is cherished by endurantists as a means to deal with identity through change, is consistent with intrinsic properties. Indeed, it seems that temporalising properties transforms them into relations to times, which would mean that there are no non-relational properties. I will analyse this quandary later in this section

and sustain that the seeming incompatibility actually disappears if one treats temporalisation in a modal framework, e.g. in a temporal counterpart theory.

Before going on I should emphasise that I do not see the subject *endurantism vs. perdurantism* as an issue about truth or falsity; nor do I consider it a *pari ontologique*. Indeed, one can concur with Barry Smith's ([121]; personal communication, July 2002) insight that perdurantism and endurantism are not competing ontologies, but just two ways of trawling through reality. Each of these perspectives may have its advantages and disadvantages: according to which view we take, some aspects of reality will go out of focus. In particular, I will defend an endurantist approach to temporality as I am convinced that for some purposes it is the right way to describe reality. The main motivation for distinguishing between spatial and temporal objects is that there is an obvious asymmetry, even dependence, of some temporal features on spatial features. Events *realise* dispositions [121] of spatial objects, e.g. the crumbling of a bridge is the temporal unfolding of a spatial feature of the construction, namely its instability. This asymmetry cannot be easily accounted for in fourdimensionalism.

First a minimal formal specification of spatial and temporal objects shall be sketched. According to the early Simons ([103], chaps. 4 & 5) and the later Chisholm ([23], chaps. 10 & 11), contingent things can be partitioned into *continuants* ("$\mathcal{K}x$") and *occurrents* ("$\mathcal{O}x$"), i.e. *spatial* and *temporal* objects.

Ax 5.1 $\mathcal{C}x \leftrightarrow_{\mathcal{P}x} \mathcal{K}x \vee \mathcal{O}x$

Ax 5.2 $\mathcal{K}x \leftrightarrow_{\mathcal{C}x} \neg\mathcal{O}x$

Universals can be divided into kinds of continuants and kinds of occurrents.

Df 5.1 $\mathcal{U}^{\mathcal{K}}x \equiv_{\mathcal{U}x} \forall y\,(\,y :: x \rightarrow \mathcal{K}y\,)$

Df 5.2 $\mathcal{U}^{\mathcal{O}}x \equiv_{\mathcal{U}x} \forall y\,(\,y :: x \rightarrow \mathcal{O}y\,)$

The distinction between continuants and occurrents has to be understood in the absolute sense: continuants and occurrents do not overlap.

Ax 5.3 $\mathcal{K}x \wedge \mathcal{O}y \rightarrow \neg Oxy$

An explicit existential assumption is made both for continuants and occurrents.

Ax 5.4 $\exists x(\, \mathcal{K}x \wedge \mathcal{E}!x \,)$

Ax 5.5 $\exists x(\, \mathcal{O}x \wedge \mathcal{E}!x \,)$

According to the Aristotelian stance of this paper, substances are either necessary particulars or continuants.

Ax 5.6 $\mathcal{S}x \rightarrow \mathcal{N}x \vee \mathcal{K}x$

No occurrent is a substance: indeed, all events are modes. However, some modes (like qualities or dispositions) are continuants.

Ax 5.7 $\mathcal{O}x \rightarrow \mathcal{M}x$

Ax 5.8 $\exists x\,(\, \mathcal{M}x \wedge \mathcal{K}x \,)$

Since occurrents are modes, they can be singled out by their substrate as well as their form, that is that universal they instantiate which characterises a kind instantiated by their substrate. Occurrents are particular *runnings*, *cravings*, *sleepings*, *writings*, and so on. An Aristotelian discrimination of occurrents, then, is more fine-grained than Davidson's causal criterion ([27], p. 179), but allows for fewer temporal entities than Kim's [52] and Chisholm's ([23], chap. 10, pp. 72, 78) conception of events as "property exemplifications". Leaving aside that Kim and Chisholm, both true fantologists, obviously confuse instantiation with the diagonal of exemplification that relates a substrate to a mode-kind, it

has to be pointed out that a sparse theory of universals reduces the cardinality of possible event types that - as forms - constitute the characteristic property of occurrents. In other words, events can be mapped onto universals that cut reality at its joints; a sparse theory of universals thus entails a sparse theory of occurrents.

For each continuant, there is at least one occurrent that inheres in it.

Ax 5.9 $\mathcal{K}x \rightarrow \exists y\,(\,\mathcal{O}y \wedge y \multimap x\,)$

The *life* of a continuant x is that occurrent that inheres in x and contains as parts all temporal modes that have x as a substrate.

Df 5.3 $\beta(x) \equiv_{\mathcal{K}x} \iota y\,(\,\mathcal{O}y \wedge y \multimap x \wedge \forall z\,(\,\mathcal{O}z \wedge z \multimap x \rightarrow Pzy\,)$

Every continuant has its own life and each occurrent is the life of at most one continuant. This strict correspondence between spatial and temporal objects underlies the unity of space and time.

5.2 Places and Times

Thus far I have distinguished only continuants from occurrents without making precise in what their difference consists. Intuitively, continuants are spatial, occurrents temporal contingents; continuants have a place, while occurrents take time. *Place* and *time* presuppose the relations of *(spatial and temporal) inclusion*. In contrast to parthood, spatial and temporal inclusion can be cross-world relations, that is, they can hold of objects that are not compossible.

The present account follows Chisholm ([23], chap. 9) and Sider ([101], p. 14) in adopting the *eternalist* view or *B-theory* of time: past, present and future are assumed to exist *sub specie aeterni*. This view has to be contrasted with *presentism* according to which only the present exists, a position defended e.g.

by Zimmermann [138]. Maybe I should point out that the bird's eye perspective of time is quite common in science and everyday life and the fact that we can draw landscapes of spacetime of limited, though astronomical, dimensions is quite consistent with the fact that the God's eye view is reserved to the divinity alone. Second, in an eternalist perspective, the place associated with a continuant is "blurred", but nonetheless uniquely attributable (project the corresponding space-time worm in a perdurantist ontology from space-time into space). Third, one should take the word "space" *cum grano salis*, not only because science tells us that three dimensions are not enough, but also because for some objects, like mobile software agents, a more abstract category of space (with more or less dimensions) than that of commonsense seems to be adequate.

Spatial inclusion is a relation of partial order defined over continuants.

Ax 5.10 $x \sqsubseteq_s y \rightarrow \mathcal{K}x \wedge \mathcal{K}y$

Ax 5.11 $\mathcal{K}x \rightarrow \exists y\,(\,x \sqsubseteq_s y \vee y \sqsubseteq_s x\,)$

Ax 5.12 $\mathcal{K}x \rightarrow x \sqsubseteq_s x$

Ax 5.13 $x \sqsubseteq_s y \wedge y \sqsubseteq_s x \rightarrow x = y$

Ax 5.14 $x \sqsubseteq_s y \wedge y \sqsubseteq_s z \rightarrow x \sqsubseteq_s z$

Parthood between continuants implies spatial inclusion.

Ax 5.15 $Pxy \rightarrow_{\mathcal{K}x,\mathcal{K}y} x \sqsubseteq_s y$

Spatial co-location is mutual spatial inclusion; identical continuants are spatially co-located.

Df 5.4 $x \cong_s y \equiv x \sqsubseteq_s y \wedge y \sqsubseteq_s x$

Ax 5.16 $x = y \rightarrow_{\mathcal{K}x,\mathcal{K}y} x \simeq_s y$

Likewise, *temporal inclusion* is a relation of partial order between occurrents.

Ax 5.17 $x \sqsubseteq_t y \rightarrow \mathcal{O}x \wedge \mathcal{O}y$

Ax 5.18 $\mathcal{O}x \rightarrow \exists y\,(\,x \sqsubseteq_t y \vee y \sqsubseteq_t x\,)$

Ax 5.19 $\mathcal{O}x \rightarrow x \sqsubseteq_t x$

Ax 5.20 $x \sqsubseteq_t y \wedge y \sqsubseteq_t x \rightarrow x = y$

Ax 5.21 $x \sqsubseteq_t y \wedge y \sqsubseteq_t z \rightarrow x \sqsubseteq_t z$

Parthood between occurrents implies temporal inclusion.

Ax 5.22 $Pxy \rightarrow_{\mathcal{O}x,\mathcal{O}y} x \sqsubseteq_t y$

Temporal co-location is mutual temporal inclusion; identical occurrents are temporally co-located.

Df 5.5 $x \cong_t y \equiv x \sqsubseteq_t y \wedge y \sqsubseteq_t x$

Ax 5.23 $x = y \rightarrow_{\mathcal{O}x,\mathcal{O}y} x \simeq_t y$

Chisholm ([23], pp. 55-56 & 96-97) argues that assuming times and places means multiplying categories beyond necessity, as they - so he maintains - are ultimately identified through occurrents and continuants respectively. He explicitly refers ([23], p. 60) to Russell's [100] proposal to reconstruct times as equivalence classes of events under the relation of temporal overlap. However, absolute space and time have their defenders, too, like Johansson who has emphasised the distinction between "relational" ([50], pp. 149-154) and "container" ([50], pp. 146-149) space, insisting that actual space *is* container space ([50], p. 152ff). Again, taking a position in this difficult debate is outside the scope of this paper. For my purposes, I will just need places and times as spatial or

temporal cross-sections through the realm of possibilia, comparable to the levels of granularity for strict parthood.

So I assume *places* or *spatial locations* ("$\pounds_s x$") and *times* or *temporal locations* ("$\pounds_t x$") as maximal wholes under the equivalence relations of spatial and temporal co-location. In other words, a spatial or temporal location is a continuant or occurrent that contains as parts all objects that are spatially or temporally co-located with it.

Df 5.6 $\pounds_s x \equiv_{\mathcal{K}x} \forall y\,(\,y \simeq_s x \rightarrow Pyx\,)$

Df 5.7 $\pounds_t x \equiv_{\mathcal{O}x} \forall y\,(\,y \simeq_t x \rightarrow Pyx\,)$

Instants are atomic temporal locations.

Df 5.8 $\mathcal{I}x \equiv_{\pounds_t x} \neg\exists y\,(\,\pounds_t y \wedge Pyx\,)$

In the following I will make the assumption that each temporal location is ultimately composed of instants. Formally, any part of an interval that is also an interval has instants as parts. The claim that time is granular is consistent with quantum physics.

Ax 5.24 $\pounds_t x \rightarrow \forall y\,(\,\pounds_t y \wedge Pyx \rightarrow \exists z\,(\,\mathcal{I}z \wedge Pzy\,)\,)$

Each continuant or occurrent is part of one spatial or temporal location.

Ax 5.25 $\mathcal{K}x \rightarrow \exists!y\,(\,\pounds_s y \wedge Pxy\,)$

Ax 5.26 $\mathcal{O}x \rightarrow \exists!y\,(\,\pounds_t y \wedge Pxy\,)$

This may seem counterintuitive in the case of continuants, but one has to bear in mind that they are looked at from the eternalist bird's eye perspective. Their spatial extension corresponds, in a perdurantist ontology, to the mereological

sum of the spatial extensions of stages. Likewise, as each occurrent has exactly one duration, and each continuant has exactly one life, it follows that to each spatial object corresponds a definite maximal duration. Now, fourdimensionalists argue that endurantism is untenable because persistence conditions for enduring objects - so they claim - are vague ([46], chap. 3, pp. 72-74 & 106-108; [101], chap. 4, pp. 120-139). Now, even if the worst case scenario would be true, namely that at each subinterval of a life's duration, a continuant would come into and go out of existence, the only consequence would be a multiplication of spatial objects, but not the existence of fourdimensional objects. A multiplication of spatial objects with overlapping lives should indeed be a nightmare for most endurantists, but it is not inconsistent with an Aristotelian distinction between spatial and temporal objects.

Also one should note that, at least according to my account, continuants have no temporal location, though their lives do. Any mereological sum of spatial and atemporal objects is just another spatial and atemporal object. Thus, pace Sider ([101], pp. 135-139), the perdurantist thesis does not follow from the multiplication of continuants with overlapping lives, even if one assumes a function from spatial objects into the temporal intervals corresponding to their respective lives' durations, as well as unrestricted mereological composition. Let x and y be two spatial objects, where a) t is the duration of the life of x and t' the duration of the life of y and b) s is the spatial extent of x and s' the spatial extent of y. It is just mistaken to assert that the sum of x and y would be a spatiotemporal object of duration $t+t'$ - on the contrary, $x+y$ can be nothing else than a spatial object whose place is $s+s'$ and whose life lasts throughout $t+t'$. Thinking it could be otherwise only rests on a confusion between "having a duration t" and "having a life that lasts throughout an

interval t" - it involves erronously attributing one's own perdurantist stance to the endurantist opponent.

While discussing Moderate Haecceitism, I pointed out that fixing the reference of a name implies also singling out essential kinds exemplified by the referent. These kinds are not supposed to be individuating, but their exemplification constitutes a necessary condition for there being a reference. However, it is not always the case that such clusters of kinds are sufficient as criteria of persistence. Especially if spatial and temporal boundaries are not clearly specifiable, there will be a multiplicity of candidates equally matching the requirements and thus questions of singular reference will have no definite answer. Vagueness, which is, so Lewis ([63], p. 170; [61], p. 212), nothing else than *semantic indecision*, concerns endurantism and perdurantism alike, and can receive the same treatment in both frameworks. In an elegant paper [63], Lewis proposes to deal with cases of vagueness as cases of partial identity, i.e. extensive overlap, of competing candidates for reference ([63], pp. 177-179). The various possible referents of *this cloud*, pointing to a particularly fuzzy cumulo-nimbus on a stormy autumn day, are many, but almost one, as each candidate almost entirely overlaps with the rest. However, as Lewis ([63], p. 179ff) concedes, this original approach has to be complemented by a supervaluational treatment of vagueness (as sketched in Smith and Brogaard [120]).

5.3 A Temporal Counterpart Theory

Under the bird's eye perspective of time, as Van Inwagen remarks ([129], p. 116), there is no way to speak about temporary identity, parthood, inherence or exemplification unless one introduces some explicit reference to a time. For an occurrent, this is easy enough: just take its slice at the time your are interested

in and you are done. In the case of a continuants, however, it seems that a more drastic measure is required: that of dropping atemporal properties and relations in favour of temporalised ones, i.e. relations with an explicit time parameter.

David Lewis ([61], pp. 202-204; [65], pp. 1-4) has argued that just this is incompatible with temporary intrinsic properties. Indeed, temporalising non-relational properties, so Lewis, changes them into extrinsic ones. In my terms: there would be no intrinsic mode-kinds, just relational ones, whose instantiations would be dependent on a particular time. According to Lewis (ibid.), only three alternatives are available: either one has to deny that there are temporary intrinsics, or to affirm that only what is present exists, or one must go for perdurantism: as we have seen for occurrents, an ontology of processes would allow for temporary intrinsics simply to be instantiated by phases of perdurants.

As already mentioned, presentism is defended by Dean Zimmermann [138] as a solution to the problem of temporary intrinsics, but this way out is not available to me, as I have already opted for an eternalist approach to time. Van Inwagen ([129], p. 116) embraces whole-heartedly the first choice, taking temporalised properties as primitive and regarding atemporal ones as derived. The present framework then would have to be changed completely, dropping e.g. atemporal parthood in favour of temporary parthood. With some qualms one might allow for exemplification to be a three-placed relation involving a particular, a universal and a time, and similarly for inherence - though I would think it would introduce an implicit dependence to time and thus exclude intrinsicness. But temporalised mereology seems formally far too obscure to me to be acceptable. Indeed, reflexivity, symmetry and transitivity would only hold with respect to fixed intervals; this and other complications involved by such a revision let me prefer the atemporal way of doing ontology.

I would agree with Lewis also in that we need to reject Mark Johnston's ([51], p. 129) proposal to temporalise the copula, which in my framework would correspond to adding a time parameter to instantiation and inherence. First, Lewis is right in protesting that this way round leads down the slippery road of relationality ([65], p. 5). Second, we would not be done by only temporalising exemplification and inherence - parthood, dependence and other formal notions would have to be manipulated too, thus leading to formal complications nobody has solved so far (despite the heroic effort of Simons in [103], chap. 5).

But is perdurantism any better in dealing with temporary intrinsics? Sally Haslanger ([44], pp. 119-120) rightly points out that even in a fourdimensionalist framework, temporary intrinsics are not simply had by the persisting objects; in fact, it is not the perdurer that instantiates the mode-kind, but a temporal part of it. Lewis replies ([65], p. 5) that speaking about perdurants we sometimes restrict the scope of our quantifiers to their present phases. However this rejoinder is far from convincing, as it does not contradict that, strictly speaking, perdurants, too, don't exemplify intrinsic mode-kinds *simpliciter*.

Haslanger ([44], p. 120f), following a proposal of Lowe [68], develops the idea that the time parameter, instead of modifying the copula, actually applies to whole statements about exemplification and, we might add, inherence, parthood, dependence as well as other formal properties. Instead of "the rose is red at t", one should say "the proposition, that the rose is red, is true/obtains at t". In other words, what she suggests is rather similar to a hybrid temporal logic based on the operator "$@_t$" ("true at t"), that extends classical modal logic with so-called "nominals" allowing direct reference to intervals, as well as operators binding them (for an overview cf. Blackburn & Tzakova [14]). Explicit reference to instants or intervals as a means for reasoning about time has been proposed

for a long time both in logic (cf. Prior [92], p. 107) and artificial intelligence (cf. Allen [2], pp. 127-131). In philosophy, very similar thoughts have been recently expressed by Judith Jarvis Thomson, who (probably unwittingly) uses a modal temporaliser in her version of a mereology for continuants ([127], pp. 214-218), and Trenton Merricks, who in a footnote of one of his articles ([75], p. 177, fn. 15) hints, with respect to temporalisation, at a parallel between times and possible worlds.

I believe that treating temporalisation in a modal framework is the right approach which leaves the whole structure of the present formalisation of formal ontology undisturbed and avoids a pervading relationalism about (mode-) kinds. Nonetheless, even leaving aside the fact that it would not be a good idea to try to do the job mathematicians are best trained for, it is the philosophers' task to understand what it means *ontologically* for a certain property or relation to hold at a given time. Note that abstract set-theoretic models are devices to establish mathematical proofs of correctness, but have only a very limited utility for metaphysical analyses. Thus the ontology of temporal statements formed by the modal operator "$@_t$" is still to be clarified. This delimits the scope of the present inquiry: it is neither my intention to sketch an alternative version of hybrid modal logic nor to indicate an ontological reading for any full-blown tense or interval logic. My objective is just to give an ontological meaning to elementary temporal statements of the forms: "$@_t\phi$", "$\forall t@_t\phi$", "$\exists t@_t\phi$" respectively, where ϕ is a formula consisting of a monadic or dyadic formal predicate and at least one variable or name ranging over or referring to a contingent particular. Furthermore, the temporal parameter t will be restricted to *instants* as atomic intervals; as all intervals are supposed to be composed of instants, time points are all that is needed for a proof of concept.

It has been shown how the ontology of modality can be based on a reasonably constrained variant of counterpart theory, where possibilia play the role of auxiliary truth-makers for modal statements about existing or non-existing objects. Similarly, it would seem, counterpart theory could be fruitfully applied to the ontology of time. Then what could be the truthmakers for temporal statements about contingent objects? In the case of occurrents, the right counterparts are simply their temporal parts. But for continuants, the matter is different. Van Inwagen is right when he criticises the naive analysis of complex nominal phrases like "Smith in the year 1992" or "London at the Age of Enlightenment" as referring to stages of perdurants; indeed, temporal modifiers should be constructed as applying to the verb of an implicit relative phrase, not to the noun phrase of the main sentence ([130], pp. 126-128).

A suitable temporal counterpart for a given continuant c would be a non-existing possible object whose life is a duplicate of, as well as temporally co-located with, an instantaneous slice of the life of c. E.g. "Smith is an undergraduate" obtains at a certain instant t iff any object *Psmith* of Smith, such that *Psmith*'s life is a temporally co-located duplicate of Smith's life at t, is an undergraduate *simpliciter*. As essential counterparts of objects can be regarded as *powers* inhering in the latter, so temporal counterparts of continuants represent *total states* or *snapshots* of the objects at given instants. Though there is no existing continuant that is the referrent of the expression "Smith at t", there is a non-existing Meinongian object that constitutes a snapshot of Smith at t.

It is obvious that not every instantaneous possible continuant can be, as a general rule, an *essential* counterpart of an existing continuant. While it is imaginable that some qualities are of instantaneous duration, for example the temperature or the pressure of a gas, it can in general be ruled out that, even

contrafactually, any existing, that is, actually subsisting substance is momentary. You are not such that you could have come into existence fully grown, clothed and brushed just ten minutes ago and vanished into thin air merely an instant later. Now, while instantaneous substances are not essential counterparts of any real object, they can still be regarded as real possibilities. First, they conform to any mereotopological or causal specification of substances, besides, of course, constraints as to the minimal duration of their life. Second, they represent snapshots or total states of possible as well as real substances.

In order to specify temporal counterparthood, I need first to define what it means a) to be the stage of an occurrent during an instant and b) to be the duplicate of an occurrent. For each instant i of an occurrent's x duration, the *stage of x at i* is that occurrent which is part of x, is located at i and contains all parts of x located at i.

Df 5.9 $\chi_i x \equiv_{\mathcal{I}i,\mathcal{O}x,Oxi} \iota y\,(\,Pyx \wedge L_t yi \wedge \forall z\,(\,Pzx \wedge L_t zi \rightarrow Pzy\,)\,)$

An occurrent x is a *duplicate* of an occurrent y iff x is temporally co-located with y and both exemplify the same material kinds.

Df 5.10 $DPxy \equiv_{\mathcal{O}x,\mathcal{O}y} x \simeq_t y \wedge \forall z\,(\,x :: z \leftrightarrow y :: z\,)$

One can now specify the temporal counterpart relation for occurrents as well as continuants. An occurrent x is the temporal counterpart of an occurrent y at an instant i iff x is the stage of y at i.

Df 5.11 $CP_i^{\tau,\mathcal{O}} xy \equiv_{\mathcal{O}x,\mathcal{O}y} x = \chi_i y$

A continuant x is a temporal counterpart of a continuant y at an instant i iff the life of x is a duplicate of the stage of y's life at i.

Df 5.12 $CP_i^{\tau,\mathcal{K}} xy \equiv_{\mathcal{K}x,\mathcal{K}y} DP\beta(x)\chi_i\beta(y)$

I assume that for each continuant, there is exactly one temporal counterpart at a given instant:

Ax 5.27 $CP_i^{\tau,\mathcal{K}}xz \wedge CP_i^{\tau,\mathcal{K}}yz \rightarrow x = y$

This assumption is trivial for occurrents, as an occurrent cannot have more than one stage at each instant. In the following, only a general notion of temporal counterparthood will be required:

Df 5.13 $CP_i^{\tau}xy \equiv_{\mathfrak{C}x,\mathfrak{C}y} CP_i^{\tau,\mathcal{O}}xy \vee CP_i^{\tau,\mathcal{K}}xy$

The next task is to list the formal relations involving contingent particulars that can be sensibly temporalised. I assume that these are *subsistence, dependence, (simple and strict) parthood, identity, instantiation, inherence* and *spatial co-location* as well as any formal relations that can be defined on the basis of the latter. In particular, neither counterparthood nor compossibility can be considered for temporalisation, as they already form the backbone of modality. As to existence, no temporal counterpart of substances can possibly have it, in other words, none of them is actual.

The fact that existence as actual subsistence cannot be temporalised is the price to be paid for an actualist scheme of essential and temporal counterparthood. Since it is possible to temporalise subsistence, however, there is a way to provide an equivalent for *(temporal) presence* in the current framework. One does not need to concur with Simons's thesis that the only truthmakers for statements about the temporal presence of continuants are their lives ([107], p. 422ff). Thus his claim that talk about substances supervenes on talk about occurrents ([107], p. 428ff) remains unfounded.

In order to demonstrate how temporal counterpart theory works, one only needs to show how atomic statements involving the formal relations listed above

can be temporalised. As already mentioned, it is sufficient to implement a very elementary hybrid logic based on the operator "$@_i$" ("at instant i") in the framework of temporal counterpart theory. The semantics of the operator "$@_i$" will be defined for formulas with two free variables ranging over contingent objects (continuants or occurrents); the one-variable case can be easily extrapolated.

A formal relation ϕ holds of two contingent objects at an instant i iff it obtains for any of their temporal counterparts at i.

Df 5.14 $@_i\phi(x_1, x_2) \equiv_{\mathfrak{I}i, \mathfrak{C}x_1, \mathfrak{C}x_2} \forall y_1 y_2 (CP_i^{\tau} y_1 x_1 \wedge CP_i^{\tau} y_2 x_2 \rightarrow \phi(y_1, y_2))$

How are temporalised statements related to non-temporalised ones ? As Van Inwagen ([129], p. 116) has remarked, contingent objects satisfy an untemporalised formula ϕ iff they satisfy its temporalisations $@_i\phi$ for each instant i at which they subsist.

Ax 5.28 $\phi(x_1, x_2) \leftrightarrow_{\mathfrak{C}x_1, \mathfrak{C}x_2} \forall i (@_i \mathcal{B}x_1 \wedge @_i \mathcal{B}x_2 \rightarrow @_i\phi(x_1, x_2))$

This concludes my sketch of a temporal counterpart theory. There are obvious affinities to the stage theory of Sider ([101], p. 193ff), as far as occurrents are concerned, and to Chisholm's theory of *entia successiva* ([21], pp. 98-104; [22], p. 76ff), as far as continuants are concerned, with the important difference that in my account, there are no *existing* instantaneous substances.

6 Subjectivity as Modality

At the end of this outline of formal ontology, I would like to make some concluding remarks about the connections between ontology, that delimits the realm of the objective, and a theory of subjectivity. Though the latter belongs to the scope of epistemology, it is appropriate to sketch the ways in which even

the subjective is grounded ontologically, if only to forestall the usual relativistic claims.

In a classic paper on the philosophy of mind, Thomas Nagel, though notably not a subjectivist, has argued that by attributing consciousness to an organism, we ascribe to it a particular way of what it is like to be that organism *for* that organism. In other words, Nagel maintains that the subjective character of experience is linked to a particular point of view specific to the experiencer ([84], pp. 436-437). Now, given that "objective" *implies* "to be accessible from any point of view whatever", it is difficult to believe that the subjective character, being a specific first-person perspective, could be reducible to objective facts about physical events such as the firings of neurons ([84], pp. 443-445). Nagel mainly discusses physicalist variants of reductionism, but it is obvious that the same argument concerns any attempt to analyse consciousness in objective terms, including Cartesian dualism.

Far from giving in to subjectivist desperation, Nagel proposes, as a preliminary step to a possible physicalist explanation of consciousness, the project of an objective phenomenology whose task is the development of an intersubjective language enabling us to describe facts of subjective experience in a way accessible to any agent ([84], p. 449). Now, as far as I am aware, nobody has actually started to implement this grand vision and I take the liberty to doubt its feasibility. I am sceptical about Nagel's project not because of its presumed difficulty but because I believe it to be fundamentally mistaken. The reason why we cannot give an objective account of subjectivity has nothing to do with language, nor with a fundamental gap separating the subjective from the objective. In fact we are the wrong way up the gum tree if we believe that consciousnesses are continuants like others, be it substances or modes.

Knowledge, beliefs and desires are not objects - they are *ways* or *modes* how things are given. In other words, I concord with the analysis of knowledge, belief and desire in terms of *modalities* indexed by names referring to organisms/agents. However, I do not claim that anything we need to say about consciousness is just multi-modal logic; indeed, it would be profoundly erronous to confuse ontology with logic. Rather, I believe that a counterpart-theoretic ontology of modalities can also be applied to problems related to the philosophy of mind. Thus, epistemic and doxastic modalities should be ontologically explained on the basis of counterpart relations indexed by knowing or believing subjects (cf. Lewis [57], p. 123). Under the assumption of rationality, one could constrain those counterpart relations to those subsumed by the essential counterpart relations relative to the subject in question. The formal details of an axiomatisation of epistemic and doxastic counterpart theory are irrelevant here, as their specification is the proper task of epistemology, but it is clear that they should match the usual formal assumptions about epistemic and doxastic logic. What should be noted here is that in a theory of subjectivity, subject-relative counterpart relations can be properly viewed as *intentions*, and are compatible with a phenomenological analysis of consciousness.

With the proviso of a more detailed characterisation, *subjects* can be regarded as the indices of epistemic or doxastic counterpart relations; indeed, with Strawson ([124], pp.101-103), I believe that persons are just ordinary flesh-and-blood continuants. This way of typifying subjecthood also hints at an explanation of why first-person statements are "absolutely immune to error from misidentification" (cf. Shoemaker [123], pp. 556-557 and Castañeda [20]). Indeed, the reason why self-reference through the first-person demonstrative cannot fail is due, so I would claim, to the fact that the first-person pronoun

is directly linked to the index of epistemic and doxastic counterpart relations associated with the speaker.

These very cursory remarks only aim at clarifying how a theory of subjectivity in particular and epistemology in general can be incorporated into formal ontology. The main purpose has been to show how the subjective is founded upon the objective, thus demonstrating the independence of formal ontology from any cognitive or social bias and the possibility of a realist account of the world.

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