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Formalizing Common Sense: An Operator-Based Approach to the Tibbles-Tib Problem

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Abstract

The paper argues, that a direct formalization of the way common sense thinks about the numerical identity of enduring entities, requires that traditional predicate logic is developed. If everyday language mirrors the world, then persons, organisms, organs, cells, and ordinary material things can lose some parts but nonetheless remain numerically exactly the same entity. In order to formalize this view, two new logical operators are introduced; and they bring with them some non-standard syntax. One of the operators is called '*the instantiation operator*'; it is needed because the existential quantifier and its traditional relatives cannot do the job required. The other operator is called '*the form-on-matter operator*', and it allows an individual (an instance of a form) to stay the same even though some of its parts (its constituting matter) is taken away from it. Also, a certain kind of predicates, called '*nature terms*', is needed in order to represent what gives a particular its *kind of identity*. Both the operators and the nature terms introduced can be used in constructions of formal languages and formal systems, but no such constructions are made in the paper. The paper is structured as a comment on the philosophical problem called 'the problem of the cats Tibbles and Tib'.

Formalizations can be made for different purposes. Aristotle introduced them in order to make the essence of everyday deductive inferences more apparent; today, they are used not only in logic but even as a means to construct artificial intelligences. In this paper, the purpose of the formalizations is to shed light on common sense reasoning around numerical identity. The result is quite in conformity with a statement by John McCarthy: “The project of formalizing common-sense knowledge and reasoning raises many new considerations in epistemology and also in extending logic (1990, 21).” In order to get hold of the adequate forms in question, predicate logic is expanded with:

- an operator called ‘*the instantiation operator*’, which is needed because the existential quantifier and its traditional relatives cannot in any straightforward way do the job required;
- specific predicates called ‘*nature terms*’, which are needed in order to represent what gives a particular its kind of basic identity;
- an operator called ‘*the form-on-matter operator*’, which is needed because common sense contains an ontology that cannot be directly mirrored by the ordinary predicates of predicate logic;
- some *non-standard syntax*, which the new operators bring with them.

Both the nature terms and the operators introduced can be used in constructions of formal languages and formal systems with inference rules, but no such constructions will be made here.

1 Common sense and the problem of Tibbles and Tib

According to common sense, entities of many various kinds can loose parts without loosing their identity. If a shirt looses a button, it remains the same shirt; and if a tree loses a branch, it remains the same tree. In particular, I would say, it holds true that I remain the same person with the same human organism even if I have to undergo an amputation. Such numerical identity is also allowed in the life sciences; for instance, cells can lose molecules while retaining their identity. However, in some corners of philosophy it is regarded as problematic, because it gives rise to what is known as the problem of the cats Tibbles and Tib. Tibbles is a cat that loses his tail, and the philosophical reasoning then goes as follows:

> Tibbles, like any normal cat, has a tail, which we can call, quite simply, 'Tail'. Tail is clearly a component part of Tibbles. But now consider the rest of Tibbles—the whole of Tibbles apart from Tail—and let us call this 'Tib'. […] Tib […] appears to be a component part of Tibbles just like Tail. Clearly, Tibbles and Tib are not identical with one another, for Tibbles has Tail as a part whereas Tib does not. However, cats can survive loss of their tails. So suppose that Tibbles loses Tail, perhaps in an accident. Since Tail was no part of Tib, the loss of Tail can apparently have no bearing on the existence or non-existence of Tib. So when Tibbles loses Tail, it seems that Tib must still exist. If so, however, then it is now the case that Tibbles and Tib exactly coincide with one another. And the question is: how is it possible for them exactly to coincide and yet to remain numerically distinct from one another? (Lowe 2002, 74)

The essence of the problem has been made visible in a very comfortable semi-formal presentation by A. C. Varzi; it then takes on the structure of a *reductio ad absurdum*. I quote (with some minor elucidating changes and insertions):

1. Tibbles at $t \neq$ Tib at t (since Tib is a proper part of Tibbles)
2. Tibbles at t = Tibbles at t' (since Tibbles survives the loss of Tail)
3. Tib at t = Tib at t' (since Tib is not affected by whatever happens to Tail)
4. Tibbles at t' = Tib at t' (since Tib and Tibbles have the same parts)

Yet 2–4 jointly imply the negation of 1 by transitivity of identity, so we are in plain contradiction (Varzi 1998, 33).

Varzi cannot decide which premise to deny, but Lowe thinks the first premise is false. There is, he claims, no cat Tib at t; where Tib is in space there is only *potentially* a cat, one that becomes actual if a corresponding amputation takes place. Neither Varzi nor Lowe has tried to work out a formal presentation of the problem and the four premises above. Perhaps this is not by accident. I suspect that there is no formalization in either a traditional first order predicate logic or a first order sortal logic, e.g., (Lowe 1989), that can represent solutions that retain the commonsensical views that only the present moment of time really exists, that things can endure in time so conceived, and that they might even endure despite loss of some parts – as is claimed in premise 2. However, I will not try to prove this negative thesis only indicate its plausibility (section 3). Instead I will positively show (sections 4-5) how a formalization that uses the instantiation operator and the form-on-matter operator can capture the relevant common sense conceptions and solve the identity problem at hand; compare (Johansson 2006a).

If the names of the cats are exchanged for the demonstrative pronoun ‘this’, then the first premise is transformed into ‘this cat is not identical with this cat’, and the other three into ‘this cat is identical with this cat’. One problem in finding a neat formalization of statements such as these is that the existential quantifier cannot capture the sense of these this-expressions. Therefore, let me start by introducing the instantiation operator.

2 The instantiation operator

First of all I have to make the generality of the problem explicit. To this effect I will introduce the predicates F (= being a Tibbles-kind of cat) and G (= being a Tib-kind of cat). I will consciously leave the determinate interpretations of these predicates open here, but specify them in various directions during the discussion of the problem.

Since the four sentences to be formalized are about individuals at specific points of time, the individual variables have to be assigned a time parameter; instead of x I need and will use x_t. The unparametricized existential quantifier '∃x …' should then be read: 'there exists at some point in time an x such that …'.

The instantiation operator, (*i*x), now to be introduced is, please note, distinct from both the inverted iota operator of *Principia Mathematica*[1] and the indefinite choice operator '*an* x such that F'.[2] It has a very non-standard syntax: the operator symbol (*i*x) is in itself only a referring term meaning '*this* instance', but when it is combined with a predicate, a *sentence* is created. The formula (*i*x)F is a sentence that shall be read '*this* instance is an instance of F'. In contradistinction to the inverted iota operator, the instantiation operator allows that there may be many Fs, but it picks out one and only one, and a definite one. In ordinary predicate logics, such a feat is accomplished by means of individual names; in the sentence Fa, the name 'a' picks out one definite individual. However, such names are not sufficient for making the structure of the Tibbles-Tib problem clear. The sentence (*i*x)F is by definition given existential import, i.e., it entails that there is an x such that F.

Granted this formal symbolism, the premises in the problem of Tibbles and Tib can be represented as in (1^P) to (4^P) below. Here, the non-identity and the identity terms relate sentences, not referring expressions; the sentences in question describe by means of their expressed propositions a state of affairs. It is just as possible to assert that two seemingly different states of affairs are identical, as it is to assert that two objects such as the Morning star and the Evening star are identical. The first statement below (1^P) should be read '*this* F is not identical with *this* G' as a short-hand for '*this* instance is an instance of F, *this* instance is an instance of G, and they are not identical':

1^P. $(ix_t)F \neq (ix_t)G$ [which by definition entails: $\exists x\, Fx_t \wedge \exists x\, Gx_t$]

2^P. $(ix_t)F = (ix_{t'})F$ [which by definition entails: $\exists x\, Fx_t \wedge \exists x\, Fx_{t'}$]

3^P. $(ix_t)G = (ix_{t'})G$ [which by definition entails: $\exists x\, Gx_t \wedge \exists x\, Gx_{t'}$]

4^P. $(ix_{t'})F = (ix_{t'})G$ [which by definition entails: $\exists x\, Fx_{t'} \wedge \exists x\, Gx_{t'})$]

At least one of these premises has to be false since, together, they entail a contradiction: the referents of $(ix_t)F$ and $(ix_t)G$ are said to be both non-identical (in 1^P) and identical (entailed by 2^P–4^P).

3 Nature terms

Natural kinds and natural kind terms can be subsumed in genera-species hierarchies such as animal-mammal-cat, and properties and property terms can be subsumed in determinable-determinate trees such as color-red-scarlet. In both cases, the hierarchies have to come to an end somewhere; somewhere there have to be *most specific natural kinds* and *most determinate properties*. I will call terms for such entities '*nature terms*'; they will be symbolized as F^N, G^N, etc. Such terms might also be called 'kind-of-identity terms', since in a definite sense they represent the basic identity of instances in the context at hand. If something is a cat it *follows* that it is a mammal (and so on upwards), but if something is a mammal it does not follow that it is a cat; similarly if something is scarlet it follows that it is red, but if something is red it does not follow that is scarlet.

When an individual variable x is connected to a nature term, $F^N x$, it is implicitly being claimed that the individuals that can be values of the variable would not exist if they did not exist as Fs. That is, the syntactic connection between the individual variable and the nature term represents a non-formal necessary connection between the individuals to be denoted and a most specific natural kind or a most determinate property. When nature terms are connected to the instantiation operator, we get expressions such as $(ix_t)F^N$, meaning '*this* instance, x at t, is an instance that gets its nature from being an F'. The everyday statement 'this is a cat (C)' can then be formalized as $(ix_t)C^N$.

In traditional predicate logic that is not given a purely set-theoretic interpretation, all generality belongs to the predicate, i.e., the name 'a' in Fa and the variable x in Fx are terms without meaning, matters of pure denotation (Smith 2005). This is not true of x_t in $(ix_t)F^N$; nor of x in $F^N x$. They have no denotation apart from the generality expressed by F^N. Neither instances of kinds nor instances of properties can possibly exist apart from what they are instances of. Of course, the formula $(ix_t)F^N$ can be substituted by $F^N a$, meaning '*this* individual named 'a' is such that it has the nature F'.

By means of the instantiation operator even subject-predicate propositions with a demonstrative pronoun can be given a simple formalization. One has merely to stipulate that kind terms should be placed to the right and property terms to the left of the instantiation operator.[3] If H symbolizes 'being hungry', then $H(ix_t)C^N$ should be read '*this* instance, x at t, is an instance that gets its nature from being a cat, and in it inheres an instance of being hungry'. More briefly: '*this* cat instance, x at t, exemplifies the property of being hungry'.[4] In everyday language, we just say 'this cat is hungry'. If S symbolizes 'being a star', then the statement (i) 'the Evening star is identical with the Morning star' can be substituted by the statement (ii) '*this* instance appearing at t (the Evening star) is an instance of a star, and it is identical with *this* instance appearing at t' (the Morning star), which also is an instance of a star'. In statement (i) 'is identical with' connects referring expressions; in statement (ii) it connects sentences. Statement (ii) can be formally represented as follows:

- $(ix_t)S^N = (ix_{t'})S^N$

Below, similar statements will be about Tibbles and Tib.

I will now formalize the four premises anew. Instead of the predicates F and G, I will use the nature terms F^N and G^N as symbols for what gives Tibbles and Tib their kind of identity. At first, I will assume that these kinds of identities (natures) are given by the kind of collection of molecules that *at each point of time* make up the bodies of the cats in question.[5] Two collections will be said to be of the same kind if they consist of the same kind and number of molecules in the same kind of spatial arrangements.[6] Different kinds of such collections of molecules will be symbolized M_1, M_2, etc.; hopefully, the context makes it clear enough what kind of spatial relations the plus sign is meant to refer to. By using nature terms together with the instantiation operator, the premises in the Tibbles-Tib reductio can be formalized in this way:

1^S.	$(ix_t)(M_1 + M_2)^N \neq (ix_t)M_1^N$	[entailing: $\exists x\,(M_1 + M_2)^N x_t \wedge \exists x\,M_1^N x_t$]
2^S.	$(ix_t)(M_1 + M_2)^N = (ix_{t'})M_1^N$	[entailing: $\exists x\,(M_1 + M_2)^N x_t \wedge \exists x\,M_1^N x_{t'})$]
3^S.	$(ix_t)M_1^N = (ix_{t'})M_1^N$	[entailing: $\exists x\,M_1^N x_t \wedge \exists x\,M_1^N x_{t'}$]
4^S.	$(ix_{t'})M_1^N = (ix_{t'})M_1^N$	[entailing: $\exists x\,M_1^N x_{t'}$]

I will not dwell on premises 1, 3, and 4. A moment's reflection will show them to be true. The second premise reads: what gets its nature from $(M_1 + M_2)$ at t is identical with what gets its nature at t' from M_1 alone. It is necessarily false. In the sense of 'nature' defined, what gets its nature from $(M_1 + M_2)$ can at no point in time whatsoever be identical with something that gets its nature from M_1 alone, since no thing can have two natures. The conclusion is straightforward: if the cats Tibbles and Tib are regarded as being identical with the corresponding collections of molecules (or some other kinds of pure matter parts), then the contradiction between the four premises gives rise to no philosophical problem. Then a Tibbles without a Tail cannot possibly – contrary to premise 2 – be a Tibbles anymore. Our thought experiment makes it clear that in everyday discourse we do not identify cats with collections of matter. Therefore, this simple representation of the problem is not an accurate formalization of common sense ontology. Everyday language is non-reductionist. There are no cats without molecules, but nonetheless we normally take it for granted that cats are more than the molecules that constitute them. In order to capture this fact, we need to implement more structure into the predicates used.

4 The form-on-matter operator

A common sense saving formalization of the Tibbles-Tib problem can be worked out if so-called Aristotelian *form-matter* metaphysics is allowed. I will now assume that to be a cat is to have a certain kind of *functional unity*, i.e., a *form* in the old Aristotelian sense of this word. Material functional unities are always unities superimposed on some matter, but they are nonetheless not necessarily superimposed on the same constituting matter all the time. In ordinary discourses (and in most biological-scientific discourses as well), living things are implicitly regarded as having such a form-matter (functional-unity-on-a-substrate) ontological structure.

Forms (functional unities) are more than the collection of their constituents. A cell is not as a functional unity identical with the collection of its molecules, and an organism is not identical with the collection of its cells and fluids. Of special interest is the fact that *form-matter ontological structures easily lend themselves to representations by means of operator symbolism*. Operators, let it be noted, are not identical with higher-order predicates; rather, an operator together with what it acts on can be called a ‘multi-leveled predicate’. In contemporary philosophy, formalizations by means of operator symbolisms are mainly used in modal logic and deontic logic, but operator symbolism can be used for ontological purposes, too. Let me outline.

In modal logic, the operators act on sentences that express propositions; out of p that represents an assumed state of affairs, the necessity operator $\Box$ can create $\Box$p that represents an assumed necessary state of affairs. In (some versions of) deontic logic, the operators act on expressions for actions; out of A that refers to a certain kind of action, the being-obligatory operator O can create OA, which says that actions of kind A are obligatory.

When representing form-matter ontological structures, we should, I suggest, let form-on-matter operators ^{F}O act on expressions for kinds of matter of various sorts, M. When they do so, we get expressions ^{F}OM that refer to kinds of form-matter unities. If, for example, ^{C}O represents the form (functional unity) of cells and M_1 some kind of collection of molecules, then $^{C}OM_1$ represents cells constituted by such kinds of collections of molecules. Similarly, if ^{H}O represents the form (functional unity) of hearts and M_2 some kind of collection of cells, then $^{H}OM_2$ represents hearts constituted by such kinds of collections of cells.

In order to get from talk about (i) kinds of forms, (ii) kinds of matter, and (iii) kinds of form-matter unities to talk about *instances* of such entities, nature terms and the instantiation operator can be used. For example, the statement ‘this thing is a cell made up of an M_1-kind collection of molecules’ can be formalized as $(ix_t)^{C}O^{N}M_1$; the statement ‘this thing is a cell’ can be formalized as $(ix_t)^{C}O^{N}$, meaning ‘*this* instance, x at t, gets its kind of identity from being a cell’. This means that also the form-on-matter operator brings with it some non-standard syntax: *together with the instantiation operator*, the form-on-matter operator can create a whole sentence even though what it operates on is not mentioned.

This way of symbolizing the difference between a (universal) nature and what is an individual (instance) of this nature can be displayed as in the matrix below (for simplicity's sake the N-superscript is taken away):

	Form	Matter	Form-Matter Unity
Universal (or Type)	some kind of form: ${}^{F}O$	some kind of matter: M	some kind of unity of ${}^{F}O$ and M: ${}^{F}OM$
Individual (or Token)	instance of ${}^{F}O$: $(ix)^{F}O$	instance of M: $(ix)M$	instance of unity: $(ix)^{F}OM$

As an axiom one might state: necessarily, if there is an instance of a certain form, $(ix)^{F}O$, then there is both an instance of some kind of matter, $(ix)M$, and an instance of a corresponding form-matter unity $(ix)^{F}OM$.

By means of the earlier introduced terms for Tibbles-kinds (F) and Tib-kinds (G) of cats, I can now introduce the specific form operators ${}^{F}O$ and ${}^{G}O$. Naming as before the two relevant kinds of collections of matter 'M_1' and 'M_2', we can then construct sentences that belong to a logic in which natural kinds are allowed to exist on top of each other, so to speak. One kind of kinds can be forms in relation to some other kinds.[7] We can construct multi-leveled predicate formulas such as:

- $(ix_t)\,{}^{F}O(M_1 + M_2) = (ix_{t'})\,{}^{F}OM_1$

But such formulas are equivocal. It is not clear what the identity sign is relating. Is it the matter symbols (M), the form symbols (${}^{F}O$), or the whole form-matter unities on each side? Since in what follows I want to focus on the form-identities, I will make a fitting disambiguation. The operators of interest are nature terms, too. Therefore, as I earlier wrote F^N, I can now write ${}^F O^N$. When these latter operators are introduced, the identity sign can be stipulated to connect nature terms and be written $=_N$. Thereby, we get unambiguous identity sentences such as:

- $(ix_t)\ {}^F O^N(M_1 + M_2) =_N (ix_{t'})\ {}^F O^N M_1$

This sentence should be read: '*this* x at t that gets its nature from the form F (and is connected to the matter ($M_1 + M_2$)) is identical with *this* x at t' that also gets its nature from the form F (but is connected to the matter M_1)'.

5 Common sense retained

The four premises of the Tibbles-Tib problem will now be discussed, one by one, in the *form-matter representation* introduced. I will start with the second premise:

$2^{F\text{-}M}$. $(ix_t)^F O^N(M_1 + M_2) =_N (ix_{t'})^F O^N M_1$ [entailing: $\exists x\ {}^F O^N(M_1 + M_2)x_t \wedge \exists x\ {}^F O^N M_1 x_{t'}$]

It says that the instance of the Tibbles-form at t is numerically identical with the instance of the Tibbles-form at t', despite the change in the underlying matter. This is in conformance with common sense. However, it is so only on the assumption – henceforth accepted – that the introductory predicate F (= being a Tibbles-kind of cat) means only 'being a cat'. If it would mean 'being a cat with a tail', then premise 2 is as trivially false as it is in the pure matter (molecule) interpretation. The form-matter representation makes the normally implicit everyday distinction between form and matter, between functional unity and underlying matter, explicit. This has quite an effect: whereas in the 'flat' (molecule) representation of the third section, premise 2 is necessarily false, it is in the multi-leveled form-matter representation true. The latter representation is able to accommodate the commonsensical view that a cat that loses its tail does not lose its identity. Next, comments on premise 1:

$1^{F\text{-}M}$. $(ix_t)^F O^N(M_1 + M_2) \neq_N (ix_t)^G O^N M_1$ [entailing: $\exists x\, {}^F O^N(M_1 + M_2)x_t \wedge \exists x\, {}^G O^N M_1 x_t$]

This premise says that the instance of the Tibbles-form at t is different from the instance of the Tib-form at t, and also that these form instances at t exist on top of different kinds of matter, i.e., on $(M_1 + M_2)$ and on M_1, respectively. In order not to make premise 2 trivially false, we had to accept that to be a Tibbles-form is simply to be a cat-form (= cat kind of functional unity). What then about being a Tib-form? It has to be remembered that the instantiation operator has existential import. There is no reason to doubt that there is at t an x such that ${}^F O^N x_t$, i.e., a cat, but what about an x such that ${}^G O^N x_t$? That there is *something* where ${}^G O^N x_t$ is in space is clear; there is an instance of M_1. But this does not answer the question whether the form ${}^G O^N$ is instantiated or not. In my (and Lowe's) opinion, there is at t no *actually* existing form ${}^G O^N$; and this independently of whether G (= Tib-kind of cat) means only 'being a cat' or 'being a cat without a tail'. There is at t no actual functional unity that can be described by the sentence $(ix_t)^G O^N$. There is only (in the matter instance of M_1) a *potentiality* for a real functional unity such as Tib. Therefore, statement $1^{F\text{-}M}$ is false. Premise 3 looks like this:

$3^{F\text{-}M}$. $(ix_t)^G O^N M_1 =_N (ix_{t'})^G O^N M_1$ [entailing: $\exists x\, {}^G O^N M_1 x_t \wedge \exists x\, {}^G O^N M_1 x_{t'}$]

It says that the instance of the Tib-form at t is identical with the instance of the Tib-form that exists at t'; it also says that these two form instances exist on top of the same kind of matter. As we have just noted, there is at t no actual x such that ${}^G O^N$, only a potential one. However, at t' there is an x such that ${}^G O^N$. At this moment the cat Tib is walking around just like any existing cat. The thought of *Tib-at-t* is directed towards a potentiality, the thought of *Tib-at-t'* is directed towards an actuality. Since a potential functional unity cannot be identical with an actual functional unity, premise $3^{F\text{-}M}$ is, like the first one, false. The fourth premise, however, is in one interpretation of G true and in another false. It says:

$4^{F\text{-}M}$. $(ix_{t'})^{F}O^{N}M_1 =_N (ix_{t'})^{G}O^{N}M_1$ [entailing: $\exists x\, {}^{F}O^{N}M_1x_{t'} \wedge \exists x\, {}^{G}O^{N}M_1x_{t'}$)]

According to $4^{F\text{-}M}$, the instances of the two forms mentioned are identical (and exist on top of the same matter instance). Identity of instances entails identity of the corresponding universal forms, i.e., if the fourth premise is true then it also holds true that ${}^{F}O^{N} = {}^{G}O^{N}$. Can this be the case? Now the interpretation of G becomes crucial. I have already disambiguated F into 'being a cat'. This means that premise 4 is true if also G means just 'being a cat'; an interpretation that is supported by the name of the problem 'the problem of the *cats* Tibbles and Tib'. But if G means 'being a cat without a tail', then premise 4 is false.

6 Summary

If form-identity and matter-identity are kept distinct, the problem of Tibbles and Tib can be solved in two completely different directions. One that is, and one that is not, in conformance with common sense. In the single-leveled formalization in the third section, premise 2 comes out as necessarily false (and the others as true). This means a rejection of common sense. However, in the multi-leveled form-matter formalization presented in the fifth section, premise 2 comes out as true (4 as ambiguous, and 1 and 3 as false). Here, common sense reasoning is preserved. Both formalizations need the *instantiation operator*, but only the common sense saving formalization needs the *form-on-matter operator*.

Notes

[1] Since on many computers the inverted iota is not available, I will use the letter kappa as a stand in for the inverted iota, and here symbolize this operator by (κx). Whitehead and Russell give the term (κx)Fx the meaning '*the* individual x such that F', where it is taken for granted that only one individual is F. The inverted iota operator has in itself no existential import, but always when used in a sentence such an import is created. The sentence G(κx)Fx means 'there is exactly one x such that F, and it is G', and E!(κx)Fx means 'there is exactly one x such that F'. See (Russell and Whitehead 1962, 30-32, 66-71, 173-175).

[2] This operator is sometimes called the epsilon operator, (εx), and sometimes the eta operator, (ηx).

[3] This is also the way property predicates are added to the inverted iota operator in *Principia Mathematica*.

[4] For more about the distinctions between instantiation, inherence, and exemplification, see (Lowe 2006).

[5] I disregard the fact that many molecules (e.g., blood molecules) are sometimes in the tail and sometimes not in the tail. This false assumption is of no consequence since my conclusion will nonetheless be that cats cannot be identified with collections of molecules.

[6] When needed, one can distinguish between *concrete* and *abstract* collections, calling collections where the spatial relations are abstracted away *abstract* and the collections spoken of in this paper *concrete*; see (Johansson 2006b).

[7] The form-matter distinction is relative, i.e., what is form in relation to some matter may itself be matter in relation to another form. For instance, cells are forms in relation to molecules but matter in relation to organs. For simplicity's sake I will not dwell on this complexity. Formally, it implies that formulas such as ${}^{F}OM^{n+1} = {}^{F}O{}^{G}OM^{n}$ and $M^{n+1} = {}^{G}OM^{n}$ are well-formed formulas; the symbol M^{n} means 'matter on level n'.

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