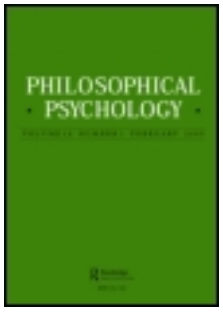

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Teleosemantics and productivity

Manolo Martinez

There has been much discussion of so-called teleosemantic approaches to the naturalization of content. Such discussion, though, has been largely confined to simple, innate mental states with contents such as "There is a fly here." Even assuming we can solve the issues that crop up at this stage, an account of the content of human mental states will not get too far without an account of productivity: the ability to entertain indefinitely many thoughts. The best-known teleosemantic theory, Millikan's biosemantics, offers an account of productivity in thought. This paper raises a basic worry about this account: that the use of mapping functions in the theory is unacceptable from a naturalistic point of view.

Keywords: Millikan; Productivity; Teleosemantics

1. Introduction

Teleosemantic accounts of mental content (e.g., Millikan, 1984; Papineau, 1998; Ryder, 2004) propose that the content of mental states depends on their biological function or on that of appropriately related states. Accommodating the possibility of misrepresentation is considered as a major milestone in the project of naturalizing mental content, and the appeal to functions provides a straightforward way of unpacking the normativity implicit in the idea of misrepresentation: misrepresentation is, simply, *malfunctioning*. To complete the naturalization of content, a satisfactory naturalistic account of the relevant kind of functions is also needed. The *etiological theory of functions* (Ayala, 1970; Millikan, 1984, 2002; Price, 1998; Wright, 1973/1994) according to most proponents of teleosemantics, is able to deliver it.

The teleosemantic approach is widely regarded as one of the most promising approaches in the project of naturalizing content. Unfortunately, it is not without its problems. Many widely discussed issues already crop up in the attribution to innate, simple mental states of contents such as "There is a fly here"; see, for example, the discussion of *indeterminacy problems* (Agar, 1993; Fodor, 1990; Papineau, 1998; Rowlands, 1997). It is fair to say that many of these problems are still open.

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Maybe the fact that there are open problems in the foundations of the theory has deterred philosophers from discussing other important aspects of teleosemantics. In any event, crucially, there has been hardly any discussion of teleosemantic accounts of *productivity*, the ability to entertain indefinitely many thoughts. But, of course, an account of the content of human mental states will not get too far without an account of productivity. In this paper I criticize the best worked-out teleosemantic approach to this problem: Millikan's appeal to *mapping functions*.

I will proceed as follows: first, in section 2, I will explain why it is sensible to design a theory of content such that the most basic contentful states are propositional (akin to, say, ''There is a fly around'') and not subpropositional (such as, say, ''fly''). Millikan's theory is one in which the bearer of content is always the fully propositional thought, and in which concepts have meaning in a derivative sense. While it is sensible to proceed in this way when laying the foundations of the theory, the exclusive reliance on propositional thoughts puts pressure on a non-negotiable desideratum of a theory of content: that it provides an account of productivity. The best explanation of productivity we have is compositionality, and compositionality (at least for our current purposes) involves having thoughts whose content is determined by their structure and by the content of their constituents. Millikan (1984, 2004) has proposed an alternative to compositionality: the appeal to what she calls *mapping functions*. It is this approach, which I introduce in section 3, that I will be criticising in the remainder of the paper. I will first raise a worry about the naturalistic[1] credentials of Millikan's reliance on mapping functions in explaining indexicality in non-human thought (section 4): the theory offers no principled procedure to choose one from among many such functions in the way that Millikan needs. Some unspecified mechanism must make the final choice of the relevant mapping function, and in the absence of specification, for all we know, the final choice may be guided by the (fully intentional) semantic intuitions of the theorist.

This problem can be bypassed at the cost of deeming many purported thoughts meaningless, and this may not be completely implausible if we are talking about the mental states of simple cognitive systems such as those of, say, bees. Unfortunately, in section 5, I will show that the problem recurs when we turn to compositionality and content determination in human thought: there is no clear, non post-hoc way to establish which is *the* mapping function linking thoughts with their meaning, and in this context deeming certain thoughts meaningless is simply not an option. Before wrapping up, at the end of the section I will take up a rejoinder on behalf of the Millikanian: even if the theory is unable to single out the relevant mapping function to endow new human thoughts with meaning, maybe other, naturalistically acceptable mechanisms (say, appeals to the simplicity or elegance of the resulting theory) can supply the missing ingredient. I will show that no unobjectionable appeal to these theoretical virtues can be made in the context of Millikan's project.

The conclusion will be that mapping functions do not suffice to account for productivity in naturalistically acceptable terms. This suggests that this project will have to progress the hard way: providing bottom-up content determination, through a compositional semantics for the language of thought.

2. Propositions-First

According to Millikan's biosemantics—and many other teleosemantic accounts of content—the most basic bearers of content are thought-like, as opposed to concept-like. That is, the most basic contents are like "There is a fly here," and unlike "fly." Placing propositions first in this way is a sensible theoretical move, at least because it is notoriously difficult to provide an interesting set of naturalistically-acceptable sufficient conditions for some mental structure M to be the concept of, say, "fly."

Let me show one of the main problems that appear in this connection, which we may call the *train of thought* difficulty. Suppose, for simplicity, that we are interested in providing a simple causal account of concepthood, such as the following:

> *Concept:* M is the concept FLY iff, in optimal conditions, only flies cause M to token.

Even if (a big if) we have a specification of optimal conditions that rules out little black pellets, mosquitoes, etc., as optimal-conditions causes of the tokening of FLY, there is another kind of causes of instantiation of concepts that simply cannot and should not be ruled out as suboptimal or abnormal: *thoughts* involving flies may cause further tokenings of the concept FLY, and ought to do so, even if the thinker is temporarily far away from any flies. Even a perfect thinker, one who never misrepresents or tokens concepts inappropriately, is such that some of her thoughts are caused by some other of her thoughts (Fodor, 1990, p. 81).

So, how should we reformulate our optimal-conditions causal theory to filter out not just cases of misrepresentations (black pellets and mosquitoes) but also cases of the concept being caused to token by the tokening of other concepts in a train of thought? Obviously, the quick fix won't do:

> *Concept**: *M* is the concept FLY iff, in optimal conditions, only flies, or appropriately related thoughts, cause it to token.

Leaving aside the extreme vagueness of the condition proposed, thoughts are appropriately related to other thoughts in virtue of their content. If so, we need an independent account of the content of thoughts to feed into Concept*. But that was what Concept* was supposed to provide.

Luckily, the train of thought difficulty does not appear with *propositional* contents such as "There is a fly here." Take the following toy account of the content of beliefs:

> *Proposition: M* is the belief "There is a fly here" iff, in optimal conditions, only the fact that a fly is there causes *M* to token.

It is not the case that, in optimal conditions, it is permissible for other thoughts, in the absence of flies, to cause beliefs or judgements with such a content. Otherwise put, a perfect thinker would never judge that "There is a fly here" in the absence of a fly being there. If other thoughts cause me to believe that there is a fly there and there is not, it is reasonable to claim that I am not in optimal conditions.

This line of argument provides a powerful reason to put propositional contents in the foundation of the right naturalistic account of content; even if the theory behind

Concept (and Proposition) is naive, it is unlikely that any other broadly teleosemantic theory of content will be able to solve this difficulty, if it chooses to base its theoretical building upon concept-contents such as "fly." Eventually, however, we will need to move on to provide concept contents, if we wish (and we certainly do) to accommodate the possibility of productivity in thought. A theory, however sophisticated, that only recognizes a fundamental level of propositional contents will not be able to account for productivity. Millikan defends precisely a sophisticated teleosemantics that accords concept-contents a merely derivative role. The aim of the next three sections will be to show that such a theory cannot explain human-thought productivity.

3. Mapping Functions

Humans clearly have the ability to entertain indefinitely many contents, many of which have never been entertained before. This is the ability I am calling *productivity*. We may distinguish two important kinds of productivity which, prima facie, appear to be very different.

One goes by the name of 'indexicality': there is a sense in which, whenever I think "There is food here now" (I will sometimes call this *the food thought*), I am thinking a wholly new content—at least because it has never been "now" before—with the content that there is food there and then. Each token of "There is food here now" is relevantly different to other tokens of the same thought. Each happens at a different time, and each means a different proposition: "There is food at <the place in which the thought is tokened, the time at which the thought is tokened>." A cognizer who is able to entertain the food thought already shows a limited kind of productivity: she is able to think indefinitely many contents, and contents never entertained before by anyone, just by tokening the food thought at different times.

But many would take this to be productivity in, at most, an honorific sense. What they have in mind, rather, is *compositionality*. A thought system is productive in this other sense, roughly, if it counts with a vocabulary of concepts and of modes of composition, such that the content of a thought is determined by the content of the concepts that compose it and the way in which they are composed. The productivity allowed by compositionality is far richer than mere indexical productivity. For example, someone who possesses *n* individual concepts (such as MICHAEL, or EVE) and *o* kind concepts (such as HORSE or SHOEMAKER) and the operation of predication will be able to entertain *n* times *o* different contents—and, one is tempted to say, these are *really* different, not just indexicality-different.

Indexicality is compatible with a *propositions-first* approach: the productivity afforded by indexicality does not depend on the recombinability of a vocabulary, or the iterability of a number of syntactic structures, but on features of the propositional thought, such as the time or place in which it was tokened. On the other hand, compositionality provides for much richer productivity but, as we have seen, it leaves open the problem of how to provide a naturalistic account of subpropositional

contents in light of, for example, the train-of-thought difficulty. Millikan's answer to this conundrum is interesting and original: she sets out to show that, appearances notwithstanding, indexicality and compositionality are, at bottom, two aspects of the same phenomenon. According to this picture, if indexicality can be explained in a framework which takes propositional thoughts to be the basic bearers of content, compositionality can be as well.

3.1. Indexicality

According to Millikan (2008), productivity in intentional systems is inherited from natural signs. Take the following, broadly Dretskean definition of natural sign. If *M* is a mechanism that can be *on* or *off*:

> *Natural Sign*: *M*'s being *on* is a natural sign of instantiations of a property *F* nearby iff :
>
> NS1: $P(F \text{ being nearby}|\text{M being on}) > P(F \text{ being nearby})$, and
>
> NS2: The difference in probabilities in NS1 is causally grounded.

Where $P(p|q)$ is *p*'s probability conditional on *q*. *M* may be inside the skull of some creature, but, for now, we do not care: Natural Sign is described in fully non-intentional terms.

Notice that, according to the definition, the relation of natural-signhood holds between events *such that some of their features are a function of one another*—namely, their spatio-temporal location: instantiations of *F* <near *M*, now> are indicated by *M*'s going on <where *M* is, shortly after>.

This kind of causally grounded relations between event types may be described using what Millikan calls *mapping functions*: mathematical transformations from features of the sign to features of the signified states of affairs. In the case just discussed, *M*'s going *on* at (x, t) indicates an instantiation of *F* at $f(x, t)$. The relevant mapping function here is *MFM*, where $MFM(x, t) = (\text{near } x, \text{ shortly before } t)$. This mapping function, in turn, individuates what (Millikan, 2004, p. 49) calls a *system of signs*: the class of possible and actual signs obtained by varying the relevant parameters. In the case just described, the relation of natural-signhood established between *M* and *F* individuates a system of signs, *SYS*,[2] which may be characterised as follows:

$$\forall x, t(M\text{'s being turning } on \text{ at } (x, t) \in \text{SYS})$$

For concreteness, suppose that *F* is the property *being food*, and *M*'s being turning *on* is a natural sign of this property because the presence of a round, orange thing nearby always causes *M*'s to switch *on* (and is the only thing that causes them to switch *on*), and most round orange things are peaches (and hence food) in *M*'s surroundings. We may assume that these causal powers are partially constitutive of what it is to be an *M*.

Under these assumptions, the causal grounds appealed to in clause NS2 of Natural Sign only support some of the mappings from signs in *SYS* to states of affairs. That is, while there are many members of *SYS* (i.e., instances of *M*'s turning *on* at a certain time and place) that have been or will be caused by the presence of a round, orange thing that is food, there are very many other members of SYS for which it will not be the case that the corresponding state of affairs (the presence of food there and then) will also occur, or even be made more probable by the causal mechanisms in place. Some clear cases are

- *M*'s being turning *on* at <around here, the distant future>
- *M*'s being turning *on* at <Mars, now>

at least if we assume that peaches will not be the predominant round orange things in the distant future around here, or now somewhere in Mars, and there is no other abundant, edible, round, orange stuff. More interestingly, the causal grounds of the natural-sign relation will also fail to support the mapping function for many everyday values of x and t—e.g., those that pick out events of *M*'s turning *on* that are not caused by the presence of peaches.

Natural signs as described by Natural Sign are a plausible precursor of indexicality. Take, again, the food thought: ''There is food here now.'' This thought is indexical because the content it expresses depends on the time and place at which it is tokened. Now consider *M*'s being turning *on* (which, for all we have said, may or may not be the same thing as the food thought). It is a natural sign of the event consisting of the instantiation of food somewhere sometime, and we have cashed this out as saying that events of *M*'s being turning *on* belong in a system of signs, *SYS*, such that each member of *SYS* has, according to *MFM*, an image in a domain of (possible or actual) events of instantiations of food. The role that thoughts, such as the food thought, play in the traditional description of indexicality is played here by the system of signs *SYS*. As we are about to see, Millikan's main idea is to identify increasingly complicated mapping functions for increasingly abstract systems of signs; one of the very complicated, very abstract examples will amount to what is traditionally understood as compositionality. Before that, though, we need to move beyond natural signs and introduce intentionality.

3.2. Intentionality

Let me provide a brief summary of the way in which Millikan puts mapping functions to use in accounting for content. The idea is that *indicative intentional icons* (roughly, her term for contentful states) are related to the state of affairs that is their *real value* (even more roughly, her term for the content of true contentful states) in the following way. Thus,

> when an indicative intentional icon has a real value, it is related to that real value as follows:
>
> (1) The real value is a Normal condition for performance for the icon's direct proper functions.

> (2) There are operations upon or transformations (in the mathematical sense) of the icon that correspond one-to-one to operations upon or transformations of the real value, such that
> (3) Any transform of the icon resulting from one of these operations has as a Normal condition for proper performance the corresponding transform of the real value. (Millikan, 1984, p. 107)

A quick introduction to Normal conditions: according to the etiological account of functions, the function of a device is a subset of the *selected effects* it produces in the system in which it is embedded: that is, those among its effects that natural selection has favored. Now, whenever there is selection, there is a set of environmental conditions that have enabled it. For example, the heart has the function of moving blood around, and it does so by contracting and distending periodically. But this only results in blood being moved if blood has the right rheology, and this only happens, for example, at the right range of temperatures, etc. There are maybe other ways in which a squeezing mechanism may end up aiding blood to be moved around, but the Normal way is the one that has to do with the hydrodynamics of normal blood circulating through veins and arteries, being pumped by the heart.

Contentful states, just like hearts, have functions, and most of the time they have fulfilled these functions they have done so by relying on a certain set of environmental conditions. These are the Normal conditions for performance of the state's function, and they are what count as the content (real value) of the state. So, in the example I have been using, we may suppose that *M*'s being turning *on* is *consumed* by the motor control area of *M*'s possessor, which proceeds to issue an order to grab and eat the round orange object nearby. *M*'s being turning *on* has improved the fitness of its possessor on those occasions in which the round orange thing was food—which it often was, being a peach. This is the (least detailed) Normal condition for the fulfilment of its function, and hence the content of *M*'s being turning *on*: ''There is food here.'' Such is, in summary, the theory behind point 1 in the quote above.

But we are currently interested in claims 2 and 3: 2 can be paraphrased, roughly, as saying that, whenever a state has content, the relation of that state to its content is covered by a mapping function; while 3 says that the rest of states in the same system of signs have as content their image according to this mapping function. In this way we can provide, for example, a content attribution for the state consisting of *M*'s being turning *on* a year from now: namely, that there will food near that token of *M* in a year. This is so because *MFM* takes the former (merely possible) tokening of *M* to the latter (merely possible) instantiation of food.

In my examples I have been using a mapping function, *MFM*, that transforms the spatio-temporal location of the sign into that of the signified event. We may now note that mapping functions may take just about any feature of the sign to any of the signified event. For example, in some domains—say, a Mediterranean beach—there is a mapping from the *distance between footprints* on the sand (sign) to the *speed* at which some hiker was going (signified). Or, in some other domain – say, a field near

Toulouse – you may find a mapping between the *number of apples* fallen on the ground and the *speed of the wind* during the past few hours. Natural Sign can be generalized so as to include these other cases:

> Natural Sign Generalized: A sign of type s's having feature *FS* is a natural sign of an event of type *E* with feature *f*(*FS*) iff:
>
> NSG1: *P*(An event *E* with feature *f*(*FS*)|A sign of type s's having feature *FS*) > *P*(An event *E* with feature *f*(*FS*))
>
> NSG2: The difference in probabilities in NSG1 is causally grounded

where, as I have said, the mapping function *f* may transform whatever features of sign and signified—not just spatio-temporal locations. Any such mapping functions may be fed into steps 2 and 3 in Millikan's quote.

Thus, if, for example, bee dances (Millikan, 1984, p. 107) are such that transformation of some of their features (number of loops, angle of the axis of the eight, etc.) correspond to transformations of features of the position of the nectar, actual bee-dances share a system of signs with bee-dances-after-transformations-of-features, and these latter entities have as content their image according to the mapping function that helps individuate the system of signs (see above). For example, if an actual dance D has as content that there is nectar 50 m from the hive in the direction of the sun, the fact that dances are members of a system of signs determined by the mapping function that takes dances to positions of nectar has as a consequence that a hypothetical dance D* in which the waggle part is a hundred thousand times longer than in D has, as content, that there is nectar 5000 km from the hive in the direction of the sun (give or take).

4. The Naturalistic Worry

Taking stock, what we have seen so far is a plausible description of what a natural sign is, encapsulated in Natural Sign Generalized, and how such a picture may help explain the limited kind of productivity we call indexicality: certain mapping functions take features of the sign (and, by extension, of contentful states) to features of the signified event (and, by extension, of the content of those states). A mild version of the naturalistic worry that I will advance against the application of mapping functions to compositionality also afflicts its application to this simpler indexical case. I will present the worry now; and, after discussing Millikan's approach to compositionality, I will show how to extend it to the more interesting case.

The relation of a natural sign to its signified, according to Millikan's picture as summarized above, may be described at three different levels. (**L1**) The first level is constituted by the *concrete causally-grounded relations* that are established by signifier and signified—that is, for example, the very causal relations that tokens of *M* that have actually existed established with the presence of food, relations such as a certain peach's being near a token of *M* at a certain time, causing *M* to activate.[3] (**L2**) Then comes the level of the *causally-grounded natural-sign relation* between types of events: every pair of signifier and signified that is covered by the causal underpinnings of the

concrete causally-grounded relations in L1. For example, only a class of distances, neither too large nor too small, indicate that a hiker was walking at a certain speed, and this has to do with causal (particularly, physiological) constraints enforced by the muscular and skeletal arrangement of the human body.[4] These constraints fix the class of pairs of signified and signifier that is covered by the natural-sign relation. (**L3**) The causally-grounded natural-sign relations in L2 may be only probabilistic, and most of them will only be effective in a small, gappy domain. So, finally, we may wish to abstract mathematical transformations that fill in and extend the domain in which the indication relation holds. These are the mapping functions—the $f(x)$ in Natural Sign Generalized—for example, that to each possible distance between footsteps *dbf*, corresponds a speed of the hiker $s(dbf)$, or to each possible waggle dance D a position of nectar $n(\mathrm{D})$.

All three levels are needed for the Millikanian picture summarized above to work. L2—that of the causally-grounded processes which cover the concrete pairs of sign-signified—provides signified events for as yet uninstantiated signs. This is what we need for a productive system of signs, which was the whole purpose of the exercise. L3—constituted by the mapping functions themselves—in its turn, is needed, at least if we want to provide signified events for members of a system of signs that lie beyond the causally-grounded domain, such as the aberrant waggle dance $D^{\star}$. Apart from these abnormal cases, there may be other, more everyday examples in which an appeal to level 3 is needed—for instance, a token of M inside the skull of a creature that has been abducted from its original habitat and placed inside a cage in a lab—where the causal explanation of, say, the correlation of round-and-orangehood with nutritiousness is entirely different from that in the wilderness.

If L3 does real work in content attributions, it is very reasonable to worry about the naturalistic credentials of the resulting theory of content.[5] The problem is that there are no facts in the causal order to determine that the content of $D^{\star}$ is fixed by the mapping function that yields 5000 km as a result, and not another function that yields any other value—or, maybe, another that has gaps for values not covered by the causal underpinnings of the relation between dances and nectar position. In choosing one of these mapping functions as *the right* one, then, we are going beyond the theory, and thus casting doubts on the non-intentionality of the whole process.

Millikan has some things to say about the closely related issue of Kripkensteinian worries about our ability to follow rules. In the following subsection I show that what she has to say does not solve this naturalistic worry.

4.1. Millikan on Rule-Following

In her (1993, chapter 11), Millikan discusses the problem of rule-following as introduced by Kripke (1982). Kripke issues a skeptical challenge against theories of meaning that make facts about the dispositions to use linguistic expressions on the part of speakers constitutive of the meaning of these expressions. Kripke puts forward two different arguments (see also Boghossian, 1989). In summary, they are as follows.

First, the *infinite truths* argument: there are infinite truths about the use of some expressions; for example, there are infinite true substitutions of the schema *a plus b is c*. But even if we leave aside our dispositions to make mistakes (Kripke, 1982, p. 26), our dispositions are finite, being the dispositions of finite beings in a finite amount of time. So, it cannot be that these infinite truths are accounted for simply by relying on our dispositions.

Second, the *normativity* argument: there are facts about the correct way in which we should apply our terms. That is, a theory of meaning should account for the fact that terms *ought* to be applied in some ways but not in others. Now, there is no way to read an ought from a disposition. Dispositions can only tell us how things are, not how they should be.

Although Boghossian (1989, p. 528) defends the claim that causal-informational theories are, for the purposes of the skeptical argument, a subset of dispositional theories of meaning, it is not clear that he was considering teleosemantic theories among the former. In any event it seems that teleosemantics has resources to answer both Kripkean worries. Millikan's (1993, p. 217) strategy is to argue that purposes to conform to unexpressed rules are *biological purposes*. The idea, as the reader has probably anticipated, is to place biological functions at the base of the normativity of meaning. The ought of meaning is a biological ought, which can be subsequently unpacked in naturalistically unobjectionable terms by an etiological theory of functions, such as Millikan's own theory of proper functions (Millikan, 1984, chapter 2, 2002). The infinite truths of the first objection, on the other hand, flow naturally from these normative facts—facts, for example, about what the terms ought to apply to cover an infinite number of cases. Millikan's example involves the mating strategy of male hoverflies. She identifies a *proximal hoverfly rule*:

> if the male is to intercept a female in flight, the male must make a turn that is 180 degrees away from the target, minus about 1/10 of the vector angular velocity (measured in degrees per second) of the target's image across his retina (Millikan, 1993, p. 218).

This, plausibly, is not simply a disposition that male hoverflies have, but rather,

> the hoverfly has within him a genetically determined mechanism of a kind that historically proliferated in part *because* it was responsible for producing conformity to the proximal hoverfly rule, hence for getting male and female hoverflies together (Millikan, 1993, p. 219).

This kind of historical property of the mechanism warrants our attribution of a biological function to it—or, in this context, a biological purpose.

If this is correct, Millikan can then give an answer to Kripkensteinian skeptical complaints. To the infinite truths argument: the hoverfly mechanism has the function of, given the angular velocity of a retinal shadow, issuing a muscular command that makes its possessor fly in a particular direction. This is so for an infinite number of angular velocities or, in any event, for a number that far surpasses the number of actual uses that actual hoverflies will make of the mechanism. To the

normativity argument: the biological function of the mechanism, attribution of which is warranted by the kind of history that it has, underwrites the relevant normativity claims made as regards its functioning. Intrinsically, mechanisms *ought* to comply with their function.

It is clear that this teleosemantic response goes some way towards answering the skeptical challenge, and this, at least, warrants a closer examination of the theory (beyond Boghossian's somewhat unfairly-lumped category of ''causal-informational theories''). What I wish to discuss now is the *scope* of the teleosemantic solution. Given that it is the hoverfly mechanism's causal history that supports the attribution of biological purposes to it, it is natural to consider that features of the history may constrain the scope over which the biological purpose is operative. In this case, the selection for the hoverfly mechanism has occurred because a couple of natural-sign relations are in place:

NSR1: P(A female hoverfly being at x,t|angular velocity of retinal image being ω) > P(A female hoverfly being at x,t)

NSR2: P(Intercepting a female hoverfly at x,t|Displaying behavior B) > P(Intercepting a female hoverfly at x,t)

where $\omega = f(x, t)$ and $B = g(x, t)$. That is, the relevant natural-sign relations hold under (1) certain transformations of angular velocities of retinal images onto positions of female hoverflies, and (2) certain transformations of behavioral responses onto positions of female hoverflies.

Millikan's *proximal hoverfly rule* may be rendered thus:

PHR: In presence of a retinal image with angular velocity ω, issue behavioral response $B = g(x, t) = g(f^{-1}(\omega))$.

Now, what is causally grounding NSR1 and NSR2? Well, the average flight speed of hoverflies remains approximately constant, because hoverfly physiognomy remains approximately constant; non-hoverfly darting things are sufficiently rare, and it remains thus, among other things, because the ratio of non-hoverfly insects versus hoverflies is also approximately constant, etc. Facts of this kind make it the case that the inequalities NSR1 and NSR2 hold—but, crucially, *only insofar as said causal grounds do ground the natural-sign relations*.

Let us suppose that these causal grounds are operative only for values of ω below 330 degrees per second (I am making this up). The problem should now be apparent: there are infinitely many mathematical functions that overlap with f in the range supported by the causal grounds, and infinitely many others that overlap with g. And there is nothing to determine which one of them should figure in PHR.[6]

It should be noticed that a number of things Millikan says against some alternative candidates for PHR have no bearing against the present worry: suppose that never in the history of hoverflyhood has a female produced an image in the retina with an angular velocity between 500 and 510 degrees per second. It is still

the case that the following *proximal* quoverfly *rule* is wrong (Millikan, 1993, p. 221):

> PQR: In presence of a retinal image with angular velocity ω, issue behavioral response $B = g^{\star}(x, t) = g^{\star}(f^{-1}(\omega))$.

where

$$\begin{cases} g^{*}(x,t) = \text{Don't move if } 500 < f(x,t) < 510 \\ g^{*}(x,t) = g(x,t) \text{ otherwise} \end{cases}$$

Hoverflies do not have the biological purpose of following PQR: it is not *that* rule that explains why males catch females. There is a principled reason to choose PHR over PQR: there is a concrete causal explanation of the fact that the behavior of male hoverflies is fitness-conducive. This explanation involves the causal underpinnings of the relations NSR1 and NSR2, and these causal grounds also cover the range of angular velocities between 500 and 510 degrees per second, regardless of whether such values have or have not actually been instantiated.

There is another, more complicated case that Millikan considers: suppose that, because of engineering constraints, hoverflies do have a blind spot between 500 and 510 degrees per second. So, their dispositions are best described by PQR. As a matter of fact, whenever a shadow between that range of velocities crosses a male's retina, it doesn't move. (Millikan, 1993, p. 222) claims that, in this case, the rule the male hoverfly has the biological purpose to follow is still PHR: the disposition to rest at ease in the blind spot in no way furthers hoverfly reproductive goals.[7] In the way I have been putting things, the causal grounds tying retinal shadows with future positions of female hoverflies are operative also in the blind spot; on these grounds we should include those values in the rule.[8]

But none of this gives a reason to choose one among the many different functions that overlap perfectly inside the zone of causal grounding and diverge, however wildly, outside of it. That is, Millikan has given no reason to decide between the different substitutions of the following proximal hoverfly rule schema:

> PHR-Schema: In presence of a retinal image with angular velocity ω, issue behavioral response $B = gi\ (fi^{-1}(\omega))$.

Where $\forall i\ (gi\ (fi^{-1}(\omega)) = g\ (fi^{-1}(\omega)))$ inside the causally-grounded domain of the function.

Millikan wants PHR to emerge as the one and only rule male hoverflies follow, but the kind of considerations she advances—having to do with what rule explains the fitness-conduciveness of the hoverfly mechanism—cannot in fact distinguish PHR from an infinite number of competitors, the infinitely many substitutions of PHR-Schema. Another way to put this point is the following: mathematical functions such as f and g have a role to play in the causal explanation of the selection of a mechanism only insofar as they describe the behavior of whatever it is that is causally effective in

said selection. But causal mechanisms underdetermine which mathematical functions describe them. This underdetermination leads directly to rule-indetermination.

Notice that it will not do to retort that *the* mapping function has a set of normal conditions for application (that yields the causally-grounded domain) and that, outside this set, the right thing to say is that the application is abnormal. In fact, the foregoing discussion has shown that there is no fact of the matter as regards which is the right mapping function outside of the causally-grounded domain.[9] So, finally, this provides reasons to remain appropriately circumspect in our appeal to mapping functions. Mapping functions, I submit, are well and good if we restrict their application to the causally-grounded domain: we should build our content theory only upon the relations recorded in Natural Sign Generalized. So, for example, a sensible teleosemantics should admit that $D^{\star}$ (the bee dance with an aberrantly long waggle part) is meaningless.

In a recent discussion, Millikan appears to agree with this conclusion ('beemese' is the name Millikan gives to the mapping function that takes bee dances to positions of nectar):

> It is unlikely that a dance that, by logical extension of beemese rules, would tell of nectar much too far to fly to could be either danced or, more central, recognized by fellow bees. No ancestor bees have had dispositions to make use of such dances. Such bee dances, then, are meaningless in beemese. (2006, p. 107)

It is informative to see in which way Millikan's diagnosis of the situation differs from the one I have been offering here. On the one hand, Millikan relies on the empirical implausibility of dances such as D*: perhaps bees are unable to dance them. Maybe so, but, in the discussion of Kripke's skeptic I have been reviewing, Millikan has strived to separate content from actual dispositions. It may well be that no bee has ever had the disposition to use D*, but in the parallel discussion, the fact that a hoverfly had a blind spot between 500 and 510 degrees—and, thus, had no dispositions to respond in that range—was (correctly) dismissed as irrelevant for the purposes of content attributions. If so, it is difficult to see why a lack of disposition to respond to $D^{\star}$ should matter. Either dispositions are irrelevant or they are not, but Millikan cannot have it both ways. Besides, what happens if, after all, bees are able to dance the dance? Suppose that the mechanism that creates dances has a tendency to create, very rarely, an aberrant dance such as D*. If I am right, we are still forced to say that $D^{\star}$ is meaningless: the causal grounds that cover the relation of typical dances to positions of nectar do not cover $D^{\star}$ and, thus, there is no fact of the matter regarding which mapping function should we apply to it. It is now unclear what Millikan would want to say about this case, and on which grounds.

On the other hand, Millikan talks of the impossibility of such an aberrant dance being recognized by other bees. *Recognition* is, presumably, an intentional notion: that there is recognition depends on whether the receiving bee is able to form a mental state with the same content as the dance.[10] We have no idea whether this is possible or not, and we should not care: there is no need, for a dance to have content,

that such contentful mental states exist. The dance might well be issuing orders directly to the wings of the bee without the intervention of the bee's cognitive system—though in point of fact dances do not, of course. That there is recognition is not necessary to fix the content of dances.

Millikan reaches the right conclusion—that aberrant bee-dances are meaningless—but by, first, making the content of dances depend on mapping functions and, then, restricting the scope of these mapping functions to those supported by actual dispositions of the consumers of the representation. This goes against the grain of her proposal regarding Kripke's skeptic and, in fact, makes it essentially a dispositional account of the kind that were the main target of Kripke's discussion. The right way to restrict mapping functions is, I have claimed, by paying attention to the causal grounds of these very mapping functions—the natural sign relations of Natural Sign Generalized.

Millikan is happy (even if maybe for the wrong reasons) to accept that some bee dances are meaningless. But she is not willing to accept an analogous result in the case of human thought. Undoubtedly, we are able to think about events which are causally isolated from us, and Millikan wishes to honor this tenet. The next section casts doubts on the resources of her theory to do so: it is even more unclear that mapping functions are able to fix the content of human thoughts than that they are to fix the content of bee dances.

5. Compositionality

As I advanced in section 3, Millikan's ultimate goal is to make both indexicality and compositionality particular cases of the general productivity afforded by mapping functions. We are now in a position to see how one may think of compositionality as depending on mapping functions of the same kind as the ones that accounted for indexicality. Remember from the above that a simple contentful state, such as *M*'s being turning *on here now*—which, I said, means "There is food here now"—belongs in a system of signs, *SYS,* together with all other actual or possible events of *M*'s being turning *on*. Members of *SYS* and their signified events are tied together by a certain mapping function, and I have just been arguing that we have a grip on this function only within the causally-grounded domain.

On the face of it, compositionality is an entirely different beast: productivity is achieved by the more or less free recombination of conceptual items into more or less iterable syntactic structures. There does not seem to be any clear place for mapping functions from thoughts to propositions in this story. Millikan (1984, pp. 108 & 144) makes the interesting proposal that there actually *is* a causally-grounded mapping function from beliefs to states of affairs, just like from bee dances to positions of nectar.

The system of signs here is, roughly, the class of all possible beliefs. In simple systems of signs such as *SYS* above, you could get from one sign to another by

modifying their spatio-temporal location. In the belief system-of-signs, the ''feature'' that must be modified to get from one sign to another is more elusive: the main transformation is *substitution*, an operation that takes, say, the thought ''Democritus jumps'' to, on the one hand, thoughts like ''Xenocrates jumps'' and, on the other hand, to thoughts like ''Democritus protracts his tongue.'' Likewise, the state of affairs consisting of Democritus's jumping transforms to the state of affairs consisting of Democritus's protracting his tongue, and to the state of affairs consisting of Xenocrates's jumping. The set of possible sentences reachable by transforming a thought *s* defines the ways in which the state of affairs that *s* represents should be considered as articulated. A state of affairs plus a certain way of articulating it individuates what Millikan calls a *world affair*.[11]

Let us call the mapping function that takes the system of signs which is the class of every belief to their meanings $MF_{Mentalese}$. How are we to establish that the belief-system maps onto meanings according to $MF_{Mentalese}$? Bear in mind that this mapping function must suffice to endow with meanings beliefs that have never been entertained before by anyone—the whole point of introducing mapping functions, after all, was to account for productivity. I will not worry about how to account for something similar to Evans' (1982) Generality Principle, according to which, if a thinker is able to entertain the thought ''Fido is brown'' and the thought ''Bill Gates is tech savvy,'' she will be able to entertain ''Fido is tech savvy.'' It is very difficult to see just what in the causal order is going to make $MF_{Mentalese}$ take ''Fido is tech savvy'' to the proposition that ''Fido is tech savvy,'' but it is also open to Millikan to defend that we cannot really think this thought. It is difficult to see what could adjudicate this issue.

It is best to concentrate in an uncontroversial subset of $MF_{Mentalese}$'s domain. Consider again the food thought, ''There is food here now,'' as entertained by a human thinker, and all other thoughts that derive from the food thought by substituting *here* and *now* with other spatio-temporal concepts, say, INSIDE THE PINATUBO VOLCANO, or THREE MILLION YEARS INTO THE FUTURE. It is clear that we can think that there is food at these places and times, and, if Millikan's account of this ability is correct, this is because $MF_{Mentalese}$ takes, for example, the thought ''There is food inside the Pinatubo volcano during the 1991 eruption'' to the proposition that there is food then and there.

Now, there are certain causal connections between thoughts of the food thought kind and facts having to do with the location of food: food being at the relevant times and places has caused the tokening of certain thoughts which, in turn, have caused fitness-improving (say, food-grabbing) behaviors. These causal facts may help ground the part of $MF_{Mentalese}$ that makes reference to places and times in the domain that humans occupy—even if the particular place and time has never been and will never be occupied by a human being—but they cannot ground thoughts that make reference to location outside this domain, for exactly the same reasons that I presented in section 4. It is only that, in the human case, we cannot simply bite the bullet and say that the thought ''There is food inside the Pinatubo volcano during the

1991 eruption'' is meaningless. That this thought means what it seems to mean is non-negotiable.

Millikan (1984, 2004, 2006) has suggested that a mechanism that tests beliefs for inner consistency may help explain our coming to have beliefs about world affairs which are causally isolated from us (let us call them *far away beliefs*), and which in no way further our biological goals:

> Consistent agreement in judgments is evidence that ... various methods of making the same judgment are all converging on the same distal affair, bouncing off the same target, as it were. If the same belief is confirmed by sight, by touch, by hearing, by testimony, by various inductions one has made, and is confirmed also by theoretical considerations (inference is a method of identification too), this is sterling evidence for the univocity of the various methods one has used to identify each of the various facets of the world that the belief concerns. (Millikan, 2006, p. 111)

So, let us suppose that I am told that water boils at 100°C outside my light cone, and independent theoretical reasoning leads me to the same conclusion.[12] Here, according to Millikan, the consistency in these two judgements works as a confirmation of the relevant hypothesis about water. Even if it's true that the workings of a consistency tester would be enough to fix a mapping function that deals with far away or useless beliefs[13], the problem with off-causal-grounds mapping functions turns into another problem: there is no fact of the matter as to whether a certain mechanism is a consistency tester. To see this, consider what it takes for a certain mechanism, let us call it CONSIST, to acquire the function to test a corpus of beliefs for consistency. At the very least, for CONSIST to acquire such a function, there must be beliefs such that it is a CONSIST-independent fact of the matter whether they are consistent or not. Otherwise, if all there is to two beliefs being consistent is that a token of CONSIST gives a positive output when confronted with them, the relation of being consistent is entirely vacuous.

Let us assume, then, that there are consistent beliefs prior to the existence of CONSIST. We may want to hypothesise the following three step process:

(1) Beliefs in a certain corpus CB acquire their meaning (and their status as consistent or inconsistent with one another) independently of CONSIST.
(2) CONSIST tests beliefs in CB for consistency, and thereby acquires the function of being a consistency-tester.
(3) CONSIST helps fix the meaning of other beliefs by testing for their consistency with beliefs in CB and previously tested beliefs.

The problem with such a story is that the description in 2 is tendentious. It is unwarranted to claim that CONSIST is testing beliefs for *consistency*, where consistency is a relation that holds between any beliefs whatsoever, far away or not, useful or not. The only matter of fact is about the following: CONSIST tests beliefs in CB for consistency*, where consistency* is consistency between beliefs about states of affairs in causal contact with human beings. A consistency* tester clearly cannot help fix the meaning of beliefs about far away beliefs.

The upshot of this discussion is that mapping functions cannot play the role Millikan accords to them in the explanation of the compositionality of beliefs – not even with the help of consistency* testers. It is wrong to think of a mapping function between beliefs and world affairs such as $MF_{Mentalese}$ as a *precondition* for beliefs to have meaning. The idea that there is *the right mapping function* to play this role is already invested with the intentionality we are seeking to explain.

5.1. Naturalism, Simplicity and Elegance

I have argued that Millikan's account of productivity, as it stands, is unable to provide a unique content attribution for new (never entertained before, and at any rate not selected for) thoughts such as "There is food inside the Pinatubo volcano during the 1991 eruption." Once we have applied the Millikanian recipe for the attribution of content to these thoughts, we still have an indeterminately large number of candidates, one for each of the candidate mapping functions among which the theory does not choose. Some unspecified mechanism has to do the final choosing, and I have suggested this is a problem for the naturalistic credentials of the theory.

Now, it might be adduced that, even if I am right and Millikan's theory of productivity underdetermines the content of new thoughts, other naturalistically acceptable tools could help secure univocity. For example, an appeal to simplicity, or elegance (from now on, also 'S&E') could help the theorist choose among mapping functions: maybe we simply need to choose the simplest, or most elegant among the different candidates. Scientific practice makes routine use of S&E considerations, so this surely is naturalistically acceptable?

The first thing to note is that Millikan herself appears to refrain from this appeal to S&E. Rather, she has insisted in the role of the consumer in fixing the right mapping function—and, as I have tried to establish in this paper, the consumer cannot do what Millikan wants it to do.

But this exegetical point is of limited interest: maybe the right theory about productivity in thought uses Millikan's recipes to reach a set of candidate mapping functions and, after that, goes beyond her doctrine in applying S&E considerations to pick out the right candidate from that set. There is a more substantial reason to resist this approach, though, and one which is not a general reason to avoid S&E considerations in science: what Millikan sets out to provide is a (metaphysically naturalistic) *theory* of what productivity in thought amounts to, as opposed to mere directions on how to find such a theory. Incorporating the S&E suggestion would amount to a theory of approximately the following form:

> Productivity: The meaning of a new thought is its image according to the simplest and most elegant candidate in the set $MF_{Mentalese}$ candidates (i.e., the set of mapping functions among which Millikan's theory cannot decide).

Now, S&E are legitimate tools in the *naturalistic approach*—in the sense that Chomsky (1994/2000) gives to this notion—to the study of intentionality. That is, the appeal to S&E may help the theorist "construct intelligible explanatory theories,

with the hope of eventual integration with the 'core' natural sciences'' (Chomsky, 1994/2000, p. 76.). But accepting this methodological role for S&E does not mean that simplicity and elegance are legitimate *ingredients* of a naturalistic theory of intentionality. It is unlikely that simplicity or elegance will play undischarged roles in the theory of intentionality that eventually turns out to be correct—that is, it is unlikely that S&E help in *making* something the meaning of a language expression or a thought. Compare: one can use S&E considerations on the way to a theory of gravity, and it may well be that the simplest and most elegant among a number of plausible candidates is the right theory of gravity; but this does not mean that the notions of simplicity and elegance (as opposed to the notions of *mass* or *field*) will play a role in the right theory of gravity. Rather, it is overwhelmingly plausible that they will not. Analogously, while the notions of cause and function will likely play a role in the right theory of intentionality, simplicity and elegance most probably will not.

In summary, what I am suggesting is that the only way to use S&E considerations to save Millikan from the charge of indeterminacy is by incorporating an appeal to S&E in the theory of intentionality itself, and this is not acceptable. The misleading appearances of acceptability come from the legitimate role that these notions can play in the vicinity, as tools in naturalistic research.[14]

5.1.1. Special Theories of Intentionality

This response assumes that Millikan is after a theory of productivity in thought in general. This is a fair assumption, and anyway the most interesting project; but what if, instead, we construed her as tackling independent explananda, such as *productivity in bee thought*, *productivity in hoverfly thought*, *productivity in human thought*, etc.? If so, then the appeal to S&E happens *en route* to these specialised theories and is unobjectionable, a mere tool in the naturalistic approach to these special problems.[15]

One worry about this rejoinder is that it amounts to renouncing the investigation of intentionality as a unified phenomenon. The resulting theories would not comment on what makes bee intentionality, human intentionality, etc., species of the same kind. Another, more pressing problem is that, in the most (the only?) interesting case for content naturalizers—that of productivity in human thought—there simply is no theory to evaluate. That is to say, there simply is no characterisation, formal or informal, of $MF_{Mentalese}$ in Millikan's writings, over and above impressionistic remarks to the effect that $MF_{Mentalese}$ should take mental sentences such as ''Theatetus swims'' to the fact that Theatetus swims. Without a characterisation of $MF_{Mentalese}$ there is no special theory of human productivity to assess, and what does not exist cannot be naturalistic.

6. Conclusion

In Millikan's account of productivity, the main bearer of mental content is the (propositional) thought. Although she recognizes a sense in which concepts such as

DOG have meaning, this meaning is entirely dependent on the thoughts in which the concept participates, in the following way: such thoughts have their meaning provided by a mapping function, and it is invariances in the world affairs to which all dog-involving thoughts are taken by such a function that fix the meaning of DOG. All of these world affairs involve dogs, and it is in virtue of this fact that DOG refers to dogs.[16] Unfortunately, as we have seen, the appeal to mapping functions is unable to do the job it was hoped it might do.

In section 2, I gave a reason to think that propositions, and not concepts, are a sensible foundation for a theory of content. On the other hand, in the rest of the paper I have, I hope, given reasons to think that relying wholly on propositional contents is incompatible with human-style productivity—or, at least, that the one account that tries to effect the reconciliation fails.

It is natural to conclude that mapping functions do not get around the classical idea according to which there are thoughts whose content is determined by their structure and the content of their subpropositional components. To progress towards a naturalistic account of productivity we need, that is, bona fide bottom-up content determination; bona fide compositionality. Thoughts such as ''Bill Gates is tech savvy'' are composed of the concepts BILL GATES and TECH SAVVY, and the operation of predication; and the meaning of ''Bill Gates is tech savvy'' derives (via a compositionality principle) from the meaning of its constituents and the way in which they are organized. ''Derives'' here is meant in the strong sense, according to which the meaning of the sentence in question is *grounded* on the meaning of the concepts in question and the meaning-endowing features of the mechanisms that effect syntactic associations among concepts.

I suggest that the sensible teleosemantic program involves providing an account of the meanings of concepts and of mechanisms able of performing syntactic operations among them. We may then simply model the meaning of thoughts with abstract structures—say, interpreted syntactic trees. This is entirely compatible with recognizing the existence of other dimensions of meaning, such as Millikanian real values and causally-grounded mapping functions. But, at any rate, we should abandon the hope of accounting for productivity simply by using mapping functions, if we remain committed to naturalism.

The outstanding problem for teleosemantic accounts of productivity is to solve the conflict between letting content determination be top-down, from thoughts to concepts—as we need to avoid, inter alia, train-of-thought objections—and accepting that it may be bottom-up, from concepts to thoughts, which we need to explain human-style productivity through compositionality. A tall order, but seeing clearly what is needed is already a step in the right direction.

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Notes

[1] The kind of naturalism that will interest me here (and I think the kind that Millikan wishes to uphold) is what has been called *metaphysical naturalism* about intentionality: roughly, the idea that intentional idioms such as *means*, *is about* or *refers to* pick out entities (relations, etc.) "of the natural physical world that science investigates" (Horgan & Timmons, 1992, p. 153; see also Dowell, 2004). It is notoriously difficult to make this idea more precise—an important discussion of some problems in this connection is Chomsky (1994/2000); see also the copious literature on Hempel's dilemma of which Melnyk (1997) and Pineda (2006) are informative examples. This is not the right place to discuss the very substantial issue of the correct formulation of metaphysical naturalism. In any event it is likely that there *is* a correct formulation, maybe along the lines suggested in (Pineda, 2006).

[2] Notice that *M* belongs to SYS only relative to the natural-sign relation it establishes with F. It may be that *M* establishes other natural-sign relations with other properties, each of which will define an alternative system of signs.

[3] And causing, or maybe constituting the fact, that food is there.

[4] For clarification, let me show how this example is a substitution of the Natural Sign Generalized schema: The sign s is a set of footsteps. The relevant feature *FS* is the distance between footsteps in s. The signified event *E* is the hiker's walk. Finally, her speed is the relevant feature of the signified event, *f*(*FS*).

[5] At the end of this section I briefly discuss whether Millikan is committed to L3 or not.

[6] Maybe facts about the simplicity of the candidate mathematical functions may help to pick the correct one? I take up this question in subsection 5.1.

[7] This is the sensible position. At the end of this section I will discuss Millikan's apparent change of mind in this respect.

[8] There is a certain complication I am putting aside here. As it stands, the case is underdescribed: the causal underpinnings of NSR2 depend, among other things, on the mean velocity of male hoverflies. If the engineering constraints alluded to in the description of the case are such that the maintenance of this mean velocity depends on leaving this blind spot in the response to retinal shadows, then this is a true gap in the causal underpinnings, and, *pace* Millikan, there is no principled reason to include these values in the rule. Another possibility is that engineering constraints do not mess with the causal grounds for the indication relations in this or other ways. If so, we can endorse PHR. This second option is the one I am taking for granted in the main text.

[9] Millikan, in personal communication (June 2009), has suggested that appeals to the needs of the consumer (the male hoverfly) can do more to fix the content of the biological purpose of the hoverfly, and thus the particular function that must go in PHR-Schema, that I am allowing here. The male needs a female hoverfly, so that is what the biological purpose is about. It is doubtful that this will work. The needs of the consumer can, surely, decide among different purposes within the range in which the consumer will use such purposes. But, for example reacting to extremely high or extremely low angular velocities of retinal shadows would never be conducive to fulfilling the needs of the consumer, because such velocities will never indicate the presence of a female hoverfly. Appeals to the consumer leave open a fair amount of indeterminacy among mapping functions.

[10] Or maybe "recognition" just refers to the bee's disposition to react in certain ways to dances. If so, the point made in the previous paragraph about Millikan's use of dispositions applies to recognitions as well.

[11] Millikan is after a fine-grained notion of state of affairs, according to which ''Theatetus swims'' and ''Theatetus exemplifies swimming'' are different states of affairs because they are differently articulated. If transformations define articulations, it may be suggested that states of affairs are articulated in *every* way. For example, there is a straightforward transformation that takes ''Theatetus swims'' to ''Theatetus exemplifies swimming''—substitution of predicates. In response to this, Millikan may, perhaps, defend that there are ways to distinguish relevant from irrelevant transformations. In any event, I do not wish to press this point any further.

[12] Whatever happens outside the light cone seems to be the stock example in discussions of teleosemantics and the reference to far away, causally-independent facts (e.g., Peacocke, 1992). I should like to note that many events outside our light cone are really near to us: the events going on a meter away from me five Planck times in the future are outside my light cone. It is clear that teleosemantic accounts may be able to deal with thoughts involving that spatio-temporal location—which is almost here, and almost now. Anyway, let us assume that we are dealing with water boiling *well* outside my light cone.

[13] See Rupert (1999) for some reasons why it may not be.

[14] Apart from simplicity and elegance, other (maybe naturalistically acceptable) tools could be considered: the interests of the theorist, say, or her intuitions about certain cases. The analogous point could be made regarding them.

[15] Probably, something like this is the right way to describe what ethologists working in bee communication are doing.

[16] In this connection, it is interesting to note that, in (Millikan, 2000), a book dedicated to the discussion of the concepts of substances (individuals, stuffs, and kinds), the space accorded to the discussion of productivity is no more than two paragraphs—and there is no discussion of compositionality. This is, I think, further evidence of the negligible role that Millikan accords to bottom-up content determination.

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