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COMPOSITIONALITY, CONTEXT, CATEGORIES AND THE INDETERMINACY OF TRANSLATION

ABSTRACT. The doctrine that meanings are entities with a determinate and independent reality is often believed to have been undermined by Quine's thought experiment of radical translation, which results in an argument for the indeterminacy of translation. This paper argues to the contrary. Starting from Quine's assumption that the meanings of observation sentences are stimulus meanings, i.e., set-theoretical constructions of neuronal states uniquely determined by inter-subjectively observable facts, the paper shows that this meaning assignment, up to isomorphism, is uniquely extendable to all expressions that occur in observation sentences. To do so, a theorem recently proven by Hodges is used. To derive the conclusion, one only has to assume that languages are compositional, abide by a generalized context principle and by what I call the category principle. These assumptions originating in Frege and Husserl are coherent with Quine's overall position. It is concluded that Quine's naturalistic approach does not justify scepticism with regard to meaning, but should rather result in a view that affiliates semantics with neuroscience.

The philosophy of language in the twentieth-century, with a grain of salt, can be regarded as the rise and fall of semantic realism. The century began with an outline of what it would mean that meanings exist as independent entities. To make this view explicit and to defend it was a major achievement of Gottlob Frege and Edmund Husserl.¹ In the second half of the century scepticism about meanings became prevalent. It was fostered importantly by two challenges, one due to W. V. Quine (1960) and well-known as the thesis of the indeterminacy of translation, the other often attributed to Hilary Putnam (1983) and discussed as the model-theoretic argument against metaphysical realism. Frege and Husserl set the rules for the game when they formulated three principles as constraints for any theory of meaning. The first one became known as the *principle of compositionality* and says that the meaning of an expression is determined by the meanings of its parts. The second one is what I call *context principle*. It claims that two expressions fail to differ in meaning just in case a substitution of one for the other has no effect on the meaning of any of their embedding contexts (Throughout the text I understand 'context' to mean linguistic rather than situational context). While the former two principles go back to Frege, the last one, the *category principle*, is due to Husserl.



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It says that synonymous expressions never belong to different syntactic categories.

The paper defends semantic realism against Quine's (1960) sceptical challenge.² This is done not by drawing into question any of his premises, but from within his own philosophical set-up. *Semantic realism*, hereby, is regarded as the assertion that the expressions of natural languages, up to isomorphism (see below), have determinate meanings, which themselves are metaphysically independent from expressions – they are neither identical with nor essentially constituted of expressions. In particular, it is shown that once the observation sentences of a language are assigned unique meanings – i.e. their stimulus meanings – the Frege–Husserl triad entails that every part of an observation sentence, up to isomorphism, has a unique meaning.

The linchpin of my argument for this conclusion is a theorem some variant of which has been proven recently by Wilfrid Hodges (2001). Its terminology is quite intricate, so we will have to work up to it until Section 6. Since the theorem has been barely noticed yet, the full proof is provided in the appendix. In the preceding Sections 1–5, the principles of the Frege–Husserl triad are made explicit and the claim of semantic realism is elaborated. It is shown that the triad is neutral with regard to both semantic realism and its negation, semantic anti-realism. Furthermore, the project of radical translation is described as an instance of the so-called *extension problem*, i.e., the problem of how to find a meaning function for a language if a meaning function for a certain fragment of the language has already been given. In Section 7 a number of objections are discussed including various alleged examples for the indeterminacy thesis. The paper closes with an outlook on how one should do semantics if one has learned Quine's naturalistic lesson and still abides by the Frege–Husserl constraints.

1. HOW TO COMPOSE MEANINGS

Frege, in the only posthumously published manuscript *Logic in Mathematics*, writes what later, to many, serves as the template for a formal definition of the principle of compositionality:³

[...] thoughts have parts out of which they are built up. And these parts, these building blocks, correspond to groups of sounds, out of which the sentence expressing the thought is built up, so that the construction of the sentence out of parts of a sentence corresponds to the construction of a thought out of parts of a thought. And as we take a thought to be the sense of a sentence, so we may call a part of a thought the sense of that part of the sentence which corresponds to it. (Frege 1979, p. 225)

The quotation is, of course, worded in Frege's jargon, which for a Quinean is outright unacceptable. A closer look, however, reveals a message that can be put in more general terms and might be convincing even to someone who refuses to adopt thoughts and senses into his universe of discourse. To uncover this message, I shall distinguish three aspects of Frege's statement.

First, he claims that there is a part-whole relation between sentences and less complex items of language ('groups of sounds' as he puts it). What kind of part-whole relation is appropriate? Cases of ambiguous expressions call for a distinction between mereological and syntactic parts (or constituents). The mereological relation is defined as follows:

DEFINITION 1 (Mereological constitution). A (spoken or written) utterance *s* is called a *mereological part* (or constituent) of an utterance *t* if and only if for any physical token of *t* in some region of space in some interval of time, *s* is physically tokened in the same region and the same interval.

Mereological constitution, thus, is a relation of spatio-temporal co-occurrence. The utterance 'brown', e.g., is a mereological part of the utterance 'brown dog' because the latter utterance cannot be uttered without uttering the former. If we, however, contented ourselves with mereological constitution, we would be likely to run into a problem with the second aspect of Frege's statement: Sentences express thoughts, where for Frege thoughts are nothing but the meanings of sentences. Mereological constitution is a relation apparently too weak to cope with the difficulty that some sentences need disambiguation in order to be related to their meanings by a function rather than by a many-many relation.⁴ In some cases ambiguity is explained as rooting in homonymy. The sentence 'John is walking from bank to bank', e.g., seems to express (at least) two different thoughts depending on whether one interprets 'bank' as a financial institute or as something adjoining a river. These cases of lexical ambiguity are supplemented by cases of grammatical ambiguity. In the sentence 'John saw Judy with a telescope' the sequence of words 'with a telescope' can be read as modifying the noun 'Judy' or the verb 'saw'. The common way to achieve disambiguation is to construe expressions as terms combined from syntactic parts and not as utterances combined from mereological parts. One can introduce more than one term in case of homonymous words and more than one syntactic structure in the case of grammatical ambiguity.⁵

While mereological constitution is a relation between utterances, being a syntactic part is a relation between terms:⁶

DEFINITION 2 (Syntactic constitution). A term *s* of a language *L* is called a *syntactic part* (or constituent) of a term *t* of *L* if and only if

- (a) there is a partial function α from the n -th Cartesian product of the set of terms of L into the set of terms of L such that t is a value of the function α with s as one of its arguments and
- (b) there is a syntactic rule of L according to which $\alpha(s_0, \dots, s_{n-1})$ is a well-formed term of L if α is defined for $(s_0, \dots, s_{n-1})$ and if $s_0, \dots, s_{n-1}$ are well-formed terms of L .

In this case the function α is called a *syntactic operation*. Since the set of rules of a language is closed under conjunction, every iteration $\beta(\dots, \alpha(\dots), \dots)$ of two syntactic operations α and β is itself a syntactic operation. In short, a term and any of its syntactic parts stand in the relation of value and argument of a syntactic operation.

In the first reading of the sample sentence, the prepositional phrase term

$$[[with]_P, [[a]_{DET}, [telescope]_N]_{NP}]_{PP}$$

is a syntactic part of the noun phrase term

$$[[Judy]_N, [[with]_P, [[a]_{DET}, [telescope]_N]_{NP}]_{PP}]_{NP}.$$

This is because English has a syntactic rule $NP \rightarrow N PP$ that allows the generation of a noun phrase term from a noun term and a prepositional phrase term. In other words, there is a syntactic operation, i.e. a partial function, $\alpha : L \times L \rightarrow L$ in English whose domain is the Cartesian product of the set of noun terms with the set of prepositional phrase terms and whose range is a subset of the set of noun phrase terms. In the second reading of the sentence, the prepositional phrase term is not a syntactic part of a noun phrase term but a syntactic part of a verb phrase term that has been built around the verb term $[saw]_V$.

Using the relation of syntactic constitution, we have thus made a distinction between two sentential terms that we could have hardly made had we stuck with utterances and the relation of mereological constitution. This distinction on the level of terms allows us to regain the functionality of the expressing relation. Each sentential term is mapped onto a different meaning.

Mereological constitution is a physical relation between the concrete phonetic or inscriptional items of language that we call utterances, whereas syntactic constitution is a functional relation between terms that are abstract in nature and are represented by means of parse trees or interlaced square brackets. When we talk of expressions we, therefore, have to decide whether we refer to utterances or terms. It will be of some importance

later on that the segmentation of expressions into syntactic parts is always relative to some grammar, while the segmentation into mereological parts is grammar-independent.

Syntactic as well as mereological constitution, as can immediately be seen, are transitive. Both relations are reflexive. This trivially holds for mereological constitution and follows for syntactic constitution from the fact that the identity mapping is a syntactic operation – it is a rule of every language that s is a well-formed term if s is a well-formed term. Both relations also are anti-symmetric, i.e., a term/utterance s is identical with a term/utterance t if s is a syntactic/mereological part of t and t is a syntactic/mereological part of s .⁷ The relation of mereological constitution, thus, introduces a partial order in the set of utterances while syntactic constitution introduces a partial order in the set of terms.

To link terms to utterances, it is common to introduce a *surface function* for a language, i.e., a surjective function that maps the set of grammatical terms onto the set of (types of) utterances. The utterance

‘with a telescope’,

e.g., is the surface of the term

$$\left[[with]_P, \left[[a]_{DET}, [telescope]_N \right]_{NP} \right]_{PP}.^8$$

Note, however, that the way of coping with ambiguity by introducing terms is not for free since identifying expressions with terms makes the partial order therein grammar-dependent.

The third aspect Frege maintains is that the part-whole relation in the linguistic realm, which, from now on until Section 7, I will identify with the relation of syntactic constitution (consequently also identifying expressions with terms), corresponds to some part-whole relation in the realm of meaning. The sort of correspondence that best fits in place is that of a homomorphism. This analysis of Frege’s statement leads us to the modern (and precise) notion of semantic compositionality as it has been successively developed by Montague (1974), Janssen (1986), Partee et al. (1990), and Hodges (2001).

We define the *grammar* G of a language L as a pair

$$G = \langle T, \Sigma \rangle,$$

where T is the set of terms of L and Σ is the set of basic syntactic operations $\alpha_0, \dots, \alpha_{j-1}$ of L . The set T is the closure of a set of primitive terms with regard to recursive application of the syntactic operations. The set of

atomic terms is uniquely determined by the grammar as the set of terms that are not in the range of any basic syntactic operation. For technical reasons, we allow terms to have variables ξ, ξ_0, ξ_1 , etc. as syntactic parts. The *set of grammatical terms* $GT(G)$ is a set of terms such that the terms of the set do not contain any variables. $GT(G)$ is closed under syntactic constitution, and all and only terms of this set surface as utterances. The scope of the set of grammatical terms of a language and the domain of the surface function of the language, thus, are interdependent. The only purpose for the introduction of variables is to specify the positions in which certain grammatical terms occur as syntactic parts within other grammatical terms. In our notation

$$t(p_0, \dots, p_{n-1} | \xi_0, \dots, \xi_{n-1})$$

is the term one obtains if one simultaneously replaces each occurrence of the variable ξ_i in the term t by the term p_i , for each index i ($0 \leq i \leq n-1$). Given that a non-grammatical term t contains the variables $\xi_0, \dots, \xi_{n-1}$ only, and given that $p_0, \dots, p_{n-1}$ are variable-free, the term $t(p_0, \dots, p_{n-1} | \xi_0, \dots, \xi_{n-1})$ is grammatical and the grammatical terms $p_0, \dots, p_{n-1}$ figure in it at the positions $\xi_0, \dots, \xi_{n-1}$ as syntactic parts.

We understand a *meaning function* μ of a language to be a function that maps a subset of the language's set of grammatical terms to their μ -meanings – for now I do not want to specify the nature of meanings any further. A grammatical term of the language is called μ -*meaningful* if the term is in the domain of the meaning function μ . Any μ -meaningful terms p and q of the language are said to be μ -*synonymous* (in symbols: $p \equiv_\mu q$) if and only if they have the same μ -meanings. A meaning function is called *total* if its domain is the entire set of grammatical terms of the language. Having introduced all these notions, we can now define the notion of a compositional meaning function:

DEFINITION 3 (Compositional meaning function). Let μ be a meaning function for a language with grammar G , and suppose that every syntactic part of a μ -meaningful term is μ -meaningful. Then μ is called *compositional* if and only if, for every syntactic operation α of G , there is a function μ_α such that for every non-atomic μ -meaningful term $\alpha(t_0, \dots, t_{n-1})$ the following equation holds:

$$\mu(\alpha(t_0, \dots, t_{n-1})) = \mu_\alpha(\mu(t_0), \dots, \mu(t_{n-1})).$$

A language is called *compositional* just in case it has a total compositional meaning function. A language, it follows, is compositional just in case the algebra of its grammatical terms

$$\langle GT(G), \{\alpha_0, \dots, \alpha_{j-1}\} \rangle$$

is homomorphous to a semantic algebra

$$\langle \mu[GT(G)], \{\mu_{\alpha(0)}, \dots, \mu_{\alpha(j-1)}\} \rangle.$$

The functions $\mu_{\alpha(0)}, \dots, \mu_{\alpha(j-1)}$ may be called *semantic operations* and their arguments may be said to be *semantic parts* of their values. The principle of compositionality can now be put as follows: Every natural language is a compositional language. In natural languages, accordingly, the syntactic parts of any grammatical term homomorphically correspond to the semantic parts of the term's meaning. This turns out to be equivalent to our introductory formulation according to which the meaning of an expression is determined by the meanings of its parts. We only have to translate '... is determined by ::' as '... is the value of some semantic operation with :: as arguments', to take 'expression' to mean term, and to specify 'part' as meaning syntactic part.

2. RADICAL TRANSLATION AND THE EXTENSION PROBLEM

Notice that the analysis of Frege's statement we have given leaves it entirely open what meanings are. If you buy into compositionality, you do not need to buy into any Fregean ontology of thoughts, senses and the like. Compositionality is only about the correspondence of two algebras. It is not about the things that figure in these algebras, especially not on the semantic level. One may well accept compositionality without hypostasizing meanings as entities over and above those physical things we have already been familiar with in daily life and the sciences. One may, for example, apply the principle to Quinean stimulus meanings. This is exactly what I am going to do.

The project of radical translation, in Quine's (1960) setting, can be regarded as an instance of the so-called *extension problem*. In a general form this problem runs as follows: Suppose you are given a language for which you have already found out the meaning function μ as defined for a domain X , which is a subset of some set of grammatical terms Y of the language. What then would a meaning function ν be that is defined on Y and compatible with μ (i.e. has the same value as μ where both functions are defined), if in addition certain other properties are desired? One variant of this problem can be identified if we apply the model theoretical notion of cofinality of partially ordered structures: Generally speaking, a subset X of a partially ordered set Y with ordering $\leq$ is said to be *cofinal* in Y if

for each element y of Y there exists an element x of X such that $y \leq x$. In our case, the case of language, the ordering is syntactic constitution. This leads to the following (derived) definition:

DEFINITION 4 (Cofinality). Provided that X and Y are sets of grammatical terms of one and the same language with grammar G , then X is said to be cofinal in Y just in case X is a subset of Y and every term in Y is a syntactic part of some term in X .

Suppose μ and ν are meaning functions with domains X and Y , respectively, and ν is compatible with μ . Then we say that ν is a *cofinal extension* of μ just in case X is cofinal in Y . The notion of cofinality is illustrated by Figure 1.

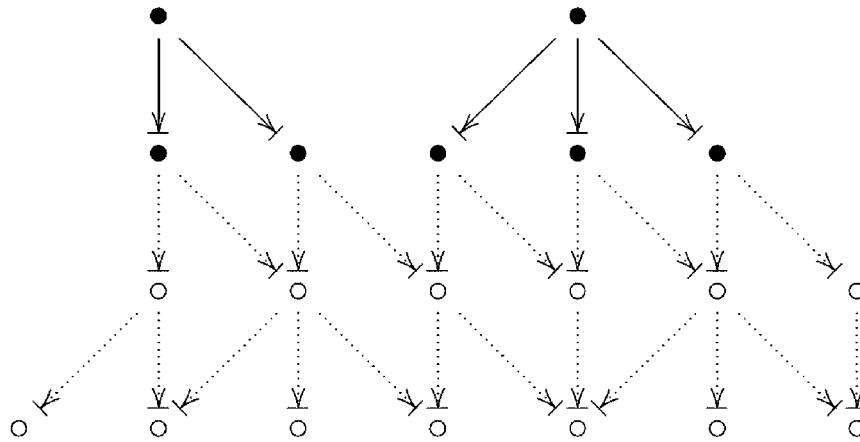


Figure 1. Example of cofinality. A tree representation of a partially ordered structure is shown. Circles represent the elements of the structure. Arrows indicate the order relation with greater or equal elements at tails. The set of elements represented by black circles is cofinal in the set of elements represented by all circles because the set of elements represented by black circles is a subset of the set of elements represented by all circles and for each element represented by a circle there is a greater or equal element represented by a black circle. The black circles might be regarded as representing sentence terms and the white circles as representing sub-sentential terms like noun phrases, verb phrases, prepositional phrases, nouns, verbs, prepositions, etc. Then the arrows may plausibly be regarded as representations of the syntactic part-whole relation.

The problem Quine faces in §15 of *Word and Object* can be described as the puzzle of how to construe a cofinal extension of a meaning function that so far only maps observation sentences onto their stimulus meanings. The extension should be a meaning function that also maps all syntactic parts of observation sentences onto *their* meanings. Quine himself prefers to put the problem in terms of translation rather than meaning in order to

avoid any premature concession to the Fregean ontology, in particular, or to a realistic ontology of meanings, in general. He puts the problem as follows:

We have had our linguist observing native utterances and their circumstances passively, to begin with, and then selectively querying native sentences for assent and dissent under varying circumstances. Let us sum up the possible yield of such methods. (1) Observation sentences can be translated. [...] (2) Truth functions can be translated. (3) Stimulus-analytic sentences can be recognized. [...] (4) Questions of intra-subjective stimulus synonymy of native occasion sentences even of non-observational kind can be settled if raised, but the sentences cannot be translated. And how does the linguist pass these bounds? In broad outline as follows. He segments heard utterances into conveniently short recurrent parts, and thus compiles a list of native 'words.' Various of these he hypothetically equates to English words and phrases, in such a way as to conform to (1)–(4). Such are his *analytical hypothesis*, as I call them. (Quine 1960, p. 68)

Quine concedes that a Native observation sentence can be translated into an English observation sentence *because* Native and English observation sentences have unique subject-independent meanings. The meaning of an observation sentence is its *stimulus meaning*, i.e., the pair of its positive and negative stimulus meaning. In general the positive stimulus meaning of a sentence is the set of states of the subject's neuronal receptors such that the subject is disposed to assert the sentence if his/her neuronal receptors are in one of these states. Likewise, the negative stimulus meaning contains the receptive neuronal states for which the subject is disposed to reject the sentence.⁹ In general the stimulus meaning of an occasion sentence – i.e., a sentence that is asserted at some occasions and rejected at others – is dependent on an individual subject, particularly on the background information available to him/her. The assertion and rejection of an occasion sentence like 'A bachelor is sitting over there' depends on what the subject knows of the observed person's biography. Only in case of observation sentences, Quine holds, stimulus meanings are subject-independent. This is because observation sentences are 'occasion sentences whose stimulus meanings vary none under the influence of collateral information' (Quine 1960, p. 68). A Native observation sentence and an English observation sentence, thus, have either the same or not the same meaning, as a matter of subject-independent linguist fact. It is an objective matter whether they are translations of each other or not.

To be sure, Quine takes stimulus meanings as the meanings properly-so-called in case of observation sentences. He doesn't view stimulus meanings as mere *ersatz* meanings as becomes obvious in a reply to Putnam who mistakenly writes:

The 'stimulus meaning' of the observation sentence [...] cannot be called the meaning of the individual sentence, Quine argues [...]. (Putnam 1986, p. 406)

With explicit reference to Putnam, Quine straightens out this misinterpretation in that he says:

On, the contrary, I did intend the stimulus meaning to capture the notion of meaning – for the linguistic community in the case of an observation sentence, and for the individual speaker in the case of many other occasion sentences. (Quine 1986, p. 428)

One of Quine's reasons for holding that the translation of sub-sentential syntactic parts is indeterminate is his opinion that there is no unique solution to the problem of how to extend a meaning function, that has already been fixed on the domain of observation sentences, to the set of observation sentences supplemented by their syntactic parts. This sort of extension, namely cofinal extension, is what Quine asks for when he, as cited above, writes: 'And how does the linguist pass these bounds?'. The compilation of analytical hypotheses is nothing but a means to pursue the extension project.

To illustrate that the problem of finding a unique extension of stimulus meanings and the problem of finding a determinate translation of sub-sentential syntactic parts in one respect are parallel, I distinguish *translational* and *neuronal meaning*. I understand the translational meaning of a Native term relative to a translation manual to be the English term into which the Native one is translated according to the manual. In addition to the translational meaning, we have the neuronal meaning that is based on a classification of neuronal states. In the case of observation sentences the neuronal meaning is identical to the stimulus meaning.

As far as translation is concerned, the extension problem can be put as follows: How is the linguist to construe a cofinal extension of a meaning function that only maps Native observation sentences onto English observation sentences – their translational meanings – in such a way that one arrives at a meaning function that maps all syntactic parts of Native observation sentences onto *their* translational meanings.

Quine famously argues for the conclusion that there is no unique solution for this problem. This is the result of §15:

There can be no doubt that rival systems of analytical hypotheses can fit the totality of speech behavior to perfection, and can fit the totality of dispositions to speech behavior as well, and still specify mutually incompatible translations of countless sentences insusceptible of independent control. (Quine 1960, p. 72)

Quine's (1960) other reason for holding that the translation of sub-sentential parts is indeterminate originates in his belief that the fixation of translations for observation sentences themselves is not determinate. Thus, the observation sentence 'Gavagai', which Natives are used to uttering in the presence of rabbits, in accordance with the behavioral data, can not

only be translated into the English observation sentence ‘Lo, there is a rabbit’ but also into the English sentences ‘Lo, there is an undetached rabbit part’, ‘Lo, there is a temporal stage of a rabbit’, ‘Lo, rabbithood is instantiated over there’, ‘Lo, there is a part of a rabbit fusion’ or even – in analogy to the event-denoting sentence ‘Lo, it’s raining’ – into ‘Lo, it’s rabbiting’. For Quine each of the six translations is equally adequate because each has the same stimulus meaning. He labels this phenomenon the *inscrutability of reference*. In the light of this problem, the cases for translational meaning functions and neuronal meaning functions are no longer symmetric. For, unlike translational meaning, the neuronal meaning in the case of observation sentences is determinate. The project of finding a neuronal meaning function for the Native language has one source of indeterminacy less than the project of finding a translation. Searching the neuronal meaning function for the whole language, thus, reduces to a variant of the extension problem, whereas the search for the translational meaning also has to deal with the inscrutability of reference – a sceptical claim of Quine’s which I do not want to draw into question.

3. MEANING IN CONTEXT

While the principle of compositionality principally links the realm of expressions to the realm of meanings, the principle I call the context principle is a principle for the individuation of meanings. According to this principle, the meaning of a term can be regarded as the contribution the term makes to the meanings of the terms whose syntactic part it is. To make the principle precise, we first define the notion of a Fregean cover:

DEFINITION 5 (Fregean cover). Let ν and μ be meaning-functions defined on some sets of grammatical terms Y and X , respectively. Then ν is called a *Fregean cover* of μ just in case it holds that any terms p and q in Y have the same ν -meaning if and only if, for all terms t that contain the variable ξ and for which either $t(p|\xi)$ or $t(q|\xi)$ is in X , both $t(p|\xi)$ and $t(q|\xi)$ have the same μ -meaning.

If ν moreover is an extension of μ , we say that ν is a *Fregean extension* of μ . The context principle, now, is defined as the claim that, for every natural language, if the meaning function ν , defined on a set of grammatical terms Y of the language, is a cofinal extension of the meaning function μ , defined on a set of grammatical terms X of the language, then ν is a cofinal Fregean extension of μ .

The principle says that any grammatical terms p and q have the same ν -meaning if and only if p can always be substituted for q (and vice versa) at some position ξ in any term of X without changing the latter term's meaning relative to the meaning function μ . If applied to the case where X contains sentences and Y additionally contains their syntactic parts the context principle comes to the claim that the meanings of syntactic sentence parts (ν -meanings) are individuated according to whether they leave unchanged the meanings of the sentences (μ -meanings) in which they figure as syntactic parts. Notice, however, that our context principle assigns no primacy to sentences over words. Even someone who held the primacy of words over sentences or the primacy of even larger contexts could hold to this principle.

Historically speaking, the context principle defined above can arguably be viewed as a generalization of a principle Frege introduced in 1884:

One always has to take into account a complete sentence. Only therein do the words in effect have a meaning. [...] It suffices if the sentence as a whole has a meaning, thereby also its parts obtain their meanings.¹⁰

Among the many competing interpretations of this passage one can find in the literature, there is one that makes it an instance of our context principle.¹¹ For, the passage can be interpreted as saying that the meaning of a word is individuated by the meaning of the sentential contexts in which the word can occur. This would amount to the claim that any difference in the meaning of two words should make a difference in the meaning of at least one sentential context in which they may be replaced for each other. But this is just what our context principle demands. Notice that this interpretation of Frege's principle as it is quoted above is advantageous over many rival interpretations. (The most frequently held interpretation is that words have meanings only in the context of a sentence. It, however, takes into account only the first half of the quotation, neglecting the second). This is because our interpretation makes it coherent with another principle of Frege's, the principle of compositionality. Making coherent the views of 1884 with those of 1914 has frequently been regarded as a great puzzle in the Frege exegesis (cf. Janssen 2001). As proven by Hodges (2001), however, the context principle, as formulated in this paper, logically entails the principle of compositionality (see condition (b) of Theorem 15) and may, therefore, be even regarded as a justification of the latter.

Quine acknowledges Frege's principle. In *Two Dogmas of Empiricism* he calls it an

important reorientation in semantics – the reorientation whereby the primary vehicle of meaning came to be seen no longer in the term but in the statement. This reorientation,

seen in Bentham and Frege, underlies Russell's concept of incomplete symbols defined in use. (Quine 1961, p. 39)

Indeed, the context principle is also entirely coherent with the idea that the meaning of terms is fixed in use if we presuppose that the use of a term comprises all contexts in which the term may occur – we may leave open here whether this really is an idea one is justified to attribute to Russell (1905). The context principle, furthermore, seems to be in due accordance with Quine's holism of meaning because the former amounts to the claim that the meaning of any expression is determined by, and dependent on, the way it affects the meanings of the contexts in which the expression may occur. The context may eventually even be a whole theory.

4. CATEGORIES – THE BOUNDS OF SYNONYMY

Let us now turn to the last element of the Frege–Husserl triad. In contrast to the former two principles the category principle primarily constrains the synonymy of terms. According to it, no two synonyms belong to different syntactic categories. The principle was first proposed by Husserl (1970, pp. 510–513) as part of his theory of *semantic categories* and since then has made a career in the science of language. The principle was taken up with explicit reference to Husserl by Leśniewski (1929) and made known to a broader audience by Ajdukiewicz (1935). Bar-Hillel (1950) made it a corner stone of his categorial grammar. It is still prevalent in many contemporary linguistic theories as for example von Stechow's (1991) categorial unification grammar.

Husserl raises the issue beginning with the observation that the words and phrases of a language can be organized into classes – let's call them syntactic categories – so that (i) for any two expressions of the same class, one expression can replace the other in any non-ambiguous meaningful context without making the context nonsensical and (ii) for any two expressions of different classes the replacement of one expression by the other will make at least some non-ambiguous meaningful contexts nonsensical. Husserl takes this classification among expressions to be the consequence of some apriori constitution in the realm of meaning. He postulates a law that

governs the formation of unitary meanings out of syntactic materials falling under definite categories having an *a priori* place in the realm of meanings, a formation according to syntactic forms which are likewise fixed *a priori*, and which can be readily seen to constitute a fixed system of forms. (Husserl 1970, p. 513)

For Husserl the reason why some expressions cannot be replaced for each other in every context without destroying the meaningfulness of the context lies in the fact that the meanings of such expressions belong to different semantic categories. In a remark on Marty he claims that any ‘grammatical division rests on an essential division in the field of meaning’ (Husserl 1970, p. 500n).

Having proposed the existence of semantic categories, Husserl envisages a new intellectual enterprise, the exploration of the *a priori* organization of the realm of meanings into semantic categories:

Hence arises the great task equally fundamental for logic and for grammar, of setting forth the *a priori* constitution of the realm of meaning, of investigating the *a priori* system of the formal structures which leave open all material specificity of meaning in a ‘form-theory of meanings’. (Husserl 1970, p. 513)

Husserl’s project to explore the categorical structures in the realm of meanings has often been compared to Russell’s (1908) theory of types. Ajdukiewicz (1935, p. 3) even takes Husserl’s theory of semantic categories – although it is much more ramified – to be the grammatical-semantic counterpart of the theory of types in logic. Indeed, the underlying purpose in both cases is similar: Husserl as well as Russell try to explain the grammaticality/well-formedness of compound expressions/formulas and the failure thereof by recourse to some structure at the semantic level.

From Husserl’s theory of semantic categories the category principle can now be derived in the following way: If two expressions belong to different syntactic categories, their meanings belong to different semantic categories. Any two expressions differ in meaning if their meanings belong to different semantic categories. Hence, synonyms never belong to different syntactic categories.

It will be convenient for my argument against Quine’s semantic scepticism to explicitly define the notion of a syntactic category using the notational conventions I have already introduced in the preceding sections. For the sake of simplicity I will from now on spare the attribute ‘syntactic’, when I talk of categories, and by convention always refer to syntactic categories, i.e., certain sets of syntactic entities (viz. terms). The proper definition of a category is relativized to a meaning function:

DEFINITION 6 (Category). For some language and some meaning function μ defined thereon, any grammatical terms p and q of the language are said to have the same μ -category (in symbols: $p \sim_{\mu} q$) if and only if it holds that, for every term t with the single variable ξ , $t(p|\xi)$ is μ -meaningful if and only if $t(q|\xi)$ is μ -meaningful.

In other words, all and only grammatical terms of the same μ -category can be substituted for each other in any μ -meaningful term whatsoever without making the term whose syntactic parts they are μ -nonsensical. A Husserlian meaning function is now defined as follows:

DEFINITION 7 (Husserlian meaning function). Let μ and ν be meaning functions for some language. ν is called μ -Husserlian if and only if it holds that, for all grammatical terms p and q of the language, if p and q have the same ν -meaning, then p and q share the same μ -category.

We say that μ is *Husserlian* if it is μ -Husserlian. The category principle, now, is defined as the claim that for every natural language, if μ is a meaning function of the language, μ is Husserlian.

At first glance, the category principle may appear controversial if one takes into consideration such pairs of words as ‘likely’ and ‘probable’. Intuitively, one may be inclined to believe that the adjectives ‘likely’ and ‘probable’ express the same meaning. The Husserlian, however, will object that the two adjectives are not always exchangeable without affecting the meaningfulness of the embedding context. Consider the following example:

- (1) It is likely that Alex will leave.
- (2) It is probable that Alex will leave.

Here, the substitution of ‘likely’ and ‘probable’ does not at all seem to change the meaning of the sentence. But consider the two sequences of words:

- (3) Alex is likely to leave.
- (4) *Alex is probable to leave.

The last one is ungrammatical and consequently lacks any meaning. The Husserlian takes this failure of substitution to indicate that, contrary to the first impression, ‘probable’ and ‘likely’ are not synonymous. Gazdar et al. (1985, p. 32) give many more examples of words that intuitively seem synonymous, but for which the Husserlian test suggests that they are not.

Husserl’s category principle has sometimes been criticized on the ground that it construes too close a relation between grammaticality and meaningfulness. In an unpublished manuscript Higginbotham (2003) insists that ‘probable’ and ‘likely’ are ‘synonymous (with some minor qualifications)’ although the substitution of the latter by the former may have an impact on the grammaticality of a sentence. Higginbotham (1985) argues that semantics is indifferent to questions of grammaticality. Gram-

matical idiosyncrasies of a word need not correspond to anything on the semantic level, he maintains.

There are (at least) two strategies to reply to this objection. The first would be to concede that 'probable' and 'likely' are synonymous, but to draw into question that 'Alex is probable to leave' is ungrammatical. Maybe it is only uncommon.¹² This strategy raises the question of an independent and mandatory criterion of grammaticality. The second, more principled strategy would be to say that 'Alex is probable to leave' is meaningful, although it is not grammatical. Here again we could, in consistency with the category principle, concede that 'probable' and 'likely' are synonymous because there would be no reason anymore to doubt that they belong to different categories. Recall that category membership is defined by invariance with respect to the meaningfulness of embedding contexts and not by invariance with respect to their grammaticality. *Mutatis mutandis*, the two strategies apply for proposed analogous counterexamples to the category principle as well.

Apart from the justification of the category principle as a consequence of Husserl's theory, which of course is rather presumptuous and has little force against Quine, there is an independent, quite compelling reason for the principle. It is widely agreed that the substitution of two synonyms for each other in any sentence leaves unchanged the truth-value of the sentence. Now, at least one sentence of the language will lose its truth-value if some syntactic part therein is substituted for an expression that belongs to a different category. For, the sentence, be it true or false, will become nonsensical. This follows directly from the definition of a category. Any violation of the category principle, therefore, would lead to a violation of the principle of the interchangeability of synonyms *salva veritate*.¹³

5. SEMANTIC REALISM

To make the view that meanings exist in reality a substantial claim it should pertain to two dimensions: the independence and the determinacy of meaning. Both dimensions, of course, have to be understood in an appropriate way. To make them explicit, let us first turn to the dimension of *independence*. Surely, meanings, if they exist, are in some sense dependent on the expressions whose meanings they are. As I have noted earlier, there is a function that maps expressions on meanings. From a realist point of view, these functions somehow are wired-in in the brains or minds or environments of subjects during the process of language learning. While children are developing language skills, realistically seen, some law-like connection between expressions and meanings is established. Consequently, for a

semantic realist some (at least weakly) nomological dependency relation holds between expressions and meanings. A semantic realist, however, should not feel comfortable if meanings were identical with expressions or in some other *metaphysical* sense dependent on expressions. Any semantic realist will rebel if meanings are to be identified with expressions, sets of expressions, patterns of expressions, or any other structures in which expressions figure essentially. I thus regard it a dimension of semantic realism that meanings are metaphysically independent of expressions, i.e., for every meaning of some expression, there is a logically possible world in which the meaning exists, but not the expression whose meaning it actually is.¹⁴ Internalist positions that, e.g., identify meanings with mental concepts or neuronal states as well as externalist positions that, e.g., regard meanings as objects, sets of objects, sets of sets thereof, etc. are realistic. In contrast, positions that identify meanings with expressions ('snow' means 'snow'), equivalence classes of synonymous expressions, inferential roles of expressions, patterns of use of expressions, etc. can arguably be called anti-realistic.

The second dimension of semantic realism, *determinacy*, originates in the view that if meanings are real the assignment of some meaning to an expression is correct or incorrect as determined by matters of fact. For a realist, the correct assignment of a meaning to an expression relative to a language is free from any arbitrary consideration of the linguist who undertakes the assignment. Even the realist can however allow that meaning assignments are uniquely determined only up to isomorphism. This concession simply grounds in the fact that isomorphic algebras are notoriously difficult to discriminate because they make the same theories true. Identity up to isomorphism is defined as follows:

DEFINITION 8 (Identity up to isomorphism). Any meaning functions μ and ν that are defined on some sets of grammatical terms X and Y of the grammar G are called *identical up to isomorphism* if and only if X is identical with Y , and the two-sorted algebras $\langle X, \mu[X], \mu \rangle$ and $\langle Y, \nu[Y], \nu \rangle$ are isomorphic.

In other words, the meaning functions μ and ν are identical up to isomorphism just in case they have the same domain and the μ -meanings of two terms in the domain are distinct if and only if their ν -meanings are distinct. To be sure, by indeterminacy Quine means substantially more than just determinacy up to isomorphism.

Semantic realism, finally, comes to the claim that the expressions of natural languages, up to isomorphism, have determinate meanings which

themselves are metaphysically independent from the expressions whose meanings they are. It can easily be seen that the Frege–Husserl triad is consistent both with semantic realism and with semantic anti-realism. To show the former, take as example a first order predicate language without variables, quantifiers, and truth-functions. Assume a realist semantics according to which the meanings of individual constants are objects, that of predicates are their extensions and the meanings of sentences are sets of possible worlds. Obviously, this semantics is realistic and at the same time satisfies the principle of compositionality, the context principle as well as the category principle. To see that the Frege–Husserl triad is consistent with semantic anti-realism as well, take any language and identify the meaning of an expression with the expression itself. Trivially, the homomorphism between grammar and semantics is fulfilled because we even have an isomorphism. Thus, compositionality holds. The satisfaction of the category and the context principle follows just as quickly. By presupposing the three principles we, therefore, do not beg the question against the semantic sceptic.

6. PUTTING THE PIECES TOGETHER

We have by now collected almost all premises we need for our argument in defense of semantic realism. The most important component, however, is a theorem that Hodges (2001) recently proved. Since this theorem does the major work here, I will provide the full, slightly modified proof in the appendix (see Theorem 17 on page 174). The theorem runs as follows:

THEOREM (Hodges’ Theorem). Given a language with grammar G , let X be a cofinal subset of the set of grammatical terms $GT(G)$. Then, if μ is a compositional and Husserlian meaning function with domain X , there is, up to isomorphism, exactly one total Husserlian and compositional Fregean extension of μ .

If you, in other words, have already compiled a meaning function for some subset of the expressions of the language such that every expression of the language is a syntactic part of some element of this subset, then there is one and, up to isomorphism, only one extension of this meaning function to the entire language, provided the language satisfies the Frege–Husserl triad.

In order to apply this result to Quine’s project of radical translation, we take X to be the set of all Native observation sentences and construe an observational sub-language that contains only observation sentences and

all their syntactic parts such that X is cofinal in the set of expressions of the sub-language. Presupposing the Frege–Husserl triad, Hodges’ Theorem assures us that the neuronal or translational meaning function for observation sentences, which the field linguistic should be able to compile by inductive methods, is up to isomorphism uniquely extendable to the entire sub-language.

A further question is to which extent the vocabulary of the observational sub-language is rich enough so that the attained neuronal or translational meaning function suffices to determine the neuronal or translational meanings of the expressions of the original language by compositionality. Recall that the principle of compositionality warrants that once the meanings of the syntactic parts of a sentence and the syntactic operation by which it has been composed are given, the meaning of the whole sentence is determined. So, the neuronal and translational meaning of all those sentences of the original language should be determinable that are built exclusively from expressions of the observational sub-language. To answer the question to which extent the vocabulary of the observational sub-language covers the vocabulary of the original language, let us turn to one of Quine’s more recent definitions of an observation sentence:

Each [observation sentence] should be associated affirmatively with some range of one’s stimulations and negatively with some range. The sentence should command the subject’s assent or dissent outright, on the occasion of stimulation in the appropriate range, without further investigation and independently of what he may have been engaged in at the time. A further requirement is inter-subjectivity: unlike a report of a feeling, the sentence must command the same verdict from all linguistically competent witnesses of the occasion. (Quine 1990, p. 3)

The three criteria, correspondence to stimulation, direct command, and inter-subjectivity, make observability a property that, for Quine, sets virtually no constraints upon the kinds of sub-sentential terms that figure in observation sentences, be they concrete, abstract, complex or primitive. Notice that Quine explicitly refuses to assign any significance to the distinction between theoretical and observational terms. In Quine’s framework, virtually every primitive expression of the language can apparently be a syntactic part of some observation sentence. For Quine, there seems to be no difference between observation sentences and theoretical sentences as regards the vocabulary they contain. Quine makes this idea very explicit: ‘We see no bar to a sharing vocabulary by the two kinds of sentences; and it is the shared vocabulary that links them’ (Quine 1990, p. 8). The range of observation sentences goes by far beyond ordinary one-word sentences like ‘Lo, a rabbit’. ‘Many of them’, Quine holds, ‘are learned not by simple conditioning or imitation, but by subsequent construction from sophisticated vocabulary’ (Quine 1990, p. 5). A sentence like ‘Lo, H_2O ’ – imagine

the speaker pointing on a tub of water – when it is seen analytically may be strongly theory-laden, Quine elaborates; taken holophrastically, however, it qualifies as an observation sentence because, at least within the language of a scientific community, it is firmly linked to stimulation, commands direct assent or dissent, and is inter-subjectively assessable.

Recognizing that Quine apparently considers the observational vocabulary to comprise a great deal of the original vocabulary (more in the case of a well-trained scientific community, less in the case of ordinary people), let us now explore what Hodges' Theorem implies for translation. As we have seen, according to Quine (see first quote on p. 153), analytical hypotheses are introduced *after* the Native observation sentences have been translated into English observation sentences and *after* the Native sentences have been segmented into words. Each analytical hypothesis assigns a translational meaning to a Native word that is a syntactic part of some observation sentence. Analytical hypotheses thus result from a cofinal extension of the translational meaning function that maps Native observation sentences onto English ones. Quine now argues that after the translational function as restricted to the set of observation sentences has been fixed and after sentences have been analyzed syntactically, there are still mutually incompatible, but behaviorally equally adequate systems of analytical hypotheses. Hodges' Theorem, however, entails that this cannot be true if the Native language is to satisfy the Frege–Husserl triad. For, according to Hodges' Theorem, in any Frege–Husserl language there is, up to isomorphism, exactly one cofinal extension of the translational meaning function from the set of observation sentences to the set of all their syntactic parts. Using the principle of compositionality it should then be possible to determine the translational meaning for most expressions of the language, at least those that are build from vocabulary that may also occur in observation sentences (With some distance to Quine, I prefer to remain neutral with regard to the extent to which terms that are standardly called 'theoretical' can be syntactic parts of observation sentences). If the Frege–Husserl principles are presupposed as, if you will, a priori justifiable conditions for translation, the translation of a great deal of the Native language into English is determined up to isomorphism once a decision has been made how to translate observation sentences and once a certain scheme of syntactic analysis, i.e., a grammar has been presumed.

With regard to translation, there still, of course, are the latter two sources of indeterminacy to which Quine could in principle withdraw while sticking to the indeterminacy of translation. The first source, viz. the choice of a translation for observation sentences, reduces to the inscrutability of reference, as we have seen earlier. As I have also noted

already, this cause of indeterminacy does not show up again when we turn to the neuronal meaning function. The second source of indeterminacy lies in the choice of grammar. Quine is, however, eager to warn us not to misunderstand the indeterminacy thesis as a case of grammatical indeterminacy:

Another of the causes of failure to appreciate the point [that there is no objective matter as to whether analytical hypotheses are right or wrong] is confusion of it with the more superficial reflection that uniqueness of grammatical systematization is not to be expected. (Quine 1960, p. 73)

Quine's eagerness to prevent us from confusion of his indeterminacy thesis with grammatical indeterminacy is, of course, outright perspicuous because hardly anything is as trivial as the claim that one and the same set of expressions forming a language can be systematized by a number of fairly different grammars. Presupposing the Frege–Husserl triad, we may hence conclude that the thesis of the indeterminacy of translation substantially reduces to nothing more than the thesis of the inscrutability of reference.

Let us now ask what Hodges' Theorem implies for neuronal meaning functions. Quine concedes that the observation sentences of the Native language have uniquely determined and inter-subjectively stable stimulus meanings, i.e., sets of receptive neuronal states. For any Frege–Husserl language, Hodges' Theorem assures us that there is up to isomorphism exactly one way to break down stimulus meanings into their semantic parts such that these parts are the neuronal meanings onto which the syntactic parts of observation sentences are mapped. There is up to isomorphism exactly one cofinal extension of the neuronal meaning function until then restricted to observation sentences that yields a dissection of neuronal states each of which serves as a meaning of some expression of the Native language. The method how to find the adequate dissection in practice is up to future neuro-scientific research.¹⁵ Hodges' Theorem only guarantees the existence of such a dissection.

It is worth noting that these dissected neuronal states are metaphysically independent of expressions in the aforementioned sense. Quine's method to assign neuronal states to observation sentences as meanings when supplemented by the three Frege–Husserl principles, therefore, determines a realistic semantics for a large fragment of any natural language.

7. OBJECTIONS AND REPLIES

Let me now briefly comment on some objections to this conclusion. The first objection, again, concerns the supposition of a determinate grammar.

The way the neuronal states are dissected, one may argue, is uniquely determined only relative to the presumption of some grammar for the language. The linguist, however, is given as empirical data the set of expressions of the language, but not the underlying grammatical structure. (S)he in other words gets utterances, not terms. Once (s)he chooses a single grammar from all possible grammars that generate the same set of expressions, (s)he makes a decision that is not rooted in matters of fact. Although Quine calls this consideration a ‘superficial reflection’, it may count as a fair objection against our argument for semantic realism. As has been mentioned already in Section 1, the introduction of a grammatical structure as opposed to a mereological structure is motivated solely by the fact that some utterances are ambiguous. Ambiguity, however, is nothing Quine will want to build the indeterminacy thesis on. If we neglect the phenomenon of ambiguity, we can identify expressions with utterances (rather than terms) and stay with mereological structure. For, all we need to derive Hodges’ Theorem is some partial order in the set of expressions – syntactic operations then are to be replaced by (ordered) mereological summation.¹⁶ In languages without ambiguities mereological structure does as good a job in Hodges’ proof as grammatical structure does in a language with ambiguities. While one may be right to hold that it is not determined by matters of fact which syntactic parts a certain term has, it undeniably is a matter of fact which mereological parts an utterance has. By neglecting ambiguities, we can turn from considerations on grammar to considerations on mereological structure and hence eliminate the very last and only superficial source of indeterminacy with regard to neuronal meaning.

The second objection I would like to comment on raises a deeper issue. Since I did not dispute Quine’s thesis of the inscrutability of reference, one may object that this thesis alone suffices to justify semantic anti-realism. For, meaning, the objection goes, is to determine reference, and reference, hence, could not be indeterminate unless meaning was. Let me first remark that the claim that meaning determines reference is neither entailed by the Frege–Husserl triad nor is it a tenet of Quine’s. The former is obvious, the latter follows from the fact that the meaning of an observation sentence, its stimulus meaning, does not determine the truth-value of the sentence (Recall that the reference of the terms of a singular sentence and the truth of the sentence are inter-definable.) We only have to imagine a situation in which a speaker of English is confronted with a perfect rabbit imitation instead of a genuine rabbit. In either case the speaker would assert ‘Lo, there is a rabbit’ because the positive stimulus meaning of the sentence would be triggered on the speaker’s neuronal receptors. The truth-value of the sentence, however, differs in the two cases. One of the consequences

one should draw from the considerations of this paper, is simply to reject the principle ‘meaning determines reference’. If one accepts the Frege–Husserl principles and has learned Quine’s naturalist lesson, one is not only free to refute the principle, one had better do so. Neuronal meanings do not determine reference.

One may thirdly object that the extension of the neuronal or translational meaning function from the set of observation sentences to the set of its syntactic parts leaves an important part of the core vocabulary of any language unaccounted for. I do not refer to so-called theoretical terms here, for which I leave open whether they can be syntactic parts of observation sentences, but have in mind certain logical constants. An utterance like ‘Black swans exist’ with the word ‘exist’ at its surface does certainly not count as an observation sentence. I can think of two ways to cope with this objection. First, for every sentence p that contains the word ‘exist’ we can construe an observation sentence that contains the very sentence and consequently the word ‘exist’ as a syntactic part. Provided that ‘Lo, there is a rabbit’ qualifies as an observation sentence ‘ p or not p ; and lo, there is a rabbit’ should also qualify as an observation sentence because it has the same stimulus meaning. This solution is, however, not optimal because it jeopardizes the validity of the context principle. Assume that not only the sentence p , but also some other sentence q occurs only inessentially, i.e., as part of a tautology, in other observation sentences. Then the substitution of q for p would fail to affect the meaning of any observation sentence of which p is a syntactic part. The sentences p and q would, therefore, have to be assigned the same meaning according to the context principle. More generally, the context principle would force us to regard all sentences synonymous that occur only inessentially in observation sentences.

Since this would be an unpleasant consequence, a different reply is in need. Logical particles like ‘exist’ need not be treated as terms and hence as syntactic parts of sentences. They can also be incorporated in syntactic operations. In fact, this is the way compositional semantics usually treat quantifiers (cf. Partee et al. 1990, p. 323). In the case of the existential quantifier, we thus have a syntactic operation defined on the set of sentential terms that takes some term ϕ as argument and yields $\exists x\phi$ as value. According to our definition of syntactic constitution, the symbol $\exists$ does not count as a syntactic part of the term $\exists x\phi$ because it has not been an argument of the generating syntactic operation. In a compositional approach, the semantic counterpart of the syntactic operation $\alpha_{\exists} : \phi \mapsto \exists x\phi$ is the operation of cylindrification (cf. Janssen 1997, p. 423). When semantic operations have been provided not only for the existential quantifier, but for all logical constants, the principle of compositionality now assures us

that also the meanings of existential sentences and sentences containing other logical constants are determined once the meanings of observation sentences are – provided that the sentences in other respects are built from observational vocabulary.

Having given his famous thought experiment in defense of the indeterminacy of translation, Quine himself apologizes for not giving a detailed example of his thesis by remarking that ‘there is an obstacle to offering an actual example of two [...] rival systems of analytical hypothesis’ (Quine 1960, p. 72). The lack of a detailed example for the indeterminacy thesis, has challenged various authors to find such cases. Let me, therefore, discuss a couple of examples for an extension of a meaning function that are often cited to confirm Quine’s thesis of indeterminacy. I will point out why they do not conflict with the conclusion of the present paper.¹⁷

The first example is Pelletier’s (1984). He discusses two modal extensions, V and T , of propositional logic. It is shown that each expression of the one modal logic can be translated into the other and *vice versa* such that (i) translations of axioms of the one logic are theorems of the other and *vice versa*, (ii) for each rule of inference of the one logic, the translations of the premises and the conclusion of the rule are linked by a derivable rule of the other logic as premises and conclusion, and *vice versa*, and (iii) the re-translation of a translated expressions is a theorem of the respective logic. Hence, by all standards, V and T have to be called translationally equivalent.

Pelletier, now, is eager to point out that the axiomatic systems of both modal logics are quite different. He even hints at cases of translationally equivalent modal logics that have non-isomorphic semantics. Pelletier thus gives an example of an extension problem where we seem to have non-unique non-isomorphic solutions and where there is apparently no violation of the Frege–Husserl principles. How can this be consistent with Hodges’ Theorem? – The answer is fairly simple, but instructive: Pelletier doesn’t look for cofinal, but for so-called end-extensions. Whereas a cofinal extension does not extend the meaning function to yet unfamiliar vocabulary – it extends it only to syntactic parts of terms whose meanings we have already been acquainted with – end-extensions strike out to new vocabulary. If X and Y are sets of grammatical terms such that $X \subseteq Y$, then we say that Y is an *end-extension* of X if every term in Y that is a syntactic part of a term in X is already in X . This condition is fulfilled when a modal logic, as in Pelletier’s case, extends a propositional logic. Cofinality, in contrast, is not given. We can, hence, conclude that Pelletier’s example does not impugn our conclusion. A similar situation would occur if we were to extend a meaning function for observation sentences to embedding

propositional attitude sentences – sentences of the form ‘John believes that it’s cold inside here’. As in Pelletier’s case, Hodges’ Theorem does not imply that there would be a unique solution to this problem.

Massey (1979) discusses several other purported examples of indeterminacy that result from extensions. Having rejected most of them himself, he construes one example – it enhances an example originally from Putnam (1975) – that allows the operation of translation to map a term to one translation in one context and to another translation in another context. This clearly amounts to a violation of the functionality of (translational) meaning as it is presumed by the principle of compositionality. Compositionality requires that the domain of a meaning function is a set of types of terms, rather than a set of tokens.¹⁸ Consequently all tokens of a type of term are supposed to contribute the same meaning to whatever context they occur.

Another of Massey’s examples localized one source of indeterminacy at a step in the project of radical translation that precedes the compilation of the translational meaning function for observation sentences. He claims that the linguist may well invert assertion and denial just as he may invert assent and dissent. Aside from the source of indeterminacy resulting from the inscrutability of reference, there would be a new source of indeterminacy that would double the number of behaviorally adequate translation functions. This case, however, does not affect the conclusion of the present paper, either. For, Hodges’ Theorem, in our argument, is applied only after a specific translational, respectively, neuronal meaning function for observation sentences has been compiled. We are here concerned primarily with sources of indeterminacy after that has been done.

8. CONCLUSION

When Quine set about to answer the question what semantic facts about a language are left if one strips off any conventional ingredients of linguistics he chose a radically naturalist approach. No statement about language should count as factual unless it was justifiable by some inter-subjectively observable data on human dispositions. The science of language thus equipped led him to the conclusion that the translation of one language into another is factually indeterminate. This has often been interpreted as an argument against a determinate and independent reality of meaning.¹⁹ Although the thesis of the indeterminacy of translation stands, the present paper has shown that it does not justify semantic scepticism. In contrast, Quine’s naturalist framework, up to isomorphism, uniquely determines a function that maps every expression of a language that may figure as a

syntactic part in some observation sentence onto its neuronal meaning, if we only presume that the language fulfils the principle of compositionality, the context principle, and the category principle. It is hard to image how Quine could reject one of these principles without running into contradictions. The three guidelines Frege and Husserl set up at the beginning of the twentieth century can be combined with Quine's naturalistic maxim. When so combined, they lead to a realist attitude towards meanings and advise us to view semantics as a part of neuroscience.

APPENDIX

I will here give the full proof of Hodges' Theorem. It closely follows Hodges (2001). In order to make the theorem applicable to the main argument of the present paper, I sometimes deviate from Hodges' original terminology. In the proof I rely on the definitions and notational conventions I have given in the main text.

THEOREM 9. Let μ be a meaning function for a language with grammar G , and suppose that every syntactic part of a μ -meaningful term is μ -meaningful. Then the following are equivalent:

- (a) μ is compositional.
- (b) If s is term and $p_0, \dots, p_{n-1}, q_0, \dots, q_{n-1}$ are grammatical terms such that $s(p_0, \dots, p_{n-1} | \xi_0, \dots, \xi_{n-1})$ and $s(q_0, \dots, q_{n-1} | \xi_0, \dots, \xi_{n-1})$ are both μ -meaningful and, for all $m < n$,

$$p_m \equiv_{\mu} q_m,$$

then

$$s(p_0, \dots, p_{n-1} | \xi_0, \dots, \xi_{n-1}) \equiv_{\mu} s(q_0, \dots, q_{n-1} | \xi_0, \dots, \xi_{n-1}).$$

Proof. (a) $\Rightarrow$ (b). Assuming (a), we prove (b) by induction on the complexity of s . In case $n = 0$, s is a μ -meaningful atomic term and the conclusion $s \equiv_{\mu} s$ is trivial. In case $n = 1$, s is a variable ξ_0 . Then $s(p_0 | \xi_0) = p_0$ and $s(q_0 | \xi_0) = q_0$, and the consequent of (b) follows trivially from the antecedent of (b), i.e., $p_0 \equiv_{\mu} q_0$. Finally, we consider the case where s is the term $\alpha(t_0, \dots, t_{m-1})$. In this case we get $s(p_0, \dots, p_{n-1} | \xi_0, \dots, \xi_{n-1})$ by substituting the terms p_i for ξ_i , with $0 \leq i < n$, in all immediate syntactic parts $t_0, \dots, t_{m-1}$ of the term s . We analogously proceed with $s(q_0, \dots, q_{n-1} | \xi_0, \dots, \xi_{n-1})$ and thus have:

$$\begin{aligned} & s(p_0, \dots, p_{n-1} | \xi_0, \dots, \xi_{n-1}) \\ &= \alpha(t_0(p_0, \dots, p_{n-1} | \xi_0, \dots, \xi_{n-1}), \dots, t_{m-1}(p_0, \dots, p_{n-1} | \xi_0, \dots, \xi_{n-1})), \end{aligned}$$

and

$$\begin{aligned} & s(q_0, \dots, q_{n-1} | \xi_0, \dots, \xi_{n-1}) \\ &= \alpha(t_0(q_0, \dots, q_{n-1} | \xi_0, \dots, \xi_{n-1}), \dots, t_{m-1}(q_0, \dots, q_{n-1} | \xi_0, \dots, \xi_{n-1})). \end{aligned}$$

Since $s(p_0, \dots | \xi_0, \dots)$ and $s(q_0, \dots | \xi_0, \dots)$ are assumed to be μ -meaningful, its syntactic parts $t_i(p_0, \dots | \xi_0, \dots)$ and $t_i(q_0, \dots | \xi_0, \dots)$, respectively, are also μ -meaningful. By induction hypotheses we may, therefore, presume that

$$t_i(p_0, \dots | \xi_0, \dots) \equiv_{\mu} t_i(q_0, \dots | \xi_0, \dots).$$

According to (a) the μ -meanings of $s(p_0, \dots | \xi_0, \dots)$ and $s(q_0, \dots | \xi_0, \dots)$, respectively, are a function of the meanings of their syntactic parts. Thus, the identity of the μ -meanings of the parts of both terms implies the identity of the μ -meanings of both terms.

(b) $\Rightarrow$ (a). (a) follows at once from the special case of (b) where s has the form $\alpha(\xi_0, \dots, \xi_{m-1})$.

THEOREM 10. Let μ be a Husserlian meaning function for a language with grammar G , and suppose that every syntactic part of a μ -meaningful term is μ -meaningful. Then the following are equivalent:

- (a) μ is compositional.
- (b) If s is term with one variable ξ , and p, q are grammatical terms such that $s(p|\xi)$ and $s(q|\xi)$ are both μ -meaningful, then

$$p \equiv_{\mu} q \Rightarrow s(p|\xi) \equiv_{\mu} s(q|\xi).$$

Proof. (a) $\Rightarrow$ (b). (b) follows from μ 's compositionality even without the Husserlian property, according to Theorem 9.

(b) $\Rightarrow$ (a). In order to prove (a) from (b), we show that, if μ is Husserlian, condition (b) of Theorem 9 follows from condition (b) of Theorem 10. Condition (b) of Theorem 9 in turn is equivalent to μ being compositional.

For each $i \leq n$, let s_i be the term

$$s(q_0, \dots, q_{i-1}, p_i, \dots, p_n | \xi_0, \dots, \xi_{n-1}).$$

We will now stepwise replace q_i -terms for μ -synonymous p_i -terms in the term $s_0 = s(p_0, \dots, p_{n-1} | \xi_0, \dots, \xi_{n-1})$ which, by antecedence of condition (b) of Theorem 9 is μ -meaningful. It suffices to show for each $i < n$ that, if $p_i \equiv_{\mu} q_i$, then s_i and s_{i+1} are both μ -meaningful and $s_i \equiv_{\mu} s_{i+1}$. Suppose it has been shown that s_i is μ -meaningful. Since, by antecedence

of condition (b) of Theorem 9, $p_i \equiv_\mu q_i$, and, since μ is Husserlian – μ -synonyms can be replaced for each other without making the comprising term nonsensical –, s_{i+1} is also μ -meaningful; and it follows, by condition (b) of Theorem 10, that $s_i \equiv_\mu s_{i+1}$.

For technical reasons we will subsequently call a meaning function *1-compositional* if and only if it satisfies condition (b) of Theorem 10. A meaning function, thus, is 1-compositional if it is Husserlian and compositional.

Any synonymy $\equiv$ for a language with grammar G is an equivalence relation whose field, i.e., the set $\{t \mid t \equiv t\}$, is a subset of $GT(G)$. We write $s \not\equiv t$ to mean that $s \equiv s$, $t \equiv t$ but not $s \equiv t$. Let us furthermore write $\nu \geq \mu$ to mean that $\equiv_\nu \supseteq \equiv_\mu$.

THEOREM 11. Any meaning functions ν and μ of the same language are identical up to isomorphism if and only if $\nu \geq \mu$ and $\mu \geq \nu$.

Proof. Immediate.

THEOREM 12. Let ν and μ be meaning-functions defined on the set of grammatical terms Y and X , respectively, and let p and q be grammatical terms. Then ν is a Fregean cover of μ if and only if the conjunction of the following three conditions holds

- (a) ν is μ -Husserlian, i.e.: If $p \equiv_\nu q$ and $t(p|\xi)$ is in the field of $\equiv_\mu$ then $t(q|\xi)$ is in the field of $\equiv_\mu$.
- (b) ν , as we say, is *partially 1-compositional* over μ , i.e.: If $p \equiv_\nu q$ and $t(p|\xi)$ as well as $t(q|\xi)$ is in the field of $\equiv_\mu$, then $t(p|\xi) \equiv_\mu t(q|\xi)$.
- (c) ν , as we say, is *fully abstract* over μ , i.e.:²⁰ If $p \not\equiv_\nu q$ then there is a term t such that either exactly one of $t(p|\xi)$ and $t(q|\xi)$ is in the field of $\equiv_\mu$, or both are and then $t(p|\xi) \not\equiv_\mu t(q|\xi)$.

Proof. Follows immediately from the definition of a Fregean cover.

THEOREM 13. Given a language with grammar G , suppose X and Y are subsets of $GT(G)$ with $X \subseteq Y$, and μ , ν and σ are meaning function with domains X , Y , Y , respectively. If ν is fully abstract over μ and σ is μ -Husserlian and partially 1-compositional over μ , then $\sigma \leq \nu$.

Proof. Assume that $\langle p, q \rangle \in \equiv_\sigma$. Then p and q are in the field of $\equiv_\nu$, which is identical to the field of $\equiv_\sigma$. We distinguish two cases. First case: Neither $t(p|\xi)$ nor $t(q|\xi)$ are in the field of $\equiv_\mu$. Then $\langle p, q \rangle \in \equiv_\nu$, because ν is fully abstract over μ (contraposition of condition (c) of Theorem 12!). Second case: At least one of the terms $t(p|\xi)$ and $t(q|\xi)$ are in the field of $\equiv_\mu$. Then both are because σ is μ -Husserlian. Furthermore, σ being

partially 1-compositional over μ then implies that $t(p|\xi) \equiv_{\mu} t(p|\xi)$. Since ν is fully abstract over μ , by contraposition of condition (c) of Theorem 12, $\langle p, q \rangle \in \equiv_{\nu}$.

THEOREM 14 (Uniqueness). Given a language with grammar G , suppose X and Y are subsets of $GT(G)$ with $X \subseteq Y$, and μ , ν and σ are meaning functions with domains X , Y , Y , respectively. If ν and σ are Fregean extensions of μ , then ν and σ are identical up to isomorphism.

Proof. Theorem 14 follows immediately from Theorem 11, Theorem 12 and Theorem 13.

THEOREM 15. Let X, Y be subsets of $GT(G)$ with X a cofinal subset of Y , and suppose Y is closed under syntactic constitution. Let μ and ν be meaning functions with domains X and Y , respectively. Then:

- (a) If ν is μ -Husserlian then ν is Husserlian.
- (b) If ν is a Fregean cover of μ then ν is compositional.

Proof. (a) Let p and q be terms of Y such that $p \equiv_{\nu} q$, and suppose a term $s(p|\xi_0)$ is in Y . We have to show that, if ν is μ -Husserlian, $s(q|\xi_0)$ is also in Y . Because X is cofinal in Y , there is a term t with variable ξ_1 such that $t(s(p|\xi_0)|\xi_1)$ is in X – i.e. some term in X contains $s(p|\xi_0)$ as syntactic part. There is a term t' such that, for any term r , $t'(r|\xi_0) = t(s(r|\xi_0)|\xi_1)$ – this follows from the transitivity of syntactic constitution: if a term r is a part of a part of some term, then r is a part of the term. Now, $t'(p|\xi_0)$ is in X because it is identical with $t(s(p|\xi_0)|\xi_1)$ and the latter, as we already know, is in X . Since p and q are ν -synonymous and ν is μ -Husserlian, also $t'(q|\xi_0)$ is in X , the field of $\equiv_{\mu}$ (see conditional (a) of Theorem 12). Since $t'(q|\xi_0) = t(s(q|\xi_0)|\xi_1)$, the left term also is in X and since X is a subset of Y it is in Y . Since Y is closed under syntactic constitution, by assumption, the syntactic part $s(q|\xi_0)$ is in Y , too, as required.

(b) Assume that ν is a Fregean cover of μ . Then ν , as a consequence of condition (a) of Theorem 12 and condition (a) of Theorem 15, is Husserlian, and since 1-compositionality plus the Husserlian property implies compositionality according to Theorem 10, we only have to show that ν is 1-compositional. Suppose for contradiction that ν was not 1-compositional, i.e., $s(p|\xi_0) \not\equiv_{\nu} s(q|\xi_0)$, although $p \equiv_{\nu} q$ and $s(p|\xi_0), s(q|\xi_0)$ are both in Y . Since ν – as a Fregean cover of μ – is fully abstract over μ , there is a term t such that either just one of $t(s(p|\xi_0)|\xi_1), t(s(q|\xi_0)|\xi_1)$ is in X , or both are but $t(s(p|\xi_0)|\xi_1) \not\equiv_{\mu} t(s(q|\xi_0)|\xi_1)$. Due to the transitivity of syntactic constitution we can again form a term t' such that for every grammatical term r , $t'(r|\xi_0) = t(s(r|\xi_0)|\xi_1)$. Since $p \equiv_{\nu} q$ and ν – as a Fregean cover of μ – is μ -Husserlian and partially

1-compositional over μ , it holds that if at least one of $t'(p|\xi_0)$ and $t'(q|\xi_0)$ is in X then both are and $t'(p|\xi_0) \equiv_\mu t'(q|\xi_0)$. This contradicts the choice of t .

THEOREM 16 (Existence). If G is the grammar of some language, X a cofinal subset of $GT(G)$ and μ a compositional and Husserlian meaning function defined on X , then μ has a total Fregean extension.

Proof. Define a relation $\equiv_v$ on $GT(G)$ as follows:

$$p \equiv_v q \text{ if and only if } p \sim_\mu q \text{ and for every term } s(p|\xi) \text{ in } X, \\ s(p|\xi) \equiv_\mu s(q|\xi).$$

We first show that $\equiv_v$ is a synonymy whose field is $GT(G)$. The field comprises $GT(G)$ because the domain of μ is cofinal in $GT(G)$ and, thus, $p \sim_\mu q$ is defined for every p and q in $GT(G)$ and consequently $\mu(s(q|\xi))$ is defined if $\mu(s(p|\xi))$ is defined. Reflexivity and symmetry are clear. For transitivity, suppose that $p \equiv_v q$ and $q \equiv_v r$. Then $p \sim_\mu r$ because $\sim_\mu$ is transitive. Suppose $s(p|\xi)$ is in X , then by assumption $s(p|\xi) \equiv_\mu s(q|\xi)$ and consequently $s(q|\xi)$ is in the domain of μ ; but then by assumption $s(q|\xi) \equiv_\mu s(r|\xi)$, too. We can now define the meaning function v for every $s \in GT(G)$ by taking $v(s)$ to be the $\equiv_v$ -equivalence class of s . It follows immediately from the definition of $\equiv_v$ that v is a Fregean cover of μ .

To prove that v or some up-to-isomorphism identical function is an extension of μ , compositionality and the Husserlian property of μ are required. It suffices to show that $p \equiv_\mu q$ if and only if $p \equiv_v q$, provided that p and q are in X . Right to left: Let p and q be terms in X such that $p \equiv_v q$ and let s be the term ξ . Then $p = s(p|\xi) \in X$ and so $p \equiv_\mu s(q|\xi) = q$ according to the definition of $\equiv_v$. Left to right: Suppose $p \equiv_\mu q$. Then $p \sim_\mu q$ because μ is Husserlian. Since μ , moreover, is compositional it is 1-compositional according to Theorem 10 and therefore $s(p|\xi) \equiv_\mu s(q|\xi)$ if $s(p|\xi)$ is in X . Hence $p \equiv_v q$ following the definition of $\equiv_v$.

THEOREM 17 (Hodges' Theorem). Given a language with grammar G , let X be a cofinal subset of the set of grammatical terms $GT(G)$. Then, if μ is a compositional and Husserlian meaning function with domain X , there is, up to isomorphism, exactly one total Husserlian and compositional Fregean extension of μ .

Proof. The existence and uniqueness of a Fregean extension follows from Theorem 16 and Theorem 14, respectively. From Theorem 12 and condition (a) of Theorem 15 it follows that the Fregean extension is Husserlian. Its compositionality follows from condition (b) of Theorem 15.

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NOTES

¹ The importance of Husserl will become obvious in the course of the paper.

² In the present paper I am concerned solely with Quine's argument for the indeterminacy of translation as he proposes it in the second chapter of *Word and Object*. This argument, the 'gavagai' argument, is commonly also called the Argument from Below. In a later paper Quine (1970) brings forward a further argument, the so-called Argument from Above. It construes the indeterminacy of translation as a special case of the underdetermination of empirical theory.

³ Though never published in Frege's lifetime, this passage is the clearest expression of his belief that language is compositional. Citing this passage, I do, however, not want to imply that he held this view only in private. That he didn't is evident from a letter to Jourdain (Frege 1980) of 1914 as well as from the essay *Gedankengefüge* Frege (1976) of 1923. Both writings contain similar, though less explicit statements of the principle of compositionality. The question whether Frege formulated the idea of compositionality already in his earlier writings is open. In a remarkable and little noticed passage from *Booles rechnende Logik und die Begriffsschrift* – the submitted paper had been rejected in succession by three journals in 1881 – Frege, while describing his project of a *lingua characterica*, writes:

Die Zusammensetzung der Wörter entspricht nur unvollkommen dem Bau der Begriffe. Die Bildung der Wörter 'Berggipfel' und 'Baumriese' ist gleichartig, obwohl die logische Beziehung der Bestandteile verschieden ist. (Frege 1983, p. 13)

He, thus, already in 1881 envisions a structural correspondence between natural language and conceptual structure. He, however, judges it as only imperfect, thereby anticipating the nowadays well discussed argument against the compositionality of natural language from the (apparent) non-compositionality of nominal compounds (cf. Johnston and Busa 1999).

⁴ The functionality of expressing had better be warranted. For, the common way to refer to thoughts is by citing a sentence that expresses the thought in question. If ambiguity was not avoided, reference to thoughts would fail.

⁵ The widespread assumption that every ambiguity roots either in lexical or grammatical ambiguity is critically reviewed by Pelletier (2000). Some sentences, e.g., 'Most critics reviewed two films', seem to owe their ambiguity to neither. This problem, which has sometimes been brought forward as an objection against the principle of compositionality, will not be of concern to us here.

⁶ I am using the word ‘term’ in the sense it is used in linguistics rather than in logic. Unless indicated otherwise, I do not imply that a term is either a singular or a general term in the logical sense.

⁷ Anti-symmetry follows immediately from the well-foundedness assumption that there are no infinite sequences of proper syntactic/mereological parts.

⁸ By convention terms are set in italics while utterances are set in inverted commas.

⁹ The stimulus meaning of a sentence is defined relative to a module. The length of the module specifies the maximal temporal distance between the stimulation and the assertion or denial.

¹⁰ The German original reads as follows: ‘Man muß aber immer einen vollständigen Satz ins Auge fassen. Nur in ihm haben die Wörter eigentlich eine Bedeutung [...] Es genügt, wenn der Satz als Ganzes einen Sinn hat; dadurch erhalten auch seine Teile ihren Inhalt’ (Frege 1884, p. 71). As Dummett (1981, pp. 192–196) points out, these lines were written before Frege developed his distinction between *Bedeutung* and *Sinn*. So Dummett argues that the words ‘Bedeutung’ and ‘Inhalt’ in the quoted passage are best translated pre-theoretically as ‘meaning’. My translation follows this interpretation.

¹¹ As far as interpretational issues are concerned I defer to Pelletier (2001).

¹² Having been sensitized to the issue by an anonymous referee, I did indeed find native speakers who had no problems with the sentence.

¹³ As is well known, Quine (1961, pp. 27–32) criticized the principle of interchangeability as a criterion for synonymy. He, however has never argued that the principle is false. For Quine, it simply has no explanatory potential because, especially with regard to intensional contexts, it leads to an explanatory circle that involves such notions as necessity and analyticity.

¹⁴ Exceptions might be self-referential expressions.

¹⁵ I tried it myself and, in accordance with recent neurobiological data, presented a theory of how compositional predicate languages might be semantically realized in the cortex (Werning 2004b). The theory, which results from a co-operation with the computational neuroscientist Alexander Maye and the neurophysiologist Andreas Engel, differs significantly from traditional connectionist attempts. Werning (2003) provides an algebra of neuronal meanings, and it holds that many isomorphic algebras will subserve the same semantic purposes; hence the importance of the qualification ‘up to isomorphism’ in the present paper. The qualification amounts to some weak form of multiple realization.

¹⁶ Hodges (in conversation) has coined the notion of a frame for this purpose.

¹⁷ I am grateful to an anonymous referee for directing my attention to those cases.

¹⁸ This is not to say that the principle of compositionality cannot be made compatible with context effects.

¹⁹ A critical analysis of the inference form indeterminacy of translation to semantic scepticism is given by Wright (1997).

²⁰ The notion ‘fully abstract’ was introduced by Milner (1977) and Plotkin (1977) in the semantics of computer programs. In that setting a fully abstract semantics distinguishes two programs if and only if they have different outputs in some context.

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