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A Model of Complexity Levels of Meaning Constitution in Simulation Models of Language Evolution

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ABSTRACT

Currently, some simulative accounts exist within dynamic or evolutionary frameworks that are concerned with the development of linguistic categories within a population of language users. Although these studies mostly emphasize that their models are abstract, the paradigm categorization domain is preferably that of colors. In this paper, the authors argue that color adjectives are special predicates in both linguistic and metaphysical terms: semantically, they are intersective predicates, metaphysically, color properties can be empirically reduced onto purely physical properties. The restriction of categorization simulations to the color paradigm systematically leads to ignoring two ubiquitous features of natural language predicates, namely relativity and context-dependency. Therefore, the models for simulation models of linguistic categories are not able to capture the formation of categories like perspective-dependent predicates 'left' and 'right', subsective predicates like 'small' and 'big', or predicates that make reference to abstract objects like 'I prefer this kind of situation'. The authors develop a three-dimensional grid of ascending complexity that is partitioned according to the semiotic triangle. They also develop a conceptual model in the form of a decision grid by means of which the complexity level of simulation models of linguistic categorization can be assessed in linguistic terms.

Keywords: Calibration, Complexity Model, Compositionality, Contextuality, Linguistic Complexity, Meaning Constitution, Semiotic Triangle, Simulation Models

1. INTRODUCTION

Recently, a range of approaches has been proposed to address the emergence of linguistic categories shared among members of the same language community (Puglisi et al., 2008; Baronchelli et al., 2010). What these approaches have in common is that they start from a situation in which the community does not share any relation of expression and meaning units to end up with a common (form-)meaning function. This goes back to Luc Steels’ seminal work on the naming game as a simulation model of language evolution (Steels, 1996). Recently, it has been reconstructed in terms of self-organizing
complex dynamical systems (Baronchelli et al., 2006; Dall’Asta et al., 2006a, 2006b). In this framework, the meaning function – as a result of successful language learning – consists of a single tuple that relates a finally unique expression unit with a semantic singleton. The reason to simplify the model in this way is to systematically study the impact of a large set of parameters while keeping the complexity of the model manageable. During simulation, the semantic singleton $s$ formally diversifies in relation to several, synonymous expression units, but is finally expressed by a single expression provided that the naming game is successful. As a matter of fact, the ontological provenance of $s$ is disregarded – it is just a placeholder of what is regarded in opposition to its alternative formal manifestations (see Figure 1).

The naming game scenario has been further developed to capture meaning functions of (non-compound) “lexical” items to (compound) semantic units as a result of articulating (Hjelmslev, 1969) a reference-semantic continuum (Figure 1). In this sense, categorization means the shared articulation of an amorph substance, shared among the members of the corresponding community (Puglisi et al., 2008; Baronchelli et al., 2010). As a touchstone of this Extended Naming Game (ENG), color terms are made an object of simulations that remarkably reconstruct several of their linguistic characteristics. In this sense, the ENG is outstanding as its predictions are in accordance with linguistic hypotheses.

In spite of this success, several questions are raised that regard the linguistic status of color predicates in particular and of linguistic predicates in general (Murphy, 2002; Taylor, 2003). The reason is that the ENG basically deals with non-compound predicates (e.g., red), which are directly related to their meanings regardless of the formation of compound signs (e.g., red bowl). This reduction leaves out all cases in which lexical units (e.g., adjectives and nouns) are combined to express complex categories based on more elementary ones. As a matter of fact, this includes non-lexicalized categories for which complex expressions are needed to express them, that is, the majority of categories being manifested by natural languages. Thus, the ENG currently disregards semantic compositionality and contextuality, that is, the systematic relation of the meaning of compound units, their constituents and contexts.

At first glance, our assessment of the ENG seems to be pedantic as it abstracts from the complexity under consideration to keep manageability of its parameter space. However, the question arises how to extend any such framework to cope with more realistic categorization scenarios in accordance with the complexity of natural language. In other words: how shall we extend the complexity of our model step-by-step to capture which aspect of the complexity of linguistic categorization?

Figure 1. Semantic diversification and semantic unification
Or to put it more concrete: How shall we extend the ENG to capture semantic compositionality and contextuality?

In this section, we propose such a sequence of candidate extensions that reflects both semantic compositionality and contextuality. We do that according to the notion of linguistic categorization in logical semantics and cognitive science (Kamp & Partee, 1995; Smolensky, 1995a, 1995b). With a focus on compound categories, we start from an interval model that ranges from full compositionality as the simplest case of categorization to full contextuality as the most complex case of categorization (see Figure 2). More specifically, we identify a sequence of types of compound categories located in this interval by specifying the type of entailment they enable. The reason to proceed in this way is that natural languages provide a range of inference mechanisms to reduce the complexity of language production and comprehension (Grice, 1989; Clark, 1996; Pickering & Garrod, 2004). In this sense, we distinguish levels of linguistic categorization that are characterized by the inferences they support where we focus on entailment as a subtype of inference. Our idea is that simulation models should be extended along these levels of complexity to capture corresponding inference mechanisms and, thus, corresponding degrees of semantic compositionality and contextuality, respectively (see Figure 2). Why? The reason is that agents who agree on a linguistic categorization should also share entailments based on this categorization as they are systematically related in a way known from natural languages. Otherwise, we can hardly speak of an adequate simulation of the emergence of complex categorization: a simulation model that disregards compositionality cannot account for entailment and, thus, fails to capture complex categories—it is doomed to focus on non compound categories.

To exemplify this, take as an example two speakers who agree on categorizing a certain stimulus $x$ as being (a) red and being (b) a bowl. In this case, we expect that they also agree on categorizing $x$ as a red bowl as this is entailed by (a) and (b). Conversely, if both agents agree on categorizing $x$ as a red bowl, they can speak of $x$ as being red or being a bowl. Obviously, both interlocutors do not need to manifest the non-lexicalized complex category by the Head-Modifier Construction (HMC) red bowl. Rather, such a categorization can be inferred on the basis of their common ground. Now, look at simulation models of this kind of linguistic categorization. We may think of a community of agents who do not only make elementary predications, say, $A(x)$ or $B(x)$, but also complex ones, say, $(A \circ B)(x)$ in order to denote categories that are not lexicalized in their language $L$. In this case, the simulation model needs to clarify the possibility of entailments of the sort $(A \circ B)(x) \rightarrow A(x)$, $(A \circ B)(x) \rightarrow B(x)$ and $A(x) \land B(x) \rightarrow (A \circ B)(x)$. Otherwise, it would disregard a fundamental characteristic of linguistic categorizations, that is, their systematic inter-relations. In this sense, meaning

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Figure 2. Levels of complexity of linguistic categorization in relation to the interval of semantic compositionality and contextuality

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functions are complemented by a network of categorizations that are related by means of entailment and other types of inferences. By disregarding this inference network, a central aspect of linguistic categorization is left out so that we can hardly speak of an adequate simulation model of non-lexicalized complex categories manifested by compound expressions.

However, things get rapidly complex when leaving the area of so called intersective adjectives as exemplified by red (see Section 2). Take the example of a skillful violinist. If two agents categorize x as skillful and as a violinist, this does not entail that they categorize x as a skillful violinist (Partee, 1995). Of course, there are many more types of linguistic categorization in conjunction with specific patterns of entailment that systematically differ in terms of their compositional or non-compositional semantics. In any event, simulation models of linguistic categorization should specify the type(s) of categories and inference mechanisms they actually capture. Otherwise, their capacity in dealing with complex categories is unclear.

If we look back on the basic scenario of the ENG, we see that it does not even deal with intersective predicates whose semantics is outstanding in its simplicity as it is mapped by a set-theoretic intersection such that entailment goes along stating subset relations in terms of an extensional semantics. But what are these other types of categories beyond this simple case and how are they captured in terms of the principle of compositionality and contextuality? In this paper, we provide both a short phenomenology of linguistic categorization (by recapitulating well-known results of logical semantics) in conjunction with a roadmap to extend the naming game for capturing these levels of complexity (where we partly refer to the notion of entailment to distinguish the corresponding levels) (Figure 3).

The specification of complexity levels of linguistic categories as manifested by head-modifier constructions is only one reference point of specifying semantic complexity. Even if all these complexity levels would be captured by a simulation model, that is, even if the different types of modifiers would be distinguished adequately in a linguistic sense, our assessment of its expressiveness would fall short. The reason is that any such simulation model has to be seen in a more systematic context of semantics, which goes beyond considering isolated HMCs. Although we cannot give a complete account of such a semantic fingerprint here, we specify three additional reference points that altogether span a semiotic triangle, that is, the ontological, the epistemological and the language-systematic dimension. This can

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Figure 3. Levels of complexity distinguished in terms of the object of calibration semantics: arcs point to the corresponding object that is calibrated subject to the meaning of the corresponding start vertex. An arc’s serial number denotes the corresponding row in Table 1
be motivated as follows. Consider a \textit{prima facie} simple, everyday example of language use like an utterance of (1):

(1) It’s raining outside.

In order to be informative for its addressee, sentence (1) should say something true about the world (if (1) was uttered falsely, it might at the most provide information about its utterer). Every competent speaker of English is able to specify when (1) is true (Tarski, 1944). If you understand the sample sentence, then you can give the conditions under which it is a correct description of the speaker’s environment. In other words, you can specify what makes a situation in the world a raining situation. In this sense, (1) has an \textit{ontological dimension}, namely what has to be the case in order to make the sample sentence true (cf. Mulligan et al., 1984). But even more. Suppose John is sitting at his desk, looks through the window and sees that it is raining outside. Then John is seeing a scene (Barwise, 1989) that is classified by sentence (1). Thus, what John is able to do is to individuate situations \textit{epistemically}. Part of John’s cognitive facilities is a recognition of situation types. Reality is epistemically structured according to recurrent features (Gibson, 1950, 1979; Dretske, 1981; Johansson et al., 1980). We prefer to use the term ‘epistemic’ (and its morpho-syntactic variants) to refer to the interpretation-related (or \textit{interpretant}, to use a term of Peirce) realm, since ‘cognitive’ has an individual-restricted connotation that does not allow to capture the social, normative range of language concepts.\textsuperscript{4} Finally, as a competent speaker of English, John also knows how to describe the perceived situation by means of his mother tongue, that is, John has \textit{linguistic knowledge}, including the full range from phonetic to pragmatic competence. The fact that pragmatics or at least a wider, contextualized notion of semantics is needed even for capturing the seemingly simple example (1) is due to the fact that (1) does not provide a location from which the “outside” is seen \textit{expressive verbis}; it has to be filled in otherwise (Perry, 1986; Recanati, 2004b).

To sum up, language as a meaningful system is rooted in three broadly conceived domains, viz. the domain of \textit{linguistic signs}, the domain of \textit{aboutness} or \textit{ontology}, and the domain of \textit{epistemology}. These dimensions have to be kept apart when pondering about meaning constitution. They make up a “meaning triangle” as shown in Figure 4. Not entirely coincidental the meaning triangle is related to the famous semiotic triangle that is usually traced back to the work of Charles Sanders Peirce (1839–1914) (cf. Peirce, 1867).

In the subsequent sections, we will illustrate the challenges of modeling meaning constitution on each of the dimensions of the semiotic triangle from the point of view of simulation models of linguistic categorization. More specifically, we will identify three key issues of the semantics of natural languages that linguistic categorization games have to account for:

- \textit{From compositionality to contextuality}: The simulation model should be specified with respect to the way it handles both semantic compositionality and semantic contextuality. The reason is that natural language is normally manifested

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{semiotic_triangle.png}
\caption{A semiotic triangle of three reference points of meaning constitution}
\end{figure}
by complex expressions whose meanings systematically depend on the meanings of their parts and on the meanings of the contexts in which they are used. In linguistics, this systematicity is described in terms of compositionality, which is classically defined as a homomorphism according to which the meaning of a compound expression is a function of the meanings of its parts and of the way they are combined (Partee, 1984; Janssen, 1997). Of course, context is always present in interpreting linguistic expressions so that a simulation model has to include procedural means that account for both compositionality and contextuality. In the following sections, we will introduce a sequence of levels of complexity that starts with the classical principle of compositionality to end up with the more general principle of contextuality. By grading simulation models along this sequence we inform about the semantic complexity captured by them. This does not only provide comparability among different approaches, but also keeps control of the limits of simulations performed on the basis of these models.

- **Meaning constitution in dialogical communication:** natural language is prototypically manifested by spoken communication, not by written communication (Pickering & Garrod, 2004). This also means that meaning is subclassified according to the reference points of dialogical communication. As a consequence, we need to distinguish between language systematic (literal or timeless) meaning on the one hand and speaker or hearer meaning on the other: since interlocutors do not necessarily coincide in interpreting the same expression so that their language learning may partly diverge, the alignment of their dialog specific interpretation will contribute to the build-up of meaning units that are shared community-wide. Obviously, the ability to distinguish between successful and unsuccessful language learning is bound to correctly distinguishing between literal and dialog specific meaning. Many simulation models obscure this distinction and therefore miss to clarify the role of dialog in meaning constitution.

- **Natural language ontology:** Natural languages provide means to express entities of whatever ontological provenance ranging from static objects of direct perception to dynamic, processual entities without perceptual correlates, from concrete situations to complex courses of possibly abstract events. Any simulation in the area of semantics is accompanied by a decision in the range of these choices, whether made explicit or not. Obviously, it is far more complex to simulate meaning constitution outside of fields of perception compared to linguistic categories that are related to physical properties. Thus, ontological provenance spans a third dimension for evaluating the expressiveness (positive) and limits (negative) of simulation models.

Contextuality, dialogical communication and ontological provenance provide three reference points to demarcate simulation models regarding the semantic complexity captured by them. Based on this model, we plead for a conceptual evaluation of simulation models that goes beyond assessments of their algorithmic complexity and learning rates. Rather, we aim at a framework by which a given approach can be ranked according to its expressiveness in terms of key issues of semantics. In this way, our approach aims to prevent overestimating simulation results (in cases where their semantics is limited to a certain degree) or, conversely, to identify promising candidates that are above-average.

The article is organized as follows. In Section 2 we discuss complexity levels of linguistic categorization from the point of view of sign formation. This is complemented by Section 3 where we extend the notion of meaning to capture aspects of natural language ontology. In Section 4 we add a short discussion of the notion of nonnatural meaning and its significance for language simulation. Finally, in Section 5
all three reference points are integrated into a single decision space. A terminological note: throughout the paper we utilize logical semantics to classify types of linguistic categorization. The reason is not to plead for a revival of model-theoretic semantics (aka possible world semantics) in simulation models of language evolution. Rather, we aim to state precisely the differences of classes of linguistic categorization that should be reflected by such simulation models. In this way, we do not only get a blueprint for classifying existing approaches but also a roadmap to extend them step-by-step so that they capture linguistic categories of increasing complexity. Henceforth, we will also speak of simulation models when denoting a member of the class of simulation models of language evolution that address linguistic categorization.

2. THREE AND A HALF THEORIES OF ADJECTIVES

A paradigmatic setting for language categorization games is given by the color palette. Colors are denoted by adjectives like pink. Of course, there are more kinds of adjectives than color terms. However, categorizations that work in one domain should in principle work in another domain, too. Is this presumption right? In order to prepare an answer, observe the difference between the structurally completely equal sets of sentences in (2) and (3):

(2)
   a. Kuno is a pink elephant.
   b. Kuno is pink.
   c. Kuno is an elephant.

(3)
   a. Kuno is a small elephant.
   b. Kuno is small.
   c. Kuno is an elephant.

Sentence (2-a) entails both (2-b) and (2-c). But although sentence (3-a) entails (3-c), it does not entail (3-b).

(2-a) can be analyzed as the conjunction Kuno is pink and Kuno is an elephant, which complies with the entailment pattern just outlined. However, (3-a) cannot be rendered conjunctively. From Kuno is a small elephant, it follows indeed that Kuno is an elephant, but it does not follow that Kuno is small (Kamp, 1975). Kuno might be small for an elephant, but since elephants are quite big animals, Kuno cannot be said to be small in general (e.g., in comparison to other sets of entities). The inferential patterns suggest to model the semantics of pink vs. small along the following lines (Chierchia & McConnell-Ginet, 2000):

\[
(2') [\text{pink elephant}]^{M,w,g} = [\text{pink}]^{M,w,g} \cap [\text{elephant}]^{M,w,g}
\]

\[
(3') [\text{small elephant}]^{M,w,g} = [\text{small}]^{M,w,g} \subseteq [\text{elephant}]^{M,w,g}
\]

The different set theoretical behavior of color predicates and of, e.g., small is reflected by calling the former ones intersective adjectives and the latter ones subsective adjectives. The semantics for pink is straightforward: it is treated as an ordinary predicate. Its application onto its argument gives the intersection of their denotations. The semantics of small is far more complex: it is highly context dependent. What counts as small does count so relative to another property, for instance, the property of being an elephant (contrast it with the property of being a mouse). An N’ like large beetle is evaluated with respect to a set of objects, the comparison class (Klein, 1980). What complicate matters is that the comparison class need not to be determined by the head noun exclusively (i.e., beetle in the previous example). Consider the example of Chierchia and McConnell-Ginet (2000, p. 464):

(4) Lee built a large snowman.

In (4), the interpretation of large is not only determined by the average size of ordinary snowmen, but also depends on who Lee is and in what context the snowman is built. What counts as large differs not only according to whether
Lee being a two-year old boy or an adult but also to whether the snowman is built in the garden or as part of a “building-a-large-snowman” contest. Further, the comparison class can also be constituted by a set coming from outside the described event. What is large for a snowman is small compared to a blue whale.

Thus, to model the semantics of subsective adjectives, we need a contextual function which determines the comparison class for each subsective adjective $A$. This function is denoted as $C_A^n(c)$. For instance, $C_A^{sm}(c)$ gives us the set of objects that are large in context $c$ relative to the $n$th class of objects whose size we are considering (Chierchia & McConnell-Ginet, 2000, p. 464). The predicate $small$ is represented by a series of predicates $small … small$. The context determines to which $small$ an occurrence of $small$ expands and the comparison class it is compared with. The meaning of $small$, thus, is not just a function of the extensions of the adjective and the noun it modifies; its domain also includes contexts, making subsective adjectives intensional:

\[
(5) \quad [[small_m]]^{d,w,g,c} = C^{sm}_m(c)
\]

In (5), $small$ is contextually interpreted as $small$ which denotes all small objects of class $m$. Small in (5) means small for an $m$. The task for any categorization game is to provide an account for this kind of relativity of linguistic categorization. If we look on the range of existing simulation models, we note that such a specification is widely missed. What predominates are “immediate” categorizations by means of non-compound items that directly refer to their extension without any preceding meaning calibration as demanded by semantic relativity.

So far, we have considered two classes of adjectives whose semantics can be captured by a compositional semantics, enhanced by a contextually given comparison class if needed. These classes have in common, that the relational meaning of the adjectives does not change when the adjective is used to modify a head within a head-modifier construction—although it may be calibrated with respect to the head and/or some outer context.

A more serious challenge to a compositional semantics is given by examples such as *toy store* or *stone lion*, which seem to go beyond a simple subjective or non-predicative reading. The reason is that within a head-modifier construction one constituent changes its meaning in the context of the other one. Kamp and Partee discuss the challenge for a compositional semantics raised by the latter example as follows:

“It would seem that in order to interpret stone lion, we do not just apply some semantic operator to the meanings of the parts but rather actually change the meaning of lion first. How does a language user know how to do this? It would seem that part of knowing the meaning of a word should have to involve knowing how the basic meaning(s) could be stretched, shrunk, or otherwise revised in various ways when necessary; since the possible revisions are probably not finitely specifiable, such a conception of meaning would take us well beyond the normal conception of the lexicon as a finite list of finite specifications of idiosyncratic information about the particular lexical items.” (Kamp & Partee, 1995, p. 163)

The problem is that a stone lion is not a lion in the literal sense so that in this case an extensional semantics hits the wall. Kamp and Partee (1995) propose a so called recalibration semantics by which the meaning of lion is first modified to get an extension outside its literal meaning. Partee (1995) discusses several constraints of calibration semantics. Amongst others, this relates to the non-vacuity principle according to which the positive and negative extension of the recalibrated head should not be empty.

It is easy to show that even examples like *stone lion* manifest a simpler part of the range of possibilities that one faces in linguistic categorization (Mehler, 2007). The first challenge is that while Kamp and Partee (1995) deal with a sort of unilateral calibration, its bilateral vari-
ant seems to predominate. Take the example of toy store. It may have at least two readings: the one according to a privative reading of toy (along the reading of fake store) and the other according to a semantic calibration of store in the context of toy. In accordance with Partee (1995) and Kamp and Partee (1995) one might say that this exemplifies unilateral calibration where store is calibrated in the context of toy, but not vice versa. However, if we remember the seminal analysis of the word game by Wittgenstein (1953), we have to think of multifaceted word meanings whose interpretation is sensitive to their context in communication so that a bilateral calibration is a more realistic scenario. This is in accordance with Lahav (1989) who questions that adjectives always contribute the same meaning to an intersective or subjective semantics. Subsective semantics is contradicted by examples like red apple, redskin, red ballpen, red figures, red party, or red book where the predicate varies its meaning dependent on the context of its head in a non-subsective sense as there is no overall extension of red that covers all these different readings. One might argue that, for example, red party is metonymical (because of communist party). However, such examples are recurrent in linguistic categorization and therefore cannot be ruled out on principle.

In Figure 5, we illustrate the mechanism of a bilateral calibration based on a geometric model of a meaning space as used by Baronchelli et al. (2010). A challenge to every calibration semantics is, as already stated by Kamp and Partee (1995), to know what aspect of the meaning of a head or a modifier needs to be calibrated. While interlocutors solve this problem so to speak on the fly, it is by no means clear how to reconstruct this in a simulation model.5

Obviously, subsectivity demands a sort of calibration, which in the simplest case is unilateral. Note that in all examples discussed so far, the context of calibration is given by a constituent of the corresponding head-modifier construction or by this construction as a whole. In this sense, we speak of calibration subject to an inner context where we distinguish unilateral from bilateral calibration (see Rows 2–5 in Table 1). In any event, this is by far not the end when considering head-modifier constructions as manifestations of linguistic categorization. The reason is that instead of an inner context, it may additionally or alternatively be the outer context, which is the source

Figure 5. Schema of a bilateral calibration in a geometric model of a meaning space by analogy to Baronchelli et al. (2010): let X and Y be two categories that are lexicalized by l(X) and l(Y), respectively. Let further l(Y)l(X) be a head-modifier construction with l(X) in the role of the head and l(Y) in the role of the modifier. Suppose further that the calibration is bilateral where the calibration of X by Y “selects” an attribute A(X) of X as the calibrating category, while Y is calibrated by A(X) in terms of the calibrating category B(Y). Finally, A(X) \ B(Y) is interpreted in an intersective manner so that x, for example, subsumed by this complex category. Note that in the case of a bilateral calibration, the extension of the calibrating category may be no subset of the extensions of any of its constituents.
of calibration. Take once more the example of \textit{toy store} as in the following sentences:

(6) a. Maria has played with the toy store.
  b. Maria has opened the toy store.
  c. Who owns the toy store? Peter has played with it before.
  d. Who owns the toy store? Not Peter who is only a salesman.

In (6-a) and (6-b), it is the sentence context that provides information how to calibrate \textit{store} in the context of \textit{toy}. In (6-c) and (6-d), it is the co-text of the subsequent sentence that provides this information. Evidently, this context of calibration may also be provided by higher level discourse units beyond the sentence level. In principle, it is neither restricted to the sentence level nor to the text or discourse level so that a gradation of context-sensitivity has to be faced.

In Section 4, we shortly analyze some of these alternatives. In Row 6 and 7 of Table 1, we mention two of these alternatives:

- On the one hand, we have examples of the sort of (6-a)–(6-d) where the linguistic co-text, that is, the so called co-text, provides calibration information.
- On the other hand, we have metaphors where the calibration affects the meaning of the head-modifier construction as a whole in a way that cannot be reduced to calibrations of its constituents.

<table>
<thead>
<tr>
<th>Type</th>
<th>Complexity Level</th>
<th>Example</th>
<th>Model-theoretic Semantics</th>
<th>Usage-based Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context-insensitivity:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>non-interactivity</td>
<td>a single color term set</td>
<td></td>
<td>meaning point</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calibration subject to an inner context:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>intersectivity</td>
<td>Fodor’s \textit{brown cow}</td>
<td>extensional intersection</td>
<td>center of gravity</td>
</tr>
<tr>
<td>3.</td>
<td>unilateral calibration</td>
<td>\textit{midget} giant</td>
<td>subjective recalibration</td>
<td>relocation of meaning points</td>
</tr>
<tr>
<td>4.</td>
<td>bilateral calibration</td>
<td>\textit{toy store}</td>
<td>intensional recalibration</td>
<td>relocation of meaning points</td>
</tr>
<tr>
<td>5.</td>
<td>non-predicative calibration</td>
<td>\textit{former president, fake flower}</td>
<td>non-predicative recalibration</td>
<td>relocation of meaning points</td>
</tr>
<tr>
<td>Calibration subject to an outer context:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>sensitivity to outer co-text</td>
<td>(6-a)–(6-d)</td>
<td>maximize discourse coherence</td>
<td>relocation of meaning points</td>
</tr>
<tr>
<td>7.</td>
<td>oversummativity</td>
<td>metaphors</td>
<td>implicature trigger</td>
<td>not specified</td>
</tr>
<tr>
<td>Calibration subject to a non-linguistic context:</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>sensitivity to a non-linguistic context</td>
<td>\textit{large snowman}</td>
<td>context-class recalibration</td>
<td>not specified</td>
</tr>
</tbody>
</table>

Table 1. Levels of complexity of linguistic categorization from the point of view of the semantic compositionality and context-sensitivity of head-modifier constructions. Note that, in principle, any meaning constitution is sensitive to numerous levels of context. So if we highlight single levels, this only for reasons of specifying prototypical cases.
These two cases are complemented by examples where it is the non-linguistic context that provides the calibration information. Above, we have discussed the example of a snowman under this header. In Row 8 of Table 1 it is reflected by a special level of complexity.

Note that there are many more classes of linguistic categories as manifested, for example, by means of so called non-predicative adjectives. Standard examples of this class are former and alleged as in the former president or the alleged thief. Adjectives as, for instance, fake in fake flower, can also be subsumed here. They block any entailment relation that hold, for example, in the case of the sentences in (2) or (3). Their logical-semantic type is that of a function from properties onto properties. Thus, they are highly intensional operators (Chierchia & McConnell-Ginet, 2000). We do not deal with them here, but note them for reasons of completeness – hence “half a theory”.

3. FROM PROPERTIES TOWARDS A NATURAL LANGUAGE ONTOLOGY

The previous section dealt with complexities of linguistic categorizations that arise when they are manifested by head-modifier constructions. We have seen, for example, that color adjectives, the paradigm case for categorization games, are intersective and, thus, are examples for the simplest class of compositionality. We now turn to ontological counterparts of color terms and will see that they belong to one of the “simpler” (in a sense that is clarified shortly) ontological classes, too.

Categories (under the name of concepts), like properties or universals, have been rejected by philosophers with a physicalist stance. A scientific ontology should only acknowledge entities for which the criteria of identity are clear. And that happens to be merely the entities recognized by physics. However, that does not mean that physicalists abandon every property. There are true physical properties which can be defined in purely extensional terms. The paradigm property is having a certain temperature. The property of $x$ having temperature $t$ can be reduced to $x$’s mean molecular energy. A similar reduction can be given for colors. Color properties can be reduced onto wavelengths. For each color shade there is a corresponding (range of) wavelength(s). That wavelength can
be identified irrespective of epistemic vagueness language users are beset, for instance humans’ perception-based discriminatory limitations known as just noticeable difference (JND). The inter-speaker fluctuation in percepts due to effects like the JND does not mean, to speak with Wittgenstein, that the corresponding concepts are imprecise. Rather, you are free to fix a definite boundary. Physicalists thus can fix wavelength ranges for colors and thereby provide an extensional identity criterion for the property of having a color. Color terms can be taken as true physical predicates. Extensional reduction is not possible for small or large. There seems to be no true physical property onto which the respective adjectives can be reduced onto. This in turns means that there are (highly presumably) no extensional identity criteria for relative size predicates. Our supposition is that current simulation models of category formation make crucial use of the extensional “objectivity” of true physical properties (where this commitment is not made explicit within the literature). It is at least not easy to see how they can handle relative, context-dependent categories. Since natural language is full of words that manifest categories which are relative and context-dependent, a realistic categorization model has to account for them. This is what we do in the following.

Given the line of reasoning sketched above, we see two ways to account for subsective categories:

1. Provide a physicalist reduction of each property expressed by a subsective natural language term;
2. Or try to capture the context-dependency and relativity of intensional categories.

Since we are very skeptic about whether the first way is feasible at all, we opt for the second one. This is the strategy already spread out in the previous section.

Non-reductive context-dependency is not the only ontological problem a framework of modeling meaning constitution has to face. Language users regularly make reference to entities that have no substantial place in the world (like colors have). Actually, natural languages exhibit their own natural language ontology, which we dwell on in the following.

To be is to be the value of a bound variable – this slogan is the rationale of the Quinean approach to natural language metaphysics (Quine, 1960) (ontology is a sub-discipline of metaphysics). The rigid, logical analyzes of natural language sentences thus reveals the kind of objects recognized as being by that language. Applying Quine’s criterion to discourse let linguists discover a plethora of objects referred to that are of different ontological types. In particular, natural language supposes a number of abstract objects like propositions or facts (Asher, 1993). We should note that natural language ontology is best conceived as a common-sense conceptualization of what there is. It does not need to be completely and consistently reducible onto the ontological inventory of “real” (philosophical) metaphysics. The first insight is that besides the classical entities, viz. objects, properties and relations, language makes reference to actions, events and situations. Language users, for instance, count events (7-a), they refer to them anaphorically (7-b), they make identity statements about events (7-c), and they quantify over events (7-d):

(7)

a. The third thunder was even stronger than the second one.
b. Max signed a contract. He did this with green ink.
c. Simon’s first attendance of a musical also was his last.
d. Each time John goes out he forgets to close the door.

Events are also involved in entailment relations. In his seminal work on The logical form of action sentences Davidson (2001a) gives the following example:

(8) Jones buttered a toast in the bathroom at midnight.
a. Jones buttered a toast.
b. Jones buttered a toast in the bathroom.
c. Jones buttered a toast at midnight.

Each of the sub-sentences (8-a) to (8-c) follows from sentence (8). According to Davidson (2001a), has the logical structure given in (9):

\[
\exists e \exists x \exists t \exists l [\text{buttering}(e, \text{Jones}, x) \land \text{toast}(x) \land \text{bathroom}(l) \land \text{midnight}(t) \land \text{in}(e, l) \land \text{at}(e, t)]
\]

In (9), variable \( e \) binds together the constituent terms of (8). The entailments simply follow from the semantics of the conjunction. The semantic representation in (9) has different sorts of variables, namely an object variable \( x \), a time variable \( t \), a location variable \( l \), and the event variable \( e \). To be obedient to the Quinean criterion this means that language users subscribe to an ontology that (at least) contains the afore-mentioned kinds of entities. So far this seems not to be problematic since events, space-time locations and objects involved in the previous examples are concrete things, that is, they have identity conditions that can be stated in terms of spatio-temporal inhabitancy and/or causal efficiency (Quine, 1960; Achinstein, 1974; Lombard, 1986, 1998; Kim, 1991, 1998). However, this is not a rule. Consider the examples given in (10):

(10)

a. Socrates’ wisdom is eminent.
b. Equity prices of world’s stock markets go down.
c. John dreamed that a huge fly creeps under his blanket.
d. If Ballack could have played in the 2002 World Cup final Germany would have become world champion.
e. The fact that Goliath is a colossus bothers David.
f. Brangäne believes that Isolde fell in love with Tristan. Kurwenal thinks that, too.

Each of the sentences in (10) refers to something, or contains a term that refers to something, that cannot be rendered in terms of space-times or causal connectivities. There are: abstract particulars (10-a), abstract events (10-b), attitudes and mental states (10-c), (counterfactual) possibilia (10-d), facts (10-e), propositions (10-f) (note the anaphoric that in the second clause). Initiated by the work of Vendler (1957, 1968) there is still ongoing work in modern linguistics on ontological typologies of various sorts, covering the full range from lexical semantics (Dowty, 1979; Pustejovsky, 1991, 1995) to discourse theory (Asher, 1993; Asher & Lascarides, 2003).

The things people talk about and refer to are organized in quite different domains. In particular, in addition to perceptual accessible concrete objects and their properties there is need for an account of abstract entities like facts and propositions. As the data shows, language users do individuate entities that are not world immanent (Asher, 1993). A semantic theory, let it be descriptive or simulative, thus, has to provide a representation format for the abstract. Abstract representations then have to be interpreted within an ontological domain that may differ from the epistemic, representational one. What is the reason for this bifurcation? Consider the following example. Both the sentence in (11-a) as well as the sentential nominal in (11-b) refer to the same event. However, (11-a) does so “event-like” while (11-b) presents its content “thing-like”. Accordingly, both types of utterance behave quite different in syntactic as well as semantic respects. (11-a) allows for a couple of defeats, while (11-b) implies that there was exactly one. Nonetheless, as a matter of fact, both utterances are satisfied by the same historical occurrence, namely the famous chess match between IBM’s machine and the human champion. What may be different on the epistemic discourse level maps onto one and the same event in the domain talked about.

(11)

b. Kasparov’s 1997 defeat (by Deep Blue).
The lesson for simulation models of meaning constitution is the following: a further dimension of semantic complexity, namely the dimension of abstractness has to be recognized. It is not sufficient to let evolution stop in a domain of perceptually structured concrete objects. Rather, highly abstract and complex domains like propositional attitude and facts also have to be accounted for. Therefore, an advanced epistemic level of representation is needed as well as an ontological model of “what there is”.

The received view fits into a stage model of ascending abstractness and complexity and can be depicted along the levels enumerated in Table 2. It seems to be consensus in the literature that the basic level of concept formation is the perceptual level (Barsalou, 1999). Having developed a set of perceptual symbols, detached symbolic function can then be abstracted from them. The levels distinguished in Table 2 are also acknowledged in one form or another in large-scale semiotic and philosophical frameworks for symbolic functions, see for instance the works of Cassirer (1923) (for whom the levels of ego and myth are the most complex ones, however) and of Carnap (1966) (who, interestingly, reverts the order of levels 1 and 2).

### 4. LEVELS OF NONNATURAL MEANING

The linguistic and the ontological dimensions we considered so far are not independent from the epistemic one, at least not in the case of language, language use and language’s representation of the world (and other ontological classes). The reference to language users we continuously have had to make in the previous sections is evidence enough. In this section we will single out an aspect of meaning that is strongly connected with the human interpretation effort and therefore rooted within the epistemic realm of meaning constitution, namely the distinction of different concretization levels of meaning. In order to present the point we want to make we use the work of Herbert Grice as a starting point. This choice seems to be quite old-fashioned, since the Gricean approach to meaning and conversation has been questioned from various sites (Sperber & Wilson, 1986; Millikan, 2005). This notwithstanding, the insights Grice has to offer remain a challenge that has to be acknowledged, regardless which theory one favors for this task. Furthermore, the position Grice is arguing has its feet in both of the opposing camps of *ideal language philosophy* and *ordinary language philosophy*.

As Grice (1969a, 1969b) noted, there are many meanings of “mean”. On a basic level, he distinguishes between *natural* and *nonnatural* meaning. For instance, (12-a) is an example for natural meaning, whereas (12-b) exemplifies nonnatural meaning. The examples are taken from Grice (1969a, p. 377f) who uses an “nn” subscript to indicate nonnatural meaning.

\[ (12) \]

a. These spots mean weasels.
b. That remark, ‘Smith couldn’t get on without his trouble and strife,’ meant\(^{\text{nn}}\) that Smith found his wife indispensable.

Since this distinction is well-known we leave it at that. We just note that language is organized into a system of nonnatural meanings.

### Table 2. Ontological levels of meanings

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Abstract world transcendent</td>
<td>Possibilia</td>
</tr>
<tr>
<td>3</td>
<td>Abstract world immanent</td>
<td>Event types, facts</td>
</tr>
<tr>
<td>2</td>
<td>Concrete non-perceptual</td>
<td>Times, mental states</td>
</tr>
<tr>
<td>1</td>
<td>Concrete perceptual</td>
<td>Objects and events</td>
</tr>
</tbody>
</table>
Meaning is differentiated in itself. The various levels can be kept apart when we take the perspective of a field researcher who translates a foreign language \( L \) for the first time (Quine, 1960, 1987; Davidson, 2001b) (we broadly unify both theoretical frameworks in order to receive a condensed exposition – Davidsonian interpretationism and Gricean utterer’s meaning have a great deal of assumptions concerning intentions and rationality in common, anyway). The data the researcher is confronted with are situated utterances. In order to make sense of them, she first has to ascribe propositional attitudes to the speakers, that is, she interprets the utterances in light of what the speakers may believe, desire, intend, etc. In other words, our field researcher applies a theory of mind onto (the community of) \( L \)-speakers. The intention a speaker might have uttering a sentence \( \alpha \) is part of \( \alpha \)'s interpretation, that is, the determination of what the speaker meant by uttering \( \alpha \) at the actual utterance occurrence. A theory of meaning that takes speakers’ intentions in addition to language conventions into account is called an interpretive theory of meaning. We shall see that a simulation model for meaning constitution also has to account for an interpretive theory. The paradigm example are indirect speech acts. Consider the following pairs of conversational bits:

(13) **ANDY:** Yesterday I solved the Millenium Prize Problems.

**ALEXANDER:** And I’m the Queen of England.

(14) **ANDY:** *(taking part in a Buckingham Palace audience)* I’m Andy.

**ELIZABETH II:** And I’m the Queen of England.

The dialog from (14) can be interpreted literally, in particular the phrase *Queen of England* means what its wording suggests. This is not the case in (13). There, *Queen of England* is not used to attribute the respective property from the speaker. But (13) is nevertheless not understood as a plain lie. Rather, the addressee assumes that the speaker wants to communicate *something*, that is, the addressee assigns the speaker a communicative intention. Reasoning over speaker intentions, amongst others, brings about a different, non-literal interpretation of (13), namely the expression of confident disbelief. The decisive point is that one cannot get at the indirect, subjective meaning when just relying on the linguistic meaning, possibly plus some context factors. A key component of interpretation is the recourse to the speakers’ mental household. The minimal assumption is that the speaker is a rational being that produces relevant utterances (Sperber & Wilson, 1986).

When the field researcher encounters a whole series of subjective meanings manifested in utterance tokens of \( \alpha \) he may be able to abstract the conventional, occurrence-invariant meaning of \( \alpha \) from the tokens. Ultimately, he will also reach the level of organization between \( \alpha \) and the other words of \( L \), that is, the field researcher will acquire a grammar, i.e., a compositional semantics of \( L \). The levels of meaning distinguished by Grice (1969b) are, somewhat generalized, summarized in Table 3 (compare also and in particular the different notions of meaning distinguished by Recanati, 2004a). Note, that there is a qualitative gap between levels 3 and 4 on the one hand and 1 and 2 on the other hand. Levels 1 and 2 deal with literal meaning (or timeless and applied timeless meaning in the terminology of Grice), whereas levels 3 and 4 are concerned with what speakers mean (i.e. utterance-type occasion meaning, resp. utterer’s occasion-meaning according to Grice’s original account), which typically diverges from what utterances mean literally. The “Holy Grail” of a semantic theory consists in specifying how to bridge the gap between those pairs of levels. Usage-based, bottom-up approaches face the problem of how to get at occurrence-invariant meanings on the basis of data that consists of subjective interpretations. Top-down, competence-based approaches, to
the contrary, have to specify how to get at non-literal occasion meanings. It was again Grice who worked out an account to handle this problem, viz. his theory of cooperativity including the four conversational maxims and the notion of implicature (Grice, 1975). Bridging the gap between literal meaning and speaker meaning is probably the biggest obstacle for any model of meaning constitution, in whatever direction – bottom-up vs. top down – the model works. To date, only the second set of meaning levels, viz. the conventional meaning levels 1 and 2, can be handled (see for instance the work of Parikh 2000, whose account singles out one of possibly more conventional readings of a constituent and thus is in effect an account of disambiguation). Currently, more ambitious accounts that approach level 4 or even level 3 of interpretive meanings (in the sense of Table 3) are just a pie in the sky. This assessment may help to evaluate a central pitfall of current simulation models, namely that they disregard the predominant place of meaning constitution, that is, dialogical communication (Pickering & Garrod, 2004). Therefore, a necessary prerequisite on the (long) way to capture meanings on the level 3 and 4 will consist in modeling the structure of dialogs based on the turn-taking of speakers and hearers (Mehler et al., 2010). In other words, a micro-model of dialogical communication has to be integrated into a macro-model of language evolution. Many current simulation models miss to integrate such a micro-simulation-model of turn-taking. What predominates are one-turn models in which the speaker utters something that is understood by the hearer or not.

5. THE GRID: COMPLEXITY LEVELS OF MEANING CONSTITUTION

Starting from the observation that the majority of models of meaning constitution following the color-paradigm treat the development of categories in an oversimplified way, the previous sections tried to set pointers that reveal complexities hidden at the linguistic, the epistemic and the ontological aspects of language. If we conceive each of these aspects as dimensions of ascending complexity, the unified model will be a three-dimensional decision space or decision cube, respectively. The complexity cube for models of meaning constitution is given as a simplified scheme in Figure 6. As a summary from sections 2 to 4 we can divide each of the cube’s dimensions into four levels of increasing complexity. These levels are collected in Table 4, sorted from the simplest (1) to the most complex (4) ones.

The decision cube provides a classificatory grid for language simulation models. For each model of meaning constitution $M$ its complexity type $\tau$ can be given in terms of a triple $\tau = (x,y,z)$, where $x,y,z \in \{1,...,4\}$ are level numbers for each grid partition as cross-classified in Table 4. For instance, if a model’s type is $\tau = (2,2,1)$ it can account for a language item like

(15) *yesterday*

<table>
<thead>
<tr>
<th>Level</th>
<th>Meaning specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>dialog specific meaning</td>
</tr>
<tr>
<td>3</td>
<td>enriched meaning</td>
</tr>
<tr>
<td>2</td>
<td>saturated meaning</td>
</tr>
<tr>
<td>1</td>
<td>conventional meaning</td>
</tr>
</tbody>
</table>

*Table 3. Four levels of meaning that, in principle, can be made an object of simulation models of linguistic categorization*
which refers to a date in a relative manner. The model’s ontological domain is the non-perceptual concrete one (see Level 2), it is concerned with saturated meaning (Level 2) and treats (15) as an atomic sign, since the model does not account for compositional decomposability, that is, the \(-\text{day}\) part is not recognized as a component of (15) (Level 1 on the sign formation dimension). “Saturated” means that the indexicality concerning times of (15) has been learned. At this point we shall emphasize that indexicality is not the same as calibration within a context. Whereas in the former case the context just fills in some contextually given constituents in the semantic representation, in the latter case the semantic representation becomes aligned (calibrated) to another semantic representation or some context class. In effect, the agents of the meaning constitution simulation are able to use (15) on more than just one day. To be precise, the acquired level of saturated meaning not only allows the agents to use (15) on each day, but also to refer to the day before the day of the respective use (and not to a fixed date in the past). This example shows that even a simple-looking word may have a quite complex semantics. To deal with the semantics of a relative term like \textit{yesterday}, a model has to be already of type \(\tau = (2,2,1)\), a type, though quite modest in terms of its complexity rank, no model we know of has achieved yet. In fact, current models are to be located near the cube’s origin. In a follow-up article, we sketch a model of meaning constitution that goes one step further on the dimension of sign formation, i.e., from compositionality to contextuality.

The example (15) also shows that the levels of the grid are not mutually independent. In order to learn a time-referential word like (15) the agents must have a concept of time that in turn has been collectively acquired through the time-experience of the language population members. Thus, the grid can be a starting point for studying the interplay of the cube’s dimensions by means of simulation studies – a research area currently left to philosophers, psycholinguists and neuroscientists.

Table 4. Complexity levels of the decision cube on each of its dimension

<table>
<thead>
<tr>
<th>Ontological provenance</th>
<th>Dialogical communication</th>
<th>Compositionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 concrete perceptual</td>
<td>conventional meaning</td>
<td>context-insensitive</td>
</tr>
<tr>
<td>2 concrete non-perceptual</td>
<td>saturated meaning</td>
<td>inner calibration</td>
</tr>
<tr>
<td>3 abstract world immanent</td>
<td>enriched meaning</td>
<td>outer calibration</td>
</tr>
<tr>
<td>4 abstract world transcendent</td>
<td>dialog-specific meaning</td>
<td>meaning change</td>
</tr>
</tbody>
</table>

Figure 6. The decision cube: The axis are made up of the dimensions language meaning is rooted in. The origin sets the reference point for the less complex axis value. The opposite point \(C_{\text{max}}\) sets the reference point for a full blown account to natural language meaning.
To sum up, the grid may serve three purposes:

1. It provides a classification scheme for meaning constitution models. A meaning constitution model can be located according to its grid type so that it can be made explicit what meaning aspects this model actually deals with.

2. The grid may help researchers in the field of language simulation studies to get some pointers on language phenomena that still wait on simulative accounts. In a related way it may help to preserve researchers from accidentally raveling in aspects of language complexity they are not interested in at all.

3. The grid, finally, can figure as a research object by itself. On the one hand, it allows to account for the interplay of the dimensions distinguished. There might be a logical primacy of the following kind: ontology determines epistemology, epistemology determines sign formation (a more cautious formulation would be constraints instead of determines). On the other hand, the levels observed may be object to refinement and further clarification.

6. CONCLUSION

This paper dealt with simulation models of linguistic categorization from the point of view of three reference points of linguistic semantics and the philosophy of language. We argued that the extended naming game is primarily concerned with non-compound categorizations based on a compositional semantics. We have shown that linguistic analyzes of adjective-noun compounds and other head-modifier constructions reveal that this is only a special case of a sequence of complexity levels, which range from a purely compositional to a purely context-sensitive semantics. Moreover, we have stressed the need to make distinctions what regards the ontological status of reference objects of linguistic signs that are made an object of simulation and that, finally, dialogical communication as the primary locus of meaning constitution asks for simulation models, which integrate a micro-model of turn-taking. All in all, we spanned a decision grid based on three reference points for assessing the expressiveness and limits of simulation models of linguistic categorization as a means to identify promising approaches by ranking their findings in a linguistic sense. As this paper has been concerned with a conceptual analysis of linguistic categorization, it will be the task of future work to implement our simulation model and to further extend its level of complexity according to our decision grid.

ACKNOWLEDGMENTS

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REFERENCES


ENDNOTES

Note that this article is not about the ENG in general, nor about criticizing this approach. Rather, we appreciate the abstract, analytical stance of the ENG and, therefore, use it as a starting point to think about extensions in the
line of capturing sorts of linguistic categorization of higher complexity.

This restriction is made for simplicity reasons as the range of inference mechanisms that are operative in natural languages are out of reach in this short review.

Note that this manifests a semantics of full compositionality (Kamp & Partee, 1995; Partee, 1995).

As we do not ride on terminological decisions, the reader may feel free to insert her favorite terms.

In a follow-up paper, we will give a first account of such an approach in terms of a graph-theoretical model of calibration. Note that instead of recalibration we speak of calibration.

The nomenclature in Table 2 is probably not the best. However, as already noted, we do not ride on terminology, but hint at some indispensable distinctions.

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