Trans. #: 25168  ILL#: 1803389

Article Location: Wilson Library 412 Se514

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*MNU,OSU,NUI,CGU,UIU

AUTHOR:
TITLE: Semantics from different points of view /

Article: article by Pinkal 'How to refer with vague descriptions'
Volume: Issue: Month: Year: Pages: 32-50

ARIEL: Yes 129.105.29.32  FAX: 847-491-5685
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How to Refer with Vague Descriptions

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This paper deals with the question how reference with vague descriptions should be analyzed formally, and gives a proposal for a solution. More precisely, it suggests a formal treatment for the reference identifying function of a special type of vague expressions, as they are used in a special type of definite descriptions. The results of the analysis, however, seem to be of more general importance. The paper consists of:

(i) some remarks on vagueness and the formal treatment of one type of vagueness;
(ii) some remarks on definite descriptions and the formal treatment of one kind of descriptions;
(iii) a short outline of the formal frame which is used to describe both phenomena;
(iv) an exemplary interpretation of one sentence containing a definite description with a vague predicate within this frame;
(v) some remarks on the results of the formal analysis concerning reference, vagueness and their mutual relations.

1. Vagueness and Truth Values

Nearly all natural language expressions seem to be vague to some extent. There is a subgroup of expressions which are vague in a quite obvious way. And there is a subgroup of this subgroup which is usually discussed as the paradigmatic case of vagueness, since it contains expressions with relatively simple meaning intuitions. It is the scalar adjectives or adjectives of degree which can be related to a one-dimensional physical scale, like tall, small, hot, cold, heavy, light, quick, slow, the latter subgroup consists of. The former, more comprehensive group contains all kinds of one- and multi-dimensional adjectives, adverbs of space and time, modal verbs and adverbs etc. On the following pages, the discussion is restricted to the second group for reasons of intuitive simplicity; the central results, however, can be extended to a large part of the first group, too.

Scalar adjectives are vague, and they are context-dependent; they stay vague and context-dependent also in case they are used attributively or in connection with modifiers of different types. Thus, neither to treat them as sharp predicates nor as sharp common noun modifiers, like MONTAGUE does [12], yields intuitively adequate results. As far as vagueness is concerned, two-valued context-dependent interpretations employing a 'comparison value' coordinate are inadequate as well as approaches which let the context provide for a comparison set. An advantage of the latter is that it is capable of semantically treating ad-adjetival constructions which specify sets of individuals rather than values. Nevertheless, being a two-valued approach, it has to specify an algorithm for the computation of a sharp numerical comparison value (something like the average) on the basis of the comparison set, and thus cannot do justice to the fact that a lot of accidental historical and psychological data may influence a native speaker's opinion of what is 'normal' with respect to a set of individuals. Obviously, there is no well-defined function connecting sets and values but just a loose probabilistic correlation between, say, the set of men and what is tall for a man. The fact is taken into account informally by CRESSWELL's formulation that, roughly speaking, for a sentence is a tall man to be true the degree of A's tallness has to be "towards the top of the scale" which is inherent to the semantics of tall man [3]. But which formal framework allows for a precise reconstruction of vagueness and inexactness?

Classical two-valued logic won't do the job. In three-valued logics, the inadequacy of a sharp boundary between truth and falsehood is replaced by the more subtle inadequacy of two sharp boundaries between boundary cases and truth and falsehood, resp., at the cost of abandoning the Law of Excluded Middle. No problems concerning boundaries arise with infinitely-valued logics, and yet the values assigned to vague expressions are completely precise entities. In fuzzy logic, sentences denote truth-values in the closed interval [0,1], predicates denote functions from the set of individuals into [0,1] (cf. [8],[18]). For predicates like red or tall, the continuity of the possible denotations thus reflects the continuity of the colour spectrum and the scale of spatial distances, resp.

There is, however, an objection to fuzzy logic which is as old as multi-valued logics are: It is not possible to give an interpretation to logical connectives which renders fuzzy logic a conservative extension of two-valued logic. Classical tautologies are contradictions like (a) and (b) take truth-values different from 0 and 1, in case partial truth-values are assigned to their constituents, and, moreover, (a) and (b) may take the same truth-value in certain cases.

(a) John's hair is red or it isn't.
(b) John's hair is red and it isn't.

An interpretation of vague concepts which avoids these undesired results is offered by the theory of super-valuations. Roughly speaking, expressions are differently evaluated at
different 'indices' [9] or 'specification points' [4]. These valuations are classical, but additionally a higher level valuation takes place which assigns to the expressions higher-level values with respect to sets of standard interpretations. Truth in the super-valuation sense is defined as classical truth at each single valuation, super-falsehood correspondingly as falsehood at each super-valuation; sentences containing vague expressions may be assigned a third super-truth value, indeterminateness, in case the respective sentence is true for some, false for some other precisifications. The crucial point in the super-valuation semantics is that the values of complex expressions are calculated from the values of their constituents not on the super-truth level, but on the elementary level, at each specific. Since the elementary level valuations are standard, the values of (a) and (b) will at each index, in each possible precisification be true and false, resp. - and therefore true and false, resp., at the super-valuation level, too.

Supervaluation semantics has three (super-) truth values at its disposal, so far. It can be provided with an infinite and numerical truth value inventory, too, in a formally quite simple way: by the definition of a probability measure on the set of all classical valuations [6]. Thus, the super-valuation approach

(i) provides for precise and, if desired, numerical value assignments for vague expressions in terms of
(ii) a conservative extension of standard predicate logic, but
(iii) it is no more truth functional in a direct sense.

In this paper, vague expressions will be analysed in a super-valuation framework, but before doing so, two substantial problems have to be considered.

First: The property (i) holds of the multi-valued approach, too. From a logical point of view, the second item may be regarded as the fundamental advantage of super-valuations - at the price of the abandonment of truth-functionality (iii). From an empirical linguistic position the argumentation is somewhat doubtful. Native speaker's intuitions about the possible truth values of sentences (a) and (b) are not very clear, and, moreover, supposed the colour of John's hair is a real borderline case native speakers tend to consider the contradiction (b) as true - a result which gives reason for the question if (ii) actually is an advantage of super-valuation semantics. Now, the reason for unsure and seemingly counter-logical intuitions with (a) and (b) can be found in the conversational extremity of these sentences. There are slightly modified versions of (a) and (b) which may be used in ordinary communication in their standard sense.

(a') John's hair is red or Bill's isn't (either)
(b') John's hair is red and Bill's isn't

provided that Bill's and John's hair are identical with respect to their colour which again be a borderline case of red, at least (b') is clearly false since the predicates in both atomic constituent sentences correlate. This nicely corresponds to the super-valuation result, as well as the fact that (c) and (d) may be regarded as partially true to a different extent, resp., also in case the super-valuations of their constituents are identical.

(c) John's hair is red, and so is Bill's
(d) John's hair is red, and Bill's is brown

Thus, the statement concerning the advantage of super-valuation semantics remains true, but the argument has to be reversed: It is the lack of plain truth-functionality which makes super-valuations a proper means for the description of vague natural language expressions; that analytic expressions of standard logic save their truth-values is a special by-product.

The second question to be taken into consideration is still more basic than the problem of compositionality with partial truth: It concerns the concept of partial truth itself. What is the intuitive correlate of degrees of truth in natural language analysis? Natural language use of true, false, and, maybe, indefinite is quite clear and unproblematic. Natural language expressions referring to degrees of truth do not occur very often, and when they are used, this usually happens in an ambiguous and metaphorical manner. true by half e. g. can be used to designate complete cases of which a part of which are true and parts of which are false, or sentences which are definitely true, but leave relevant information unmentioned. It therefore seems impossible to explain degrees of truth by referring to ordinary language intuitions. Now, whereas in fuzzy logic numerical truth-values are undefined basic terms, in super-valuation semantics they can be defined as probabilities. But probabilities of what? Surely no epistemic probabilities: That (e) is true to degree 0.5 cannot mean that it is likely to 50% that (e) is (definitely) true.

(e) John's hair is red

Could it mean the probability that a native speaker will accept (e) as true? Probably not, for whether a hearer of an utterance of (e) will accept it as true depends mainly on the special conversational function of that utterance. In case (e) is used to describe an unknown person, the hearer will accept it anyway (if there are no complications of the speaker); he might or might not accept it in case he faces John, and the same, but with different criteria, holds in case he faces several persons, and (e) is used to identify John. There is, however, one precise task vague expressions observe: they contribute to reference identification in definite noun phrases. If it can be shown in an intuitively satisfying way how partial truth and partial membership are employed in the context-dependent evaluation of complex NPs, this will give at least some intuitive support to semantics with numerical values. As will be seen later on, the analysis
can actually be carried out in a super-valuation framework; as far as definite NPs are concerned, it will follow the way informally indicated in the next section.

2. Definite Descriptions

Definite descriptions are used to refer to single individuals. There are at least two types of definite descriptions to be distinguished with respect to the way they refer to individuals. One type is represented by expressions like the king of France and the father of John, or, shortly, the king and the father. These noun phrases presuppose that there be one and only one thing which possesses the property specified by the respective common noun phrase; the CN phrase is a function expression, either with or without an explicitly given argument. In the latter case, the context of utterance has to answer the question whose king or whose father is talked about, rather than which king or which father is the individual under consideration. Context has to specify the argument of the function rather than its value. Once the argument is identified, existence and uniqueness presupposition hold for the elliptical version, too.

The second class of definite NPs, which is of special interest in connection with the vague ness phenomenon, behaves completely different. The girl, the dog, the pig, the girl over there, the small dog, the pig over there with the floppy ears do not contain function expressions, neither explicit nor hidden ones. The denotations of the respective CN constituents are more or less comprehensive sets of individuals - there usually is no opportunity for them to satisfy a uniqueness presupposition in the sense first type descriptions do. Nevertheless, second type descriptions are used to refer to single individuals, and, moreover, once they denote an individual in an utterance at all, they denote the same individual (during that utterance) independently of world and time talked about. Similarly to proper nouns, they are exclusively used as rigid designators, whereas first type descriptions have a de dictu reading as well as a de re reading.

RUSSELL's classical analysis of definite descriptions or at least its reformulation in terms of the presupposition concept [7] may be applicable to first type NPs. It should be clear from what has been said so far that second type descriptions require a completely different treatment. M. CHESSWELL suggests to employ "e-specifying context properties" where e is a set of candidates for definite NP reference (23, p. 180 f.). A description is evaluated in those and only in those contexts which specify a set e containing exactly one individual of the kind indicated by the CN phrase. As D. LEWIS pointed out, the inadequacy of this approach is shown by (f).

(f) The pig is grunting, but the pig with the floppy ears isn't

If just one pig is given by the context - which is necessary for the evaluation of the first part of (f) - the whole sentence gets either an odd reading (in cases this pig has floppy ears), or no one at all (in case the pig has not). This problem, among others, caused LEWIS to replace the set by a salience ranking [10]. The definite NP refers to the individual of highest salience which is member of the extension of the CN-expression. Thus a second type NP the a does not request the hearer of an utterance in which it occurs to assume that there is just one a among the things under consideration. It rather asks him to look up the most salient a - which may of course be an individual different from the most salient a.

The intuitions underlying the analysis of definite descriptions suggested in this paper run along these lines, except for one item: The approach allows for more sensitive modifications of the salience ranking than the LEWIS approach does, and thus does justice to the fact that vague expressions like small in the small dog influence the relative position of individuals in the preference scale rather than separating the individuals into two distinct classes. For, which of two dogs is to be selected as the object referred to, if one of them is slightly more salient in advance, whereas the other one is slightly smaller? Formally, the analysis avoids the introduction of an isolated preference scale, and treats the phenomenon of preference modification within a general semantic framework. In advance, some informal remarks may indicate the way the analysis will proceed. The formal framework will be described in the next section.

Although which individual is referred to by a definite NP depends on the situation of utterance, natural situations of communication usually do not determine one single individual completely. Except for the speaker, it is only more or less likely for the discourse participants that a special individual is the one thought of, where "likeliness" correlates to LEWIS' salience. In other words the possible precisifications of the under-determined context may differ with respect to the referred-object coordinate, and different precisifications may be more or less plausible, which can be modelled in a probabilistically extended super-valuation frame without problems. CN phrases contribute to reference identification by increasing the hearer's knowledge about context. More technically speaking: the CN phrase in the a excludes precisifications from the super-assignment which yield as the referred object an individual which is no a.

3. The Formal Framework

Before the analysis of vague expressions in definite descriptions can take place, it is necessary to give a survey of the employed technical devices. There is no need to go too much into details,
since the notations and central parts of the theory are related to
well-known systems in formal semantics. In short terms, the frame-
work presented is a combination of the LEWIS [9] coordinate ap-
proach and the theory of super-valuations, written down in the
\( \lambda \)-categorial notation of CRESSWELL [2].

According to the previous informal considerations, the
formalism is defined in two steps. The central concept to be de-
defined in the first step is that of context. A context \( \mathcal{C} \) is a
function from a - possibly infinite and non-empty - arbitrarily
chosen set \( \mathcal{I} \). The values for each \( i \in \mathcal{I} \) have to be taken from some
prespecified inventory \( \Gamma_i \), which is a possibly infinite, non-empty
set, too. The definition of the set of contexts is given by (1):

\[
\mathcal{L} = \{ \mathcal{C} \mid \mathcal{C} \text{ is function from } \mathcal{I} \text{ and } \mathcal{C}(i) \in \Gamma_i \text{ for each } i \in \mathcal{I} \} \tag{1}
\]

The difference of the function writing to the usual notation is
not a substantial one. Like a context n-tuple, a function \( \mathcal{C} \) single-
out an appropriate value for each context coordinate: an individu-
als for the 'speaker' and 'referred-object' coordinate, resp., a tri-
uplet of real numbers for the 'place-of-utterance' coordinate, a set of
individuals for the 'comparison set' coordinate, etc. Intuitively,
a context may be understood as a 'world relative to a single
utterance event' including the most remote and unimportant in-
formation, but without taking into account focus of attention and
knowledge of the discourse participants. According to the informal
remarks in the preceding sections, contexts may be conceived of
as complete precisifications of the shared knowledge of the dis-
course participants.

Given the definition of context set, an interpretation of a
\( \lambda \)-categorial language can be defined as an ordered sextuple \( \mathcal{U} \),
in accordance with standard second-order semantics.

\[
\mathcal{U} := < W, U, D, \mathcal{L}, \Gamma_i, \mathcal{V} > \tag{2}
\]

\( W \) (the set of possible words) and \( U \) (the set of individuals) are
non-empty; the system of possible denotations consists of indexed
sets of possible values for each category, with \( D_0 = \mathcal{F}(W) \) and
\( D_1 = U \) and the respective sets of complex functions for derived
categories: \( \mathcal{F}(W)^U \) for one-place predicates, the set of functions
from predicate denotations into predicate denotations for predicate
modifiers, etc. The meaning of each basic expression \( a \) is given
by the assignment function \( \mathcal{V} \) as a function from contexts into the
set of possible denotations of \( a \).

There is a substantial restriction placed upon the context-
dependent value-assignment. For every basic expression \( a \), \( \mathcal{V}(a) \)
must be definable in terms of a function of at most finitely many
context coordinates. Informally speaking, the denotation of an
expression depends on a finite subset of context features.

One more restriction, which is not less important, can be seen
from (3), the definition of the value assignment function for
complex expressions.

\[
\mathcal{V}^+ (\mathcal{C}, a_1, \ldots, a_n) (\mathcal{C}^*) := \mathcal{V}^+ (\mathcal{C}) (\mathcal{V}^+(a_1) (\mathcal{C}^*), \ldots, \mathcal{V}^+(a_n) (\mathcal{C}^*)) \tag{3}
\]

The denotation of a complex expression at one context depends only
on the denotations of its constituents at the same context, not
on their meanings as a whole. To use CRESSWELL's term, meanings
are regarded as distributive ([2], p. 119). An argument for this
treatment of context-dependence which differs from the way most
semanticists proceed is given by THOMASON [16]. One more reason
which strictly demands the distributive treatment is the way con-
texts and context-dependent interpretations are employed on the
second level, i.e., the presentation of which will follow after a final
remark concerning definition (2). The first level
assignment is two-valued, except at one point: the denotations of
expressions of a derived category, at some contexts, may be un-
defined for certain arguments. Thus, each context \( \mathcal{C} \) induces a
classical interpretation for each expression - in case it induces
an interpretation at all.

The central notion of the second level is that of a situation.
Intuitively, a situation \( \mathcal{R} \) is a cluster of information taken
from the physical surroundings, previous talk and common-sense
knowledge: it comprises anything which is available to the dis-
course participants for the evaluation of an utterance, and
approximately may be thought of as a fragment of a context (in
the sense of 'context' described above). Formally, a situation is
definable as a subset of the context set, i.e., the set of those
categories which are compatible with the accessible knowledge.

\[
\mathcal{R} \subseteq \mathcal{L} \tag{4}
\]

As each context \( \mathcal{C} \) induces a standard valuation, each situation \( \mathcal{R} \)
induces a super-valuation. Expressions are indetermined at a
situation \( \mathcal{R} \) in case context coordinates relevant for their
evaluation are not uniquely specified in \( \mathcal{R} \). Expressions can be
made more precise in a situation by partially undefined modifiers.
By preventing the valuation of the expression at certain members
of \( \mathcal{R} \), they specify the situation: incompatible subsets of \( \mathcal{R} \) are
filtered out.

For the following, a couple of subsidiary definitions are
required.

\[
\mathcal{R}_i^d := \{ \mathcal{C} \mid \mathcal{C}(i) \in \delta \} \quad (i \in \mathcal{I}, \delta \subseteq \Gamma_i) \tag{5}
\]

\[
\mathcal{R}_a^d := \{ \mathcal{C} \mid \mathcal{V}^+(a) (\mathcal{C}) \in \delta \} \quad (a \in \mathcal{E}_i, \delta \subseteq D_0) \tag{6}
\]

\[
\mathcal{R}_a^\delta := \{ \mathcal{C} \mid \mathcal{V}^+(a) (\mathcal{C}) \text{ is undefined} \} \tag{7}
\]
$R_i$ is the situation the only information of which consists in the fact that coordinate $i$ takes one of the values of $d$. By (6) the set of those contexts is defined at which $a$ is assign one of the values of $d$. $R_i$ is the set of alternatives excluded by context-modifying phrases contained in $a$. Now, let $P$ be a probability measure on the context set $L^{11}$. Given $P$ and an interpretation $V$, a super-assignment function $V^*$ is definable which at each situation $R$ assigns to each expression $a$ a probability distribution on the set of possible denotations of $a$.

$$V^*(a)(R)(d) := \frac{P(R \cap R^d_a)}{P(R^d_a)} \quad \text{(8)}$$

Loosely formulating, $V^*$ gives an estimate of the denotation of each expression. In advance, however, the situation can be pre-classified by constituents of the expression, as the denominator in the definition of (8) shows.

So far, $V^*$ and $P$ are a means to describe context-dependence, vagueness and verbal context modification in a formally correct, but very general and abstract way. But $P$ as a probability measure on the set of contexts not only assigns probabilities to possible denotations, but moreover completely determines (intuitively: reflects) the probabilistic correlations between context coordinates. Therefore, it is possible to proceed the opposite way and to define $P$ in terms of correlations among coordinates, and, furthermore, to replace $V^*$ by a set of elementary estimate functions $\gamma_i^*$ for each coordinate $i$, which, loosely speaking, represent the inductive procedures a discourse participant employs to find out the unknown value of context features which are relevant for the evaluation of an utterance, starting off from information given by the situation. Technically, the domain of each $\gamma_i^*$ is the set of situations $C_i$, the ranges contain probability distributions on the respective sets of coordinate values $R_i$. The mutual relation of the $\gamma_i^*$ and $P$ is described by (9), which formally is a definition of $\gamma_i^*$-functions on the basis of $P$.

$$\gamma_i^*(R)(d) := \frac{P(R \cap R^d_i)}{P(R)} \quad \text{for} \quad d \leq R_i \quad \text{(9)}$$

Given (8) and (9), it is possible to prove a theorem concerning the way $V^*$ can be expressed in terms of the $\gamma_i^*$-functions, using a couple of quite elementary theorems of the theory of probabilities. The theorem - which is presented in a footnote here because its formulation is rather complicated and not necessary for the comprehension of the applications in the next section 13 - allows to reduce the estimate for a complex expression to the estimates of the values for its finitely many coordinates, which again base on the available context information represented by the situation $R$.

4. The Small Dog

Underlying intuitions and facilities of the system which has been described in a quite abstract way so far will become more apparent by the exemplary interpretation of a couple of expressions of English, given in this section.

(g) The small dog barks.
(h) It barks.

Sentences (g) and (h) will be analysed; the lexical entries for basic expressions employed in the sample sentences are given at a time, in advance. As with the definitions of the last section, the formal correctness of the following interpretations sometimes is neglected in favour of greater lucidity. For the same reason, syntactic surface phenomena are not taken into account. In opposition to the general framework defined above, the whole interpretation will be an extensional one. There are certain additional problems connected with the intensional version 14, but they do not directly affect the aims of this paper, and thus will not be discussed further.

At a context $\ell$, in the following, sentences denote truth-values, predicate expressions denote characteristic functions from $U$, which correspond to sets of individuals, etc. Relevant context coordinates employed in the interpretation are $qu$ (comparison value), ref (referred object), and $mgqu$ (comparison set), with

$$\gamma_{qu} = R^+ ; \quad \gamma_{ref} = U ; \quad \gamma_{mgqu} = P(U) \quad \text{(10)}$$

'gr' denotes a function which, intuitively, settles individuals on a tallness scale, by assigning positive real numbers to them 15.

dog: \begin{equation} \langle 0,1 \rangle \end{equation}

$$V(\text{dog})(\ell) = V(\text{dog})(\ell') \quad \text{for each} \quad \ell, \ell' \in L$$

barks: \begin{equation} \langle 0,1 \rangle \end{equation}

$$V(\text{barks})(\ell) = V(\text{barks})(\ell') \quad \text{for each} \quad \ell, \ell' \in L$$

small: \begin{equation} \langle 0,1 \rangle \end{equation}

$$V(\text{small})(\ell)(a) = 1 \quad \text{iff} \quad \text{gr}(a) < \ell(\text{qu}) \quad \text{for each} \quad \ell \in L, \quad a \in U$$

it: \begin{equation} \langle 0,0,1 \rangle \end{equation}

$$V(\text{it})(\ell)(u) = \omega(\ell(\text{ref})) \quad \text{for each} \quad u \in D_{\langle 0,1 \rangle}$$

the: \begin{equation} \langle 0,0,1 \rangle \end{equation}

$$V(\text{the})(\ell)(u,u') = \begin{cases} \omega'(\ell(\text{ref})) & \text{if} \quad \omega(\ell(\text{ref})) = 1 \\ \text{undefined} & \text{for each} \quad u,u' \in D_{\langle 0,1 \rangle} \end{cases}$$
att: \( \langle 0, 1 \rangle, \langle 0, 1 \rangle, \langle 0, 1 \rangle \)  

\[
V(\text{att})(\langle 0, 1 \rangle)(w, \omega')(a) = \begin{cases} 
\min(\omega(a), \omega'(a)) & \text{if } \zeta'(\text{mqu}) \subseteq \omega' \\
\text{undefined else} & 
\end{cases}
\]

for each \( w, \omega' \in D_{0, 1} \)

dog and barks are analysed as sharp and constant one-place predicates, although both are - like most natural language predicates - vague to a certain extent. small is classified as a predicate, too. Alternatively, it could be analysed as a predicative modifier (of category \( \langle 0, 1 \rangle, \langle 0, 1 \rangle \)) in which case instead of the deep-structure operator att a different one would be required for the conversion of adjectives into predicates (cf. [2], p. 185). The semantics of small is defined as simply as possible. Of course, small is more correctly paraphrased by significantly smaller than standard or by smaller than standard. small does not exclusively refer to the aspect 'maximal distance in vertical direction', but to other aspects of shape, too (and therefore smallness will not induce a strict ordering); after all, which individual is to be considered as small does not only depend on a standard or average, but also on various norms and requirements (which are context-specific, too; cf. [13], pp. 104 ff.). The crucial point is that small is interpreted by means of a comparison value coordinate rather than a comparison set coordinate - seemingly in contradiction to our former considerations. As usual, it is defined as a basic term phrase dependent on the referred-object coordinate; the reference specifying function of gender is neglected. According to (12) and (14), (h) is interpreted in the following way:

\[
V_{\zeta'}(\langle \text{cit}, \text{barks} \rangle)(\zeta') = V(\text{barks})(\zeta'(_\text{ref})) 
\]

As opposed to the lexical items considered so far, the interpretation of the and att yields incomplete functions for certain contexts. the is analysed as a quantifier, i.e., according to [2], as a phrase which takes two predicate expressions and makes a sentence thereof. According to (15), the dog barks, which is \( \langle \text{the}, \text{dog}, \text{barks} \rangle \) in \( \lambda \)-categorical representation, is assigned truth at \( \zeta' \) if the object referred to at \( \zeta' \) barks, falsehood otherwise. But an assignment of either truth or falsehood takes place just in case the referred object is a dog; otherwise, the interpretation is blocked up. - att combines two predicates to a complex one, and for this complex predicate introduces a new relevant context coordinate. According to (16), the denotation of \( \langle \text{att}, \text{small}, \text{dog} \rangle \) is the set of those individuals which are dogs and are smaller than the comparison value given by the context; a denotation, however, is assigned only in case the comparison set consists of dogs only. Otherwise, the interpretation is blocked up.

The \( \lambda \)-categorical representation of sentence \( (g) \) is given by (18), its interpretation by (19)–(21), where (20) specifies the conditions placed upon context by the context-specifying elements of \( (g) \), and (21) comprises the result of the interpretation in a more lucid manner.

\[
\begin{align*}
V^+(\langle 18 \rangle)(\zeta') &= V(\text{the})(\zeta')(V(\text{att})(\zeta')(V(\text{small})(\zeta'), V(\text{dog})(\zeta')), V(\text{barks})(\zeta')) \\
&= \begin{cases} 
V(\text{barks})(\zeta'(_\text{ref})), & \text{if } (20) \\
\text{undefined else} & 
\end{cases}
\end{align*}
\]

\[
\begin{align*}
V(\text{small})(\zeta)(\zeta'(_\text{ref}))) &= \text{if } V(\text{small})(\zeta)(\zeta'(_\text{ref}))) = V(\text{dog})(\zeta'(_\text{ref}))), \text{if } \zeta'(\text{mqu}) \subseteq V(\text{dog}) \text{ undefined else} \\
V^+(\langle 18 \rangle)(\zeta) &= V(\text{barks})(\zeta'(_\text{ref})), \\
&= \begin{cases} 
\text{if: } (i) \zeta'(_\text{ref}) \in V(\text{dog}) \\
(ii) \text{ gr}(\zeta'(_\text{ref})) \prec \zeta'(\text{qu}) \\
(iii) \zeta'(\text{mqu}) \subseteq V(\text{dog}) & 
\end{cases}
\end{align*}
\]

In natural language terms: If \( (g) \) is evaluated at all, it is assigned truth exactly in case the referred individual given by the context barks; i.e., once there is assigned a denotation to \( (g) \), this denotation is identical with the denotation of \( (h) \), given in (17). But differently from \( (h) \), \( (g) \) is assigned a denotation only if the individual referred to is a dog (1), and is smaller than the context-given comparison value (ii), and the context-given comparison set consists only of dogs (iii).

What has been done up to this point concerns the first level of completely specified contexts. The super-valuation which will follow now does not require any new information or decisions. \( V' \) of sentence \( (g) \) is completely determined by (21). In connection with the super-valuation, however, a difficulty arises which in part is due to the fact that the analysis is purely extensional. In an intensional interpretation, different individuals as values of the referred-object coordinate cause different valuations for sentences containing personal pronouns or definite descriptions. If the analysis is restricted to extensions, all valuation alternatives for definite NPs on the sentence level collapse to truth and falsehood, resp., and the truth estimate does not reflect the more interesting probability distribution on possible noun phrase denotations. Therefore it is more illucidating to compute the \( V' \)-value of the definite NP the small dog separately, which is in \( \lambda \)-categorical notation

\[
\langle X_{\lambda}, 1 \rangle, \langle \text{the}, \langle \text{att}, \text{small}, \text{dog} \rangle, X_{\lambda}, 1 \rangle 
\]

A straight-forward \( V' \)-assignment for (22) is possible without serious difficulties; it will, however, be easier and more instructive to give a second-level interpretation of (22) in terms of \( V(\text{it}) \).

Be \( K^* \) the set of those contexts which are compatible with the noun phrase (22). barks in (18) does not contribute to context restriction; therefore the value of \( K^* \) may directly be taken
from the restrictions listed in (21), the first-level interpretation of (18):
\[ R^* = R_{\text{ref}}^V \cap R_{\text{mqv}}^V(V(\text{dog})) \cap \{ f' | \text{gr}(f(\text{ref})) \prec f(\text{gu}) \} \] (23)

Since (24) holds\(^7\), and for all contexts admitted by (22) the denotations of the small dog and it are identical, the estimate of the NP may be reduced to the estimate of the personal pronoun as shown in (25).
\[ V^*(22)(R) = V^*(22)(R \cap R^*) \] (24)
\[ V^*(22)(R) = V^*(i)(R \cap R^*) \] (25)
The V*-valuation of the small dog is the same as for the personal pronoun, but it is based on a situation which has been enriched with the information that the individual referred to is a dog, that it is smaller than standard, and that the comparison set the standard relates to consists of dogs only.

Furthermore, using (26), the estimate of the definite description can be reduced to the estimate function of the referred-object coordinate; \( \iota_a \) in (26) and (27) be the term denotation which referentially corresponds to the individual \( a \).
\[ V^*(i)(R \cap R^*)(\iota_a) = r_{\text{ref}}(R \cap R^*)(a) \] (26)
\[ V^*(22)(R)(\iota_a) = r_{\text{ref}}(R \cap R^*)(a) \] (27)
According to (27), the probability that an individual \( a \) is referred to by (22) in a situation \( R \) is given by the respective \( V^* \)-value of the referred-object coordinate on the basis of a properly specified situation.

5. Results

Result 1 (concerning vagueness): Common nouns accompanied by adjectival attributes have a function that they share with several types of adjective-modifying phrases: they specify features of the situation of utterance which are relevant for the valuation of the adjective. Like certain prepositional phrases (e.g., for a dog) they specify a comparison set rather than a comparison value. In the given interpretation, the set is related to a numerical standard by a probabilistic correlation rather than a sharp standard, which fits to natural language intuitions.

Result 2 (concerning vagueness): Context dependence and vagueness are preserved in case of explicit modification. They are, however, reduced in a proper way by the interaction of situation and explicit specification. Lexical items of different categories may be treated in the same way\(^8\).

Result 3 (concerning definite descriptions): Definite descriptions, as they are used in ordinary discourse, often neither take one individual as their definite value, nor are they left without any value. They are assigned an estimate of the individual referred to, which is modelled by the given interpretation. Whether the utterance is accepted by its addressee, depends on the current standards of exactness (cf. [10]). The speaker of an utterance may (and has to try to) satisfy the standards by using more or less specific common noun phrases.

Result 4 (concerning definite descriptions): Definite descriptions and personal pronouns are reduced to the same type of context dependence, the former being treated as specified pronouns. Analogously, proper nouns could be treated as an extreme case of specification. The 'salience ranking' of LEWIS [10] may be defined in terms of the probability distribution which is assigned to the personal pronoun by the \( V^* \)-function of the referred-object coordinate, with respect to a given situation.

Result 5 (concerning both): The way definite descriptions are related to pronouns is very similar to the way complex common noun phrases containing adjectives are related to adjectives in predicative use: in both cases, the more complex phrases are interpreted as context-specifying versions of the simpler ones.

Result 6 (concerning both): The referred-object coordinate in definite descriptions may be specified by vague expressions, e.g., adjectives of space and time as well as by adjectives of time. Accordingly, the way specifications take place is not restricted to set-theoretical intersection nor by deletions in a preference ordering of the LEWIS type, but in terms of a more sensitive procedure, by which the comparative salience of two individuals may be reversed.

Result 7 (concerning both): The analysis is not restricted to constructions of type the + adjective + CN; without great effort, it can be extended to noun phrase constructions of considerable variance and complexity. E.g., it treats descriptions containing sharp and context-invariant attributes like married and rectangular and recursive attributive constructions without any modification; combinations of vague modifiers of different type, like in the small dog over there; common nouns which are vague themselves (which indeed seems to be the case for nearly all natural language common nouns to some extent); modifying phrases containing vague CN-phrases (the small dog with the large ears barking at the red-haired guy) - provided, of course, suitable value assignments for adverbs and vague common nouns in the given framework.

Result 8 (concerning both): On the other hand, a quite fundamental result may be obtained by considering the most elementary cases of definite NPs. In a sentence like (k), the connection between the \( V^* \)-valuation of the definite NP and the super-valuation of the vague predicate red is rather plain, since for colour adjectives the influence of the comparison set coordinate on the denotation may be neglected.
(k) Give me the red box

Now, take an utterance of (k) in an elementary situation which e.g. consists of the information that there are exactly two candidates for the referred-object coordinate, and that neither of them is favoured. Provided that the felicity of the utterance only depends on the condition that the standard of precision is satisfied by the description the red box, and further provided that the standard of precision is explicitly available, it is possible to draw a direct line from the behaviour of discourse participants to partial truth-values: usually, the reaction of the addressee of (k) can be taken as an evidence for the felicity of the utterance; (k) is uttered successfully, if and only if the standard is satisfied: the comparative degree of redness of the two individuals under consideration may be computed on the basis of the standard; finally, there is a direct correspondence between partial membership relations contained in the second-level valuations of adjectives and partial truth. Of course, these considerations are rather hypothetical in different respects. Independently of the question to which degree standards of precision for standard situations can be made available, however, they show that in the system described in this paper straight-forward connections can be established between ordinary communication and partial truth-values, in an intuitively acceptable way.

There are a lot of problems concerning vagueness and definite descriptions which are not taken into account in this paper. Two of these problems are so closely connected with the topics discussed that they at least should be mentioned. First, context coordinates relevant for an adjective may be specified not only by direct modifiers, but also by independent constituents of the sentence.

(l) This dog is small
(l') This is a small dog
(m) Ascot is small

An interpretation which generally treats (l) and (l') as paraphrases does not provide for a satisfactory solution of the problem. As well as this dog in (l), Ascot in (m) modifies the value of small, provided Ascot is known to be a dog. Both (l) and (m), however, may have different readings, due to different underlying comparison predicates (e.g. animal or beagle). In the version of the system presented in this paper, context-specifying expressions prevent first-level valuations for the whole sentence, anyway – at the price of undesirable interferences between different definite NPs occurring in the same sentence. Thus, (l) and, possibly, (m) are assigned the (l') reading anyway – the latter in case proper nouns are treated as modifiers. The system may be adjusted to the second (non-specifying) reading, in which case however the first one is lost. The ambivalence of weak specification cannot be modelled.

Secondly, the estimate of the referred individual is not only based upon the situation of utterance and modifiers of different type, but additionally influenced by the attempt of the addressee to evaluate the utterance in such a way that it comes out to be true. In case (g) is uttered in a situation which specifies a set of exactly two possible referents a and b, which both are dogs and of equal stature and the salience of which is identical, a will be preferred if a barks and b does not, and vice versa – to render (g) true. Unlike the first problem mentioned, interactions between sentence denotations and estimates of context features cannot be treated in the system without far-reaching modifications.

Notes

1 The topics referred to in (i) and (ii) are discussed in greater detail in [15] and [14], resp. A full-length description of the formal framework is given in [13]. The analysis of vagueness presented in this paper is strongly related to KAMP's view, as described in [6]. The intuitions underlying the analysis of def-erence descriptions correspond to ideas – at the price of undesirable interferences between different definite NPs occurring in the same sentence. Thus, (l) and, possibly, (m) are assigned the (l') reading anyway – the latter in case proper nouns are treated as modifiers. The system may be adjusted to the second (non-specifying) reading, in which case however the first one is lost. The ambivalence of weak specification cannot be modelled.


3 BARTSCH and VENNEMANN who give a detailed account of the comparison set approach in [1] mention this problem (p.63) as well as WHEELER does in [17], but in both cases the problem is abandoned from linguistics and attached to psychology and other disciplines. Indeed, which correlation holds between set and value may be a matter of psychology; the fact however that only a correlation holds has to be taken into account for a semantic theory of adjectives.

4 For a detailed discussion of formal variants of supervaluation semantics, cf. [4]

5 To a great deal, the following arguments are due to extensive discussions of the the intuitive implications of the system presented, at the "Arbeitsgemeinschaft Sprache und Logik", Bielefeld.

6 Since (a) and (b), in their direct reading, violate general conversational postulates (cf.[5]) in being trivial and false, resp., they are to be interpreted differently in ordinary discourse; e.g. (b) could be understood as a meta-language hypothesis that red is a sharp predicate (with respect to hair colour), or as a request to attach one colour predicate definitely, based on that hypothesis.

7 The generic use of the definite article is not taken into account here, as well as descriptions containing collective, abstract and mass terms, to keep the analysis free from additional problems.
Correspondingly, there exist characteristic restrictions on common noun modifiers: the former pig sounds as strange as the king over there. Both phrases, however, are acceptable in special contexts, which seems to indicate that the semantic of the CN phrase suggests one interpretation of the NP rather than determines it.

A full-length account of the semantic system can be found in [13]. The syntax is exactly that of [2]. Basic categories are O (sentence) and I (proper noun); derived categories are combined by less complex ones in the usual way (<<0, 1>> for one-place predicate, <<0,1>,<0,1>> for predicate modifier etc.). Complex expressions are built up from simpler expressions of proper category by concatenation (<<John, runs>> ∈ E I from John ∈ F I and runs ∈ E <<0,1>> ) and λ-abstraction (λx1<<x1, runs>> ∈ E <<0,1>> with <x1, runs>> ∈ E O).

It might be convenient to exclude combinations of incompatible context features by defining L as a subset of the f-funcions which are formally possible:

\[
L \subseteq \prod_{i \in I} F_i
\]

The problem, however, can be solved in the second step, too, by means of a suitable definition of the probability measure.

Roughly speaking, a probability measure on an occurrence set M assigns to each subset of M a value from the closed interval [0,1], with P(M)=1, P(∅)=0, and, for N1 N2 ⊆ M, if N1 N2 = M, then P(N1 ∪ N2) = P(N1) + P(N2). The definition only holds good for enumerable M; for non-enumerable sets of contexts P would have to be defined in a far more complicated way; cf. [13] p.54ff.

For non-enumerable L, the set of situations would have to be restricted to something like standard situations, two of which e.g. would have to differ at least at one coordinate relevant for the interpretation of a basic expression.

Be o∈Qo, d∈Ω, R ⊆ L, P(R) ≠ 0, I = {i1, ..., iN} the set of coordinates relevant for at least one constituent of s, and

\[
K = \{i | \exists \in E_d \text{ or } \in L_i \}
\]

Then the following holds:

\[
V^*(a)(R)(d) = \sum_{i \in K} \prod_{j=1}^{N} (R \cap \bigcap_{k=1}^{j-1} R^d_{i_k})(i_j)
\]

A proof is given in [13], p.51. The theorem requires the set of contexts to be enumerable, cf. n.11,12. By the way, the theorem reflects the fact that V* is not compositional in a straight-forward manner.

In the framework, e.g. adverbs of space, local prepositions and their modifiers (immediately, straight etc.) can be given an interpretation analogously to the interpretation of adjectives and adjective modifiers. Cf. [13], pp.94ff., 114ff.

In the framework presented, an algorithm can be derived which does the job, under the above-mentioned assumptions. Since the whole argument is quite tentative, this algorithm will not be presented in this paper. It should, however, be clear that it does not consist in the plain identification of the maximal amount of partial membership with the standard of precision. The latter seems approximately to be the case with conditioned orders like:

If there is a red box on the table, give it please to me

If there is only one table among the things under consideration, and only one box on the table (which is definitely a box), the order will be carried out in case the box is red at least to the degree which is required by the standard of precision.
Concealed Questions

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The use of noun phrases as so-called concealed questions may be a rather marginal phenomenon in natural languages, but it touches quite fundamentally on considerations about the notion of noun phrase scope and its proper role in a formal semantic description of natural language. My main point in this paper is that a theory that handles ordinary noun phrases fails to carry over to concealed questions in a simple straightforward manner. To illustrate this, I will list some inadequacies of an unsophisticated extension of MONTAGUE'S PTQ fragment [8]. I will then offer a choice of two different remedies, neither of which seems to be the ultimate solution, however. Throughout my argumentation, I will completely ignore the fact that there are paraphrase relations between concealed and overt questions which may suggest interpreting the former via the latter. This doesn't mean that I have any evidence which would rule out that sort of approach, but I do have some practical justification for my neglect. Unless otherwise indicated, I presuppose everything in PTQ, but that is just a matter of convenient presentation.

1. What are Concealed Questions?

Roughly speaking, a noun phrase is used as a concealed question if it has the meaning of an embedded wh-question. Take e.g. the underlined NP in (1):

John knows Bill's telephone number.

(1)

As we naturally understand the sentence we could paraphrase it as "John knows what Bill's telephone number is," where the overt embedded question "what Bill's telephone number is" replaces the NP "Bill's telephone number". Here are some more examples:

John's favorite drink is obvious.
They revealed the winner of the contest.
Everything that John did surprised Mary.
The temperature of the lake depends on the season.

(2)
(3)
(4)
(5)

Paraphrases we could use instead of these are e.g. "It is obvious what John's favorite drink is", "What the temperature of the lake depends on which season it is," etc. As far as German is concerned, mostly the literal translations of those verbs behave just the same, except for "know", which splits into two German verbs "wissen" and "kennen". Some German dialects syntactically restrict "wissen" to sentential and infinitival complements, but where an NP object is permitted with "wissen", it clearly gets a concealed question reading: