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A Cognitive Science Approach to the Semantics of Spatial Gradation

Abstract

This paper presents a new approach to the semantics of spatial degree and comparison (gradation) expressions (e.g., *2m less long than*). Taking a broad cognitive science perspective, results of different research fields are combined into a cognitive framework for the 'semantics of gradation' (Bierwisch 1989). A distinction between implicitly and explicitly represented aspects of space will be made, and selective spatial attention will be proposed as a cognitive construct that is essential for the explanation of gradation phenomena.

Introduction

Much work in cognitive science has been devoted to the investigation of the conceptual and linguistic aspects of *spatial gradation* which underlie the description of the dimensional extents (length, height etc.) of and the distance between spatial objects expressed by adjectives in their positive and comparative forms (Clark et al. 1973, Banks et al. 1975, v. Stechow 1985, Bierwisch 1989, Klein 1990, Staab/Hahn 1997).[1] For an illustration of some of the phenomena involved, consider the sentences in (1).

(1) a. The pole is (very) long.
  b. The match is a (very) short thing.
  c. The pole is 20 m long and the match is 5 cm long/*short.
  d. The pole is 19.95 m longer than the match.
  e. The match is 19.95 m shorter than the pole.
  f. The pole is ((very) much) longer than the match.
  g. The pole is (much) more than 10 m longer than the match.

[1] The term 'gradation' itself is meant to cover a broader range of phenomena which can be called „quantitative evaluations regarding dimensions or features" (Bierwisch 1989:71). In the following, I will subsume both dimensional and distance extents under the term „dimensional".

All of these can be true with respect to a single state of affairs (a situation with a pole having a length of 20 m and a match having a length of 5 cm). Yet each sentence adresses a different aspect of the situation: An implicit reference to the length norm of poles (1a) or all objects (1b), an absolute characterization of the length of pole and match (1c) and various characterizations of the length difference of both objects (1d-1g). Note that although a match is not a 'long thing', the unmarked adjective (*long*) has to be used with measure phrases while the use of its marked antonym is unacceptable.

Differing from other approaches which only address selected aspects of gradation and comparison[2], Bierwisch (1989),[3] in his 'Semantics of gradation' (henceforth SoG), takes all the subleties of expressions like those in (1) into account. They are analyzed in a semantic framework that is founded on assumptions about the cognitive phenomenon underlying the generation and understanding of these linguistic constructions. Essentially, gradation is regarded as being based on a comparison of *scale intervals* which is reflected as an interval relation in the semantics of dimensional adjectives. This relation figures both in positive and comparative adjectival forms and relates the amount of a dimensional extent to another scale interval.

It is one of the central assumptions in SoG that the second interval is itself complex and composed of two intervals. By postulating two composition operations for these subintervals ('+' and '–'), the *polarity* of the adjectives can be represented. The '+'-operation then reflects the unmarked (+Pol-) adjectival case (*long*, *wide* etc.) while the '–'-operation involves an additional operation (scale inversion) leading to a more complex, marked adjectival form (*short*, *narrow* etc.). This corresponds to the *markedness effect* (processing marked adjectives takes more time than processing unmarked adjectives) observed in psycholinguistic experiments (e.g., Schriefers 1985).

There is a problem with this approach, however (see also Carstensen 1992). According to the theory, 'long' poles are semantically characterized by adding an existentially bound value c to the length-norm of poles N_L, resulting in $[N_L + c]$. 'Short' poles are represented as having a maximal extent that is less than the corresponding norm, namely $[N_L - c]$. Obviously, this semantic treatment should be expected to apply also to other dimensional extents (width, height, depth, distance etc.). Yet, examples in (2) reveal that –Pol-adjectives are not always applicable (despite 'shortness'

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2 For example, in most of the articles in volume 3 of *Journal of Semantics* dedicated to the semantics of comparison, only the unmarked adjectival forms (e.g., *long*, *longer*) are treated.

3 In fact, this work is a partial result of a bigger project investigating grammatical and conceptual aspects of dimensional adjectives (see Bierwisch/Lang 1989).

of the extents). This is admitted by Bierwisch/Lang who remark that „[t]he SFs [semantic forms] and CSs [conceptual structures] proposed so far are not designed to solve [this] problem“ (Bierwisch/Lang 1989:506).

(2) a. jump high/*low
b. travel far/*near

In this paper, I will show that the problem can be best discussed within the broader framework of cognitive science. I will argue that its source lies in the direct reference to scale intervals and their relations which —using the well-known implicit-explicit-dichotomy of Olson/Byalistok (1983)— will be regarded as representing only *implicit* aspects of one-dimensional representations. I will demonstrate, that there is a level of *explicit* representations consisting of so-called *microperspectives* of unidimensional extents. Different microperspectives are assumed to underlie the directional asymmetries showing up, for example, in distance expressions (3).

(3) a. far *(away) from* / close *to* / near *by*
b. *near/close (away) from / *far to / *far by

According to Logan (1995), shifts of focused spatial attention between objects are necessary for the construction of conceptual (explicit) spatial relations. I will generalize these results, transferring them to the domain of gradation. As a result, microperspectives will be regarded as representing shifts of spatial attention that occur both in spatial representations and in those one-dimensional representations underlying actual processes of gradation. The attention-based theory of gradation combines different views on and aspects of gradation and, by transcending and complementing the level of implicit representations, lays the foundation for the solution of the above problem.

The semantics of gradation

The semantics of dimensional adjectives

How do the linguistic phrases in (1) relate to the phenomena of gradation? Within a cognitively oriented paradigm, this question clearly has to be answered by specifying the relation between linguistic and extralinguistic (conceptual) structures. In the approach of Bierwisch (1983, 1989), this is reflected in the assumption of abstract semantic representations of lexical

items which constitute a separate interface between the conceptual system CS and various modules of the grammatical system G.[4]
An example of a semantic representation is given in (4) which shows the simplified lexical semantic entries for the dimensional adjectives *long* and *short* as proposed in SoG:

(4) long: (λc [Degr]) λx [QUANT(MAX (x)) = [v + c]]
short: (λc [Degr]) λx [QUANT(MAX (x)) = [v – c]]

This characterizes the adjective syntactically as a two-place predicate with an optional internal degree argument and an external argument that corresponds to the noun to be qualified. Semantically, dimensional adjectives (DAs) are three-place relations, because a free variable, v, appears in the SF besides the lambda operator bound variables x and c. The SF itself reflects the comparison ('=') of scalar values that allegedly underlies gradation. 'QUANT' maps a certain dimensional extent on a pertinent scale (in (4), the *maximal* extent of an object x by the function 'MAX(x)'), and '[v+c]' denotes the scalar summation of a comparison value v and a difference value c. (5) gives an abstract characterization of the SF of DAs.

(5) [QUANT(DIM (x)) = [v ± c]]

Note that in this approach, the SF is *decomposed* into different components that have to be interpreted with respect to CS. Thus it becomes possible to explicate and directly address the different modules of conceptual representation that are involved in the semantics of an item (as opposed to an undifferentiated semantic predicate 'LONG(x)'). Such explicitness in the semantic forms of DAs is advantageous in at least three respects.
First, it elucidates the conceptually motivated structure of lexical fields: while the whole class of DAs can be easily semantically described by the general schema (5), subdivisions of this class can be characterized as resulting from local variation in the schema. For example, while the abstract parameter DIM is involved in the semantics of a larger set of words expressing dimensional aspects of objects (*long*, *wider*, *height* etc.), the specific functor MAX restricts this set to the words designating the maximal dimension of objects.[5] Another example is the distinction of

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[4] It is a matter of ongoing debate between Bierwisch (e.g., 1996) and Jackendoff (e.g., 1996) whether the assumption of a distinct level is justified. As this discussion is not relevant to this paper, I will not take up a position on the debate here.

[5] Note that these are aspects of *semantic*, i.e. linguistically relevant, variation. As Lang (1989) has shown, this has to be distinguished from *conceptual* variation which means differences in which object extent can be designated as being a certain dimension of the object. Think of a cube that can have different heights, depths and widths, according to

comparative and positive forms of DAs. *Longer* can be simply distinguished from *long* by the fact that its comparison value v gets instantiated by a syntactic complement in the argument structure, which is shown in (6) (an example taken from Bierwisch 1989:155).

(6) longer: $\lambda W\ (\lambda c)\ \lambda x\ [\mathrm{QUANT}(\mathrm{MAX}\ (x)) = [[\alpha c_i\ [W\ c_i]] + c]]$[6]

Second, it helps to anchor lexical relations in structural oppositions contained in the semantic representations. In the case of DAs, the antonymy of, e.g., *long* and *short* is reflected in the difference of the scale operators '+' and '–', corresponding to the *polarity* aspects of gradation. Note that +Pol-adjectives can take a measure phrase as a complement (*10 cm long*) while –Pol-adjectives cannot (**10 cm short*).

Third, decompositional representations make it possible to formulate and discuss explanatory theories of lexical properties, the *markedness* of DAs being a case in point. By having different options for instantiating '±' in (5), one of them can be regarded as default, or unmarked, and the other as non-default or marked. In SoG, this difference is further explained by considering the complexity of the operators '+' and '–' when interpreted in CS. An interpretation ('Int') is proposed which maps '+' on the concatenation of two simple scale values (intervals) and '–' on a concatenation whose second argument is an inverted scale interval (7).

(7) $\mathrm{Int}(\ [x + y]) = \quad di \bullet dj$
$\mathrm{Int}(\ [x - y]) = \quad di \bullet I(dj)$

This leads us to the central part of SoG, the assumption that gradation is constituted by interval comparison on a one-dimensional scale. Such a comparison requires that the projected dimensional extents (say, of objects v1 and v2) *overlap* and have a *common starting point* on the scale. Intervals satisfying these conditions can then be regarded as *degrees* (d_1 and d_2) on that scale. The relevance of this interrelation is explicitly stated: „there is no degree without comparison and no comparison without degrees“ and even „[m]y proposal is to regard degrees as actually being constituted by the comparison operation“ (Bierwisch 1989:112).

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its actual position with respect to the surrounding space (cf. also Lang/Carstensen/Simmons 1991).

6 Note in passing that according to SoG, another variable c_i bound by an operator must be introduced in the SF of a comparative.

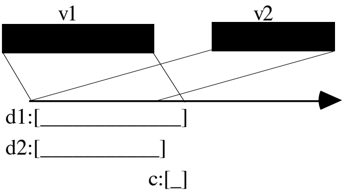

fig. 1

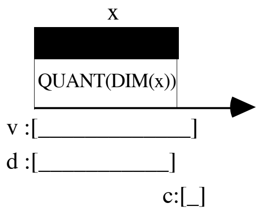

fig. 2

Fig. 1 depicts this general situation of comparison, and fig. 2 depicts the more specific case of the comparison of a dimensional degree d with another (the comparison) degree v. This decompositional treatment of antonymy and markedness in the lexical semantic analysis of DAs contrasts with approaches which assume that there are already dichotomous predicates (e.g., LONG and SHORT) on the conceptual level which simply are labelled by the linguistic terms (Banks et al. 1975). Before I go on presenting and discussing more details of SoG, it will be interesting to see whether there is psychological evidence for the cognitive adequacy of the proposed semantic representations.

Congruity and Markedness

By carrying out various psycholinguistic experiments, Schriefers (1985) investigated how people process comparisons of dimensional extents and whether the observed phenomena can be explained on the conceptual level alone. In one experiment, he presented the subjects with pairs of sticks like those in fig. 3.

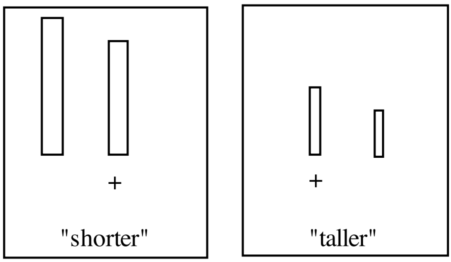

fig. 3

In each trial, the '+' appeared first on the screen, shortly followed by the pair of sticks. The subjects had to react verbally by saying „taller" or „shorter" depending on the size of the object marked by '+'. As fig. 3 shows, the objects were of different *relative* and *absolute* size (where absolute size implies a relation to the length norm of the objects). What

Schriefers found was a strong *congruency* of the absolute size of the objects and the polarity of the adjective: Subjects were quicker in saying „taller“ when there was a pair of tall sticks, and they were quicker in saying „shorter“ when both sticks were short. Most importantly, he obtained this *congruency effect* also with non-verbal responses, that is, when subjects were asked to press push buttons (one for indicating the taller object, another one for indicating the shorter one). Schriefers assumed that the effect is due to the interference of the concepts TALL or SHORT (activated by the respective absolute size of the objects) with the preparation of the verbal or non-verbal response in question. Hence, the congruency effect must be regarded as a conceptual-level phenomenon.
This contrasts with the result of another experiment in which the objects belonged to only one absolute size category (fig. 4).

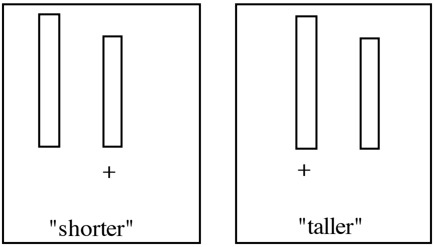

fig.4

Here, when subjects had to react verbally, the response „taller“ (the *unmarked* adjective) came reliably more quickly than the response „shorter“ (the *marked* adjective). However, Schriefers could show that this effect (*markedness effect*) necessarily involves language: When required to give non-verbal (push button) responses, the effect disappeared. Thus he concluded:

> "A translation of Bierwisch´s conception in a more process-oriented psychological theory could be achieved in the framework of procedural semantics where the meaning of dimensional adjectives would be conceived of as a sequence of test procedures on, among others, the values of c and v and the polarity of their concatenation." (Schriefers 1985:133)

Aspects of SoG

There are five aspects of SoG which are relevant for the discussion in this paper and which are therefore presented shortly in the following.
Standardization of different interpretations. The examples in (8) and (9) show that DAs can be interpreted differently. In SoG, *nominative* and

contrastive uses are distinguished. If DAs are used nominatively as in (8), they only identify a certain value on a scale (i.e., the pole does not need to be LONG). In their contrastive use, the interpretation depends on a contextually determined comparison class and implies a relation to a certain norm value (in (9a), the pole is in any case LONG and in (9b), it is presupposed to be SHORT). The occurrence of measure phrases as degree complements determines interpretation: (8a) cannot be interpreted contrastively, and (9a) cannot be interpreted nominatively.

(8) a. The pole is 19m long.
    b. How long is the pole?
    c. The pole is longer/shorter than the match.
(9) a. The pole is long.
    b. How short is the pole?

With the schema in (5), these uses of DAs are standardized by the schema '[v ± c]' because the reference value v is semantically not yet fixed with respect to being instantiated by a norm value (contrastive use) or by an absolute value (nominative use). SoG contains context sensitive instantiation conditions to guarantee correct interpretations. Ignoring the details, they can be roughly described as follows: A numerical value instantiates c if and only if v is instantiated as '0' (standing for an empty interval), and a norm value N_c instantiates v if and only if c is not a numerical degree. This account leads to (10) and (11) as representations of (8a) and (9a), respectively.

(10) [QUANT(MAX (POLE)) = [0 + [19m]]]
(11) ∃c[QUANT(MAX (POLE)) = [Nc + c]]

Polarity of DAs is represented by interval operations. See above.
The relation of comparison reflects interval containment/inclusion. According to SoG, the comparison relation underlying gradation ('=') has different interpretations on the conceptual level which are asymmetrical. Bierwisch gives examples like (12) for his supposition that gradation constructions do not set an absolute value on a scale but only state lower or upper bounds according to the polarity of the adjectives (see also Horn 1989). In these examples, antonymous DAs show a different „directionality“ of entailment (upward or downward monotonous). Formally, DAs therefore involve an inclusion relation between intervals that is oriented differently according to polarity (13).

(12) a. The pole is 19m long (perhaps even 20m /?18m).
b. The pole is as long as the stick (but probably longer / ?shorter).
c. The match is as short as the stick (or even shorter / ?longer).

(13) +Pol-DA: $(\lambda c\ [Degr])\ \lambda x\ \ [QUANT(DIM\ (x)) \supset [v + c]]$
–Pol-DA: $(\lambda c\ [Degr])\ \lambda x\ \ [QUANT(DIM\ (x)) \subset [v - c]]$

Unified treatment of degree complements. There are different types of degree complements for DAs: measure phrases (*10 m*), degree constituents (*much/less, very*), factor phrases (*three times*).[7] They receive a unified treatment according to (13) in that they figure as syntactic arguments of the adjective. A slight differentiation is necessary, however: In order to capture the distinctions in the complements of positive and comparative forms (e.g., *how long* vs. *how much longer*, and *so/as long* vs. *so/as much longer*), two different DP categories must be assumed in SoG: Complements of positive DAs must be analyzed as DPs (degree phrases) while those of comparative DAs must be analyzed as DP′s (with *much* being a DEGREE′, the head of DP′).
Term status of degree complements. From the unified treatment of degree complements as syntactic arguments instantiating the difference value c, it follows that they have *term* status. Because of that, *much* has to be semantically represented as in (13'), that is, with its variable x bound by an existential term operator ε.[8]

(13') *much*: $(\lambda c\ [Degr])\ \varepsilon x\ \ [QUANT(x) \supset [v + c]]$

Optionality of degree complements. According to SoG’s assumptions sketched so far, degree phrases are not necessarily required by DAs but may or may not appear as complements. This does not only require a formal marker for optionality (the round brackets in (13)) if a complement does not need to appear, but also requires additional principles to guarantee that a DA without a DP is marked as ill-formed if a degree complement must appear.

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7 Bierwisch also treats *too* and *enough*, which will not be considered here, in a similar way.

8 In the semantic representations of certain expressions, this may lead to unintuitively complex nested constructions, and sometimes even to operator confusion (compare Bierwisch/Lang 1987:193, example (290) with Bierwisch/Lang 1989:175, example (300)).

Linking semantics and spatial attention

Counterevidence

The foregoing sections should have made clear that SoG represents a tremendously complex and detailed approach to specifying the semantics of gradation expressions. It has already been mentioned, however, that it cannot give an adequate account of why –Pol-DAs cannot always be used to indicate small extents (see 14).

(14) How far does the highway follow the railway line?
*Close/*Near/Only a few kilometres/Not very far!

In another psycholinguistic experiment, Banks et al. (1975) obtained results that directly run counter to the assumptions of Bierwisch and Schriefers. They presented their subjects with displays A or B shown in fig. 5. Slightly different from the experiment testing for the markedness effect, subjects were asked which one of the two objects in the displays shown in fig. 5 (called „balloon“ in A, and „jo-jo“ in B) was the higher or lower one, and they had to give a push button response.

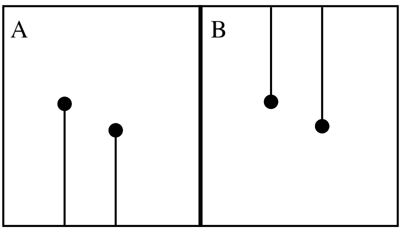


fig. 5

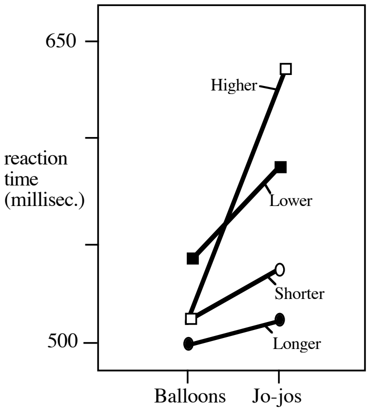


fig. 6

Observe that only relative distance is relevant here (no norm aspects involved), which should lead to a clear markedness effect (consistently quicker response for +Pol-adjective). However, as can be seen from fig. 6 (after Banks et al. 1975:40), this was not the case: Subjects took longer to

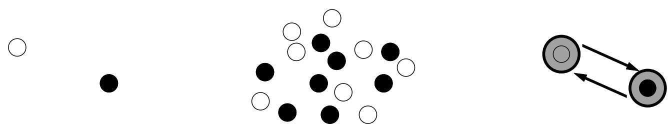
respond to the „higher"-question than to the „lower"-question in B.[9] This shows clearly that there is more involved in „processing for speaking" than operations on objectively given intervals, and that the semantics of gradation cannot be reduced to modelling these objective aspects.
Banks et al. remark on their results that "[...] it may be that subjects have *visual scanning strategies or expectations* that favor the balloons" (Banks et al. 1975:43, my emphasis). What could be the role of scanning in spatial semantics?

The case for explicit relations

Based on evidence from language learning and development, Olson/Bialystok (1983) argued for the importance of distinguishing implicit and explicit (spatial) relations. For example, while it is easy even for very young children to correctly categorize certain things as 'lollipop' —which includes identifying the *implicit* relation between a 'round thing' and a 'sticky thing'— they may not yet have this relation *explicitly* available for thinking and speaking. This proposal, though still phrased in a strictly propositional framework, is supported by recent work in cognitive science. In the spirit of this distinction, Kosslyn criticizes the meanwhile famous „what"/"where" dichotomy (Ungerleider/Mishkin 1982, Landau/Jackendoff 1993) for being too simple with regard to the representation of spatial relations:

> „Although the [what] system cannot represent explicit spatial relations, it must be able to represent implicit spatial relations; such relations are inherent in any pattern" (Kosslyn 1994:421).

What are explicit relations and how do they get established? Olson/Bialystok assign *attention* a special role in this respect, which is confirmed by current research in the field of visual spatial attention, albeit for different reasons. Consider the two objects in fig. 7a.



a. b. c.
fig. 7

9 Note also that when asked „Which string is longer/shorter?", reaction times were shorter altogether and did not exhibit a qualitative change („cross over").

Obviously, there is an implicit spatial relation between them. These objects and their relation are also present in fig. 7b. However, as is demonstrated clearly, mere presence of the implicit relation does not lead to its availability to the observer. As regards cognitive processing (somehow the same observer situation transferred inside), it has been shown (cf. Theeuwes 1993) that there is a serial stage at which objects in the visuo-spatial medium (the „visual buffer“ of Kosslyn) are attentively selected one after another for further processing in the what-system. Exactly what gets attended at a certain point of time is jointly determined by the properties of the given and preprocessed entities of the „display“ (-> bottom up aspect) and stored patterns of attentional behaviour (attentional templates, -> top-down aspect). As to the bottom-up aspect, it is controlled by two main principles: Differences in the display attract the attentional window and thus determine salient entities (bounded regions or *boundaries* of regions) to be further processed, and inhibition of visited places/objects prevents immediate return to those entities.

Shifts of attention are therefore necessary for establishing explicit spatial relations („Computing relations requires directing attention“, Logan 1995:163). As fig. 7c shows, these shifts have the effect of imposing a certain perspective (which I will call „microperspective“[10]) on the implicit relation[11]. These microperspectives themselves —the displacements of the attentional „window“— are coded in the where system[12] and thus constitute the core of explicit spatial relations.

Microperspectivization and spatial gradation

I have argued elsewhere (Carstensen 1998) that aspects of microperspectivization are essential for the characterization of linguistic spatial relations (e.g., spatial prepositions). In the context of this paper, it needs to be shown that microperspectivization is relevant for spatial gradation, too.

Consider again the process of gradation as proposed in SoG. Somehow, it must be true that the amounts of scanning distances or dimensional extents must be mentally „superimposed“ on a scale —roughly as depicted in fig. 1— to enable comparison. Taking SoG seriously and regarding this as a

10 I use the prefix „micro“ in order to keep this notion distinct from aspects of (representations of) observing a spatial scene which is usually associated with spatial uses of „perspective“ (cf., e.g., Tversky 1996).

11 Microperspectivization corresponds in part to the processes of perspectivizing space in microplanning utterances (cf. Levelt 1989).

12 The necessity for coding microperspectives derives from the simple observation that this displacement information is required for programming different actions (eye movements, grasping). Other evidence results from experiments in which intentional, top-down controlled displacement (so-called endogenous attention shifts in Posner 1980) could be proved to exist.

(neuro)psychologically real phenomenon, one can take such a scale as a kind of one-dimensional working memory into which the amounts are projected. However, by analogy to the previous discussion of implicit and explicit relations (between objects in the visual buffer), the relations between the intervals in this medium are only implicit and not available for further processing. This is where attention theory comes in again: The *boundaries* of the intervals on the scale (not coincident with the origin of the scale) constitute salient entities which attract attention in the same way as entities in the visual buffer do.

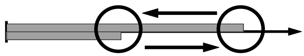


fig. 8

I will call these interval boundaries the degrees of a scale and will, in the following, regard gradation as establishing explicit relations between degrees by attentional microperspectivization.

Microperspectivization-based semantics of gradation

Formal modelling of microperspectives

From the assumption –shared by many cognitive semanticists–[13] that conceptual representations mediate language and perception, it follows that specific microperspectives are conceptually categorized and must therefore be modelled qualitatively.
Explicit spatial relations will be formally represented as pairs <MP, ENV>, where MP is a description of a microperspective (a shift of attention between objects), and ENV is a qualitative description of the spatial environment associated with MP. Microperspectives are characterized as 'SHIFT(SOURCE, GOAL)^{RefPol}'. The feature RefPol (for „reference polarity", with values ∈ {'+', '–'}) reflects the fact that from a functional perspective, SOURCE and GOAL have different conceptual roles: if one of them is the thematic object, then the other one must be the reference object. This defines +RefPol-relations (SOURCE is reference object) or –RefPol-relations (GOAL is reference object). ENV represents the most specific spatial environment with which MP is associated – usually an axis of a reference frame. This information is modelled by functional descriptions of the type 'AXIS(RF)^{DIR}', where AXIS is one of the represented environ-

13 E.g., Miller/Johnson-Laird (1976), Jackendoff (1983).

mental axes (e.g. the Vertical VERT)[14], DIR is the direction (‘+’/’–’) of the axis, and RF is the active mental reference frame (INTRINSIC, ABSOLUTE, RELATIVE)[15]. As an example, (15) shows the formal representation of the spatial relation corresponding to the linguistic relation *above*: a description of a +RefPol-microperspective running along the Vertical of some reference frame, in positive direction.

(15) $<SHIFT(y, x)^{+}, VERT(RF)^{+}>$

As to explicit degree relations, they differ from (15) in that x and y do not refer to spatial objects but to degrees, and that env is a description of the relevant scale. For example, (16) roughly represents the degree relation corresponding to *more*.

(16) $<SHIFT(y, x)^{+}, SCALE(x)^{+}>$

In contrast to SoG, degrees are not identified with intervals. Although they are based on a mapping of microperspectives to intervals on a scale, they are identified with the boundaries of intervals not coincident with the origin of the scale. This is illustrated by the definition in (17).

(17) $degree(d) =_{def} \exists mp\ [d = DEGR(QUANT(mp))]$

In the semantics of dimensional adjectives, the parameter DIM for dimensional designation of an object x will therefore be replaced by a corresponding parameter MP for the designation of a microperspective wrt. x. Furthermore, a subscript is added to MP indicating reference polarity of the relation and dimensional designation (see (18)).

(18) $microperspective(mp) =_{def} \exists x\ [mp = MP_{<SHIFT\{+/-\},DIM\{+/-\}>}(x)]$

Semantics of dimensional adjectives

Having introduced the theoretical background of spatial gradation and the formal prerequisites necessary for the further argumentation, it is now possible to highlight the differences between the microperspectivization approach and SoG in more detail. To do this, I will use the aspects of SoG listed above as points of comparison.

Non-standardization of different interpretations. Although representational economy is surely an advantage of theoretical explanations in general (and

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14 Cf. Lang/Carstensen/Simmons (1991).

15 Cf. Levinson (1996) for a discussion and description of these reference frames.

of SoG in particular), there are reasons for *not* assuming a common lexical semantic basis for the nominative and contrastive interpretations of a DA. Compare (19) and (20). Why is there a deficit in (19) and none in (20)? Notice that apart from the third argument of *longer*, the positive and comparative forms are structurally identical. Both can take a degree complement (which would make (19) acceptable), but only in (20) it can be left out.

(19) *The pole is long. (nominative)
(20) The pole is longer than the stick.

In SoG, (19) is simply ruled out by a condition stating that there cannot be an existentially bound degree variable c in nominative use (that is, with v realized as ‘0’). In the current approach, nominative uses of the positive adjectival form on the one side, and contrastive and comparative forms on the other side, are viewed as fundamentally (and therefore structurally) different: It is assumed that the latter contain an explicit degree relation while the former does not. This is accompanied by the further assumption that the complement of nominative positives is not a degree but a property asserting a degree relation, and that contrastive positives and comparatives do not have any complement whatsoever. (21) shows the resulting SF of nominative *long*. It contrasts with the SFs of contrastive *long* (22) and comparative *longer* (23). Thus, it is clear from (21-23) that a missing complement leads to a deficit of nominative positives but does not present any problem to the inherently relational lexical items. If one considers a possible complement like *more than 5 m* (24), its combination with *long* yields (25) which comes out correctly as an equivalent to *longer than 5m*.

(21) long (nominative): $\lambda P\ \lambda x\ \ [P(DEGR(QUANT(MP_{<SHIFT+,MAX+>}(x))))]$

(22) long (contrastive):
$$\lambda x\ \lambda mp\ [mp\ inst\ [SHIFT(N_c,\ DEGR(QUANT(MP_{<SHIFT+,MAX+>}(x))))^{+},\ MAX(x)+>]]$$

(23) longer:
$$\lambda y\ \lambda x\ \lambda mp\ \ [mp\ inst\ [<SHIFT(y,\ DEGR(QUANT(MP_{<SHIFT+,MAX+>}(x))))^{+},\ MAX(x)+>]]$$

(24) more than 5m:
$$\lambda x\ \lambda mp\ [mp\ inst\ [<SHIFT(‘5M’,\ x)^{+},\ SCALE(x)^{+}>]]$$

(25) more than 5m long:
$$\lambda x\ \lambda mp\ [\ mp\ inst\ [<SHIFT(‘5M’,\ DEGR(QUANT(MP_{<SHIFT+,MAX+>}(x))))^{+},\ MAX(x)^{+}>]]$$

Polarity of DAs is not represented by interval operations. Instead, polarity is represented by the different directions of microperspectives with respect to a directed dimension/scale. While unmarked adjectives code the unidirectional, default microperspectivizations of a spatial scene, marked adjectives involve a change of direction resulting in more complex structure and processing. If the spatial scene involves clues which induce a different (non-default) microperspectivization (see the „jo-jos“ in fig. 5), however, this may affect the generation/understanding of unmarked adjectives in a way not predicted by an interval-based theory of gradation.[16]

The relation of comparison does not reflect interval containment/inclusion. It has already been shown that this is due to the implicitness of interval relations which are replaced by explicit degree relations based on micro-perspectivization. As opposed to the duality of interval containment and inclusion, there are at least three different types of explicit degree relations resulting from instantiations of the parameters RefPol and scale direction $D^{+/-}$: ‘+RefPol, D^{+}’ (as in *The pole is more than 5m long*), ‘+RefPol, D^{-}’ (as in *The pole is less than 5m long*), and ‘–RefPol, D+’ (as in *The pole is nearly 5m long*). This variation can best be captured within the relational approach adopted here, which leads to the generalized structure (26) for the given examples. The corresponding implicit and explicit relations of a reference degree r and a thematic degree d are depicted in fig. 9.

(26) The pole is [$_{AP}$ [$_{GP}$ DEGREE RELATION 5m] long]

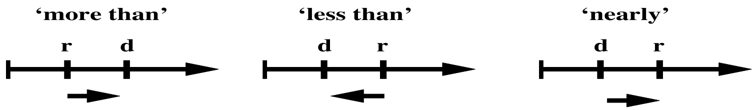

fig. 9

The „directionality“ (upward or downward monotonicity) of DAs may be better explained in terms of the directions of microperspectives. This can be seen from (27), where the implicit relation (interval(d) ⊂ interval (r)) should lead to downward monotonicity but is upward monotonous instead.

(27) The pole is nearly 5m long
(perhaps even [longer/ exactly 5m long/*shorter])

Furthermore, the use of simple measure phrases as DA complements is analyzed differently in the relational approach. It is assumed that there is a syntactically empty DEGREE RELATION ‘~’ meaning „irrelevantly different from“ (corresponding to the tolerance relation of Pinkal 1995).[17] According to this analysis, (28), which is semantically licensed in SoG, is correctly treated as ill-formed.

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16 A closer examination of these phenomena would probably include an explanation in terms of the match/mismatch between conceptual and linguistic codes, and of the necessity of conceptual recoding in case of mismatches (cf. Banks et al. 1975).

17 However, this relation of „irrelevant difference“ is interpreted directly in terms of a missing attention shift, that is, as simultaneous attention of both degrees.

(28) *The pole is 5m long, to be more exact, it is 20m long.

Distinction of complements and modifiers. Recall that different constituents cooccur with nominative positives and with comparatives, respectively, as is exemplified by (29).

(29) a. how long (*how much long)
b. how much longer (*how longer)

To account for this phenomenon, SoG distinguishes two types of degree phrases which are distributed differently in adjectival subcategorization patterns. In contrast to that, I will only regard *how* as a „degree complement" while *how much* will be simply analyzed as an AP modifying the comparative. In other words, while (29a) is a case of complementation, (29b) is a case of modification. According to Bierwisch (1988), modification of a constituent C1 by a constituent C2 is formally realized by unifying the referential θ-role of C1 with the external θ-role of C2 and then dropping the latter. However, what if there is no referential θ-role as is the case in current adjective semantics? My answer to this question –paralleling the treatment of modification in event semantics– is already visible in (22)-(25): I will assume that there *is* a referential variable in adjective semantics which reifies the spatial relation and figures as an argument of the predicate 'inst' (for „instantiates", cf. Bierwisch 1988).[18] Thus, in accord with the foregoing assumption that the complement of a nominatively used DA is relational (a gradation phrase GP), the structural analysis for *much less than 5 m long* as an example for complementation and modification in spatial gradation is given in fig. 10.

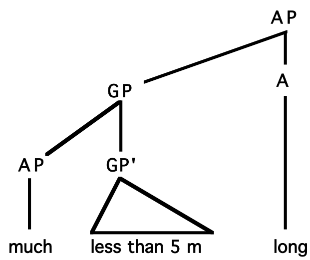

fig. 10

Degree complements are properties. It follows from the previous discussion that complements of nominative DAs do not have term status but that they

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18 See also Hobbs (1985) for a pragmatic justification for such a formal treatment.

are relational properties. Besides that, they may have an internal structure constituted by recursive application of modification and complementation (e.g., *very much more than 50m less than 1km longer than*). In that case, scale values may themselves be projected on scales, leading to so-called „scale stacking“ (Bierwisch 1989:115).

Degree complements are obligatory. Due to the differentiation of complementation and modification, degree complements can be uniquely regarded as obligatory.[19]

Problems reconsidered

Let us turn back to the examples (2) and (3) now. They pose a problem for SoG because by solely referring to implicit (interval) relations, it is not obvious why a small extent should be excluded from being expressed by its corresponding –Pol-DA. In the microperspectivization approach, however, aspects of representing and processing explicit spatial relations can/must be considered for the following reasons.

First, microperspectives are inherently asymmetrical and show a characteristic reference polarity when conceptually represented. As these aspects are grammatically coded in the SF of spatial expressions (both in DAs and prepositions, cf. Carstensen 1998), compatibility of combined expressions can be put down to the representational congruence (e.g., same reference polarity) of SFs. Thus, distance adjective-preposition combinations are restricted by the microperspective given in the SF of the preposition (see 3).

Second, conceptual factors influence microperspectivization. This has been shown in the above mentioned experiments of Banks et al. (1975), where different conceptualizations of identical spatial scenes led to a reversal of the markedness effect (see fig. 6). Thus, actual (or situated) processing of microperspectives is apparently constrained by simultaneous processing of contextually given (aspects of) reference frames. This may be the reason for the contrast of (30a) and (30b).

(30)	a.	high/low building	(canonical orientation)
	b.	high/*low pole	(contextual specification)

Furthermore, in DA-verb combinations, only the unmarked, default DA can be used (see 2). Memory overload and/or processing difficulty may therefore be responsible for the fact that *short* is used as the –Pol-DA in these cases (cp. also *tall/short person*) and that there is no universally applicable

[19] This fits in with the observation that *very longer* is inacceptable. However, it requires a more complex analysis of phrases like *5m longer* in which a syntactically empty modificational construct (‘x-much’) has to be assumed (cp. *how much longer*).

antonym of the DA *deep* (*deep/*shallow drill-hole*). At present, however, these conclusions must remain speculative.

GROBI

The microperspectivization approach to spatial gradation has been implemented and tested for a German fragment covering dimensional and distance adjectives, measure and factor phrases (as in *three times as long as*). I have extended OSKAR, a PROLOG system for testing Lang's theory of dimensional designation (cf. Lang/Carstensen/Simmons 1991), by taking aspects of explicit spatial relations (between objects and degrees) into account — in addition to implicit aspects of dimensional reference and interval relations. The resulting system GROBI[20] accepts natural language expressions as input, parses them (using a simple DCG grammar) and tries to provide a conceptual interpretation according to its built-in semantic theories and its stock of knowledge about the conceptual representation of spatial objects and relations. While developing GROBI, it proved useful to be able to verify its results quickly and easily. Because of that, a graphical output is automatically generated from these results which contains both implicit spatial aspects (scales and intervals) and explicit aspects (microperspectives between degrees / boundaries of intervals). Fig. 11 gives an example of this: The microperspectives are shown as directed arrows, and the scales and intervals (assumed to be superimposed) are separated for better visual comprehension, and annotated with relevant information.

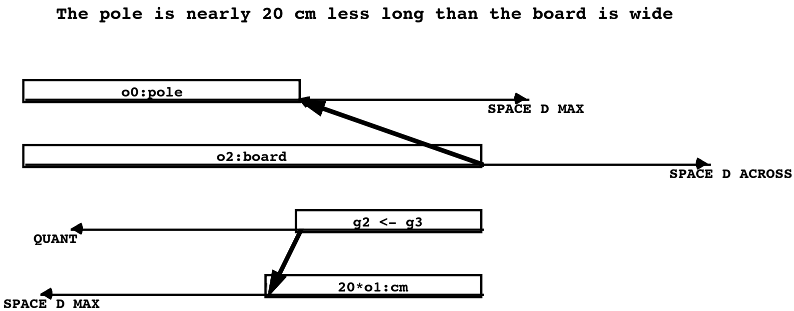

fig. 11

20 „*GR*aduierung *O*hne direkten *B*ezug auf *I*ntervalle" (gradation without direct reference to intervals).

Conclusion

In this paper, it has been shown that it is necessary –both for conceptual representation and for semantic interpretation– to take explicit aspects of spatial (degree) relations into account. Therefore, the level of micro-perspectivization introduced here can be regarded as a neccessary interface between language and (implicitly represented aspects of) perception.

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