DIMENSIONS OF COGNITION

Kenneth Holmqvist
Department of Cognitive Science,
Lund University

Introduction

How do you update your knowledge and your concepts in the face of new information and new insights? It is for his treatment of this complex question in its logical form that Peter Gärdenfors won his international fame.

When I meet scholars expressing admiration of his Knowledge in Flux (Gärdenfors 1988), I often get the question what graduate students have continued with this work at LUCS, the Lund University Cognitive Science group that Peter has developed since 1988. "None" , I answer, and they express regret, wondering why noone has continued this work of his at his own department.

In 1988, I was a graduate student in computer science, interested in logical systems for artificial intelligence, but with a broad interest in linguistics, philosophy and psychology. Since I knew Peter as a teacher, it would have been natural for me to continue with some part of Peter's "Knowledge in Flux" research. But I did not.

At this time, Peter had already started working on the Conceptual Spaces. I guess that his interest in this non-logical form for concept representation originated in the insight that - although logics is beautiful - it is rather the nature and form of the concepts themselves that play the important role in knowledge revision in humans, rather than the manipulation of referring symbols (Gärdenfors 1990, 1993a, 1993b, 1995, 2000).

The large variety of so-called non-monotonic logics in the Artificial Intelligence(s) appeared to me to be hampered by the same problem. Therefore, when I started my cooperation with Peter more than ten years ago, the focus was on topological concept models (Gärdenfors & Holmqvist 1994).

Seminars during the first years at LUCS critically examined the appropriateness of the fundamental properties of logics, such as reference and deduction, to the description and modelling of cognition, and found them inadequate. It would be untrue to say that we during these first years at LUCS found a solid alternative paradigm to the logical one within which we could perform our research. Research at LUCS is and has always been very multidimensional. Rather than having a paradigm, it is loosely kept together by a common belief that the information processing systems of the human body and mind are our objects of study, and that these are largely visual and spatial.

To date, seven doctoral dissertations have been produced at LUCS under Peter's supervision. Two of these explore computational models of cognition using neural networks (Pallbo 1997) and other multi-agent bottom-up models such as genetic algorithms (Balkenius 1995) to simulate parts of (human) intelligence. My own dissertation proposes a computional framework for language understanding using image-based semantics (Holmqvist 1993). Two dissertations discuss planning, the first one distinguishing between two evolutionary different types of planning (Gulz 1991), the other describing the design process in contrast to classical planning (Gedenryd 1998). Language-in-use is the common denominator for two dissertations, one studying how clashing views on forestry is expressed in language (Andersson 1994), the other examining the relation between social action and linguistic meaning (Winter 1998).

The conceptual spaces span across the many research branches developed at LUCS. Conceptual spaces can be used, e.g., both to describe the states of subconceptual representations in neural networks and the semantic properties of symbolic representations such as language terms. So my answer to the question must be: The reason that no graduate students at LUCS continued the work from the Knowledge in Flux is that under Peter's supervision so many other fascinating dimensions of cognition revealed themselves that felt more natural to work with.

In honor of the multidemensional research spirit at LUCS, the rest of this paper will be about dimensions, albeit in the sense of proposed constituents of objects and spaces. I will describe some of the research touched at by LUCS people (using work done in Berlin) about the dimensionality in the semantics of objects, and the exploitation of dimensionality in discourse.

Object schemata

When dimensional adjectives and spatial objects are considered, the most elaborate model was created by Ewald Lang (see Lang 1991).

A spatial object is conceived of by Lang as extending in 3D space. Since 3D space consists of three dimensions, 3D objects will extend in three dimensions. Lang gives a more or less complete description of the extension of objects in 3D space from an analysis of the applicability of dimensional adjectives on them. Here, I will summarize this description of objects.

First, there are three *dimensions*, called `a b c`. The most salient dimension, usually the one with the maximal extension, is placed first. The least salient, i.e. the least extended dimension is placed last. This order of dimensions correspond to the proportions of the object. Object schemata make use of what Lang calls the IPS (inherent proportion schema), which basically reflects our sense of proportion in objects.

Second, Lang deals only with *bounded* objects[1]. To mark this, he places angled brackets around the dimensions: `< a b c >`.

Finally, some dimensions may be *integrated*. In a pole the length axis is indeed a normal dimension of 3D space. The thickness of the pole, however, integrates two spatial dimensions into one single diameter. Lang marks an integrated dimension by putting brackets around the two 3D space dimensions that have been integrated. A pole is thus an `< a (b c) >` object, where the `(b c)` part stands for the diameter. A wall is `< a b c >`, a ball is `< (a b c) >` and a disk is `< (a b) c >`. A dimension which is not integrated is called disintegrated.

```
    [POLE]              [WALL]              [BALL]              [DISK]
< a   (b   c) >      < a   b   c >      < (a   b   c) >      < (a   b)   c >
  max   sub            max vert sub          diam                diam   sub
```

Fig. 1: The object schemata for [POLE], [WALL], [BALL] and [DISK].

Each dimension, integrated or disintegrated, can then be described by one or more *dimension assignment values* (DAVs). The DAV `max` - maximal dimension - tells us of a dimension that it is a disintegrated dimension with the maximal extension of all dimensions in the object. For instance, a pole has a `max` under its `a` dimension, as does a wall. See fig. 1.

A `sub` DAV says that the dimension is either a diameter or a very unsalient third dimension, such as the thickness of a wall, a pole or a disk.

---

[1] Bounded objects roughly correpond to the countables. Jackendoff (1991: 19 - 20) presents the following useful criterion for boundedness: If we split an unbounded substance (such as water) into two parts, each may still be called by the same name as the original substance (water). Half an apple can not be called an apple, hence an apple is bounded.

The DAV `diam` says that the dimension is a diameter of a solid object and that it is the most extended of the dimensions. In both the disk and the ball, the diameter extension value supersedes the value of other dimensions.

If a dimension is described by `vert`, it means that that dimension is vertically directed. One of the dimensions of a wall is vertically directed.

There are more DAVs than `max`, `sub`, `diam` and `vert`. In particular, the DAV `obs` will be of interest to us. In lexicon, object schemata have the encoding of integrated and disintegrated dimensions, as well as the description of dimensions that DAVs provide.

Lang's IPS and PPS

In Lang's model, objects can be attributed properties that are either inherent or that depend on the location of an observer in a perceptual situation. The object schemata presented so far have had only inherent properties. For instance, the spatial proportions of a pole is an inherent property which says of the pole that it has a maximal extension along one dimension and a smaller diameter along the other two dimensions. In his research on dimensional adjectives, Lang concludes that the adjectives "long" and "thin" apply to objects only with reference to the inherent proportions.

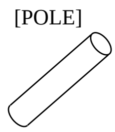


Fig. 2: "pole"

In order to explain why "long" and "thin" concern only inherent proportions of objects, Lang assume a perceptual (visual) categorization grid called IPS (inherent proportion schema). IPS provides three so-called DAPs, *dimension assignment parameters*, `MAX`, `SUB` and `DIST`. We are interested in how these DAPs combine with the DAVs (dimension assignment values) above to model the application of dimensional adjectives on spatial objects.

The dimensional adjectives "high" and "deep", cannot be applied to all extended objects. The presupposed existence in their semantics of an observer places restrictions to their application. For "high" to apply to an object (which we will call [HIGH].TR), that object must not only be vertically extended. It is also required that the observer must view the object from the side, *perpendicular to the vertical axis.* This observer position is possible in combination with a pole, so "high pole" is a semantically correct combination.

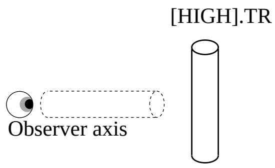


Fig. 3: "high"

It is, however, not possible to view the vertical extension of a well or of an elevator shaft from the side. Thus, "high" cannot apply to these objects: a "high well" is semantically anomalous. Instead, a well and an elevator shaft are always viewed *in parallel to the vertical axis* (we look down into the well or up through the elevator shaft).

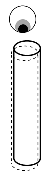


Fig. 4: "well"

The dimensional adjective "deep" applies to objects where the viewer's observer axis runs in parallel to the extended axis. Thus, "a deep well" or "a deep elevator shaft" are semantically proper combinations.

In Lang's terms, the categorization grid responsible for the inclusion of an observer axis is called PPS (primary perceptual space). The PPS provides three more dimension assignment parameters, `VERT`, `OBS` and `ACROSS`, which we will see describe different relations of extended axes to the observer axis.

The application of dimensional adjectives to object schemata

For the application of dimensional adjectives to object schemata, Lang uses an intermediary description, the dimensional assignment parameters DAPs. The DAPs are connected to the (German) adjectives as in the following table (Lang 1991:71):

Adjective(s)	*DAP*	*DAV(s)*
lang/kurz	MAX	max, imax
breit/schmal	ACROSS	across
dick/dünn	SUB	sub/d_sub
weit/eng	DIST	dist/d_dist
flach	FLACH	flach
hoch/niedrig	VERT	vert/ivert
tief	OBS	obs/iobs
gross/klein	SIZE	ø
-	-	diam
-	-	empty

When the adjective "long" (≈ German "lang") is to apply to the noun "pole" , the DAP `MAX` is evoked together with the object schema for [POLE] (this was depicted in fig. 4).

```
         < a   (b   c) >             < a   (b   c) >            < a   (b   c) >
[POLE]   max    sub        [POLE]    max    sub       [WELL]    vert   dist
                                                                obs
         ____________                ____________               ____________
[LONG]      MAX            [HIGH]       VERT          [HIGH]       VERT
```

Figs. 5a- 5c: Object schemata and DAPs for combinations of schemata.

In figs. 5a - 5c, we find this kind of application. In fig. 5a, [LONG] (with the DAP `MAX`) beneath the line is applied to [POLE] (the object schema) above the line. Fig. 5b shows [HIGH] applying to [POLE] and the fig. 5c depicts [HIGH] and [WELL].

The application of a dimensional adjective to an object can take one of two different forms: Either it is an identification or it is a specification. The DAP `MAX` in fig. 5a identifies with the DAV `max` for dimension `a`, and the result is that dimension `a` is still a `max` dimension. In Lang's model, a long pole is still just a pole.

In fig. 5b, we have a specification. The DAP VERT specifies the a dimension by adding to max the DAV vert. A high pole is not just a pole, it is also a vertical pole. Figs. 6a and 6b show the resulting object schemata for long pole and high pole.

```
[LONG POLE] < a    (b    c) >        [HIGH POLE] < a    (b    c) >
              max     sub                          max     sub
                                                   vert
```

Figs. 6a and 6b: A long and a high pole (compare figs. 5a and 5b).

Lang's apparatus correctly identifies the semantics of "a long pole" and "a high pole" . We will now turn our interest to the anomaly of "a high well" and see how Lang lets the model recognize that anomaly. To see this we need a closer look at the two rules for identification and specification that Lang uses (Lang 1991:67). In these two rules, P is a DAP and p is a DAV. During identification, the DAV P should be replaced by a corresponding[2] DAP p which already describes the dimension (as MAX turned into max in figs. 5a and 6a).

Identification: P $\Rightarrow$ p
where P $\in$ {MAX, SUB, DIST, VERT, OBS, ACROSS, FLACH}
and p is the last DAV describing the dimension.

In 5a, MAX $\Rightarrow$ max because max was the last DAV for dimension a. In fig. 5c, however, VERT $\Rightarrow$ vert is prohibited by there being an obs last in the description list (such a list Lang calls an OS-section). The purpose of placing the obs last is to cut off access from the VERT to the vert in the identification rule. Hiding vert behind (i.e. above) obs is Lang's formal mechanism for recognizing the anomaly.

We saw an instance of the second rule, specification, in fig. 5b. There VERT was turned into vert and added below max in the description of the a dimension. The rule is formally spelt out like this:

Specification: Q $\Rightarrow$ p
where Q $\in$ {VERT, OBS, ACROSS, FLACH}
and p $\in$ {max, ø, vert} and restrictions on the dimensional description are not violated

The restrictions on specification are that the list of DAVs describing a dimension may only be in one of the combinations shown in fig. 7:

```
Simple:    max   vert   obs  across   sub   dist   ø

Multiple:  max    ø    vert    max    max     ø      ø     ø
           vert  vert  obs     vert   obs   across  vert  obs
           obs   obs
```

Fig. 7: Allowed combinations of DAVs for a single dimension.

---

[2] This correspondence is shown in table 1. MAX is replaced with max or imax, ACROSS with across, etc.

In fig. 5c, the specification rule allows us to make the VERT into a max, an ø or a vert. But where should we place these? We cannot place any of them under the obs of dimension a in [WELL], because obs must always be the last DAV in order for the identification rule to function properly. Neither can we place it below dist of dimension (b c), because nothing may be below dist. There is thus no way that [HIGH] can specify [WELL]. "A high well" is and remains an anomaly.

Object schemata and spatial configurations

From the viewpoint of cognitive linguistics, Lang's object schemata correspond to spatial configurations (Langacker 1987, Holmqvist 1993). We will now first look at the representation of configurations in Holmqvist 1993, 1999a, 1999b, and then make more detailed comparisons between Lang's model of object schemata and the model for spatial configurations given in Holmqvist 1993.

Image-schematic concepts, such as spatial objects and dimensional adjectives, always have a matrix. The matrix consists of one or several domains. Typical domains are exemplified by colour, time, emotion and 3D space. Here, we shall be exclusively interested in the 3D space domain.

In the 3D space domain, image schemata predicate configurations. [BALL] predicates a round configuration and [POLE] an extended configuration. Just like in Lang's representations of object schemata, the configurations are also represented by dimensions. We can sum up those structures of a configuration relevant to this article as in fig. 8.

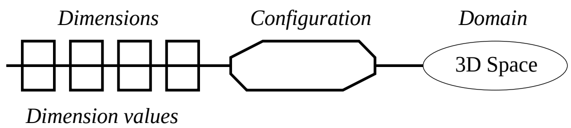


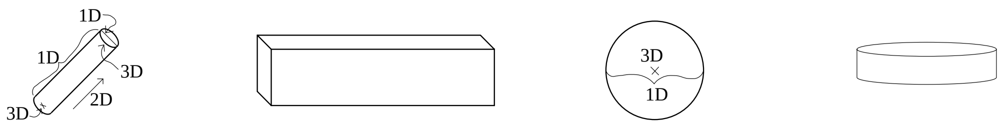
Fig. 8: A 3D space configuration with dimensions and dimension values.

Let us now compare object schemata and configurations. First, as we saw above, for 3D objects, Lang uses exactly three dimensions. A 3D configuration is instead generally described by more dimensions than three. A pole is described by ten dimensions, three for the starting and ending points of the main axis, two for the direction and one for the extension of that axis and finally one dimension for the diameter. This is because all these ten dimensions may have values that are important in the description of the pole or its place in its surrounding (Holmqvist 1993:50).

Langs dimensions and those of Holmqvist are not on the same level: Lang uses the dimensions of the domain in which the configuration extends. Holmqvist's dimensions instead belong in the description domain: Each dimensional description that can be made about the configuration is made into a dimension in the description domain.

Lang employs integrated and disintegrated dimensions. A 3D configuration only has disintegrated axes. Integrated axes are not directed and hence have another description, which makes them diameters. In fig. 9 we compare the object schemata of fig. 4 with the corresponding configurations.

[POLE]	[WALL]	[BALL]	[DISK]
`< a (b c) >`	`< a b c >`	`< (a b c) >`	`< (a b) c >`
`max sub`	`max vert sub`	`diam`	`diam sub`



Six axis position dimensions Two axis direction dimensions One axis extension dimension One diameter Total: Ten description dimensions	Three axes each of which has: Six axis position dimensions Two axis direction dimensions One axis extension dimensions Total: Twentyseven description dimensions	Three position dimensions One diameter Total: Four description dimensions	Six axis position dimensions Two axis direction dimensions One axis extension dimension One diameter Total: Ten description dimensions

Fig. 9: Object schemata and configurations.

[POLE] in fig. 9 has a larger axis extension than diameter, hence Lang places the disintegrated dimension first. With [DISK] the proportion is reversed. In our representation of configurations, we do not encode the proportion information in the order between dimensions. Instead, the relation in size between dimension values decide the overall shape of the configuration. The costraints on dimensional values can then be described by regions in a dimensional space (as in Holmqvist 1993, and Gärdenfors & Holmqvist 1994).

Because Lang and Holmqvist apply different kinds of dimensions, the values of these dimensions will also be of different kinds. Lang uses DAVs (dimension assignment values) to describe the dimensions. Holmqvist instead uses numerical values of dimensions. We therefore need to examine the relation of DAVs to general configuration representation, not just to single dimension values.

For several of Lang's DAVs, it is possible to give a direct translation into the kind of representation used for configurations. For others, more elements of the image schema must be employed.

DAV	*Interpretation in Lang's model*	*Configuration correspondent*
`max`	This disintegrated axis dimension has the maximal extension of the dimensions in the object.	Decided from the relative values of the dimensions describing extensions of axes.
`sub`	This axis or integrated dimension has the least extension of the dimensions in the object. There is some other more extended dimension.	Decided from the relative values of the dimensions describing extensions of axes.
`dist`	This integrated dimension is an inner diameter of a hollow (or negative) object.	A diameter dimension.
`diam`	This integrated dimension is an outer diameter of a solid object.	A diameter dimension.
`vert`	This disintegrated axis dimension is vertically directed.	Decided from the values of the axis direction description dimensions.
`obs`	This disintegrated axis dimension is parallel to the observer axis.	This axis have position and direction values equal to the values in the observer axis.

For instance, a `max` or a `sub` DAV only expresses relative sizes of dimensions in the object. In a configuration representation, such DAVs correspond to a certain relation between the numerical values of the description domain.

The DAV `vert` even more purely expresses the value of a description dimension. If an object has a `vert` dimension, the corresponding configuration has the numerical values of vertical extension for the dimensions describing directionality.

Some DAVs contain more. The `dist` and `diam` distinction is made to handle the difference between hollow or negative objects like wells and solid objects like poles. In both cases, the corresponding configuration only has a diameter dimension. In the configurations proposed by Holmqvist, dimensions are not responsible for carrying the information that the object is hollow or negative. A description dimension only concerns positions, extensions, directions etc. That an object is negative can only be seen in relation to an object at a higher level, that Holmqvist 1993 calls its whole. A well is a negative object in the ground, which is the whole for the well. Holmqvist 1993:70 argues that the negative object [WELL] should be a part in its whole [GROUND], but with other values on the predication in its substance domain: A well is made up of air and water, while the ground is made up of soil and rocks.

The DAV `obs` specifies a relation of parallelism between a dimension and the observer axis. This relation cannot be encoded in the dimensions of a configuration. The only way to include the observer axis in image schemata like [WELL] and [HIGH].TR (cf. figs. 2 and 3) is to let both the actual well configuration and the observer axis configuration be parts of [WELL]. The concept of a well would then presume a specified observer axis as part of the concept. There is then no problem to include parallelism between the two configurations.

It might seem questionable to include an observer axis in all wells, but this is what Lang does in his object schemata (cf. fig 5c.), on the grounds that a well can only be observed along the vertical dimension (a property of the primary perceptual system PPS). In effect, it only reflects our common background experience of wells.

Let us notice two things about configurations versus object schemata. The first is that configurations are devised to function in all domains, object schemata only in the 3D spatial domain. There are thus extended configurations in the temporal domain for characterizing the processual nature of verbs, and teher are configurations in the pitch domain for the cord terms.

The second thing to notice is that the same configurations are used both in objects and in adjectives: The [POLE], [HIGH].TR and [WELL] configurations are the same (except for small variations in the dimension values). This is the main prerequisite for superimposition. Lang's model instead employs DAVs for the object schemata and DAPs for the adjectives, which underlye the identification and substition rules. Yet the very connection between DAVs and DAPs indicates that the two could perhaps have been made into one single type.

Superimposition compared to the identification and specification rules

When a dimensional adjective in Langs model is applied to an object schema, the rules of identification and specification are used to compare the semantics of adjective and object schema to decide the resulting object schema and to detect anomalies.

In the model presented by Holmqvist 1993, the configuration of the adjective is superimposed onto the configuration of the object. Superimposition is an image schema operation for yielding and evaluating valence relations between concepts. Following Holmqvist 1993, the computational version of the superimposition process can be described as proceeding along the following steps:

(1) Domain identification: The common domains of the two image schemata are decided. When it concerns the application of dimensional adjectives on spatial objects, the common domain is always the spatial one.

(2) Predication identification: The two configurations are compared w.r.t. to their dimensions and axes. In anomaly-free cases the description dimensions are the same in both configurations: Long pole (above), high pole (above) etc.

(3) Dimension value adjustment: If the two configurations share a dimension, such as a direction dimension, then the value must be made the same, as in the example "long flagpole".

(4) Part accommodation. This process only concerns objects composed from conceptualised parts.

(5) Whole accommodation: The surrounding of the configuration is taken into account. It is in this step that the "high well" anomaly is detected. The superimposition of the respective observer axes fail.

To explain the behaviour of a "high well" it is sufficient to include an observer axis in the [HIGH].TR schema. The superimposition mechanism for evaluating composition of schemata can work whether or not [WELL] also includes the observer axis. This is because the superimposition mechanism is able not only to see *that* the observer axis must be parallel to the well but also to some extent *why* (that is, that the observer cannot be in the ground).

Lang's powerful description of objects thus appears to be able to incorporate in the more general predication and domain model from cognitive linguistics. The details and implications of this remain to be investigated.

Focus within 1D domains

Dimensionality is not just a property of static lexical elements. Dimensions are also exploited in actual every-day discourse. Here, I will limit the discussion to the simplest one-dimensional predications in discourse: Three basic groups, and some variants on them. All examples, unless otherwise indicated, will be from a transcript of an authentic spoken discussion (Holmqvist & Holsanova 1996a, b).

In the flow of discourse, our consciousness can focus on a vague but expandable area, whose large semantic structure is then hidden in its domains at at lower level of activation (Chafe 1994). Focus of attention changes with each new intonation unit, the spoken correspondant to a single focus of attention.

Some intonation units point out something, while at the same time contrasting it to something else.

314(A) …$_{0.79}$ många pengar (much money)

659(A) ..$_{0.12}$ för oss (for us)

758(A) …$_{0.44}$ de e en bra ide (it´s a good idea)

The *much money* in 314 exemplifies a *polary onedimensional domain*, which contrasts *much* to *little*. In a polary domain, the distance between the poles is important to contrast them, but this distance is given no description in itself. We never get to know anything about the distance between *much* and *little*, *us* and *them*, *here* and *there*, *high* and *low*, *good* and *bad*, *famous* and *unknown*. We only get to know that there is a distance.

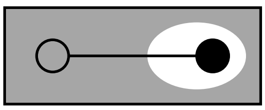


Fig 10: Focus on one pole in 314, 659, 758, 931, here shown with the other pole still unelaborated.

Instead the description is made exclusively of the two contrasting poles. The poles are themselves usually multidimensional, so the description involves many contrasting dimensions.

931(B) varmt (warm)
932(B) ..$_{0.25}$ för fötterna (to your feet)
933(A) då e de inte kallt å så där (then it's not cold an)

The temperature dimension in 931 is used in its polary variant, and focusses on the *warm* pole in the temperature domain. 933 focusses on the *cold* pole of the same dimesion. Thus, in these examples, focus is always on one of the two poles in the polary dimension.

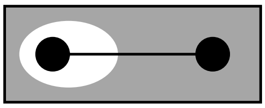


Fig 11: Focus in 933 on the second pole of the *varm - kall* (warm - cold) dimension.

2(A) ..$_{0.15}$ som e ..$_{0.19}$ skìlt frå=n det riktiga fallet,
(which is separate from the real fall)
96(A) ..$_{0.40}$ kanadensarna mot svenskarna
(the canadians against the swedes)

When the distance in a polary dimension is focussed, it is only focussed. The linguistic construction that put the light on the distance is not accompanied by other words that further describe it. For instance, the *skilt från* (separate from) in 2 only puts the light on the distance. Description by words and constructions that add more semantic structure is reserved for the poles. This is very clear with the *mot* (against) in 96.

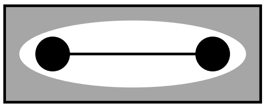


Fig 12: Focus on the contrasting distance between poles in 2 and 96.

The polary dimension can be recognised from the lack of descriptions of the distance between the poles. Requesting a description of the contrasting distance is a possible way to break down the contrast into a graded dimensions (which in every day terms would correspond to going from a black and white view to a nuanced view).

Temporally directed onedimensional predications

Onedimensionality is a prerequisite for flow directedness. Different dimensions can however be directed for different reasons. Path dimensions, for instance, describe a motion in time from a starting point to an end point (Holmqvist 1993: 88 - 102, Langacker 1986:24). The path is directed because our perception of passing time is involved in it.

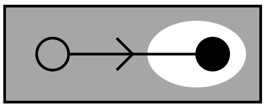


Fig 13: The *till* (to) construction in 175 and 340.

175(A) att ja ska åka över till sverige i sommar
(that I'm going over to sweden this summer)
339(A) ..$_{0.42}$ alla dom här kommer in med bud
(all of these give offers)
340(A) till kommuner
(to the districts)

Different elements in the intonation units contribute differently to the path. The *åka över till* (go over to) contribute to the path in 175, and *kommer in … till* (≈give… to) to the path in 339 - 340. *Till* (to) focusses on the endpoint of the path, while for instance *åka över* (go over) focusses on the entire path.

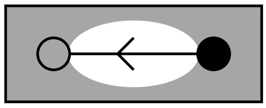


Fig 14: Focus on the constrasting distance in 392.

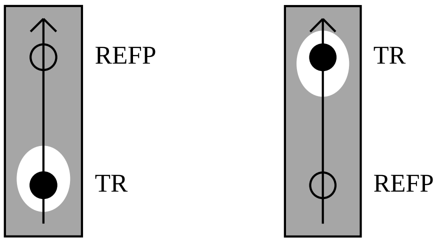
392(A) …$_{1.65}$ nu ska vi gå tillbaks ett par kapitel här
(now, let's go back a couple of chapters)

Paths are neither polary nor contrastive. Other entities are allowed to exist along the path as in **ja ska åka över atlanten* (i'll go across the atlantic). Also, the distance between start and ending points may be described, as in 392: *ett par kapitel* (a couple of chapters).

In paths, the end point is sometimes removed completely out of reach for our attention. There are even special lexemes, such as *endless* and *ceaseless*, for removing the end of paths, as in *his ceaseless moaning* (Holmqvist & Pluciennik 1996)

Spatially directed onedimensional predications

Another way for a dimension to receive direction is to link itself to one of our basic perceptual dimensions, usually VERTICALITY, but also OBSERVER and HORIZONTALITY (Lang 1991: 27 - 40) or even TIME. Very many dimensions have a vertical direction, in which more is up and less is down (Lakoff & Johnson 1980). These vertical dimensions measure the amount or intensity of something.



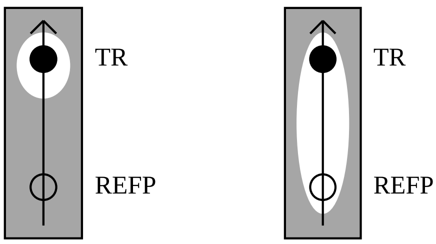
Figs 15 and 16: Focus on a lower TR value with a higher REFP value in 1, and on a higher TR value with a lower REFP value in 495.

1(A) …$_{0.8}$ amerikànerna har ett litet fall.
(the americans have a small fall)

495(A) ..$_{0.38}$ tjockt
(thick)

The measurement dimensions have an asymmetric pair of TR (trajector) and REFP (reference point) instead of a symmetric pair of poles. The *litet* (small) of 1 and *tjockt* (thick) of 495 are both focussed TR points on their respective amount scales.

Although these dimensions measure amounts and intensities, they have no absolute value scale. Their content lies entirely in the comparison between the focussed TR *litet* (small) and the peripheral REFP *stort* (big). When *litet* combines with an object like *fall*, this object normally has a rough size value that it got from lexicon and discourse, which it can handle over as the REFP value in the dimension.



Figs 17 and 18: *mycket* (much) and *mer* (more).

21(B)   [så] dom e mer patriotiska [än kanad]ens/
             (so they are more patriotic than the canadians)
72(B)   ..$_{0.40}$ känner du dig mer som kanadensare
             (do you feel more like a canadian)
361(A)   de e ett vidare spektru[m]
             (it's a wider spectrum)

The same difference in degree of attention, albeit lexical, explains the difference between the positive *mycket* (much) and the comparative *mer* (more). In *mycket*, the REFP has a low degree of attention on it. In *mer*, the REFP and the difference between TR and REFP is given a much higher degree of attention. Figs 17 and 18 illustrate this difference. Because *mer* draws more attention to the REFP and to the comparison, it is much better than *mycket* (much) in explicitly revealing the differences in a contrast relation. Using *mycket* instead hides the fact that you are making a comparison. In her questions, for instance 21 and 72, B uses *mer*. A mainly uses the positive forms of the adjectives.

32(A)   å dom hade det **värst** å allting
             (an they had it worst an everything)
64(A)   ..$_{0.24}$ tror att dom är …$_{0.86}$ störst´ bäst´ och vackrast i världen
             (think they're the biggest, best and most beautiful in the world)
216(A)   ..$_{0.18}$ den största glädjen
             (the greatest joy)
594(A)   ..$_{0.67}$ så kommer dom med det sämsta dom kan hitta
             (an so the offer the worst they can find)

The superlatives are like the positive forms: The comparison is implicit. However, superlatives compare their TR not to a single REFP but to a whole group of semi- and unactivated entities.

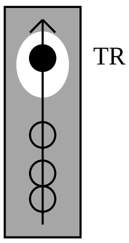


Fig 19: The upward superlative.

Often, as in 32 and 594, the surrounding context provides the reference group to the superlative. But just as often, as in 64 and 216, it is not very clear what is included in the reference group. The superlative then functions like a positive form with a vague REFP: *den största* (the biggest) simply means *stor* (big)

Meta- and iterative use of the TR - REFP asymmetry

Some intensifiers like *väldigt* (very), *stor* (big) and *så* (so) specify that the distance between REFP and TR is bigger than normal. In a sense, these intensifiers are metadimensions, with a meta-TR for the distance between TR and REFP and a meta-REFP for the normal distance between TR and REFP. Fig 20 shows how a metadimension, for instance *så* (so), measures a basic dimension.

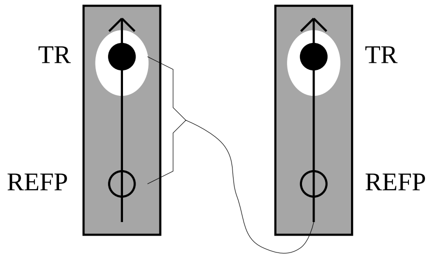


Fig 20: Basic dimension (left) and meta-dimension (right), the latter predicating the distance between TR and REFP in the basic dimension.

15(A) ...$_{1.05}$ så stolta över sina bedrifter
(so proud over their acheivements)
140(A) ..$_{0.32}$ hon blev så irriterad <SKRATTANDE>
(she was so annouyed <LAUGHING>
149(A) ...$_{0.53}$ stor triumf
(great triumph)
157(B) ..$_{0.29}$ de var väldigt lite
(it was very little)
620(A) ...$_{0.53}$ dom har en **vä´ldigt brá** idé.
(they have a very good idea)
844(A) så får man lite mer vatten
(so you can have a little more water)

Fig 20 applies to 15, 140, 149, and 620. Example 157 has a reversed TR/REFP configuration in the basic domain: The TR is low and the REFP higher. The combination in 157 thus means that the distance from the low TR to the high REFP is bigger (meta-TR) than normal (meta-REFP). Example 844 has a reversed TR/REFP configuration in the meta-domain: The distance from the high TR to the low REFP is smaller (meta-TR) than normal (meta-REFP).

Using intensifiers on a dimension makes that dimension graded. A polary dimension allows no descriptions of the distance between the poles, while intensifiers attempt to describe precisely this distance.

434(A) å så blir de mer å mer å mer
(an so it gets more an more an more)

The TR/REFP difference can also be used iteratively, as in 434, where the REFP of each successive *mer* (more) connects to the TR of the preceding *mer*, thereby giving us the sense of continuous growth.

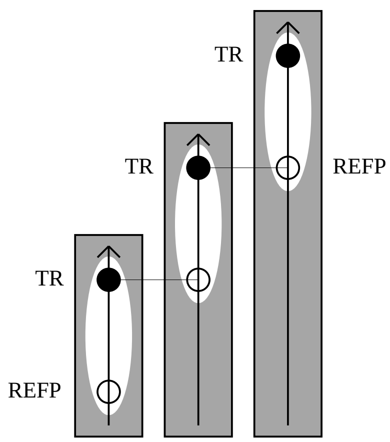


Fig 21: Iterative use of TR - REFP distance in 434 to give a sense of continuous growth.

The iterative requires the particular focus structure of the comparatives, because the REFP must be salient enough to connect to the previous TR. In the other adjective forms, this connections fails, making *å så blir de mycke å mycke å mycke* (an then it gets much an much an much) three independent amount levels.

Descreet dimensions

The descreet dimension is a variant of the contiuous dimension. A descreet dimension is formed by binding portions of a continuous dimension to units. The binding operation places borders in continuous dimensions, and these borders then define the units. Holmqvist & Pluciennik 1996 discuss the properties of boundedness in detail.

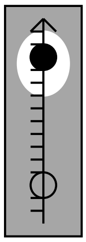


Fig 22: The descreet dimension in 35 and 205.

35(A) ..$_{0.33}$ många (many)
102(A) varje gång kanadensarna gjorde mål
(every time the canadians scored a goal)
205(A) de e så många invandrare där ändå
(there are so many immigrants there anyway)

Descreet versions of amount dimensions are exemplified by *många* (many) in 35 and 205. Example 102 involves a descreet variant of the time dimension.

Threshold and bottom dimensions

A threshold dimension is an amount or intensity dimension with a threshold (THR) or fullness level instead of a REFP. When the THR level is reached, some often non-specified event occurs or state takes place; such that the bathtub floods, or it becomes possible to take a bath. Threshold dimensions therefore appear when the speaker wants to express a casual relation, as in 598 and 847.

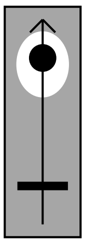


Fig 23: Focussed TR supersedes THR in 598 and 847, allowing something to occur.

598(A) …$_{0.71}$ om det kòstar för mycket å bygga hus,
(if it costs too much to build a house)
599(A) så naturligtvis så s`äljer man inga hus.
(so of course they don't sell any houses)

847(A) ..$_{0.43}$ tillräckligt mycket för att täcka
(enough to cover)
848(A) ..$_{0.76}$ den delen utav kroppen
(that part of the body)

849(A) som är nere i vattnet
(which is down in the water)

The vertical dimensions borrow their direction from the physical vertical axis which is of such importance to our perception and balance. The vertical axis has a *bottom* or *zero point* (Lang 1991: 32 - 33), which seldom accompanies the derived vertical dimensions. In the transcript, however, 828 clearly have a bottom in its dimension.

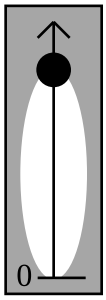


Fig 24: Focussed depth distance from bottom to level.

828(A) $\ldots_{1.09}$ gissa hur djup den nivån är
(guess how deep that level is)

The 1D dimensions in discourse

The following table shows the characteristics of the three types of 1D dimensions. In addition, there are variants with descreet dimensions, thresholds and bottoms replacing the REFP of graded dimensions.

	Elements	*Distance*
Polary	Two poles, contrasted but equally focussed	Seldom focussed, never described
Path	Start and ending points	Within focus, describable
Graded	TR/REFP asymmetry	Within focus, describable

Does the content matter of the dimension not play any role for its behaviour as polary or graded? For instance, 314 *många pengar* (much money) was said to be polary, when in fact *många* (much) is a graded TR/REFP dimension and the amount of money is clearly continuous. The dimension in 314 therefore rather seems to be a graded TR/REFP dimension.

In isolation, the dimension in 314 is graded. But 314 is embedded in discourse. The passage where it appears involves moving the focus back and forth between what in 314 is TR and REFP. New dimensions are added with there TRs where the old REFP was and vice versa. In this process, both TR and REFP are assigned equal attention, while the distance between them is left undescribed. When treated like this in discourse, the graded dimension becomes polary.

The difference between a contrastive polary dimension and a graded dimension is thus established in discourse, by how much attention is assigned during discourse to each pole and to the distance between them. This does not mean that some items are not lexically stored as more polary or more graded. It is just to say that whatever dimensional properties are stored, they are possible to change during discourse.

Why then do people construct these different dimensions? Sometimes for pedagogical reasons. A contrast is easier to understand than a graded difference, which makes it appropriate for introductions. Sometimes a polary contrast is chosen simply because of the speaker's current emotional state of mind.

The origin of 1D dimensions

The question about the origin of 1D dimensions has attracted considerable attention in recent years. Lang 1993 presents an elaborate model of the dimensionality of objects and the application of dimensional adjectives to them (see above). His work indicates that our biological system incorporate the basic axes (among them verticality, the observer axis and the horizontal left-right axis), whose properties appear in the dimensions of adjectives as well as in the objects denoted by nouns.

Also in the cognitive linguistics, dimensions are of importance. Krzeszowski 1993 sketches the “axiological principles” of, among others, the up-down, the front-back and the right-left axes. These axes are, according to Krzeszowski, grounded in our basic bodily experiences.

There is little doubt that the basic perceptual axes are the origin to the 1D dimensions in discourse. Also structures like the vertical bottom are directly perceptual, as well as paths, and perhaps even the descreet boundedness.

However, the difference between polary and graded dimensions cannot be explained without invoking our attentional system. The difference between positives, comparatives and superlatives also requires our attentional mechanism. Attention reshapes the basic axes into the dimensions visible in discourse.

The indirect presentation of 1D dimensions

In this exposition of one-dimensional domains, I have tried to use as clear examples as possible. But the speaker often hides the 1D dimensions behind more interesting and entertaining structures, letting the listener find the focus in the dimensions by structures in the context.

325(A)	dom gör av med snabbt pengarna
	(they spend quickly the money)
326(A)	å dom ..$_{0.36}$ bryr sig inte
	(an they don’t care)
535(A)	i sverige vet dom minsann hur man bygger vägar
	(in Sweden they do know how to build roads)

For instance, in 325, the explicit focus is on the process of spending money quickly. In the preceding context, however, we have already focussed on the much money pole of the ‘money amount’ dimension. The focus moves made by the speaker makes us expect an elaboration of the negative pole of this dimension. Since the end result of the explicitly focussed process is having little money, having little money becomes the current focus of the ‘money amount’ dimension, the speaker could allow himself to be entertaining, since it was so clear from context which dimension was relevant (in the terminology of relevance theory, Sperber & Wilson 1986) and how it should be focussed.

Similarly, in 535, the speaker allows himself an entertaining quote, since discourse makes it obvious that the ‘road quality’ dimension is focussed and given a positive value.

The visualisation of 1D dimensions

This analysis is based on the principle that people visualise when they use language. People also visualise 1D dimension. However, the figures 10 - 24 do not always depict what the speaker or listener visualises. For example, the growth in fig 21 is not an abstract upward linear growth. It is the growth of a hole in a wet Canadian dirt road being hollowed out by heavy truck traffic. From the context, it it clear that if we visualise anything, we visualise this hole in the dirt road.

Even though we do not visualise fig 21, the dimensions in fig 21 are still involved in the visualisation of the hole. In the visualised image, they are percieved inside the hole, as its size dimensions. When the speaker then says *mer å mer å mer*, the process in fig 21 makes us visualise the growth of the hole. Linguistically, he makes the dimensions grow, and its growth effects our image of the hole in the road.

There are also cases where what is actually focussed is too abstract to be visualised, whereby the dimension can appear more saliently. Figs 13 and 14 exemplify this. The district in 340 is nothing but a black dot, and the *till* (to) path leading to it can be visualised instead.

Summary

There are three major groups of 1D dimensions in discourse; polary, path and graded dimensions. Onedimensionality originates in perception, which gives to us a number of its properties. In discourse these dimensions appear with attentional focus on parts of them. Usually the dimension is part of some bigger semantic image, such as a hole. There it functions as a mediator for the speakers linguistic adjustments of the image.

Conclusions

I hope to have shown two things in this paper: First that dimensions is a fascinating and worthwhile object of study in cognitive science. Second that the work is far from finished. If it is true as supposed above that dimensions and their values are fundamental to language and cognition, you would like to see a more systematic review of dimensions, would you not?

References

Andersson, T. (1994) *Conceptual Polemics: Dialectic Studies of Concept Formation*, LUCS 27

Balkenius, C. (1995) *Natural Intelligence In Artificial Creatures*, LUCS 37

Chafe, W. (1994) *Discourse, Consciousness, and Time*, Chicago: Chicago University Press

Gedenryd H (1998) *How Designers Work*, LUCS 75.

Gulz, A. (1991) *The Planning of Action as a Cognitive and Biological Phenomenon*, LUCS 2

Gärdenfors, P. (1988) *Knowledge in Flux: Modeling the Dynamics of Epistemic States*, Bradford Books, MIT Press, Cambridge, Mass.

Gärdenfors, P. (2000), "Conceptual Spaces" , to appear, MIT: Bradford Books

Gärdenfors, P. & Holmqvist, K. (1994) "Concept Formation in Dimensional Spaces", LUCS 26.

Holmqvist, K. & Holsanova, J. (1996a) "Focus movements and the internal images of spoken discourse" , LUCS 50.

Holmqvist, K. & Holsanova, J. (1996b) "Jag längtar efter svenska kvalitet och tänkande - Hur vi använder kategoriseringar i samtalet" , LUCS 49.

Holmqvist, K. & Pluciennik, J. (1996) "Conceptualised Deviations from Expected Normalities - a Semantic Comparison between Adjectives Ending in *-ful* and *-less*" , in *Nordic Journal of Linguistics*, 19, 3-33, also LUCS 39 (with J. Pluciennik).

Holmqvist K (1999b) "Conceptual Engineering - implementing cognitive semantics" ,. in *Cognitive Semantics*, Allwood, J. & Gärdenfors P (eds), pp 153 - 171, Amsterdam, Philadelphia: John Benjamins

Holmqvist, K. (1999a) “Implementing cognitive semantics - overview of the semantic composition processes and insights into the grammatical composition processes” , in *Issuse in Cognitive Linguistics*, de Stadler L. and Eyrich, C. (eds), pp 579-600, Berlin: Mouton de Gruyter.

Holmqvist, K. (1993) *Implementing Cognitive Semantics*, Lund University LUCS 17

Jackendoff, R. (1991) “Parts and boundaries” In: *Lexical & Conceptual Semantics*, ed. by B.Levin and S. Pinker, 1992 Blackwell, Cambridge MA & Oxford UK.

Krzeszowski, T. P. (1993) “The axiological parameter in preconceptual image schemata.” In: *Conceptualizations and Mental Processing in Language*, ed.by R. A. Geiger and B. Rudzka-Ostyn. Berlin, New York: Mouton de Gruyter.

Lakoff, G. & Johnson, J. (1980) Metaphors we live by, Chicago: University of Chicago Press.

Lang, E., Carstensen, K-U. & Simmons, G. (1991) *Modelling spatial knowledge on a linguistic basis*, Berlin, Heidelberg: Springer-Verlag

Langacker, R. (1987) *Foundations of Cognitive Grammar*, Vol I, Stanford: Stanford University Press

Pallbo, R. (1997) *Mind in Motion: The utilization of noise in the cognitive process*, LUCS 57.

Sperber, D. & Wilson, D. (1986) *Relevance: Communication and Cognition*. Blackwell, Oxford.

Winter, S. (1998): *Expectations and Linguistic Meaning*, LUCS 71.