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2 From Conceptual Spaces to Predicates

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Abstract. Why is a red face not really red? How do we decide that this book is a textbook or not? Conceptual spaces provide the medium on which these computations are performed, but an additional operation is needed: Contrast. By contrasting a reddish face with a prototypical face, one gets a prototypical 'red'. By contrasting this book with a prototypical textbook, the lack of exercises may pop out. Dynamic contrasting is an essential operation for converting perceptions into predicates. The existence of dynamic contrasting may contribute to explaining why lexical meanings correspond to convex regions of conceptual spaces. But it also explains why predication is most of the time opportunistic, depending on context. While off-line conceptual similarity is a holistic operation, the contrast operation provides a context-dependent distance that creates ephemeral predicative judgments ('this book is not a textbook', 'this author is a linguist') that are essential for interfacing conceptual spaces with natural language and with reasoning.

Keywords. Conceptual spaces, contrast, predication, language of thought, aspect.

2.1 Introduction: Meaning *vs.* predicates

The word 'concept' has been heavily used in semantics, despite its ambiguity (Machery, 2009). Most authors in linguistics use it to designate 'lexical meanings'. They would speak of the concept of 'book' and may sometimes write it BOOK. Some authors continue by 'grounding' the concept in perception, considering that the concept refers to an actual object (a book) or, in the absence of any context, to a *prototype* of book. Advocates of the prototype approach would allow membership (being a book or not) to be gradual (Rosch, 1978). Authors from the logical tradition or the philosophical tradition would rather consider the membership function BOOK(*x*) as having a binary value (true or false) and would call it a (logical) *predicate*. Advocates of this second approach will equate the concept with its 'extension', which corresponds to its so-called 'truth values' (the set of all *x* that make BOOK(*x*) true). Much misunderstanding results from the fact that the word 'concept' may be used by different authors to designate sometimes prototypes and sometimes predicates. The purpose of the present paper is to suggest that the two notions should be kept separate.

This position may be surprising, as predication, understood as concept membership, is often considered by both schools to rely on fundamental cognitive abilities, such as object recognition, that we share with other animals. Hence the proposal that animals do have concepts (Fodor, 1975) and that there is full evolutionary continuity between non-human primates and humans in this aspect of the semantic competence (Tomasello, 1999; Hurford, 2003).

There are strong reasons, however, to consider that prototypes and predicates both exist as cognitive representations, but are different in nature. The suggestion will be that predicates are transient representations that are built 'on the fly' based on prototypes, or rather on the kind of conceptual representations hypothesized by Gärdenfors (2000; 2014). In the next section, I will oppose the two traditions mentioned above (prototypes *vs.* predicates) and highlight the fact that both, separately, are unsuccessful in solving the problem of lexical meanings. Then, I consider how conceptual spaces (Gärdenfors, 2000) deal with the challenge of interfacing with reasoning. Building on that model, I will define the *contrast operation*,

to show how conceptual spaces may support logical reasoning. As will be suggested, predicates are formed 'on the fly' and are ephemeral constructs. To illustrate this point, I will consider temporal aspect and its role in predication. Lastly, I will consider the predicative ability from a functional and evolutionary perspective.

2.2 Two incompatible definitions of meaning

Meanings are attached to language: words, phrases and sentences can be meaningful. But meanings play other roles. They refer to perceived objects, scenes or events.

(1) The red book on the chair to the right of my desk

In (1), the phrase refers to a specific object that may be, for instance, wanted by the speaker. To be fully understood, the phrase must be processed in the current environment, in interaction with perception. One wouldn't say that the interpreter got the meaning of the phrase if she is unable to provide a spatial description of the scene, for instance by drawing a sketch of it. Meaning is not only in words; it is 'rooted', or 'grounded', in perception. The difficulty of assigning a meaning to (2) does not lie in the meaning of words, but in the difficulty of forming an image of the object in the absence of any particular context.

(2) The garden of the door

Meanings are not only related to perception, but also to reasoning. Language is not used just to refer to things in the environment, as in (1). It is used to convey propositional attitudes. Example (1) is incomplete in this respect and may generate an answer like: "So what?". Attitudes express surprise, (dis)belief, and positive or negative emotions or desires (Bratman, Israel & Pollack, 1988; Dessalles, 2007). One may continue example (1) by saying "It's no longer there!", or "It's the best I've read recently". In the Fregean tradition, only *predicates* (with no free variables) can support attitudes. A basic test to recognize predicates is negation. A perceptual meaning of 'book' cannot be negated. No perception can illustrate what a *not*-

book would look like. However, negation can be systematically used on predicates: “It isn’t a book”, “it’s not red”, “I haven’t read it”.

When defining the nature of meanings, one has to ensure that they correctly interface with these three domains: language, perception, reasoning (figure 2.1). Unfortunately, the corresponding requirements seem irreconcilable (Ghadakpour, 2003). Perceptual representations such as prototypes *à la* Rosch (1978) or regions of ‘conceptual spaces’ *à la* Gärdenfors (2000) are of course perfectly fit for matching perceptions. They also interface well with words. Using figure-ground distinctions (Gärdenfors, 2014), they can be used to provide different meanings to expressions like “the neighbour’s cousin” and “the cousin’s neighbour”. However, they do not support negation and logical reasoning: there is no prototype for ‘not-book’ or ‘not-red book’. Attempts to define negation as a comparison procedure would miss the point. The problem is to define a context-sensitive distance and a context-sensitive threshold to decide whether this object is, or is not, a book. No absolute distance from prototype can support judgments like “This is not a book, it is too thin”, “This is not a book, it lacks bibliographic references” and “This is not a book, it’s a collection of essays”.

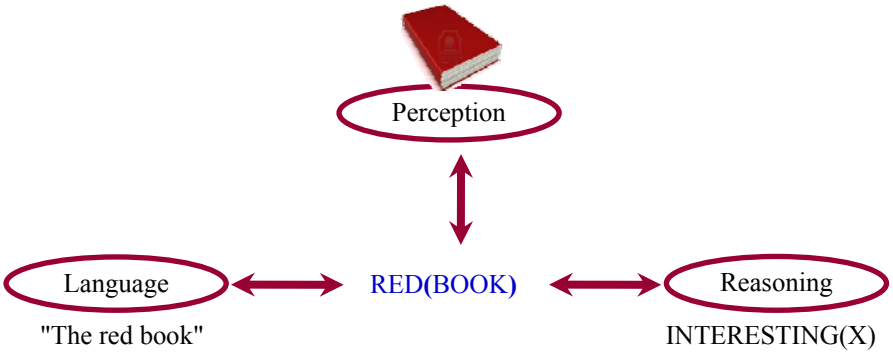

Fig. 2.1. The three interfaces of meaning

Another famous attempt to define meanings consists in considering that they are built on a ‘mental lexicon’. According to this tradition, meaning construction boils down to a mere translation from actual language to a ‘language of Thought’ (LOT) (Fodor, 1975). This approach has potential internal inconsistencies, though, depend-

ing on how the mental lexicon is constructed (Fodor, 1981; 1998; Fodor & Lepore, 1992; Ghadakpour, 2003). One may choose to *define* lexical meanings in terms of other meanings. The meaning of 'kill' will be equated with something like KILL(x, y) ≡ CAUSE(x, DEATH(y)). Various formalisms have been proposed to encode such definitions, including flat logical expressions, description logics, λ-calculus, lexical conceptual structures, recursive feature structures and frames. The very idea of definition is, however, problematic (Fodor, Garrett & Walker, 1980; Fodor, 1994). First, correct and complete definitions are nearly impossible to find (except in the limited domain of mathematics). For instance, one wouldn't say that a judge is killing the defendant by sentencing her to death, despite definitely causing her death by doing so. Second, definitions do not avoid the problem of having primitive, undefined meanings, such as CAUSE in certain accounts (Jackendoff, 1983). Third, definitions offer no grounding in perception (Harnad, 1990). They provide no means to distinguish geese from ducks (Jackendoff, 1983) or pebble from stone or rock. Lastly, by making no distinction between the inner structure of lexical meanings and the structure of combined meanings attached to phrases, the definitional approach explains meaning construction by mere structural matching or unification; but meanings can only grow in this process, leading to implausibly large structures when discourse is processed. This problem has been called the *monotonous compositionality paradox* (Ghadakpour, 2003).

Different studies in cognitive linguistics proposed dynamic mechanisms as an alternative to static definitions. For instance, force dynamics (Talmy, 1988) intends to capture aspects of causation and modality. Note, however, that most of these approaches still postulate the existence of static structures attached to words, such as image schemas (Langacker, 1987). For this reason, they are not immune to the critique addressed to the definitional version of LOT. The same is true of procedural approaches to meaning, such as frames (Johnson-Laird, 1977), in which lexical meanings depend on procedures that must be executed on the fly. Despite their dynamic aspect at the time of execution, the procedures themselves constitute static structures attached to the lexicon. This makes them vulnerable to all the problems of the definitional version of LOT.

An alternative version of the LOT hypothesis considers that lexical meanings are atomic, *i.e.* have no internal structure, but are linked to each other. Different formalisms have been proposed to represent links between meanings, including logical knowledge bases, semantic networks, theories and conceptual graphs. This *relational* view of meaning is however exposed to the problem of holism and to the frame problem (Fodor & Lepore, 1992): There is no way to circumscribe the effects of elementary changes in knowledge.

Both approaches to LOT, the definitional one and the relational one, are equally exposed to the grounding problem. Their representations are just floating symbols, defined using other symbols or being linked to them, without ever being connected to perceptions (Harnad, 1990). The very idea of a LOT, based either on definitions or on relations, amounts to a clumsy duplication of perception. How can we decide which perceptions deserve being represented in LOT? Since perceptions are continuous and graded, whereas a LOT, like any language, is necessarily discrete, most perceptual nuances are supposed to remain outside of our conceptual power. The LOT hypothesis therefore does not explain why human beings can conceptualize any perceptual distinction. For instance, one may compare two colours and state that one is lighter than the other, without being able to define the two colours or even being able to name them.

Considering certain problems of the traditional approaches to LOT, Fodor proposed a non-definitional and non-relational approach, in which all concepts preexist, before some of them happen to be used (Fodor, 1998; Chomsky, 2000). This innatist model of conceptual knowledge is still vulnerable to the grounding problem. Moreover, it is forced to deny the very possibility of acquiring new meanings that were not pre-existent. Note that the definitional and the relational version of LOT are quite uncomfortable with the acquisition issue, as the child has to guess non-trivial (external or internal) structures when exposed to a new word.

Neither the prototype approach nor the LOT hypothesis seem to support the three interfaces that any theory of meaning must explain: with language, with perception and with reasoning. Prototypes do not support negation, and LOT meanings are not grounded. The only way out of the conundrum, as we suggest following Ghadakpour

(2003), is to consider that there are no such things as complex permanent symbolic structures attached to the lexicon. The structural part of meanings that supports their logical role will be presented as an ephemeral construct. In the model presented here, predicates are only transitory and do not exist as permanent structures.

2.3 Conceptual spaces and categorization

Our problem, in a nutshell, is to define grounded predicates. Let's start by accepting Harnad's (1990) point that by combining purely symbolic structures, one will never get grounded representations. One may know that a book is a physical object made of paper that can be read, but if one has no perceptual grasp of what 'physical', 'paper' and 'read' mean, one will never be able to recognize actual books when one perceives them. Moreover, one will be unable to understand metaphors involving perceptual distance such as "It's not a letter you are writing, it's a book!" or "This cupboard opens like a book".

Our best chance is therefore to start from grounded representations and see how we can allow them to support negation, propositional attitudes and logical reasoning as predicates do. We may start from conceptual spaces (Gärdenfors 2000, 2014) because, as we will see, their geometrical nature makes them suitable to our purpose.

Gärdenfors (2000, 2014) offers an original account of the nature of meaning. He insists that meanings are geometrical entities. They belong to metric spaces that they share with perceptions. As a consequence, two meanings in the same 'conceptual space' may be more or less similar. More importantly, lexical meanings refer to convex regions in one of these 'conceptual spaces'. This means that if two objects are called 'book', all objects that fall in-between in the conceptual space will be identified by the word 'book' as well. Gärdenfors set himself the goal of identifying the various spaces in which lexical meanings are located, depending on the semantic nature of meanings (such as events, actions or qualities) or on their syntactic role (such as nouns, adjectives, verbs). He observes for instance that nouns correspond to regions in multi-dimensional spaces,

whereas adjectives refer to low-dimensional or even one-dimensional domains.

Conceptual spaces, as they are described by Gärdenfors, support categorization, but not predication. Categorization means that when an object is perceived, it can be assigned to a known category. Since conceptual spaces are metric spaces, such categorization is straightforward: Just associate the object to the closest category represented by the exemplars and prototypes that have been memorized. This closest-neighbour device, when strictly applied, divides the semantic space in juxtaposed polygonal cells and produces a pattern called a Voronoi partition (Gärdenfors, 2000:97). Categorization, performed this way, differs however from predication.

First, categorization is a very basic operation that is far from representing the type of membership judgments performed by human beings. Even bacteria can be said to categorize, when they accelerate in acidic regions and slow down in neutral environments, or when they synthesize β-galactosidase only in the presence of lactose. Are we ready to say that bacteria categorize regions based on their acidity? That they possess the concept of acidity? Or the concept of lactose?

On the other hand, membership judgments, when performed by human beings, have two non-trivial properties: they are context-dependent and they can be justified. One may say for instance, talking about an electronic book: "It is a book, because it has been properly published". Though a prototypical book is still nowadays a physical object, a scrolling text on screen can be called 'book' without hesitation in an appropriate context. The membership judgment in this example contains a justification which is also context-dependent: "because it has been properly published". Negative membership judgments like "This is not a book, it is too thin", "This is not a book, it lacks bibliographic references" and "This is not a book, it's a collection of essays", contain context-dependent justifications as well. These justified positive and negative membership judgments are exactly what predicates do.

Distance-based categorization does not produce any negative membership judgment. Everything is a book, more or less. The only way to refuse bookness to an object would consist in finding a closer resemblance to another prototype, *e.g.* a notebook. But a thin book

may look like a notebook and still be a book. Distance-based categorization cannot produce context-dependent negation. Moreover, convex regions of conceptual spaces do not support negation. Attempts to define 'not-book' and 'not-red' would produce non-convex regions. For instance, if 'not-red' is understood as 'any colour but red', it will correspond to the whole colour space with a convex hole in it and will not itself be convex. Moreover, standard distance-based categorization cannot give rise to any justification, other than "It looks like X". This mere resemblance statement given as justification cannot be context-dependent. As we can see, there is quite a gap between standard categorization and predication.

Conceptual spaces can obviously produce basic categorization, based on distance to nearest neighbour. However, Gärdenfors does not provide any mechanism through which conceptual spaces would produce predicative judgments. The next section shows how such a mechanism can be defined.

2.4 The contrast operation

The main thesis of the present paper is that membership judgments, which are sometimes considered to be the main role that 'concepts' have to fulfill, cannot be deduced from distance to prototypes. Available distances, such as those used in prototype theory, in neural networks or in conceptual spaces, are *holistic*. This means that they are computed on many dimensions: all available dimensions in prototype theory, dimensions that are statistically relevant in neural networks, or the various dimensions of the conceptual space to which the prototype belongs. An object that differs from the prototype in only one respect is unlikely to be rejected using a holistic distance. A negative membership decision like "This object is not a book, it is too thin" will not be generated if the object has all the typical characteristics of a book but thickness. Discrepancy on only one dimension does not make a difference when there are many dimensions (colour, shape, matter, pages, printed content, title, publisher, references, …) on which the object matches the prototype.

Following Ghadakpour (2003), we claim that membership judgments are generated by using a *contrast operation*. The object *O*

is contrasted with the *closest* prototype *P*. We may write the output of this operation $C = O - P$. The use of the minus sign is not fortuitous: in the spirit of conceptual spaces, the contrast operation can be implemented using the difference between vectors. Note that *C* is not a distance, but a vector (*i.e.* a concept). Figure 2.2 illustrates how contrast works. The representation of a given book *O* is contrasted with the 'textbook' prototype. The resulting vector, shown as a dashed arrow, provides a *contrastive dimension*. Though figure 2.2 shows only two dimensions, the contrast operation is performed in a multi-dimensional space including all dimensions on which objects (here, books) are perceived.

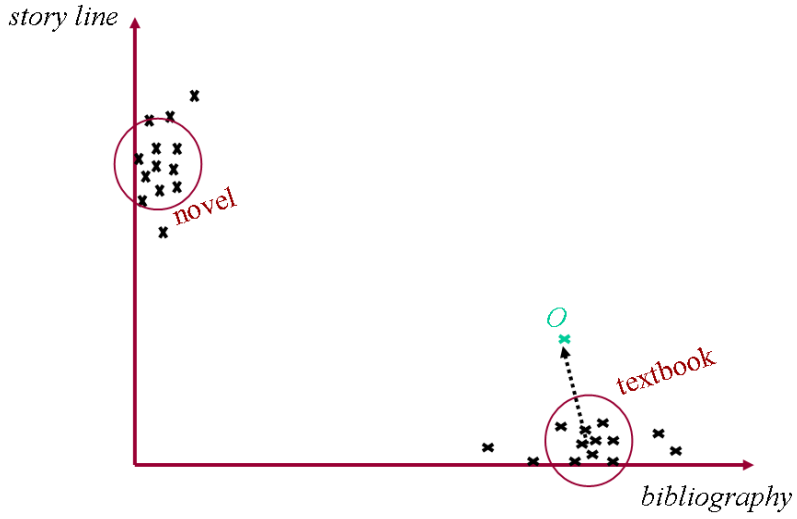

Fig. 2.2. Schematic representation of the contrast operation. Circles represent two prototypes (novel and textbook) along two dimensions: quantity of bibliographic references and coherence of the story line. Dots represent a few books that are close to the two prototypes. The dashed arrow represents the contrastive dimension between book *O* and the 'textbook' prototype.

The contrastive dimension serves as basis for several further operations. One of them is *modification*. For instance, as far as the contrastive dimension matches the 'story line' dimension, *O* may be characterized as 'a textbook with a story line', or as a 'narrative textbook'. Since *O* and the associated prototype are close along many dimensions, *C* can often be approximated by a low dimensionality vector. For this reason, according to Gärdenfors, *C* is likely to

fall in the region of an adjective. If one compares a 20-page book to a prototypical book, the difference will be close to the prototype of 'thin' or 'thinness'.

Modification through adjectives ('narrative', 'thin') or through specifying phrases ('with a story line') is involved in the operation of predication, and translates directly into logical predicates (*thin*(*O*), …). These predicates, which result from contrastive judgments, are not easily produced by systems that rely exclusively on global distances, such as prototype-based models or conceptual spaces in their basic form, without introducing external notions such as 'salience'. Modifying predicates, however, come naturally with the contrast operation. In a judgment like "This girl has a red face", the adjective "red" needs not be metaphorical nor a distorted version of the redness prototype. It merely results from the contrast between the girl's face and a prototypical face, as the difference may happen to match the prototype of 'red'. The modifier ('narrative', 'with a story line', 'red') is not a distorted representation, but an accurate representation of the difference $O - P$ (figure 2.2).

The contrast operation, as proposed here, can be seen as a cognitive device that supports 'lexical contrast' (Murphy, 2003:170). Moreover, it avoids any notion of 'salience' to explain context dependency. Adjectives like 'thin' or 'big' may be applied to objects of various sizes: "a big flea", "a big galaxy". The meaning of these phrases cannot be determined by two separate computations, as in a writing like BIG(x) & FLEA(x) (Kamp & Partee, 1995). The meaning of 'big' has to be understood in the flea context or in the galaxy context. The contrast operation provides this context dependency by determining both that the adjective 'big' is relevant and on which scale it is interpreted. The perceived flea (resp. galaxy) contrasts with the prototype of flea (resp. of galaxy) by its size; the scale (millimetres *vs.* thousands of light-years) comes from the standard deviation of the prototype. This works if the prototype of 'big' belongs to the conceptual space of homothetic transformations.

The contrastive dimension plays also an essential role in the most basic form of predication: membership judgments. In the example of figure 2.2, should we opt for *textbook*(*O*) or for its negation? The contrast operation by itself does not produce membership

judgments. A binary decision is required in addition. The contrast operation provides the space on which this membership decision will be made. “This book is thin, but it is still a book”, or “This book is too thin to be a proper book”. This kind of binary decision is a *topological* decision. It first creates a frontier *F* on the contrasting dimension, and then decides whether the object and the prototype are on the same side of the frontier or on opposite sides (figure 2.3).

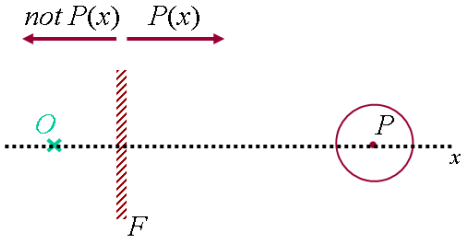

Fig. 2.3. Membership decision based on contrast.

The combination of contrast and binary separation has been invoked to account for antonym pairs (Paradis & Willners, 2011). By taking ‘contrast’ literally as a difference, however, we explain context sensitivity in oppositions (‘chair *vs.* stool’, ‘chair *vs.* sofa’) without appealing to notions such as ‘contextually relevant properties’. Relevance is an output, rather than an input, of the contrast operation (Dessalles, 2008).

Interestingly, the combination (contrast + binary decision) provides additional support to Gärdenfors claim about the convexity, or at least the star-like nature of concepts, considered as regions in a conceptual space (Gärdenfors, 2000:69). If an object is found to fall inside the frontier, any other object that is closer to the prototype along the contrasting dimension will be located inside as well. The same reasoning can be made about any contrasting dimension. As a consequence, we expect membership judgments to generate star-shaped regions around the prototype. The observation that meaning should self-organize to produce a Voronoi partition (Gärdenfors, 2000:91) may follow from this star-like property, but only indirectly. Gärdenfors’ observation refers to average lexical meanings emerging from language use within a linguistic community. The contrast operation, however, produces only situated judgments, for one

speaker at a given moment. It is performed dynamically, on one dimension at a time. For convexity to emerge in conceptual spaces, judgments must be consistent across speakers, at least on average.

The present model makes a clear distinction between prototypes and predicates. The former are long-lasting representations. The latter are ephemeral representations. They are produced 'on the fly', possibly with insincerity as their purpose is often to make a point, as in "This is not a book, it's a collection of essays". Predicates support negation and attitudes, and are used in reasoning. They differ from prototypes, but are built on them. The fact that we can perform membership judgments on any object–prototype pair gives the illusion that predicates are permanent representations. They are not. They are created when needed, and they vary according to contexts. Similarly, our ability to impose binary decisions on any contrasting dimensions, graded or not, gives the illusion that 'concepts' can be defined. But these 'definitions', which serve as basis for most LOT approaches to semantics, are just-so constructs that are made up on the fly. They are not stored permanently (except in the rare cases in which their linguistic form is memorized, as when a student learns definitions by heart) (Ghadakpour, 2003). For instance, anyone knows the difference between the meanings of 'walk' and 'run', but few people are able to provide a definition for these terms. In race walking competitions, 'walking' obeys two constraints: both feet cannot lose contact with the ground simultaneously, and the supporting leg must straighten from the point of contact with the ground and remain straightened until the body passes directly over it. Such fixed definitions are no more than *ad hoc* conventional constructs. They have no cognitive reality, except for the very few that have been learned by heart (Fodor, Garrett & Walker, 1980). The only permanent conceptual features are perceptual, and are well modelled by prototypes or exemplars located in conceptual spaces, as described by Gärdenfors.

The predicative ability shows up in various parts of our linguistic competence. I mentioned membership judgments, negation and attitudes. The contrast operation is also involved in comparatives such as "warmer" and "taller". No wonder, since contrast is likely to produce low-dimensionality output, that comparatives are generally expressed through adjectives, as observed by Gärdenfors (2014). A

comparative adjective like ‘first’ is ambiguous: “The first 4G-network” may mean the first by its geographic coverage or the first to be deployed. This ambiguity is best explained by the fact that the contrast operation can produce different dimensions, depending on the context.

This last example highlights the fact that contrast may operate on any dimension, including time. Contrasting operations are even essential for generating aspectual distinctions. This is what we explore in the next section.

2.5 Predication and temporal aspect

From a cognitive perspective, the most basic aspectual property is the notion of *perfectivity*. This notion corresponds to the fact that a situation may be perceived and expressed either as bounded (perfective) or as unbounded (imperfective). Since perfectivity may change during semantic processing, as we will see, I prefer to use the notion of *viewpoint* (Ghadakpour, 2003; Munch & Dessalles, 2014; Munch, 2013). A situation can be seen from the outside, in which case it is seen as a (bounded) *figure*, or from the inside, in which case it is seen as an (unbounded) *ground*. The notions of ‘figure’ and ‘ground’, borrowed from Gestalt psychology, seem appropriate here, as they avoid any idea of border, contour or limit. A ‘figure’ is a whole (with neither interior nor frontier) and a ‘ground’ is regarded as a limitless area. The figure/ground distinction associated to perfectivity is illustrated in French by the difference between present perfect (“Elle a mangé”) and the imperfective (“Elle mangeait”). Incompatible viewpoints provoke semantic errors.

(3) She wants to eat the entire cake in one minute

(4) # She wants to eat the entire cake for one minute

Example (3) is correct. Example (4), however, is hardly acceptable. “To eat the (entire) cake” is a figure. It is compatible with the figure introduced by ‘in’ (“in one minute”) but it does not match the ground introduced by ‘for’ (“for one minute”). In examples (5) and (6), we can observe the converse conflict, as “to snore” is perceived as a ground (‘snoring’ refers to a homogeneous situation).

(5) # She is expected to snore in one hour (tomorrow)

(6) She is expected to snore for one hour (tomorrow)

Note that (5) would be acceptable with a meaning like (7), which is sometimes called ‘inchoative’.

(7) She is expected to snore after one hour (tomorrow)

The effect of ‘in’ would be the same as in “He would confess his crime in one hour (if I could question him)”. Similarly, (8) is perfectly acceptable.

(8) She is expected to snore in one hour (from now)

In (7) and (8), the mention of duration concerns not the situation itself (snoring), but the period that precedes it. The simplest explanation of this apparent inchoativity consists in the fact that ‘snore’ denotes a situation in (5) and (6), but is predicated in (7) and (8). In these latter sentences, the ‘snoring’ situation is contrasted with a ‘non-snoring’ situation. Both ‘snoring’ and ‘non-snoring’ become figures that are topologically separated on a snoring gradient space. This change of conceptual space means also that ‘snoring’ looses its temporal dimension (Munch & Dessalles, 2014; Munch, 2013). A meaning cannot be contrasted on two different conceptual spaces at the same time. Being now atemporal, the ‘snoring’ situation cannot be matched with ‘in one hour’. The English language allows the atemporal event to shift towards the end of the period introduced by ‘in’.

The loss of temporality due to predication can also be seen in the two following examples.

(9) She intends to drink champagne next year (to celebrate her election)

(10) She intends to drink champagne next year for one hour

In (9), ‘to drink champagne’ has the meaning of ‘to celebrate’ or even, metonymically, of ‘to be elected’. This is a predicative use, where the contrast is ‘drink’ *vs.* ‘not drink’. In (10), temporality is imposed by the mention “for one hour”. The predicative use of ‘drink champagne’ is now excluded. ‘drink’ recovers its concrete meaning of activity and can no longer designate the act of celebrating.

Predication plays a prominent role in the determination of aspect. The phrase ‘to eat cookies’ normally corresponds to a ground, as it refers to a repetitive activity. But in (11), it plays the role of a binary action. This binary nature results from predication: ‘to eat cookies’ is contrasted with its negation (figure 2.4). It has therefore no temporal dimension. For instance, she was supposed to fast, but she broke her vow. Under this binary interpretation, ‘to eat cookies’ is now a figure. This allows the perfective aspect indicated by the present perfect.

(11) I know that she has eaten cookies

As we can see, the contrast operation on which predication relies provokes a change of conceptual space. The resulting situation must be considered as having no duration whatsoever (figure 2.4).

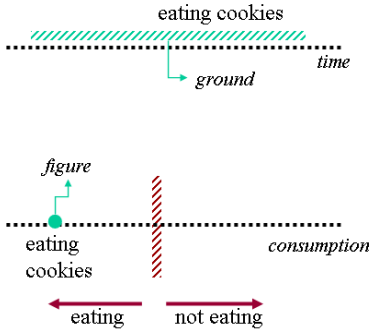

Fig. 2.4. Loss of temporality after contrast. When ‘eating cookies’ is contrasted with its negation, ‘not eating cookies’ (lower diagram), it is no longer a temporal ground (upper diagram), but a figure.

The existence of this mechanism shows that most situations are not by themselves figures or grounds. For instance, activities and states are classically distinguished from achievements and accomplishments (Vendler, 1957). Both accomplishments (to eat the entire cake) and achievements (to sneeze) are systematically regarded as figures (*i.e.* they are perfective), whereas states and activities are systematically supposed to be grounds (they are imperfective). The process of predication through contrast shows, however, that the distinction is not ‘hard-wired’. Any state or activity, once predicated, becomes an atemporal figure. It then behaves as if it were instanta-

neous (figure 2.4). In (12), 'be happy' must be turned into a figure to match the figure introduced by 'in'. Predication does the job, but moves the 'happiness' state to another space, a happiness gradient, where it looses its temporality. As a consequence, (12) cannot mean that her happiness lasted for one month. Only the inchoative meaning is available (to become happy after one month).

(12) She wanted to be happy in one month. (= after one month)

We understand why predication provokes a conceptual space change in these examples. The contrast operation is performed on a conceptual space, which is not the temporal one (figure 2.4). One should not conclude that the output of predication is systematically atemporal. The binary interpretation of (11) is impossible in (13), where 'to eat cookies' must keep its temporal dimension.

(13) I know that she has been eating cookies for one hour

But "eating cookies for one hour" is a ground. It does not match with the figure imposed by the present perfect. Predication can again do the job of turning it into a figure. How? By performing contrast, not on a conceptual dimension, but on duration. The binary distinction that supports predication is now between 'less that an hour' and 'more than an hour'. As a consequence, the propositional attitude in (13) must be toward the temporal extension ('more than an hour'), *e.g.* if eating cookies for that long is a feat. The same phenomenon applies in examples (3), (6) and (10). Note that in (3), the predication of "to eat the entire cake in one minute" is achieved through the converse contrast, this time 'less than one minute' against 'more than one minute'.

2.6 The origin of predicates

The central thesis of this chapter is that there is a fundamental difference between lexical meanings and predicates. Lexical meanings refer to exemplars and prototypes, which belong to conceptual spaces. Predicates, on the other hand, are produced on the fly through a contrast operation. The necessary use of contrast when performing membership judgments contributes to explaining why

the ‘extension’ of lexical meanings in conceptual spaces is found to correspond to convex regions, as observed by Gärdenfors (2000).

This position entails that predicates are exclusively dynamic representations that have no long-term, context-independent existence. This solves the three-interface problem (figure 2.1). Predicates are no duplicates of perception, since they are built on perception when needed. And the fact that predicates are not permanent structures avoids all the paradoxes associated with the LOT hypothesis (Ghadakpour, 2003): absence of correct and complete definitions, holism, grounding problem, monotony of compositionality.

The difference introduced here between meanings and predicates allows us to consider the possibility that we share the former with other animals, but not the latter (Dessalles, 2007). Animals like chimpanzees are perfectly able to learn lexical meanings (Savage-Rumbaugh & Lewin, 1994). There ability to form predicates is however doubtful. Animals can be trained to perform contrasts and to name them on specific dimensions. For instance, a grey parrot (Alex) was able to tell the difference between two collections of objects (Pepperberg, 1999). Alex could say that the two collections differed by their shape or their colour. He could even say ‘None’ when he noticed no difference. This is exactly what our predicative ability allows us to do. Note, however, that Alex’s performance results from hundreds of repetitive exercises and cannot be transferred to new conceptual spaces. It is likely that this performance, which can be reproduced with artificial neural networks, is obtained by statistical selection of relevant dimensions. The claim is not that animals cannot perform complex distinction between objects. They obviously can. But the distinction has no predicative status. The output of contrasts performed by human beings is a new conceptual representation that can be named. Every human being does this spontaneously on any perceptual dimension, without previous training. This ability, universal in our species, seems inexistent in other species.

If this hypothesis is correct, then we must ask what type of function the predicative ability has in our species that it has not in other species. I submitted elsewhere that predication emerged as a device to detect lies and errors (Dessalles, 1998; 2007), and to do it publicly. The ability to contrast what others say with what we saw allows us to name the difference (“What she wrote is too *thin* to be a

book"). In other words, predication would have emerged in the first place because it supports our ability to perform explicit negation. It is perfectly possible to process perception and even to communicate about it without the predicative ability. This is possibly what previous hominin species did if protolanguage, as defined by Bickerton (1990), ever existed. The combination of lexical meanings ("house + neighbour + fire") can be done without any need of predication. However, negation, logical reasoning, comparisons and the expression of attitudes are achieved in our species by means of predicates.

We only considered here predicates with one variable. Though some authors claim that all predicates can be constructed based on one-place predicates (Hurford, 2003), the way events and actions undergo predication is not yet clear from a cognitive perspective. The Gärdenfors (2014) model of events, which involves two entities (agent and patient) and two vectors (one representing the force exerted by the agent on the patient, the other to represent the resulting change), is an interesting step towards an explanation of how complex predicates are dynamically formed. Again, we must draw a clear line between lexical meanings (especially the meaning of verbs), which are prototypes, and predicates, which are built on the fly. The role of the contrast operation in such a process is still unclear.

By distinguishing lexical meanings from predicates, one avoids many of the traditional theoretical difficulties in which fundamental semantics is entangled. The acknowledgment of the dynamic nature of predicates, which are no more than transitory representations, opens the way to new approaches to some semantic phenomena. The case of aspectual properties has been evoked in the preceding section. We need to investigate other dynamic devices that lie at the interface between language, perception and reasoning (figure 2.1) and that allow us to process spatial relations, tense, determination, quantification or modality. The contrast operation, which operates on conceptual spaces, could play a significant role in these future theories.

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