Universiteit Utrecht
Faculteit Geesteswetenschappen
UiL OTS

MA Thesis
Programme: Research Master Linguistics

The Constraints on Space

- An Optimality Theoretic View on Dutch Spatial Prepositions -

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Utrecht, 2012

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Acknowledgements

I want to thank Joost Zwarts for his help with this project. Without his patience, willingness to spend hours and hours discussing the design of space, and his ability to accept my changes of mind and sometimes diverging approach, I would have failed along the way. His enthusiasm and commitment to research into spatial language and concepts in general have been very inspiring and allowed me to get into contact with other researchers working on spatial language. Many thanks also for all the help and guidance to find my PhD project in the domain of categories and concepts, for last-minute phone-calls and for boosting my confidence before the interview.

I want to thank the Max Planck Institute for Psycholinguistics in Nijmegen, especially their Language and Cognition department, for generously making available their field study materials from the Space Stimuli Kit.[1]

I want to thank both my fellow presenters and the audience at the Workshop on Spatial Prepositions in Utrecht in June 2012, for their comments on my project and the stimulating discussions on spatial prepositions in general. I especially want to thank Sascha Morel for all her advice on *boven* and *op*.

I want to thank Henriëtte de Swart for allowing me to be part of her Weak Referentiality Reading Group and the continuous involvement with semantic issues which followed from that. Many thanks also for helping me to prepare my PhD application and interview, and for enabling me to see ways in which to make this thesis as good as possible.

I want to thank all the members and presenters of the Weak Referentiality Group for the stimulating discussions and the many insights I have had thanks to them.

I want to thank Maaike Schoorlemmer for tearing apart my PhD proposal over and over again until I managed to make it perfect, and for providing feedback and encouragement. Many thanks also for organising this MA programme, especially the incredible introduction days.

I want to thank all of my professors at UiL OTS who have nurtured and increased my interest in linguistics and taught me many things.

I also want to thank all of my classmates for two incredible years full of linguistics, cooperation, “hang out in the basement” days and all the parties we have had.

Last but not least I want to thank my friends and family for their unfaltering support and believe in me and my ideas (even though I'm not sure they understood all of them).

[1] The material, regulations on use and additional information can be found at http://fieldmanuals.mpi.nl/volumes/1992/topological-relations-picture-series/.

1 Introduction

Interest in spatial language has a wide and diverse history, ranging from early attempts to characterise the meaning of spatial adpositions (cf. Talmy, 1983, Landau & Jackendoff, 1993) to large-scale cross-linguistic research employing newly developed methods for semantic typology (cf. Levinson & Meira, 2003) and attempts to model spatial meaning in similarity spaces (e.g. Khetarpal, Majid & Regier, 2009), as well as to implement such models into computers and machine learning (see Xu & Kemp, 2010) or develop accounts suitable for use in artificial intelligence (cf. Herskovits, 1986).

The appeal of this domain is its apparent limitation and well-definedness, as opposed to other lexical domains: The extension of spatial language was thought to be limited to easily configurable scenes, and it was believed that the intension ("meaning") of the spatial domain can be characterised using comparatively simple geometrical notions[2] (cf. Herskovits, 1986). Additionally, it was long believed that spatial meaning is encoded exclusively in the closed grammatical class of adpositions (cf. Brala, 2002). Such a clear-cut domain, which is dominant in everyday language and cognition, promises the possibility for deeper insights into the language-thought relation.

Yet cross-linguistic studies have questioned this apparent simplicity in both form and meaning. With the emergence of the results of studies collecting extensive data on how spatial language is encoded in up to twelve mostly unrelated languages (e.g. Levinson & Wilkins, 2006), the assumption that different languages share similar spatial categories, i.e. respect and express the same distinctions, stands in need of revision.

But if different languages have different spatial categories, can the claim of the universality of human spatial cognition survive? That is, given the results of recent cross-linguistic studies, can we still say that all human beings share the same mechanism to conceptualise space? This claim has explicitly been tested by Levinson & Meira (2003), who state that:

> "The domain of topological relations constitutes a coherent semantic space with a number of strong attractors, that is, categories that languages will statistically tend to recognise even if some choose to ignore them.
> (Levinson & Meira, 2003; p. 502)

However, this raises a new question. How can the universality of the spatial domain be accounted for, while at the same time respecting the differences of individual languages? How do this "strong attractors" surface in individual

[2] Though see e.g. Vandeloise (1991) for a functional as opposed to geometrical account.

languages? Levinson & Wilkins (2006) suggest an optimality theoretic account, stating that:

> "These [cross-linguistic] patterns [of spatial language] are sometimes quite abstract - they may, for example, take the form of an underlying hierarchy, which may determine splits in the coding of different kinds of spatial scenes, but will not predict [...] the type of coding itself [...]"
>
> (Levinson & Wilkins, 2006, pp. 512 / 513)

And further:

> "One can imagine a feature-optimizing account along Optimality Theory lines [...]"
>
> (Levinson & Wilkins, 2006, p. 515)

In the following, I will therefore attempt to answer this question of universals vs specifics by applying to the spatial domain Optimality Theory, a linguistic theory specifically designed to account for individual languages' differences based on a set of universals.

In section 2, I will give an overview over research into spatial language, specifically into the features and distinctions that have been suggested to be responsible for the formation of categories of spatial language. I will also present my own feature decomposition of a number of spatial pictures used by (field-) researchers worldwide, the Topological Relations Pictures Series (Bowerman & Pederson, 1992). This Series will also form the basis of my analysis presented later. In section 3, I will summarise the origins of Optimality Theory in phonology, and how it was extended into a number of other linguistic disciplines. Section 4 contains my analysis of spatial language. Due to limits in time and resources, I will focus mainly on Dutch as an example of how spatial universals surface in an individual language, although as further proof for my universals, cross-linguistic comparisons are drawn on where possible and further predictions are made. It is important to keep in mind that the analysis I present is designed to be able to explain the coding of spatial meaning in all languages, not just in Dutch and the handful of other languages for which I found some data. This is possible not only through the technicalities of Optimality Theory, but also because my analysis is based on a conceptual, pre-linguistic and, as I claim, universal decomposition of spatial meaning, which will be introduced in section 2.

A quick note on my notation: I use italics for *terms* of any language, with the exception of translations of *non-English terms* (which will be in parentheses). Italics are also used to paraphrase spatial situations such as *cup on table*. Most of the situations I discuss in this paper also exist as pictures and can be found in the Appendix in 6.1.3. I use single quotation marks for 'attributes' and 'values'. Double quotation marks, in case they are not used to mark a citation, are used to refer to "non-standard terms", expressions that I use because they are closest to what I want to say, yet that have not been established, i.e. not given an academic definition.

2 Research into Spatial Language

Spatial language as such is in fact a rather large domain, containing everything from static locative constructions to frames of reference and motion. I will limit myself to static locative uses, i.e. the relation between two static objects: the reference object (the Ground) and the to-be-situated object (the Figure).

Even in this limited domain, a relatively vast number of attributes are at work for defining spatial categories. Their number far exceeds the early suggestions concerning spatial primitives. This is so because spatial primitives are rather coarse-grained versions of the attributes, and are said to be encoded directly in individual spatial prepositions. For example, 'inclusion' is usually said to be the sole primitive corresponding the English preposition *in*. In accounts such as that of Feist (2000), these primitives are broken down into more fine-grained attributes. In the case of e.g. 'inclusion', it is not only of relevance that there is inclusion of one object by another, but also which entity is included, if it is completely or only partially included, the type of inclusion, loose or tight fit, etc.

In this section, I will first give a summary of relevant work concerning features of spatial categories, and then present my own work on this matter. The terms *attribute* and *feature* can in principal be used interchangeably in this paper. I try to stay faithful to the respective authors' terminology, and when concerned about my own work to use only the term *attribute* because I will present a so-called attribute-value structure. But this is not a rule, and whenever either the term *feature* or the term *attribute* is used, they essentially mean the same thing.

2.1 Spatial Features

Due to the necessity of investigating individual languages more closely, as well as the efforts involved in both collecting and analysing a large sample of cross-linguistic data, many approaches to identify relevant spatial features have started out by focusing on only one language. Cuyckens (1991) was one of the first to give a thorough treatment of (some) Dutch spatial prepositions. His account is based on the family resemblance theory, first formulated by Wittgenstein (1953). According to family resemblance, concepts always share some, but not all features, much like members of a family. In a family, some members might share the shape of the nose, others the colour of the eyes, but seldom do two family members look exactly the same. Cuyckens focuses on the prepositions *op* (on), *aan* (on) and *tegen* (against), identifying 'coincidence' as the main feature shared by all three prepositions. That is, all three prepositions require that the Figure and the Ground touch. They differ, however, with respect to the nature of the contact and some additional features. For the use of *op*, the nature of the contact must be such that a great part of the surface of the Figure object is in contact with the Ground object, as in e.g. the situation in picture 3 (cf. Appendix 6.1.3): *de postzegel op de brief* (the stamp on the letter). Additionally, *op* expresses 'support', as in picture 1, *het kopje op de tafel* (the cup on the table), where the weight of the Figure is supported by the Ground. The additional feature required for the use of *aan* is 'attachment'. Consequently, the nature of the contact in case of *aan* is restricted to one (or several) points of the Figure and the Ground, mostly via a mediating entity like a nail or a knot. In e.g. picture 20, *de ballon aan de stok* (the balloon on the stick), the balloon is attached to the stick via a knot, which is also the mediating entity for the contact between the two objects. The nature of contact in case of *tegen* is described as "casual contact". That is, the Figure is neither fully supported by the Ground, nor attached to it. In e.g. picture 58, *de ladder staat tegen de muur* (the ladder stands against the wall), the ladder is not only supported by the wall, but also by the ground on which it stands.

Cuyckens account has been revised by Bowerman (1996) and Beliën (2002), who both try to attribute the differences between the two prepositions *op* and *aan* to a single feature: the force dynamics at work on the Figure and the Ground in a given situation. Bowerman focuses on whether there is a force that operates to pull Ground and Figure apart. In cases like in e.g. picture 1, *het kopje op de tafel* (the cup on the table), where there is no (overt or covert) force pulling the two objects apart, the situation is conceptualised as stable and *op* is used. In cases such as picture 20, *de ballon aan de stok* (the balloon on the stick), where a force is operating to separate the two objects, and the Figure needs to be attached to the Ground by e.g. a nail, string or glue, *aan* is the preposition of choice. The force that operates to pull the two objects apart is mostly gravity, but can also be e.g. the wind. If the balloon were not tied to the stick, it might fall to the ground (gravity) or be blown away (wind).

Beliën, on the other hand, gives an explanation focusing on the source of the force pulling the two objects together (not apart, as in Bowerman's account). The force dynamics determining the use of *op* have their source in some property of the Figure (e.g. its being higher than the Ground or having some sort of adhesive property). For example, in picture 1, *het kopje op de tafel* (the cup on the table), gravity can operate to pull Figure and Ground together because the Figure is higher than the Ground. *Aan* is used when the source of the force working to keep Figure and Ground together cannot be found in either the Figure or the Ground. For example, in picture 20, *de ballon aan de stok* (the balloon on the stick), the "force" that keeps Figure and Ground together is the knot tying the balloon to the stick. This knot remains crucial to keep the two objects together, no matter how the balloon (the Figure) is orientated towards the stick (the Ground). Beliën also includes *tegen* into her account, claiming that this preposition is used when there are no forces operating on either of the objects, when there is no "sticking" of the Figure to the Ground. In e.g. picture 58, *de ladder staat tegen de muur* (the ladder stands against the wall), the Figure is not wholly supported by the Ground, it therefore can be said to "stick" to it less than a cup would stick to a table (in picture 1): If one moves the table, the cup moves along with it; but if one could move the wall, the ladder would simply fall over and not move along. This is close to the account of Cuyckens, who also says that "tegen-situations" are characterised by an absence of features, 'support' and 'attachment' in his story.

Brala (2002) develops an account of the meaning structure of the closed class of adpositions, based on Bowerman's (1992) work on the spatial categories forming the English prepositions *on* and *in*, and on Vandeloise's (1991) model of 'control'. Instead of taking into consideration the geometry of a spatial situation, Brala takes a functional perspective: Prepositions sort spatial situations into categories according to the function of the feature 'control', i.e. how the Ground controls the location of the Figure. All other features merely serve to further distinguish instances of 'control'. In cases like e.g. picture 2, *apple in bowl*, the Ground (the bowl) controls the location of the Figure (the apple) in more than one direction. The Ground surrounds the Figure, it limits its possible locations downwards and sidewards. Control in more than one direction is therefore 'containment'. Control in the vertical axis corresponds to 'support'. In e.g. picture 1 (*cup on table*), there is direct control in that the table (the Ground) directly controls the location of the cup (the Figure) on the vertical axis, by virtue of its being underneath the Figure. In picture 44, *painting on wall*, on the other hand, the control of the Ground over the location of the Figure on the vertical axis is not direct, but exercised via an intermediary entity, the nail holding the picture on the wall.

All of the above accounts have been limited to only a few spatial features and a few spatial terms in a few languages. And while all make a good point about the structure of spatial language in the domain to which they are restricted, these accounts face problems when extended to other terms, other languages or other situations. As Levinson & Meira (2003) show, making use of the Topological Relations Pictures Series, languages differ quite a lot in how they categorise spatial scenes. The extent of language variation in the spatial domain shows that there cannot be just a few spatial features, but that there are many from which languages make selections in particular ways. Any analysis that focuses on only one feature, no matter how well it works for explaining one language, will therefore not be able to account for the range of data observed cross-linguistically.

Yet it is precisely that which is desirable, to formulate a theory that can account not only for a few terms in a few languages, but systematically explains how perceptually universal features structure spatial categories in separate, largely unrelated, languages.

Feist (2000) provides such an extended approach to spatial language. Based on both cross-linguistic comparisons and the results of a detailed experimental study of the English prepositions *on* and *in*, she provides a list of features that are both functional and geometrical in nature and that serve as the basis for spatial categories in a number of languages:

> "verticality, higher entity, contact, inclusion, bigger entity, control by Ground, animacy, functional relation, support by"
>
> (Feist, 2000; p.94)

Based on the above list, Feist systematically identifies the features relevant for a number of spatial scenes and shows how they interact in building up the lexical entries for spatial terms. In doing so, she uses a certain internal "geometry" of features, which requires treating the features listed above as attributes that take a set of values. This kind of feature structure is explained in some detail by Smith et. al. (1988). Working on the modification of noun concepts, Smith et. al. define an attribute as comprising a set of values. As an example, they list the attribute 'colour' which is part of the concept denoted by the common noun *apple*. The attribute consists of the values 'red', 'yellow', 'green', etc. All apples are specified for the attribute 'colour', but the values differ from apple to apple. Part of our knowledge of apples is what values they can take for the attribute 'colour'.

Applied to the spatial domain, this means that not only the attributes of spatial categories need to be found, but also the specific values they can take. That is, if I identify e.g. 'direction of support' as an attribute relevant to describe spatial scenes, I also need to specify from which direction the support can come: from above, from below, etc. Feist does exactly that with her list of attributes. 29 pictures, partially taken from the Topological Relations Pictures Series, partially from elsewhere, have been given a value for every one of the attributes listed above. This is a powerful tool in analysing spatial language. By putting those pictures together that have been described by the same term in a given language, one can now infer the attribute-value structure of that term. In this way, it is possible to derive the structure of spatial categories in any language that can be used to describe the pictures.

My own work on spatial features is to a high degree influenced by that of Feist, though I extended both the number of spatial scenes as well as the number of attributes and values. I will use all of the 71 pictures of the Topological

Relations Pictures Series, because I will take this Series as a coherent set of conceptually universal spatial scenes which include all major distinctions between basic spatial configurations. Due to the greater variation present in this greater number of pictures, I was in need to also extend the number of attributes and values: By evaluating the conceptual distinctions between the pictures, the necessity of a more detailed attribute-value structure to express these distinctions became apparent.

2.2 A Feature Decomposition

In this section, I will introduce my own decomposition of spatial situations.

Cross-linguistic work (e.g. Levinson & Wilkins, 2006; Feist, 2000) has shown that languages differ sometimes quite a lot in the attributes they code in spatial expressions. Any account limited to only one language will therefore inevitably fail when extended to other, unrelated languages. My concern, as laid out in the introduction above, is to offer an explanation as to how the claim of a universal spatial cognition can survive this cross-linguistic evidence.

The function of the decomposition below is therefore two-fold: First, to offer all attributes that might be of importance in any language (so as to avoid the draw-backs of the language specific approaches presented above), and second, at the same time, to come up with purely conceptual distinctions of the situations shown in the pictures of the Topological Relations Pictures Series. These purely conceptual distinctions I take as the universal building blocks of spatial language, the cognitive or perceptual foundations all human beings share.[3]

Since there simply is no data on spatial expressions and the kind of distinctions relevant in all the languages world-wide, my selection of attributes needs to compensate for that. The sources of my attributes, as presented below, therefore serve both the cross-linguistic and the conceptual function of my decomposition.

Attributes and Values The decomposition is based on the 71 pictures of the Topological Relations Pictures Series (see the Appendix in 6.1.3): For every picture, I specify the values of a number of attributes.

The attributes I use have two sources: They are influenced by the work presented in section 2.1, first and foremost by the work of Feist (2000), whose above list of attributes I have taken as a starting point. But also by e.g. Cuyckens (1991), and to an extent also by Herskovits (1986), who provides interesting

[3]Should some of my attributes be found to not matter for any language (and in fact there seems to be evidence that some of them don't), this would make an interesting statement about the kind of differences in spatial configurations that we can perceive, versus the kind of differences in spatial configurations that we express in language.

examples out of what she calls the "normal situation types" and deviations from that. For example, Herskovits discusses the use of the English preposition *on* in a situation where a book lies on a table versus a situation where a book lies on a brick stone which in turn lies on a table. In English, both situations are described by *on*, but there is undeniably a conceptual difference, which I worked into my decomposition. Wherever below I present an idea that was directly influenced by the work of one of the authors presented above, I will make a short reference to the respective publication. Some of these ideas, however, appear in a reduced or somewhat adjusted form.

The second source of attributes is the need to distinguish the spatial situations from each other. My aim was not to provide a unique classification for every picture, but to evaluate them conceptually, to work out the systematic differences between them. This I did in the hope that it allows the decomposition to be as conceptually universal as possible, but also to compensate for the lack of data on spatial expressions and the distinctions relevant in all the languages world-wide. This second "source" of attributes is based on my assumption that the Topological Relations Pictures Series offers a coherent set of spatial situations, covering all basic configurations. This might not be the case, at least not entirely. Yet I trust on the Series use to collect spatial data world-wide and the authors' familiarity with spatial features, as well as their constant updating of the Series, to lend enough authenticity to the claim that the Series covers the basic set of spatial configurations. I have therefore formulated as attributes all the distinctions that serve to distinguish one picture from another, making the list as exhaustive as possible.

The values I assigned to the attributes are inspired by the 71 pictures themselves. For each attribute in each picture, I specified the value that best describes the scene. The set of values making up an attribute is thus largely provided through the situations shown in the pictures. However, some of the logically possible values for attributes don't come up in Bowerman's and Pederson's sample of spatial scenes. To test if such a "missing" value is a "real" value (and not one that is only theoretically possible without practical relevance), I give examples of my own. For instance, there is no picture in the Topological Relations Pictures Series where both the Figure and the Ground are animated, so I provide the example *man on horse* (both a man and a horse are animated). If it were not possible to think of a situation where both objects are animated, then I would take this as proof that such a situation does not exist. The attribute 'animacy' could then never take the value 'both' (both Ground and Figure are animated) to characterise a spatial scene.

The choices for the values are not always unequivocal. In cases of ambiguities, I always chose the value that is most relevant. For example, in *shoe on foot* (picture 21), it is relevant that a shoe is in contact with the sole of the foot, not the sides (think of e.g. flip-flops or sandals). I therefore specified the region of contact as the sole of the foot (i.e. 'underneath'), not the side.

The attributes fall into two rough classes: attributes relating to either Figure or Ground individually (section 2.2.1), and attributes relating to the topological relationship between Figure and Ground (section 2.2.2). Below I list the attributes and their values with examples and short explanations and comments, designed to help comprehend my motivation behind this particular attribute-value structure. The examples that are taken from the Topological Relations Picture Series are marked with the number they have in the original material in Bowerman & Pederson. All pictures from the Series can be found in the Appendix in 6.1.3. The examples I provide myself to account for "missing" values are marked with xx (and can also be found as pictures in the Appendix 6.1.3).

2.2.1 Figure and Ground Attributes

Table 1 lists all the attributes relating to the orientation, form, function, integrity and animacy of Figure and Ground, their values and examples.

Attribute	*Value*	*Example*
Orientation Figure	axis vertical	cup on table (pic01)
	axis horizontal	papers on spike (pic22)
	axis tilted	box in bag (pic14)
	axis variable	apple in bowl (pic02)
Orientation Ground	axis vertical	apple in bowl (pic02)
	axis horizontal	cup on table (pic01)
	axis tilted	man on ladder (xx)
	axis variable	stamp on letter (pic03)
Spatial Form Ground	3D	cup on table (pic01)
	2D	stamp on letter (pic03)
Spatial Form Figure	3D	cup on table (pic01)
	2D	stamp on letter (pic03)
Chemical Form Ground	liquid	ship on water (pic11)
	gas	man next to fire (pic38)
	solid	cup on table (pic01)
	soft solid	hair on butter (xx)
Chemical Form Figure	liquid	raindrops on window (pic38)
	gas	cloud over mountain (pic36)
	solid	cup on table (pic01)
	soft solid	butter on knife (pic12)

Degree of Functional Intention Ground	made for the Figure	dog next to doghouse (pic06)
	made for a Figure	cup on table (pic01)
	none	ribbon on candle (pic04)
Degree of Functional Intention Figure	made for the Ground	stamp on letter (pic04)
	made for a Ground	ribbon on candle (pic04)
	none	cup on table (pic01)
Negative Space	neither	cup on table (pic01)
	Ground	finger through hole (xx)
	Figure	hole in towel (pic18)
Integrity Impaired	neither	cup on table (pic01)
	Ground	apple through arrow (pic30)
	Figure	papers on spike (pic22)
Natural	neither	cup on table (pic01)
	Ground	hose around tree stump (pic55)
	Figure	apple on stick (pic70)
	both	tree on hill (pic65)
Animated	neither	cup on table (pic01)
	Ground	necklace around neck (pic51)
	Figure	owl in tree (pic67)
	both	man on horse (xx)

Table 1: The attributes, values and examples relating to orientation, form, function, integrity and animacy of Figure and Ground

Concerning the attribute 'orientation' The axis of the Figure and the Ground can be classified as 'horizontal', 'vertical' (cf. Feist, 2000) or 'tilted' if it is temporally or permanently fixed. The axis is 'variable' if it is not fixed. The axis is mostly taken to be the functional axis of an object (e.g. bookshelves in their canonical function are horizontal). For animated entities, i.e. potentially moving entities, axis is also specified because of the conceptual difference between e.g. *dog lies in basket* (horizontal) and *dog sits in basket* (vertical). For some entities, axis is irrelevant, such as *writing on shirt* (picture 68). For the relation between the writing and the shirt itself, it doesn't make much of a (conceptual) difference if the shirt is worn (vertical) or lies folded in the wardrobe (horizontal). In these cases, the axis is also defined as 'variable'. This attribute is about the absolute position or orientation of the Ground and the Figure, not about the relative position of Ground and Figure towards each other, which is part of the Figure-Ground relationship and is listed below.

Concerning the attributes relating to the form of Ground and Figure The spatial form of both Figure and Ground can be either in 2D for flat items as in *stamp on letter* in picture 3, or in 3D. The chemical form can be 'liquid', 'gas' or 'solid'. "Mass noun" Figure or Ground that are neither liquid, gas nor (hard) solid are specified as 'soft solid' (e.g. butter). Negative spaces can be specified for both 2D or 3D for the attribute 'spatial form', depending on the spatial form of the object they are part of (e.g. *hole in towel* (picture 18) is 2D and *crack in cup* (picture 26) is 3D). The attribute 'chemical form' does not apply to negative spaces and is always set for n.a.

Concerning the attributes on function A Ground is made for **the** Figure if its intended function applies only to instances of this specific kind of Figure (e.g. a flag mast is made for a flag and nothing else). A Ground is made for **a** Figure if its intended function applies to all kinds of Figures (e.g. a bowl is made for fruit, sweets, salads, etc.). A Ground has no functional intention if it isn't made for any kind of Figure. The same distinctions apply to Figure; a Figure can be made for **the** Ground, for **a** Ground or have no functional intention. This attribute only applies to man-made objects. Nature is not considered as an intentional agent, non-man-made objects like trees and hills are therefore not understood as serving a function.

What is encoded in this feature is the degree of A being made for B, not of B requiring A. In *dog in doghouse* in picture 71, the doghouse is made for the dog (Ground made for the Figure), but the dog doesn't require the doghouse (no functional intention Figure). The degree of functional intention is always specified with respect to the specific situation (cf. Feist, 2000). In the *cup on table* scenario in picture 1, the cup is said to have no degree of functional intention because it is not made to be set on tables, it is made to hold liquid.

Concerning the attributes 'negative space' and 'integrity impaired' These two attributes are partially dependent on each other. If one object is a negative space, then the integrity of the other is impaired, given it is part of the explicit constellation. For example, in *hole in towel* in picture 18, the hole is a negative space and therefore the integrity of the towel is impaired.

There are also instances where neither object is a negative space, but where nonetheless the integrity of one or the other is impaired, as in *papers on spike* (picture 22). Note, however, that in this case there is also a negative space involved (the hole in the paper that is made by the spike). But this negative space is not part of the Figure-Ground constellation to which is explicitly being referred[4], it therefore doesn't come up as a value in the feature specification.

In examples such as *owl in tree* in picture 67, there is a fusion of the tree with a negative space, a hole (which is not explicitly marked), to form the Ground. This is a "complex" Ground, in that there are three instead of two entities involved. In *hole in towel*, we have the hole as the Figure (negative space) and the towel as the Ground (impaired integrity). This would correspond to *hole in tree* (Figure is a negative space, Ground has impaired integrity), or maybe *owl in hole* (Ground is a negative space). But in the case of *owl in tree*, we have three "objects": owl in hole in tree. I treat this "complex" Ground (hole in tree) as one entity. That means that the features for Ground in *owl in tree* are 'impaired integrity' but not 'negative space', because that is not explicitly being referred to.[5]

The attribute 'chemical form' is always set to n.a. in the case of a negative space. The attribute 'spatial form' for the negative space always corresponds to the spatial form of the carrier, i.e. the entity whose integrity is impaired; therefore, in *crack in cup*, the spatial form of the negative space is 3D, because the cup is in 3D, and in *hole in towel* it is 2D.

Concerning the attributes 'animacy' and 'naturalness' 'Animated' applies to all entities that are intentional agents, i.e. humans and animals (cf. Feist, 2000). 'Natural' applies to all natural things, i.e. everything that is animated but also plants, flowers, fire, earth, water, air, etc. The attribute 'natural' is needed in order to distinguish between man-made and non-man-made (natural) objects. If something is animated, it is therefore always also natural. But entities can be natural without being animated.

2.2.2 Attributes of the Relation between Figure and Ground

Table 2 lists all the attributes relating to contact, support and inclusion of the Figure and Ground objects, as well as their relative orientation and size.

Attribute	*Value*	*Example*
Quantity Contact Ground	none	dog next to doghouse (pic06)

[4]Given only the pictures, there is of course no way to really say what is explicitly being referred to. There might well be a language which somehow takes into account the negative space in *papers on spike*. But since all the literature focuses on binary Figure-Ground relations, I will assume that only the specifically marked objects, the papers and the spike in this case, are part of the relation.

[5]Again, given only the pictures it is hard to tell what is explicitly being referred to. This case is similar to *papers on spike*, where I take the negative space also not as part of the explicit Figure-Ground constellation.

	partial	cup on table (pic01)
	full	shoe on foot (pic21)
Height Contact Position Ground	underneath	spider on ceiling (pic07)
	bottom	apple in bowl (pic02)
	side	ribbon on candle (pic04)
	back	wall behind poster (xx)
	on top	cup on table (pic01)
	variable	stamp on letter (pic03)
In/Out Contact Position Ground	outside	cup on table (pic01)
	inside	apple in bowl (pic02)
	interior	arrow through apple (pic30)
Quantity Contact Figure	none	dog next to doghouse (pic06)
	partial	cup on table (pic01)
	full	book on shelve (pic08)
Height Contact Position Figure	underneath	cup on table (pic01)
	bottom	balloon on stick (pic20)
	side	ribbon on candle (pic04)
	back	phone on wall (pic25)
	on top	apple on branch (pic27)
	variable	laundry on line (pic37)
In/Out Contact Position Figure	outside	cup on table (pic01)
	inside	ribbon on candle (pic04)
	interior	papers on spike (pic22)
Attachment	yes	clothpin on line (pic33)
	no	cup on table (pic01)
Temporal Manner	temporal	ribbon on candle (pic04)
	permanent	stamp on letter (pic03)
Supported Entity	Ground	spoon under cloth (pic24)
	Figure	cup on table (pic01)
	independent	lamp over table (pic13)
	reciprocal	card against card (in card-house) (xx)
	neither	dog next to doghouse (pic06)
Quantity of Support	full	cup on table (pic01)

	partial	spoon under cloth (pic24)
Direction of Support	from below	cup on table (pic01)
	from above	spider on ceiling (pic07)
	from same level	phone on wall (pic25)
	from around	box in bag (pic14)
	from inside	ribbon on candle (pic04)
	depends on axis	stamp on letter (pic03)
Manner of Support	direct	cup on table (pic01)
	indirect	fish in bowl (pic32)
Included Entity	Ground	ribbon on candle (pic04)
	Figure	apple in bowl (pic02)
	neither	cup on table (pic01)
Type of Inclusion	core	papers on spike (pic22)
	wrapped	ribbon on candle (pic04)
	convex hull	apple in bowl (pic02)
Quantity of Inclusion	full	apple in bowl (pic02)
	partial	ribbon on candle (pic04)
Container/Containee	yes	box in bag (pic14)
	no	ring on finger (pic10)
Accessibility of Included Entity	change in container	shoe on foot (pic21)
	no change in container	apple in bowl (pic02)
Relative Vertical Position	Ground completely higher	spider on ceiling (pic07)
	Ground partly higher	dog next to doghouse (pic06)
	Figure completely higher	cup on table (pic01)
	Figure partly higher	hat on head (pic05)
	same level	balloon on stick (pic20)
´	inclusion	apple in bowl (pic02)
	depends on axis	stamp on letter (pic03)
Horizontal Extension	overlapping	ribbon on candle (pic04)
	depends on point-of-view	dog next to doghouse (pic06)
	Ground one side	railing on staircase (xx)
	Ground both sides	cup on table (pic01)
	Figure one side	cigarette in mouth (pic39)
	Figure both sides	papers on spike (pic22)
Relative Size	Ground bigger	cup on table (pic01)
	Figure bigger	jacket on hook (pic09)
	equivalent	hat on head (pic05)

Part-Whole Relation	yes	roof on house (pic60)
	no	apple in bowl (pic02)
Controlling Entity	neither	dog next to doghouse (pic06)
	Ground full	cup on table (pic01)
	Ground partly	cloth over spoon (xx)
	Figure full	strap on bag (on arm) (xx)
	Figure partly	spoon under cloth (pic24)
	both	arrow through apple (pic30)

Table 2: The attributes, values and examples relating to contact, support and inclusion of the Figure and Ground objects, as well as their relative orientation and size

Concerning the attributes relating to contact The place where Figure and Ground touch is defined in two ways: the height of the place of contact on the objects and whether the contact is on the outside, the inside or the interior. The difference between 'inside' and 'interior' is that between e.g. an apple in a bowl and a nail in a fence. The nail is in the true "stuffing" of the fence, i.e. surrounded by the fence's physical material. The apple, on the other hand, is in the convex hull created by the bowl, i.e. the space created by the shape of the bowl (cf. Herskovits, 1986; Cohn & Renz, 2007), not its material. This distinction will also be relevant for the attributes relating to inclusion.

The values 'bottom' and 'back' in the height position attributes are understood in a functional way, i.e. relative to the respective object's frame of reference. For example, in *phone on wall* (picture 25), the part of this rather old-fashioned phone that is in contact with the wall is its back, if the side with the dials is taken to be the front. The attributes of height position are defined as 'variable' in cases of "mass" entities (e.g. *butter on knife*, picture 12) and "through" cases (e.g. *apple through arrow*, picture 30). If the value is set to 'side', no distinction is being made between higher or lower on the side.

The quantity of the contact is always defined with respect to the "place involved" (i.e. the value of the attribute 'height position contact'). That is, if we are dealing with a table in e.g. *cup on table* in picture 1, it is only part of the involved surface of the table (the upper surface) that is in contact with the Figure. But if we are dealing with *tablecloth on table* as in picture 29, it is the full upper surface of the table which is in contact with the Figure, albeit not the whole table.

The attribute 'attachment' is specified positive for man-made objects when they are intentionally put together, i.e. through a mediating entity such as a knot, glue, a nail, etc. (cf. Cuyckens, 1991). For natural objects, attachment is specified positive when the objects are joined together or attached (as in e.g. *tree on hill* in pictures 17 and 65) as opposed to separate (as in e.g. *owl in tree* in picture 67). For both natural and man-made entities, attachment can be temporal (e.g. *fruits on tree* in picture 45 and *clothpin on line* in picture 33) or permanent (e.g. *tree on hill* or *roof on house* in picture 60). If this feature is set for permanent, it can be independent of the status of attachment only if the two objects are in a part-whole relation as in *face on stamp* (picture 28). According to my definition, objects in a part-whole relation are not attached to each other (attachment only holds between two "independent" objects).

Concerning the attributes relating to support Support has a quantity ('full' or 'partial') and a direction. Additionally, it has a manner, which can be direct or indirect (cf. Herskovits, 1986). Most cases of support are direct. Support is indirect if there is an entity that is supported by the Ground/Figure and which in turn supports the Figure/Ground, e.g. *fish in water in bowl* = *fish in bowl* or *cup on book on table* = *cup on table*.

The supported entity is the Figure or the Ground. The support usually comes from the other entity, but it can also be independent, as in *lamp over table* (picture 13), where it is provided by an entity outside the Figure-Ground constellation (the ceiling in this case). It may also be that Figure and Ground support each other in a reciprocal manner as in *card against card* in a card house. In principle, the *setting strap on back* is also reciprocal. The strap supports the bag if it's hanging from someone's shoulder. But the bag supports the strap if it's sitting on the table. The attribute in picture 66 (*strap on bag*) is set for the Figure being the supported entity, as in this case the bag (Ground) sits on the table and therefore supports the strap (Figure).

Concerning the attributes relating to inclusion Inclusion can be of either Ground or Figure, and it can be partial or full.

The type of inclusion is a three-fold attribute. If it is set for 'core', this means that the included entity is inside the "stuffing", the physical material of the "includer", e.g. a nail in a fence or a knife in the butter. In this case, the contact attribute 'in/out position' is set for 'interior' (see above). If the type of inclusion is set for 'wrapped', this means that the including entity is wrapped tightly around the included (e.g. a tight fit, Bowerman & Choi, 2001), but there is no inclusion in the actual material. If the type of inclusion is set for 'convex hull', the included entity is contained within the space created by the "includer", as in *house in fence*, *fish in bowl*, etc. In case of these last two values, the contact attribute 'in/out position' is set for 'inside' (or not at all, if there is no contact, as in *house in fence*).

The inclusion can be of a container/containee relation, i.e. a conventional, functional relation. In this case, the attributes relating to function (see above) must be set positive for at least one object (Figure or Ground). This attribute does not apply to non-man-made objects. If the relationship is one of container/containee, the attribute 'accessibility of included entity' applies. It can take two values: one where the state of the container needs to be changed in order to access the containee, as in a box that is sealed and needs to be opened; and one where the state of the container does not need to be changed in order to access the containee, as in a fruit in a bowl.

Concerning the attributes related to relative orientation, size and control The relative vertical position of Figure and Ground is defined with respect to the vertical axis (i.e. direction of gravity). Thus Figure and Ground can be on the same level of that axis, one can be partially higher in that the upper part of one is still on the same level as the lower part of the other, or one can be completely higher, so that no parts are on the same level any more (cf. Feist, 2000). The attribute is set for 'inclusion' if one entity is surrounded by the other, as in e.g. *fruit in bowl* (picture 2), so that none of the "next to each other" values apply. Sometimes entities can be conceptualised as being next to each other, but the axis of the entities is variable, so that they can also be conceptualised as being atop of each other, as in e.g. *stamp on letter* in picture 3. This means they cannot satisfactorily be described with respect to the general vertical axis of gravity, because their position towards that axis is variable. In this case, the value is 'depends on axis'.

The attribute 'horizontal extension' is meant to capture something like the curvature of the objects, which object stretches out to the side of which object, or which object "sticks out" from the other. The values can be 'overlapping', if there is no extension of either object in the horizontal direction (as in *ribbon on candle* in picture 4); or 'depends on point of view' if it cannot be clearly said which object exceeds the other on the horizontal dimension, (as in *dog next to doghouse* in picture 6, where the dog can be hidden behind the doghouse or, if one walks around, be seen sitting next to it). The other values are: 'Ground one side', where the Ground object exceeds the Figure object on one side (as in *railing on staircase*, for which no picture is available, with the railing only being on one side of the staircase); and 'Ground both sides', where the Ground exceeds the Figure on both sides (as in *cup on table* in picture 1, with the table stretching out from both sides of the cup)[6]; and respectively for Figure 'Figure

[6]In some of the situations for which the horizontal extension is set for 'Ground both sides',

one side' and 'Figure both sides'. In order to make this overview more coherent, I repeat here the relevant parts of Table 2 above.

Attribute	Values	examples
Horizontal Extension	overlapping	ribbon on candle (pic04)
	depends on point-of-view	dog next to doghouse (pic06)
	Ground one side	railing on staircase (xx)
	Ground both sides	cup on table (pic01)
	Figure one side	cigarette in mouth (pic39)
	Figure both sides	papers on spike (pic22)

Table 3: Values and examples for the attribute 'horizontal extension', repeated from Table 2.

Horizontal here always refers to the functional orientation. That is, if a book were to be glued to a board and the board then put sideways, I would still classify it as a horizontal extension of the Ground on both sides, even though the way it is currently set up would be a vertical extension of the Ground on both sides.

The attribute 'horizontal extension' is partly dependent on the attribute 'type of inclusion'. If the type of inclusion is set for 'convex hull' (as in *apple in bowl* in picture 2), the including object extends to both sides of the included. The bowl in *apple in bowl* stretches out around the apple. If the type of inclusion is set for 'wrapped' (as in *ribbon on candle* in picture 4), there is an overlap of both entities. The ribbon in *ribbon on candle* ends at the same point as the candle on both the left and the right side (at least in a tight fit as in picture 4).

The attribute 'horizontal extension' is always set with respect to what "matters". That is, in *handle on cupboard door* in picture 61, the value is 'Figure one side', because what matters is that the handle sticks out, can be grabbed and used to open the door; and not that the material of the door stretches to both sides from the handle (which corresponds to the value 'Ground both sides').

The relative size of Ground and Figure is set for which is bigger (cf. Feist, 2000), unless Ground and Figure are equivalent in size.

If two entities are in a part-whole relation is not always that clear. I take negative spaces to always be in a part-whole relation with the "non-negative" entity. For the question *apples on branch* (picture 27) versus *leaves on branch* (picture 41), I take the latter to be a part-whole relation, not the former. The reasons are mainly intuitive: There are no branches without leaves (except dead ones), but there are a number of branches without apples, or without fruits, if we

the Ground does in fact not only exceed the Figure on both sides (left and right from the speaker's position), but on all sides. In *apple in bowl* in picture 2, for example, the Ground pretty much surrounds the Figure. I will take the value 'Ground both sides' to include all scenes where the Ground exceeds the Figure object on more than one side. Whether that are two sides or more will then be determined by the attributes relating to inclusion.

think of various bushes with a variety of fruits in different sizes and colours, or of plants that have branches and leaves but never any fruits. The same reasoning holds for *tree on hill* (pictures 17 and 65), because there are hills without trees. Trees are apparently not per default a part of hills.

The attribute ‘control’ matters if we have some form of support or inclusion, so that one entity “controls” the location of the other (cf. Feist, 2000; Brala, 2002). The question of if there is control by one entity over the other, and if so, which entity controls which, can be checked for in two ways. One way is to imagine moving one object and then either the other is being moved as well (control) or not (no control): A mat controls the location of the cat on it in that if I pull the mat, the cat will also move (even if it doesn’t get up). But control can also be tested for by imagining one object were to dissipate into thin air. Then the other object would either remain in the same place (no control) or change location (control): A hill controls the location of a tree on it in that if the hill weren’t present, the tree would be closer to the ground.

The attribute ‘attachment’ does not matter for the attribute ‘control’, i.e. there can be control of one entity over the other without the entities being attached. Both a branch controls the location of an apple (attached) and a table controls the location of a cup (not attached). There can also be reciprocal control as in *arrow through apple* in picture 30. Clearly, one can grab either and thereby also move the other, assuming that we are talking about a tight fit and not a loose fit (cf. Bowerman & Choi, 2001).

2.3 Interim Summery I

In this section I have presented work on spatial features, i.e. on the meaning aspects or properties of spatial language and perception. I have summarised accounts of spatial features that focus on one language only, primarily on Dutch (e.g. Cuyckens, 1991), and cited work on semantic typology that shows that these accounts cannot easily be stretched to explain cross-linguistic data (e.g. Levinson & Wilkins, 2006). I have given an overview over research trying to systematically identify the features at work in cross-linguistic categorisation (Feist, 2000). I have cited considerations of some complex examples (Herskovits, 1986). I have also repeated an approach to the internal structure of features (Smith et. al, 1988), dividing features into attributes and their values; an approach that has been used quite successfully in studies on categorisation, both in the spatial domain and elsewhere. I have proceeded to show how I make use of this approach and presented and explained my own work on spatial features, a decomposition of the 71 pictures of the Topological Relations Pictures Series into their attributes and values. This decomposition serves two functions: First, to provide all attributes that might be of relevance to any language found worldwide. And second, to give a purely conceptual, pre-linguistic list of attributes, which form the universal building blocks of spatial language.

Before I move on to my analysis in section 4, I will present in section 3 the framework I intend to use, Optimality Theory.

3 Optimality Theory

In this section, I will introduce Optimality Theory (OT), starting with its origins in phonology, then presenting its extension to other linguistic disciplines and finally explaining its application in a lexical domain. This last point will be reviewed in much detail, since there is little work on OT and the lexicon and my approach is heavily based on the only one I found: OT and the kinship domain (Jones, 2003).

3.1 Origins of Optimality Theory

Optimality Theory was developed by phonologists in the early 1990ies (e.g. McCarthy & Prince, 1993). Their motivation was to formalise the observation that while individual languages differ in how and what they pronounce, there are certain universals that guide that process. For example, Dutch word-final obstruents (i.e. plosives and fricatives) are devoiced. That is, the word *bed* it pronounced with a *t* at the end, not a *d*.[7] This can, and has been, captured by an individual rule applying to Dutch only. English has no such requirement on devoicing word-final obstruents and instead keeps the underlying *d* in the pronunciation of *bed*. This can also be captured by an individual rule, applying only to English. The same holds for other languages, such as German, which requires word-final devoicing like Dutch.

Creating a separate set of rules for each language accounts for all these individual observations, but fails to recognise the connections and recurring patterns across languages. Individual rules applying to only one language can say nothing about universals in both language (i.e. the human mind) or pronunciation (i.e. human motor control). So instead of formulating a different set of rules for every language, phonologists re-formulated these rules as "soft", i.e. violable, constraints.

These constraints are meant to account for the pronunciation patterns of all languages. The differences between languages are generated not by adding or dropping constraints, but by ranking them differently in a hierarchy. The different rankings are given in tableaus, where every possible output candidate, i.e. every possible way to pronounce an underlying lexical form, is evaluated by the constraints. Seeing that the constraints are necessarily conflicting in order to account for all languages (you cannot devoice word-final obstruents and respect the underlying voiced form at the same time), and the fact that all constraints are always present in the ranking for any language, every candidate output will inevitably violate a constraint sooner or later. The "winning" output candidate

[7] We know that the underlying form is *d*, not because it is written that way, but because it emerges in the plural *bedden* (beds).

is therefore not the candidate that satisfies all constraints (that is impossible), but rather the optimal candidate (hence the name of the theory), the one that violates the least highest ranked constraint. An example of how this accounts for the contrast in Dutch and English *bed* is given in Figure 1 (taken from Kager, 2010).

Ranking for Dutch: *Voiced-Coda » Ident-IO(voice)   M » F

Input: /bɛd/	*Voiced-Coda	Ident-IO(voice)
a. [bɛd]	*!	
b. ☞ [bɛt]		*

Ranking for English: Ident-IO(voice) » *Voiced-Coda   F » M

Input: /bɛd/	Ident-IO(voice)	*Voiced-Coda
a. ☞ [bɛd]		*
b. [bɛt]	*!	

Figure 1: Constraint ranking for the pronunciation of the Dutch and English words for *bed*, taken from Kager, 2010.

The underlying form, the input, is the same for both languages. The constraints that matter with respect to the pronunciation of the last obstruent in the word are *Voiced-Coda and Ident-IO(voice). The first constraint, *Voiced-Coda, forbids the word-final consonant (the coda) to be voiced.[8] The second constraint, Ident-IO(voice), requires the output to be identical to the underlying input form with respect to the feature 'voice'.

By ranking *Voiced-Coda higher than Ident-IO(voice), the pattern for Dutch is generated. In Dutch, it is more important that the last obstruent of a word is not voiced than that the word is identical to the underlying form. This can be seen by the asterisk (*) in the first cell for output candidate (a): this candidate violates the first constraint. The exclamation mark (!) signals that this is a so-called fatal violation, meaning that this output candidate will no longer be considered. Output candidate (b) also violates a constraint, but this violation occurs lower down in the hierarchy than that of output candidate (a). Therefore, candidate (b) "wins", i.e. this form is pronounced in the language/s for which this ranking holds.

The opposite ranking, Ident-IO(voice) » *Voiced-Coda, generates the pattern for English. Here, it is more important that the input and output forms are

[8]To be voiced means to be pronounced with vibrating vocal cords, the difference between *d* (voiced) and *t* (de-voiced).

identical than that the word-final obstruent is devoiced. Accordingly, candidate (a) is the winning candidate and the word that is pronounced in English.

These two rankings do not only account for Dutch and English, but also for other languages with the same pattern, like German. They therefore present a more elegant analysis than three or more sets of unrelated rules. Furthermore, using soft, universal constraints as opposed to hard, language-specific rules allows to capture the connections between languages with respect to the patterns of pronunciation, and thus also makes a claim about the relation between human cognition and language. Whether one thinks of these constraints as hard-wired into the brain, or as resulting from other underlying cognitive factors, this approach has a definitive advantage over the rule-based analysis, especially where cognitive economy is concerned.

Some more things about OT stand to be noted. The first concerns the types of constraints. There are two basic types of constraints: markedness and faithfulness constraints. Faithfulness constraints require that the output form be "faithful", i.e. identical, to the underlying input with respect to certain properties of the input. The above Ident-IO(voice) was such a faithfulness constraint, requiring the output to be faithful to the input with respect to the feature 'voice'. Markedness constraints, on the other hand, forbid certain "marked" outputs. A pronunciation (or structure or interpretation, if we talk about OT in other disciplines) "is marked if it has complexities or unusual features" (de Swart & Zwarts, 2009, p. 285). The above *Voiced-Coda is such a markedness constraint, forbidding pronunciations with voiced word-final obstruents.[9] Markedness constraints are always introduced by the asterisk (*).

OT tableaus are usually more extensive than the one presented in Figure 1. What is important to remember about the more extensive tableaus is that the only thing that decides which output candidate will be pronounced is the hierarchy, not the number of violations. In an OT tableau, the "winning" candidate may have twice as many violations of constraints as all other candidates. However, as long as all other candidates have a violation higher up in the hierarchy than the "winning" candidate, that does not matter at all. What counts for determining the final output is not the number of violations, but that the highest ranking constraints, i.e. the most important ones, are not violated by that output.

A related concern is the resolution of ties between output candidates. During the evaluation process, starting with the highest ranked constraint on the left in the tableau, it can happen that two output candidates violate the same constraint. In these cases, the violations are not considered fatal, i.e. both

[9] As to why the voiced form is more marked then the devoiced form, i.e. what about voice is unusual or complex, please consult relevant literature on phonology.

candidates will remain available for evaluation by constraints further down in the hierarchy. The candidate which, following the initial violation, is the first to have a second violation further down in the hierarchy, "looses" the resolution of the tie, that is, will not be the "winning" candidate. The important point in this case is that the first violation will not count in determining the eventual winner, even though it is of a higher constraint, because both candidates fare equally bad. Only once one of the candidates has a second violation of a less high ranked constraint will that candidate be ruled out and leave the other to be the "winner".

3.2 Extensions of Optimality Theory

Optimality Theory has such a great appeal to linguists that is has been adopted into several other domains, syntax and semantics first among them. OT Semantics is structurally different from both OT Phonology and OT Syntax, though. In both of the latter, the input is some sort of underlying meaning or lexical element, and the output is the optimal form for that underlying meaning or lexical element. Both OT Phonology and OT Syntax are concerned with the production of language, they take, one could say, the perspective of the speaker. OT Semantics, on the other hand, is concerned with the comprehension of language, corresponding to the perspective of the hearer (Hendriks & de Hoop, 2001): The input is a well-formed sentence, the output the optimal meaning. Take for example the sentence in (1), taken from Hendriks & de Hoop (2001), p. 16:

(1) Often when I talk to a doctor, the doctor disagrees with him.

The question under concern is how to resolve the respective references of *a doctor*, *the doctor* and *him*. Two constraints are at work: one that forbids to interpret two semantic arguments of the same relation as identical, unless they are marked as being identical (Principle B); and one that requires to make use of every possibility to anaphorise (DOAP). By ranking Principle B higher than DOAP, *a doctor* can be correctly interpreted as either the antecedent for *the doctor* or *him*.[10] All other possibilities of co-referentiality are ruled out.

In this case, there is no shuffling of constraints to generate the interpretation patterns of another language. However, there are a number of other constraints, based on well-known and established syntactic, semantic and pragmatic principles, such as conservativity and parallelism. By ranking these, Hendriks & de Hoop account for several more or less tricky examples of anaphoric or elliptical

[10]This interpretation, of course, requires the other element to be known from the discourse.

expressions.[11]

Other uses of OT in semantics have been e.g. the bidirectional approach developed by Blutner (2000). Bidirectional OT takes both the perspective of classical OT Syntax and classical OT Semantics, that is, both the hearer's and the speaker's perspective. Bidirectional OT is defined in a recursive way (de Swart & Zwarts, 2009, p. 285):

(2) $\langle f, m \rangle$ is optimal iff:

a. there is no optimal pair $\langle f', m \rangle$ that is better than $\langle f, m \rangle$ and

b. there is no optimal pair $\langle f, m' \rangle$ that is better than $\langle f, m \rangle$.

De Swart & Zwarts (2009) make use of this definition of bidirectional OT to account for the fact that bare nouns have stereotypical meanings, as in (3), whereas nouns with articles have less "rich" meanings, as in (4).

(3) John is in jail.

(4) John is in the jail.

The sentence in (3) is commonly understood to mean that John is imprisoned, and not e.g. just visiting someone. The sentence in (4) shows the opposite pattern, meaning that John is doing some other business in the jail and is not a prisoner. The former is the optimal form-meaning pair $\langle f, m \rangle$. Any pair of the type $\langle f', m \rangle$ or $\langle f, m' \rangle$, in this case *in the jail* meaning imprisoned or *in jail* meaning just visiting respectively, is less optimal. The pair $\langle f', m' \rangle$ has no optimal alternative and is therefore the optimal connection between a complex form and a complex meaning.

What makes the sentence in (3) the optimal form-meaning pair are several markedness and faithfulness constraints relating to both form and meaning. Three faithfulness constraints requiring functional structure in the nominal domain are ranked above a markedness constraint forbidding this functional structure. This accounts for the fact that regular nominals in English and other Germanic (and Romance) languages usually appear with an article (which counts as functional structure). The nominal in (3) above, however, is not in a regular argument position, thus all three faithfulness constraints can be said to be vacuously satisfied (because they don't apply in (3)).[12] What determines the optimality pattern in (3) and (4) is the combination of the above markedness constraint repressing functional structure in the nominal domain (*Form), and

[11]For a more detailed account of how these constraints interact, I refer the interested reader to the original paper by Hendriks & de Hoop.

[12]For a detailed account of bare nominals please consult the original paper by de Swart & Zwarts

a markedness constraint on the interpretation, deeming stronger, i.e. stereotypically enriched, meanings as better (less-marked) than non-enriched meanings (*Meaning).

Apart from the here presented analyses making use of OT, there are numerous other applications, many of which can be found at the Rutgers Optimality Archive (http://ruccs.rutgers.edu/roa.html). In the next section, I will introduce one last use of OT, namely OT in the lexical domain, where it is also important to account for variation.

3.3 Optimality Theory and the Lexicon

The most relevant use of OT, at least with respect to this paper, is the OT analysis of the kinship domain by Jones (2003). Using OT in a lexical domain is different still from all the other uses laid out above. In order to understand Jones' approach to OT and the lexicon, and how it is feasible to explain spatial language, it is necessary to first explain some properties of the kinship domain.

The Lexical Domain of Kinship There are a number of different individuals in a family tree. All of them can be uniquely conceptualised by their precise relation to the speaker (the speaker's perspective in kinship analyses is called *Ego*). Members of the family tree are characterised, one could say, by a distinct combination of features relating to their relative age, generation, connection to either Ego's mother or father, etc. A visualisation of a subset of these distinct instances in the family tree and how they are characterised in terms of features can be found in Figure 2.

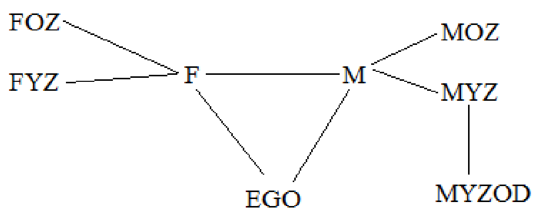

Figure 2: A subset of Ego's relations in a family tree: F (Father), M (Mother), FOZ (Father's Older Sister), FYZ (Father's Younger Sister), MOZ (Mother's Older Sister), MYZ (Mother's Younger Sister), MYZOD (Mother's Younger Sister's Oldest Daughter).

Every human being knows about these differences, uniquely identifying every one of one's relatives. They are conceptually universal. But not all languages regard all of these distinctions. English, for example, has one term referring to only mother, while equating all the distinctions possible in the category of parents' female sibling into the sole term aunt. Other languages have a separate term for FZ (father's sister) and one term referring to both MZ (mother's sister) and M (mother) (Jones, 2003).

Jones, making use of a database of cross-linguistic kinship terminology, provides an optimality theoretic analysis that accounts for the systematic way in which languages world-wide divide the family tree into terms.

How to Use OT on a Lexical Domain Using OT to analyse a lexical domain is very different from using OT in any other linguistic domain. When OT is applied to pronunciation, grammar or interpretation, it explains a process which can be thought of as the hearer's or speaker's perspective, and during which the constraints are actively determining the outcome. OT applied to a lexical domain does not account for a similar process. The balance between rules and memorisation is different than when applied to grammar or pronunciation (Jones, 2003, p.323). Lexical OT accounts for a process of categorisation. It explains how different languages form different categories out of a number of universal concepts.

The input to lexical OT analyses are unique instances from, in this case, the family tree (e.g. FZ = Father's Sister).[13] They are unambiguously characterised by bundles of universal features. The output of lexical OT analyses are terms. Lexical OT cannot predict the exact form of the respective language's term, and it shouldn't. What this kind of analysis tells us instead is which individual instances are grouped together into a linguistic category, i.e. into the extension of one term in a given language, regardless of its concrete form. This results in a big difference between the tableaus for lexical uses of OT and the kind of tableaus used in phonology (or elsewhere), as presented in Figure 1 above. In Figure 1, the first tableau is enough to account for the pronunciation of the Dutch term *bed*. Nothing else is needed. In lexical OT, with the input being a bundle of features corresponding to concrete entities, and with every tableau only evaluating one such entity, only if all the tableaus are taken together, can they say anything meaningful about the linguistic categorisation process. Which entities share a term only becomes clear when considering the tableaus of all the concerned entities.

Another difference between lexical OT and other uses of OT concerns the output candidates. In OT Phonology, all possible output candidates for any given input are restricted to pronounceable words formed from that input. In OT Semantics, the number of output candidates is limited to logically available interpretations. The sentence in (1) has only five possible interpretations with respect to anaphora. There is no such natural limitation for output candidates

[13]In anthropology these instances are called "kinship types".

in lexical OT. One could, of course, take the whole lexical domain and evaluate every concept of a relative, i.e. consider every possible way to categorise together the members of the family tree, every possible neutralisation of the distinctions between the members of the family tree. But this would, in effect, mean to consider categorising e.g. mother's father's mother (MFM) with father's youngest sister's oldest daughter (FYZOD), a combination that seems intuitively unlikely. So the way Jones goes about this, is to limit himself to coherent subdomains of the family tree. He separates aunt and uncle terminology, cousin terminology, sibling terminology and grandparent terminology, etc. That is, for the categorisation of aunt terminology, the possible outputs, i.e. those instances that can be categorised into a single term, are limited to mother and the individuals in the domain of parents' female sibling.[14]

OT analysis of the kinship domain Despite these differences in input and output, lexical OT makes use of faithfulness and markedness constraints much like OT Phonology. Jones formulates faithfulness constraints that require that certain distinctions found in the family tree (the input) be honoured by separate terms. For example, in order to account for the two separate English terms *mother* and *aunt*, a faithfulness constraint is needed which requires that Ego's lineal kin (parents, grandparents, etc.) be linguistically distinguished from Ego's collateral kin (aunts, uncles, great-aunts, etc). And in order to make sure that father's sister and mother's sister are equated in one term (aunt), i.e. not marked by separate expressions, Jones formulates corresponding markedness constraints. Figure 3 shows the OT tableaus generating English aunt terminology.[15]

These tableaus require some explanation concerning the constraints and their function. The constraints and their definitions are given below:

- DLin: Distinguish lineal and collateral kin
- DBif: Distinguish maternal and paternal kin
- *FZ: Don't express separately the feature combination 'sister, father's side'
- *MZ: Don't express separately the feature combination 'sister, mother's side'

The faithfulness constraint DLin, as already mentioned above, requires different linguistic expressions depending on whether the input considered is lineal

[14] The reasons for carving out this particular subdomain seem mostly intuitive, but are also partly inspired by the patterns observed cross-linguistically.
[15] Jones refers to this set of tableaus as aunt terminology. However, the concept mother is also included.

Lineal aunts: tableaus

Mother (M) is "mother" (M) . . .

M	*DLin*	**FZ*	**MZ*	*DBif*
M✓				
MZ	*!		*	
FZ	*!	*		*

mother's sister (MZ) is "mother's sister" (MZ) . . .

MZ	*DLin*	**FZ*	**MZ*	*DBif*
M	*!			
MZ✓			*	
FZ		*!		*

and father's sister (FZ) is also "mother's sister" (MZ).

FZ	*DLin*	**FZ*	**MZ*	*DBif*
M	*!			*
MZ✓			*	
FZ		*!		*

Figure 3: OT tableaus showing how English categorises the concepts mother, mother's sister and father's sister. Taken from Jones (2003), p. 325.

kin (parent, grandparent, etc.) or collateral kin (aunt, uncle, great-aunt, etc). The high rank of this constraint explains why the concept mother is marked with a separate term, not including any parent's sister. The faithfulness constraint DBif requires different terms depending on whether the input is maternal kin or paternal kin (thus demanding two different terms for father's sister and mother's sister). The two markedness constraints *FZ and *MZ serve to counter the distinction required by DBif. They forbid a separate term for the individual that is the sister of Ego's father (*FZ) and a separate term for the individual that is the sister of Ego's mother (*MZ), thus serving to "neutralise" the effects of the faithfulness constraint DBif. By ranking the markedness constraints higher than DBif, the distinction between father's sister and mother's sister is not expressed in the languages corresponding to this ranking (i.e. there is only one term for parent's female sibling).

The relative order of the two markedness constraints in the tableau in Figure 3 is irrelevant and chosen randomly, they form what Jones calls a stratum. It does not matter whether the concept for Ego's mother's sister is categorised under the term for Ego's father's sister or vice versa. Lexical OT makes no claim whatsoever about the concrete morphological or phonological form of the final term. The important thing is that both the concepts MZ and FZ are mapped onto the same output candidate (MZ in the tableau above), that they share a term. The fact that their relative order does not matter is represented by a dashed line between the two markedness constraints (or parentheses when listed in a ranking).

It is also possible to derive the same results as in Figure 3 if one of the markedness constraints were to be dropped. There would still be only one term for both the sister of Ego's mother and the sister of Ego's father. The reason why Jones included both markedness constraints is, as he says, that they make certain psychological predictions about typicality. If only the markedness constraint *FZ were to be included in the above tableau, forbidding a separate term for father's sister, and there was to be no constraint relating to mother's sister, Ego's aunts on the mother's side would be predicted to be more typical of the category aunt. This is an undesired effect, necessitating the inclusion of both markedness constraints, even though the actual results are the same (i.e. there will be only one term for all kinds of aunts, no matter if only one or both markedness constraints are included). I will make use of the same practice when analysing spatial language, deviating from it only once.

When first introducing the kinship domain, I said, following Jones, that some languages categorise the subdomain of aunts differently than English. Jones shows how a simple switching of constraints generates a language where mother and mother's sister receive the same term, and where father's sister is categorised apart. The tableaus are given in Figure 4.

By ranking the faithfulness constraint DBif highest, higher than the corresponding markedness constraints *FZ and *MZ, a terminological distinction is required between kin on Ego's mother's side and kin on Ego's father's side (see the definition of DBif above). This results in separate terms for father's sister and mother's sister. The fact that mother and mother's sister share one term in that language is accounted for by the low rank of the faithfulness constraint DLin. For this language, the distinction between lineal kin (parents, grandparents, etc) and collateral kin (aunts, uncles, great-aunts, etc) is the least important.

3.4 Interim Summery II

In this section, I have introduced the theoretical framework I use for my own analysis: Optimality Theory. I have outlined its origins in phonology (McCarthy & Prince, 1993), where it has been successfully used to account for patterns of pronunciation across languages. I have highlighted all that is important to know about the technicalities of the theory: the evaluation tableaus, the underlying input and the output candidates, the faithfulness and markedness constraints as well as the process of evaluating the optimal output. I have

Bifurcate merging aunts: tableaus
Mother (M) is "mother" (M) . . .

M	*DBif*	**FZ*	**MZ*	*DLin*
M✓				
MZ			*!	*
FZ	*!	*		*

mother's sister (MZ) is also "mother" (MZ) . . .

MZ	*DBif*	**FZ*	**MZ*	*DLin*
M✓				*
MZ			*!	
FZ	*!	*		

but father's sister (FZ) is "father's sister" (FZ).

FZ	*DBif*	**FZ*	**MZ*	*DLin*
M	*!			*
MZ	*!		*	
FZ✓		*		

Figure 4: OT tableaus for aunt terminology fusing mother and mother's sister, with father's sister treated apart. Taken from Jones (2003), p.328.

shown why Optimality Theory has such an appeal to linguists, mentioning the elegance of covering cross-linguistic data with one set of soft constraints, the improved explanatory value over rule-based approaches and the advantages for perspectives on cognitive economy. I have repeated numerous uses of this theory beyond phonology, and shown how it can be altered to account for various other linguistic systems, like the semantic interpretation of anaphora resolution (Hendriks & de Hoop, 2001) or the bidirectional use to account for bare singulars (de Swart & Zwarts, 2009). Lastly, and most importantly with respect to my approach, I have outlined how OT can be used to analyse a lexical domain (Jones, 2003). I have shown the differences of in- and output in lexical uses of OT, and explained how markedness and faithfulness constraints conspire to give an account of cross-linguistic categorisation in a given lexical domain.

In what follows, I will put OT to use in the lexical domain of spatial language, building on my work as presented in section 2.

4 Optimality Theory and Spatial Prepositions

In this section, I will present my own analysis of spatial meaning, employing OT as outlined above. Spatial language and OT are not an entirely new combination, though.

There have been earlier optimality theoretical analyses of spatial language, and before I go into detail about my own work, I will briefly present one such approach (Zwarts, 2008), show how it differs from mine and say why both approaches are necessary.

4.1 Earlier Approaches to OT and Spatial Language

Zwarts (2008) uses an optimality theoretical approach to account for the use of English spatial prepositions. He focuses on the competition between prepositions in situations where more than one might be applicable, and shows how the conflict is resolved. Each preposition is said to be characterised with one major feature.[16] *On*, for example, is usually associated with 'support', *in* is said to be mainly 'inclusion', *above* and *over* are characterised by 'superiority' and so on.

Yet if an object is put into a box, it is not only included by the box, but in most cases also supported: If e.g. the box is lifted up, it will support the object within. The use of *in* in this situation can be explained by a faithfulness constraint, requiring that the feature of 'inclusion' is present in the output preposition if it is present in the input situation. This faithfulness constraint is ranked higher than the faithfulness constraint relating to the feature of 'support'. Take e.g. a situation where a book lies on a table versus where a book lies in a box. Both are characterised by 'support': the table supports the book, but the box does so as well (at least if it is lifted). The situation with the book on the table is described by the preposition *on*, the core feature of which is 'support'. Yet then why is *on* not used to describe the situation of a book lying in a box, even though the box also supports the book? Because the book is not only supported by the box, but also included. 'Inclusion' is added to the already present 'support' in this situation, it is therefore more important than 'support' in situations where both apply. This is expressed by ranking the faithfulness constraint related to 'inclusion' higher than the faithfulness constraint related to 'support'.

Similarly, uses of *on* are characterised by 'support' and 'superiority', whereas uses of *above* and *over* focus on 'superiority' alone. If a lamp stands on a table, it is both superior to the table and supported by it. If it hangs over / above the

[16] Zwarts notes that the notion of feature as he uses it in this approach is a rather rough one that could do with some refinements. Due to the focus of his paper not being on characteristics of spatial features, however, such refinements are not provided.

table, it is not supported by it, but still superior to it. The respective higher rank of the faithfulness constraint relating to 'support' over the faithfulness constraint relating to 'superiority' accounts for the fact that even though both 'support' and 'superiority' are present in the situation *lamp on table*, *on* is used, the core feature of which is 'support'. The faithfulness constraint relating to 'support' must be ranked higher than the faithfulness constraint relating to 'superiority' to account for these three English prepositions.

In this way, Zwarts systematically analyses the English prepositions *in*, *on*, *over*, *above* and *around*. He formulates a hierarchy of faithfulness constraints relating to the features 'support', 'inclusion', 'superiority' and certain qualities of the feature 'path' that explains why these prepositions are used for situations where one or several of their "core" features are at play.

This is a good way to account for the use of prepositions in potentially ambiguous situations. The starting point of the present approach, however, are not a set of competing spatial terms, but those spatial scenes in need of description. My primary interest are the fine conceptual distinctions in the spatial domain and how they are categorised into linguistic expressions. The matter of conflicts between terms and how they are resolved with respect to certain core features will be addressed only briefly in section 4.5 below. I will not provide an account as extensive and systematic as that of Zwarts with respect to ambiguous situations.

4.2 Translating from the Kinship Domain

Since my own approach is heavily based on the analysis of the kinship domain presented above, I will first make some necessary "translations" from that domain to spatial language in order to facilitate understanding.

I said earlier that the kinship domain is conceptually universal. All individuals in the family tree can be uniquely classified by a set of features, one could say, relating to their respective age, generation, connection to either maternal or paternal kin, etc. The faithfulness and markedness constraints Jones uses are based on the distinctions expressed by these features, either requiring or forbidding them. Their ranking determines which distinctions are more important than others in a given language and will therefore be marked by receiving their own terms.

In order to arrive at a similar analysis for the spatial domain, the first concern is finding a spatial equivalent to the universal family tree. I mentioned in section 2 above, where I summarised work on spatial language, that several cross-linguistic studies on spatial expressions have been carried out (e.g. Levinson & Wilkins, 2006). In order to ensure comparability between the languages in a sample, all of these studies have made use of the same set of spatial scenes to elicit linguistic data: the Topological Relations Pictures Series. I have already shown above that there are certain "logically" necessary pictures missing from the Series, which cannot by itself account for all the values of some of the attributes (at least for my account of a decomposition, as presented in section 2 above). But, as stated in section 2, I will nonetheless assume that the authors' continued updating of the Series and their research into spatial features, as well as the Series' use around the world, give enough authenticity to the claim that these pictures form a basic set of universally distinguishable spatial scenes. This Series will therefore form the spatial equivalent to the family tree in my approach.

Another "translation" necessary concerns the input and the output of the analysis. Jones takes individual instances from the family tree as his input, and evaluates which of these are categorised into one term (the output). Similarly, I will take individual pictures from the Topological Relations Pictures Series and analyse which of these are categorised into one term. A slight distinction between Jones' approach and mine is the type-token distinction. One could say that while Jones is working with kinship types, abstract entities in the family tree, I work with tokens, with concrete spatial situations. However, while this distinction is certainly relevant, I will claim that my way of selecting the input allows an extension away from the concrete situations to all others of that type, i.e. all others that are characterised by the same set of relevant attributes.

Since there is no "natural" limit to the output candidates in lexical uses of OT, Jones chooses coherent subdomains of kinship terminology and limits himself to those. The analysis I repeated above was restricted to aunt terminology; to a domain, one could say, where only instances characterised by the features 'female' and 'parent' or 'parent's sibling' are considered. Other features, like e.g. 'generation', are not taken into account. Accordingly, I will limit myself to certain subdomains as well, to subdomains that are characterised by certain attributes while disregarding others. Based on my own data and on analogies in the data summaries provided by Levinson & Wilkins (2006), as well as distinctions worked out in the literature, I chose three subgroups of the spatial domain for analysis: Group 1 will focus mainly on a subdomain that has also been described as the projective relation between two objects, making use of my above attributes 'relative position' and 'quantity of contact' (projective and relative position terminology). Group 2 is limited to spatial scenes of different types of inclusion (inclusion terminology), and Group 3 focuses on the attributes 'direction of support' and 'attachment' (support terminology). Further motivation for these particular groups is given at the beginning of each sub-analysis below.

Jones formulates constraints based on the distinctions in the family tree.

The faithfulness constraint DBif, presented above, can be said to refer to the attribute 'lineage', and to require that the different values for that attribute ('maternal' and 'paternal') are expressed by separate terms. The markedness constraints were set up to counter the requirements of the faithfulness constraints, i.e. to prevent the expression of certain distinctions (corresponding to the different values). By ranking either the faithfulness constraint or the corresponding markedness constraints higher, it is possible to generate languages that either express a distinction, or else languages that "neutralise" the difference into one term. I will make use of this system to formulate faithfulness constraints requiring that the different values of an attribute are expressed by separate terms. And to formulate markedness constraints that prevent the expression of certain distinctions, thus countering the effects of the faithfulness constraints.

In order to carry out such an analysis of how languages categorise spatial scenes, I will need linguistic data. In the next section, I will briefly lay out my method of data-collection and how I prepare the data for analysis.

4.3 Collecting Dutch Spatial Expressions

As already mentioned above, my starting point are the 71 pictures of the Topological Relations Pictures Series plus eight pictures of my own design to compensate for the missing values in the decomposition (see above).[17] All pictures can be found in the Appendix in section 6.1.3. Due to limits in both resources and time, my analysis is primarily on Dutch spatial expressions (though cross-linguistic data will be considered wherever possible in the analysis and I expect my analysis to be expandable to any other language). So in order to get Dutch descriptions of 79 pictures, I created an online questionnaire.

4.3.1 Method

I designed the questionnaire using the software provided by the following website: www.soscisurvey.de. The questionnaire contained the 79 pictures for which I wanted descriptions. For every picture, I named both the Figure and the Ground (in Dutch) in order to prevent potential misunderstandings, and asked

[17] In Table 1 and Table 2 above, I give a total of nine examples to account for values that I found to be of importance, yet that cannot be found in the pictures of the original Series. I have therefore created examples of my own, marked with *xx* in the tables above. But only eight out of these nine examples were used as pictures in my research and included in the analysis. This is due to one of them being the result of an attribute that was added to the decomposition later: Horizontal Extension. I found I needed that attribute despite attempts to avoid anything related to the curvature or path of objects, features which are much more often found in description of motion or trajectory related uses than not. However, I don't expect this late addition and missing picture to influence the analysis in any way, since the bulk of my theory is based on other pictures.

participants to fill in the missing verb and preposition that are needed to describe the setting.[18] The to-be-completed sentences were presented in an N V P N format. That is, the two nouns that were given (the first corresponding to the Figure and the second to the Ground) were divided by an entry slot, looking something like this: Het kopje ______ ___ de tafel (The cup ______ ___ the table). All Dutch labels for the Figure and Ground objects in the 79 pictures can be found in the Appendix in 6.1.1.

Some of the scenes could not naturally be described by the N V P N format, so for every picture, I gave participants the possibility to write down another sentence in a free entry field. Participants were asked to always provide the verb and the preposition in the N V P N schema, whereas the filling in of the free entry field was optional. I asked participants to only make use of the free entry field if they felt that the additional sentence provided a better description of the situation. The instructions to the questionnaire can be found in the Appendix in section 6.1.2. 22 native speakers of Dutch filled out the questionnaire.

4.3.2 Preparing the Data for Analysis

Although I said at the outset that spatial expressions are much more diverse than just the closed class of adpositions, there is reason to focus on prepositions when talking about Dutch spatial expressions. Even though Dutch also codes semantic information of spatial configurations in verbs, these are mostly used for descriptions of motion (van Staden et. al, 2006, p.485). My focus here is on static locative descriptions, which are almost exclusively limited to prepositions (van Staden et. al, 2006, p.485).

The reason why I asked participants to also provide a verb for each picture is that the less restricted the question, the more natural the results. The verbs also help to identify interpretations involving motion. For example, in picture 52, where a number of insects are hanging on the wall, participants might say: *De beestjes lopen over de muur* (the insects walk over the wall). This is a description of motion, an interpretation of the scene that is undesired, because I limit myself to static locative expressions. The preposition *over* does not occur with this picture in static descriptions. The verbs, *lopen* in this case, thus helped me to discard prepositions used for descriptions of motion.

In the analysis, I have therefore focused primarily on the prepositions, with the verbs being only of secondary interest and mostly used to exclude certain prepositions from the analysis. In the Appendix in 6.1.1, I give the percentages with which each preposition occurred in the description of a picture, and then the percentages of how often which verbs have been used with that preposition.

[18] Spatial meaning in Dutch is coded in prepositions and verbs (van Staden et. al, 2006).

Since I allowed two answers for each of the situations, and two answers were given in a number of cases, I count each participant as having given two answers for each picture. This is not always so, in which case the first answer is counted twice. This method, of course, reinforces the standard answer: If participants were satisfied with the first sentence (in the N V P N pattern) and didn't give an alternative, the first sentence is now counted as having been given twice. I make use of this method nonetheless, for there is no other straight-forward strategy that I know of to deal with the cases where participants made use of the free entry field, while maintaining applicability of the data for quantitative analyses. Inferential Statistics, if it should ever be applied to my data, can deal with this problem by simply adjusting the degrees of freedom. The disadvantage is that it is now not immediately obvious if an answer that has only been given twice was given by only one participant or by two different participants, who both also gave other answers.

The data of two of the 22 participants have not been considered, because they consistently neglected to give the verb. All the percentages for prepositions and verbs given by the remaining participants are listed per picture and can be found in the Appendix in 6.1.1.

I have sorted the pictures into groups corresponding to the prepositions that have been used to describe them. Following that, based on my decomposition of all the 79 pictures, I was now able to "compile" the attribute-value structure of all the pictures in one such group to determine the attribute-value structure of the respective preposition. For example, if preposition A has been used to describe pictures 1, 2 and 3, I went back to my decomposition, as introduced in section 2, and checked which values I specified for the situations in pictures 1, 2 and 3. If for e.g. the attribute 'direction of support', I find in picture 1 the value 'from above' and in pictures 2 and 3 the value 'from same level', I will specify both these values for preposition A. That is, preposition A is used to describe situations where support comes either from above or from the same level. I systematically did this for all the attributes in my decomposition, and for all the prepositions that have been used to describe the pictures in the decomposition.

4.4 My Analysis

For the analysis of my chosen subgroups, I only consider "majority prepositions", that is, any preposition that has been given in the majority of times for at least one picture. I have also ruled out prepositions that are only used in motion descriptions in my sample (e.g. *langs* (along)), and prepositions that involve a different conceptualisation of direction. Even though I deal only with static locative situations, some of the scenes seem to involve a sense of direction nonetheless. For example, a scene with a box being contained by a bag can be described from two different "directions": *de doos zit in de tas* (the box sits in the bag) and *de doos steekt uit de tas* (the box sticks out of the bag). I have also excluded prepositions that involve the use of a frame of reference, i.e. that relate to the point of view of the speaker, such as *achter* (behind). Frames of reference and point of view are not part of my analysis and have consciously been excluded of my decomposition in section 2 above. The excluded prepositions thus are: *achter*, *af*, *bij*, *binnen*, *bovenaan*, *bovenop*, *langs*, *rond*, *rondom*, *tussen*, *uit*, *van* and *voor*.

The remaining prepositions are: *aan* (on), *boven* (above), *door* (through), *in* (in), *naast* (next to), *om* (around), *onder* (under), *op* (on), *over* (over) and *tegen* (against). These can be put into the three groups that I take as the subdomains from which I define my output candidates: projective and relative position terminology, inclusion terminology and support terminology. For each of these groups, only a subset of the attributes I list in my decomposition in section 2 is relevant. This way of not formulating all attributes as constraints is in accordance with the approach of Jones (2003). However, one could also imagine that the "ignored" attributes are formulated as constraints that are ranked so low for the respective group that they don't matter at all, i.e. that the output does not depend on them.

As to why they don't matter, I cannot say much, though one thing is noteworthy with respect to the type of the attributes that are not considered: The attributes that relate to the Ground and Figure objects individually, i.e. the attributes listed in section 2.2.1, hardly seem to play a role in my analysis. The only exception to that is the attribute 'negative space', which comes into play for the analysis of inclusion terminology (group 2). All other attributes under consideration are attributes of the relation between Figure and Ground. This might be because the prepositions (and the verbs) are used to establish a relation between the Figure and the Ground. Attributes relating to properties of the individual objects, if a language expresses them, might be expected to be coded on the respective nouns themselves, maybe in the form of affixes expressing case (cf. Landau & Jackendoff, 1993).

I will proceed in the following by first giving a motivation for choosing each particular subdomain. For each subdomain (corresponding to one of my three groups), I will then give a reduced attribute-value structure for all the Dutch prepositions generated by the analysis of that subdomain. The attribute-value structure of the prepositions is determined by the attribute-value structure of the scenes that have been described by that preposition (see section 4.3 above for a more detailed explanation). I will then present the input, i.e. the individual spatial scenes taken from the Topological Relations Pictures Series or my own design. Only then will I present the constraints and give the tableaus that generate the Dutch categorisation of the input.

The constraints are NOT motivated by the Dutch patterns. In fact, a much reduced constraint system is sufficient to account for the Dutch data in all groups. I included all constraints that represent "important"[19] attributes from my above decomposition and that I think might be relevant to generate the patterns in other languages (though I do not find evidence for all of them). For every group, I will also draw on cross-linguistic data provided by Levinson & Wilkins (2006) and Levinson & Meira (2003) to show how a simple shuffling of constraints can generate the pattern in another language. However, not having extensive data of my own for any language but Dutch, the claim I make about other languages is mostly limited to a subset of my input (not all the pictures that I use as input for any given group are part of the summaries of other languages in Levinson & Wilkins). I will end by making some predictions about the possible rankings that can be expected to be found in languages, based on some assumptions about general cognition.

4.4.1 Group 1: Projective and Relative Position Terminology

I chose this subdomain of spatial language because projective prepositions are an established subgroup of spatial prepositions (cf. Morel, 2012). Projective prepositions or projective senses of prepositions do not involve contact, one object is "projected" at a certain distance from another. It seemed therefore reasonable to contrast these prepositions (or senses of prepositions) with their "contact-counterparts" of the same relative positions. This is also not an entirely new idea (cf. Morel, 2012). The over / under contrast seems to be very salient cross-linguistically (cf. Levinson & Meira, 2003), giving further support for the choice of this particular subdomain. The attributes that I formulated as constraints for this group are therefore determined by the work that has been done on projective prepositions.

The attributes and values of this group, and how they are expressed in the relevant Dutch prepositions *boven* (above), *naast* (next to), *onder* (under) and *over* (over), are given in Table 4.

attributes/prepositions	**boven**	**naast**	**onder**	**over**
'quantity of contact'	none	none	some, none	some
'relative position'	Figure higher	same level	Ground higher	Figure higher

Table 4: Attribute-value structure of the Dutch prepositions of group 1.

[19]"Important" is a rather vague and intuitive notion here. I hope that it becomes clearer when I introduce my spatial subdomains in more detail.

Concerning the Attributes The two attributes relevant for this group are 'quantity of contact' and 'relative position'. Both are taken from my above decomposition (see section 2.2), though for convenience sake I adjusted both of them a bit.

The attribute 'quantity of contact' is in fact a collapse of the above attributes 'quantity contact Ground' and 'quantity contact Figure'. Since contact always involves both objects, i.e. if the Figure is in contact with the Ground, the Ground by default is also in contact with the Figure, it seems reasonable to compress these two attributes. The attribute is binary, meaning there is either contact (expressed by the value 'some') or not (expressed by the value 'none').

For the attribute 'relative position', the values 'inclusion' and 'depends on axis', which are given in the decomposition in section 2.2 above, are not relevant with respect to this group. The values 'Ground partly higher' and 'Figure partly higher' are disregarded and counted on a par with the value 'same level', since the data suggests that this distinction between the objects being on the same level of height and one object being only partially higher is irrelevant. There are thus three values for this attribute: 'Ground', 'Figure' and 'same level'.

Concerning the Prepositions I chose the preposition *over* (over) and not *op* (on) for this group, even though the contrast to *boven* is usually drawn with *op* (Morel, 2012). The reason for my choice is that, given my data, the extension of *over* seems to be a more specific subset of the extension of *op*.[20] That is, *op* is in a way too "difficult" to consider for this group; it has too many meaning layers. For example, while there is only the one value 'Figure higher' for the attribute 'relative position' in "over-situations", the use of *op* allows for a variety of values for the attribute 'relative position'. The scene with e.g. a stamp on a letter (picture 3), which in Dutch is described by *op*, can hardly be conceptualised as the Figure (the stamp) being higher than the Ground (the letter). Considering the whole range of uses for *op* would complicate the analysis for this group unnecessarily.

The preposition *naast* is set for not involving contact in the above table. While I'm perfectly sure that situations where Figure and Ground are on the same level and touch each other can also be described by *naast*, there is no such scene in my set of pictures. *Naast* will therefore be conceptualised as not involving contact. Yet the ranking I'm about to give will be able to deal with both types of "naast" categories.

[20] *Over* is mostly used for Dutch descriptions involving some form of the attribute 'path', which I do not consider. However, the use of *over* here is limited to static situations only, most of which can also be described by *op*.

The Input The input for group 1 are five scenes taken from the Topological Relations Pictures Series.[21] Mainly for convenience's sake, they are labelled with the respective Dutch prepositions, though that is not always a one-to-one match. *Onder*, for example, corresponds to two different inputs, one where there is contact between Figure and Ground, and one where there isn't. The pictures described by *onder* are therefore labelled onder1 and onder2.

The input pictures can be found in Figure 5. Each of the scenes can be characterised by a set of attributes, much like each individual in the family tree can be characterised by a set of attributes (e.g. FZ for father's sister). Below I give the number of the input pictures, their labels, their descriptions in terms of the above attributes and the abbreviations for the descriptions, which will be part of the labels in the analysis.

- boven (picture 36): Figure higher, no contact (FnC)
- over (picture 43): Figure higher, contact (FC)
- onder1 (picture 31): Ground higher, no contact (GnC)
- onder2 (picture 53): Ground higher, contact (GC)
- naast (picture 06): same level, no contact (SnC)

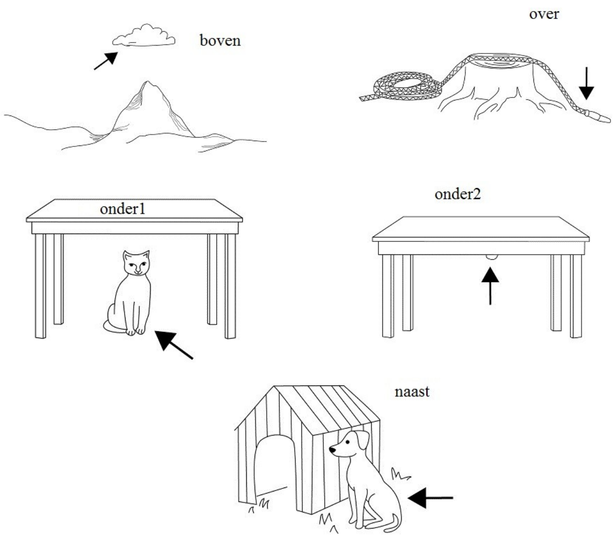

Figure 5: Input for Group 1

[21] The input scenes are always pictures that have been described by only the one preposition.

Table 5 shows how the input of group 1 is distributed over the possible feature combinations.[22]

Features	no Contact	Contact
Figure higher	boven (FnC)	over (FC)
Ground higher	onder1 (GnC)	onder2 (GC)
same level	naast (SnC)	

Table 5: Distribution over the possible feature combinations of the input of Group 1.

Analysis Group 1 Two faithfulness constraints, DRelPos and DCon, are needed to make sure that the distinctions with respect to which entity is higher and if there is contact or not are expressed. Four markedness constraints, *GnC and *GC as well as *FnC and *FC, are needed to counter the effects of the faithfulness constraints and allow for languages that have fewer terms for these five inputs. The constraints and their definitions are given below:

- DRelPos: Distinguish between the relative positions of the objects
- DCon: Distinguish between contact and no contact
- *GnC: Don't express separately the feature combination 'Ground higher, no contact'
- *GC: Don't express separately the feature combination 'Ground higher, contact'
- *FnC: Don't express separately the feature combination 'Figure higher, no contact'
- *FC: Don't express separately the feature combination 'Figure higher, contact'

The tableaus that generate the Dutch terms can be found in Table 6. As the input, I give the labels of the pictures and their specifications in terms of features (or rather, the abbreviations of that). Please keep in mind that even though the labels for the pictures are the Dutch prepositions, I do NOT take the terms as inputs, but the pictures given in Figure 5. The winning output candidates in the tableaus below are marked by a ☺.

[22]As I said above, I have no input for the feature combination 'same level, contact' and take *naast* (next to) to only refer to situations where there is no contact involved. However, the analysis can be easily extended to accommodate two "naast-situations".

boven (FnC)	**DRelPos**	***GnC**	***GC**	**DCon**	***FnC**	***FC**
boven (FnC)☺					*	
over (FC)				*!		*
onder1 (GnC)	*!	*				
onder2 (GC)	*!		*	*		
naast (SnC)	*!					
over (FC)	**DRelPos**	***GnC**	***GC**	**DCon**	***FnC**	***FC**
boven (FnC)				*	*	
over (FC)☺						*
onder1 (GnC)	*!	*		*		
onder2 (GC)	*!		*			
naast (SnC)	*!			*		
onder1 (GnC)	**DRelPos**	***GnC**	***GC**	**DCon**	***FnC**	***FC**
boven (FnC)	*!				*	
over (FC)	*!			*		*
onder1 (GnC)		*!				
onder2 (GC)☺			*	*		
naast (SnC)	*!					
onder2 (GC)	**DRelPos**	***GnC**	***GC**	**DCon**	***FnC**	***FC**
boven (FnC)	*!			*	*	
over (FC)	*!					*
onder1 (GnC)		*!		*		
onder2 (GC)☺			*			
naast (SnC)	*!			*		
naast (SnC)	**DRelPos**	***GnC**	***GC**	**DCon**	***FnC**	***FC**
boven (FnC)	*!				*	
over (FC)	*!			*		*
onder1 (GnC)	*!	*				
onder2 (GC)	*!		*	*		
naast (SnC)☺						

Table 6: Tableaus to generate the Dutch terms for the input of Group 1. The winning candidates are marked with a ☺.

Through ranking the faithfulness constraint DRelPos highest, it is ensured that there are at least three separate terms in this group, corresponding to the three values of the attribute ‘relative position’: One where the Figure is higher (Dutch *boven/over*), one where Figure and Ground are on the same level

(Dutch *naast*) and one for where the Ground is higher (Dutch *onder*). That is, if the input is either picture 36 (boven, FnC) or picture 43 (over, FC), the output candidates onder1 (GnC), onder2 (GC) and naast (SnC) violate DRelPos because they have a different relative position of Figure and Ground. This is marked by the exclamation mark (!) in the first cells of these output candidates, in the first two tableaus above.

There are two strata of markedness constraints, *GnC / *GC and *FnC / *FC, marked by dashed lines. As outlined in section 3 above, it is not technically necessary to include both markedness constraints of a stratum. The same results can be obtained by including only one markedness constraint of each pair e.g. *GC and *FC. The reason why I include both of each pair here is to avoid making any predictions about the typicality of "onder-situations" and "over-situations" when they are categorised into only one term each (though the two types of "over-situations" receive two separate terms in Dutch, this is not the case in all languages). Like much of the framework for my analysis, this decision is also inspired by the analysis of Jones, as outlined above, who makes use of two markedness constraints to suppress the "aunt distinction" between mother's sister and father's sister.

The relatively higher ranking of the stratum of markedness constraints *GnC / *GC with respect to the faithfulness constraint DCon ensures that there is only one term for the two "onder-situations", i.e. for the situations where the Ground is the higher entity, disregarding contact. Note that when the input is the scene corresponding to onder1 (GnC), the winning output candidate is onder2 (GC), even though it has more violations of constraints than the candidate onder1 (GnC). This is due to the fact that the candidate onder1 (GnC) violates a higher ranking constraint (*GnC). Note also that, in the end, it does not matter which specific output is the winner. The important thing is that both the input onder1 (GnC) and onder2 (GC) have the same output, disregardful of its lexical form! This means that Dutch puts the situations labelled onder1 and onder2 in Figure 5 above into one category, i.e. has only one term for them, even though they are conceptually distinct (they differ with respect to contact).

Figure 6 shows how Dutch groups the five input pictures into linguistic categories.

By ranking the stratum of markedness constraints *FnC / *FC higher than DCon, a different pattern can be generated, one where the two "over-situations" are equated into only one term. This is the case for both Japanese and Warrwa (see Levinson & Wilkins, 2006, summaries on Warrwa and Japanese, p. 553 / 554). The ranking for these two languages is given in Table 7. A visualisation of the Japanese and Warrwa categories of the input is given in Figure 7.

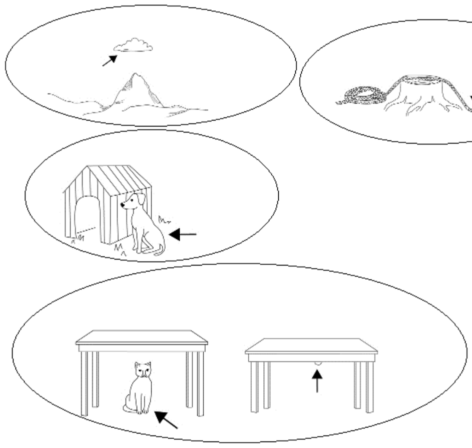

Figure 6: Dutch categories of Group 1. Terms are not given to emphasise the fact that the concrete lexical form is of no importance to the analysis here.

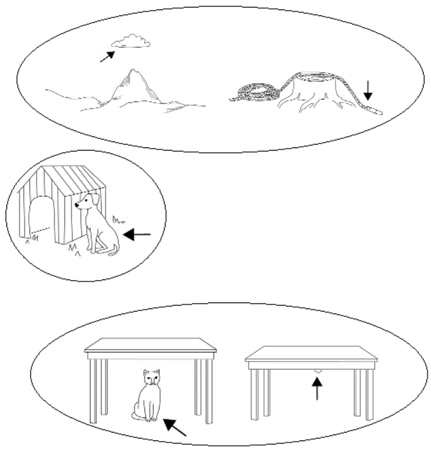

Figure 7: Japanese and Warrwa categories of Group 1. Terms are not given to emphasise the fact that the concrete lexical form is of no importance to the analysis here.

boven (FnC)	**DRelPos**	***GnC**	***GC**	***FnC**	***FC**	**DCon**
boven (FnC)				*!		
over (FC)☺					*	*
onder1 (GnC)	*!	*				
onder2 (GC)	*!		*			*
naast (SnC)	*!					

over (FC)	**DRelPos**	***GnC**	***GC**	***FnC**	***FC**	**DCon**
boven (FnC)				*!		*
over (FC)☺					*	
onder1 (GnC)	*!	*				*
onder2 (GC)	*!		*			
naast (SnC)	*!					*

onder1 (GnC)	**DRelPos**	***GnC**	***GC**	***FnC**	***FC**	**DCon**
boven (FnC)	*!			*		
over (FC)	*!				*	*
onder1 (GnC)		*!				
onder2 (GC)☺			*			*
naast (SnC)	*!					

onder2 (GC)	**DRelPos**	***GnC**	***GC**	***FnC**	***FC**	**DCon**
boven (FnC)	*!			*		*
over (FC)	*!				*	
onder1 (GnC)		*!				*
onder2 (GC)☺			*			
naast (SnC)	*!					*

naast (SnC)	**DRelPos**	***GnC**	***GC**	***FnC**	***FC**	**DCon**
boven (FnC)	*!			*		
over (FC)	*!				*	*
onder1 (GnC)	*!	*				
onder2 (GC)	*!		*			*
naast (SnC)☺						

Table 7: Tableaus to generate the Japanese and Warrwa terms for the input of Group 1. The winning candidates are marked with a ☺.

Unfortunately, I lack the data for the Japanese and Warrwa terms for "onder-situations". However, I assume that these two languages only have one term for these two situations (just like Dutch). This is because it seems intuitively likely to assume that the distinction with respect to contact is more important in situations where the Figure is the higher entity than in situations where the Ground is the higher entity, since we are seldom concerned with what goes on underneath objects. Situations where the Figure is higher than the Ground seem to be cognitively more important than situations where the Ground is higher than the Figure. I therefore assume that there is no language that has two terms for “onder-situations” yet only one for “over-situations”, i.e. that the following relative ranking of the strata of markedness constraints holds for all languages:

- (*GnC / *GC) » (*FnC / *FC)

This means that I predict that there are no languages that express the contact distinction in situations where the Ground is higher but not in situations where the Figure is higher (which would be generated by the reverse ranking of the strata of markedness constraints).[23]

It also seems likely that the distinction with respect to the relative position of the objects is always more important than the distinction concerning contact, though I know of no research to prove that claim. If true, this makes the relative ranking DRelPos » DCon applicable to all languages, requiring always at least three terms for the categorisation of group 1, corresponding to the three values ‘Figure higher’, ‘Ground higher’ and ‘same level’.

I lack the data for further cross-linguistic comparisons, but given the above assumptions, there are three logical categorisations of the input in this group:

- languages that have only three terms, like Japanese and Warrwa, expressing only the distinction with respect to relative position, generated by the ranking:

  DRelPos » (*GnC / *GC) (*FnC / *FC) » DCon

- languages that have four terms, like Dutch, expressing the distinction of contact only if the Figure is the higher entity, generated by the ranking:

  DRelPos » (*GnC / *GC) » DCon » (*FnC / *FC)

- languages that have five terms, always respecting the distinctions relating to the relative position of the objects and to contact, generated by the ranking:

  DRelPos » DCon » (*GnC / *GC) (*FnC / *FC)

[23]It is not usual in other, non-lexical uses of OT to assume such universally true rankings. This is something that I have learned from the kinship analysis by Jones. For every one of his subgroups, Jones gives what he calls “markedness gradients”. These are rankings that he finds to always be applicable. He relates those to psychological assumptions about how we think about kinship.

4.4.2 Group 2: Inclusion Terminology

The choice for the subdomain of inclusion terminology was determined to no small extent by the fact that inclusion has been treated as a spatial primitive, a core feature, which is sometimes said to be directly encoded in spatial expressions (cf. Levinson & Meira, 2003, Xu & Kemp, 2010). My wish was to further break down such primitives, and my own data as well as the evidence from cross-linguistic studies suggest that there are several ways of doing so with respect to inclusion. The attributes that I formulated as constraints for this group are determined by distinctions in inclusion terminology cross-linguistically (cf. Levinson & Wilkins, 2006).

The attributes and values for inclusion terminology and how the relevant Dutch prepositions[24], *door* (through), *in* (in) and *om* (around), are distributed over them are given in Table 8.

attributes / prepositions	**door**	**in**	**om**
'included entity'	Figure	Figure	Ground
'horizontal extension'	Figure both sides	Ground both sides	Figure both sides, overlapping
'negative space'	Ground	Figure, Ground, neither	neither

Table 8: Attribute-value structure of Dutch inclusion terminology.

Concerning the Attributes I have included three attributes into this group, even though I did not find linguistic proof for all the distinctions they require. The attribute 'included entity' is the most important for this group, the most salient (cf. Levinson & Wilkins). It specifies whether the Ground or the Figure is included (the value 'neither' is irrelevant for the subdomain of inclusion terminology). The attribute 'horizontal extension' is needed to specify the relative horizontal position of Figure and Ground. Of all the values listed in Table 2 above, only three are relevant here: 'overlapping', 'Figure extends to both sides' ("sticks out") and 'Ground extends to both sides' ("surrounds"). The other values don't come up in my input (see below).

The attribute 'negative space' does not represent a distinction that is made in Dutch, and that is only partially made in other languages. I include this attribute despite the lack of full linguistic proof, because I think that all the

[24] The attribute-value structure given for the prepositions in this group corresponds to their "pure" uses. That is, only pictures that have been described by just one and the same preposition enter into the attribute-value structure of that preposition.

distinctions it requires are cognitively very salient, and I expect that there are languages that express them all.[25] The attribute is a fusion of the two above attributes 'negative space' and 'impaired integrity'. The reason for this fusion is that in the case of the Ground, it is not always clear if what we are dealing with is a negative space or impaired integrity. Take for example the situation of *owl in tree* (picture 67). Now, what this really is, is in fact *owl in hole in tree.* Yet because holes in trees are not so important in human society, the two entities hole and tree are fused into one term: tree. This situation would, strictly speaking, be an instance of impaired integrity. However, if we imagine the same situation with a rock instead of a tree, the whole configuration changes. Instead of *owl in hole in rock* or *owl in rock*, suddenly we speak of *owl in cave.* This is so because caves were inherently more important throughout human history (and maybe still are) than holes in trees. Because of this blurriness concerning the distinction between Grounds as negative spaces and Grounds with impaired integrity, I collapse the two attributes into one and specify it for 'Ground' whenever the Ground is either a negative space or has an impaired integrity. In the case of the Figure, the attribute is only concerned about negative spaces, not about impaired integrity.

The Input The input for inclusion terminology corresponds to six pictures from the Topological Relations Pictures Series and can be found in Figure 8. As in group 1 above, the pictures are labelled with their Dutch prepositions, even though that is no one-to-one match. And again, I do not take the terms as the input, but the pictures. The terms used in the input formula serve merely as labels for the pictures. In this group, there are three pictures categorised under the Dutch term *in* and two pictures that are categorised under the Dutch term *om.* Below I give the labels of the pictures, their numbers in the Series, and a list of features that characterises each one of them (again analogue to Jones' conceptualisation of the kinship domain as bundles of features).

- door (picture 30): Figure included, Figure extends to both sides, Ground is a negative space (FiFbsGn)
- in1 (picture 67): Figure included, Ground extends to both sides, Ground is a negative space (FiGbsGn)
- in2 (picture 02): Figure included, Ground extends to both sides, no negative space (FiGbsNn)

[25] Maybe this distinction with respect to negative spaces is even relevant for Dutch, in a way. There seems to be a restriction on the use of *binnenin* (inside-in) depending on the type of negative space that is involved. *De spijker is binnenin het hout* (the nail is inside-in the wood) is not possible, but *de spijker is binnenin de klok* (the nail is inside-in the clock) is acceptable. Thanks to Joost Zwarts for pointing this out.

- in3 (picture 26): Figure included, Ground extends to both sides, Figure is a negative space (FiGbsFn)
- om1 (picture 04): Ground included, Figure and Groud overlapping, no negative space (GiOvNn)
- om2 (picture 15): Ground included, Figure extends to both sides, no negative space (GiFbsNn)

Table 9 shows how the input of group 1 is distributed over the possible feature combinations.

Features	Ground Negative Space	Figure Negative Space	no negative space	no negative space
Features	Figure included	Figure included	Figure included	Ground included
Figure both sides	door (FiFbsGn)	n.a.	n.a.	om2 (GiFbsNn)
Ground both sides	in1 (FiGbsGn)	in3 (FiGbsFn)	in2 (FiGbsNn)	n.a.
overlapping		n.a.		om1 (GiOvNn)

Table 9: Distribution over the possible feature combinations of the input of Group 2. N.a. stands for logically impossible combinations. Empty spaces stand for possible but absent combinations.

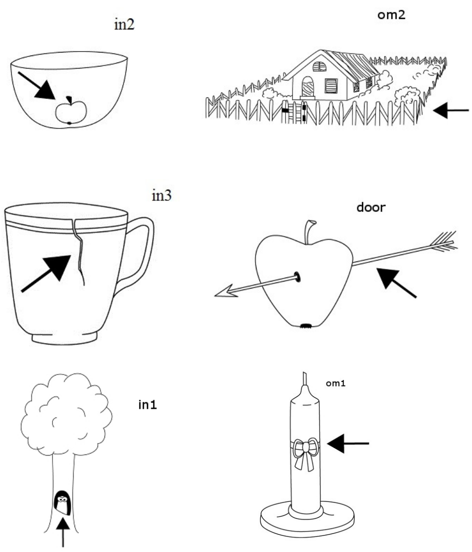

Figure 8: Input for Group 2.

Some of the feature combinations in Table 9 don't come up in my input. For example, the combination 'Figure included, Ground and Figure overlapping, no negative space' is missing, yet entirely possible if one thinks for instance of a *gift in wrappings*. The Figure is the gift, which is included by the Ground, the wrappings. It is wrapped tightly, i.e. Ground and Figure overlap, and there is no negative space. Other missing feature combinations, on the other hand, are logically impossible. For example, it is impossible that the Figure is the included object, yet extends the Ground on both sides ("sticks out"), if the Ground is not a negative space or has an impaired integrity.

Analysis Group 2 There are seven constraints needed to generate the patterns of categorisation found in inclusion terminology. They are given below:

- DInclObj: Distinguish between the included objects
- DHorExt: Distinguish between the horizontal extensions of the objects
- *GiFbs: Don't express separately the feature combination 'Ground included, Figure extends to both sides'
- *GiOv: Don't express separately the feature combination 'Ground included, Figure and Ground are overlapping'
- DNegSpace: Distinguish between which objects are negative spaces
- *FiGn: Don't express separately the feature combination 'Figure included, Ground is a negative space'
- *FiFn: Don't express separately the feature combination 'Figure included, Figure is a negative space'

Dutch categorises the six input scenes into three terms, Ewe and Tiriyó (cf. Levinson & Wilkins, 2006, p. 561; Levinson & Meira, 2003, pp. 502 / 503) into four, equating the situations in1, in2 and door, while separately expressing in3, om1 and om2. In the tableaus, given in Table 10 and Tables 11 below, it is not important what the actual output form is. The way the constraints are formulated, Dutch equates all "in-situations" to the output term corresponding to in2. But whether all "in-situations" are equated to in1, in2 or in3 does not matter. What matters is that all three "in-situations" have the same output, which means that they share one and the same term, disregarding that term's concrete lexical form. The same holds for Ewe and Tiriyó, where the output for in1, in2 and door is also the term corresponding to in2.

Again, the violation patterns of the faithfulness constraints in the tableaus below are determined by the different values their respective attributes can take.

For example, DInclObj demands two different terms, corresponding to the two values ‘Ground included’ and ‘Figure included’ of the attribute ‘included object’. If the input is a situation where the Figure is included, all output candidates where the Ground is included will violate DInclObj. This faithfulness constraint thus does not allow for situations where the Figure is included to be categorised into one term with situations where the Ground is included.

In order to present the results of the tableaus in Tables 10 and 11 more accessibly, Figures 9 and 10 contain a visualisation of the category structure in Dutch and in Ewe and Tiriyó respectively.

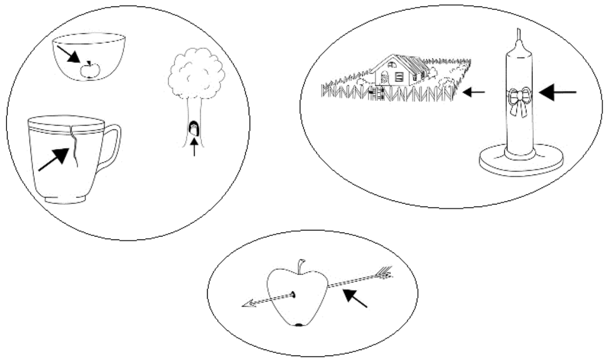

Figure 9: Dutch categories of Group 2. Terms are not given to emphasise the fact that the concrete lexical form is of no importance to the analysis here.

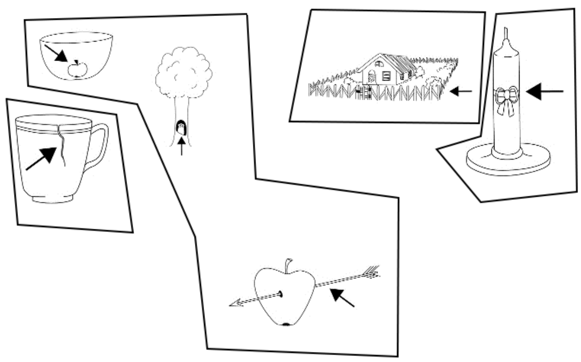

Figure 10: Ewe and Tiriyó categories of Group 2. Terms are not given to emphasise the fact that the concrete lexical form is of no importance to the analysis here.

door (FiFbsGn)	**DInclObj**	***GiFbs**	***GiOv**	**DHorExt**	***FiGn**	***FiFn**	**DNegSpace**
door (FiFbsGn)☺					*		
in1 (FiGbsGn)				*!	*		
in2 (FiGbsNn)				*!			*
in3 (FiGbsFn)				*!		*	*
om1 (GiOvNn)	*!		*	*			*
om2 (GiFbsNn)	*!	*					*

in1 (FiGbsGn)	**DInclObj**	***GiFbs**	***GiOv**	**DHorExt**	***FiGn**	***FiFn**	**DNegSpace**
door (FiFbsGn)				*!	*		
in1 (FiGbsGn)					*!		
in2 (FiGbsNn)☺							*
in3 (FiGbsFn)						*!	*
om1 (GiOvNn)	*!		*	*			*
om2 (GiFbsNn)	*!	*		*			*

in2 (FiGbsNn)	**DInclObj**	***GiFbs**	***GiOv**	**DHorExt**	***FiGn**	***FiFn**	**DNegSpace**
door (FiFbsGn)				*!	*		*
in1 (FiGbsGn)					*!		*
in2 (FiGbsNn)☺							
in3 (FiGbsFn)						*!	*
om1 (GiOvNn)	*!		*	*			
om2 (GiFbsNn)	*!	*		*			

in3 (FiGbsFn)	**DInclObj**	***GiFbs**	***GiOv**	**DHorExt**	***FiGn**	***FiFn**	**DNegSpace**
door (FiFbsGn)				*!	*		*
in1 (FiGbsGn)					*!		*
in2 (FiGbsNn)☺							*
in3 (FiGbsFn)						*!	
om1 (GiOvNn)	*!		*	*			*
om2 (GiFbsNn)	*!	*		*			*

om1 (GiOvNn)	**DInclObj**	***GiFbs**	***GiOv**	**DHorExt**	***FiGn**	***FiFn**	**DNegSpace**
door (FiFbsGn)	*!			*	*		*
in1 (FiGbsGn)	*!			*	*		*
in2 (FiGbsNn)	*!			*			
in3 (FiGbsFn)	*!			*		*	*
om1 (GiOvNn)☺			*				
om2 (GiFbsNn)		*!		*			

om2 (GiFbsNn)	**DInclObj**	***GiFbs**	***GiOv**	**DHorExt**	***FiGn**	***FiFn**	**DNegSpace**
door (FiFbsGn)	*!				*		*
in1 (FiGbsGn)	*!			*	*		*
in2 (FiGbsNn)	*!			*			
in3 (FiGbsFn)	*!			*		*	*
om1 (GiOvNn)☺			*	*			
om2 (GiFbsNn)		*!					

Table 10: Tableaus to generate the Dutch terms for the input of Group 2. The winning candidates are marked with a ☺.

door (FiFbsGn)	**DInclObj**	***FiGn**	**DNegSpace**	***FiFn**	**DHorExt**	***GiFbs**	***GiOv**
door (FiFbsGn)		*!					
in1 (FiGbsGn)		*!			*		
in2 (FiGbsNn)☺			*		*		
in3 (FiGbsFn)			*	*!	*		
om1 (GiOvNn)	*!		*		*		*
om2 (GiFbsNn)	*!		*			*	
in1 (FiGbsGn)	**DInclObj**	***FiGn**	**DNegSpace**	***FiFn**	**DHorExt**	***GiFbs**	***GiOv**
door (FiFbsGn)		*!			*		
in1 (FiGbsGn)		*!					
in2 (FiGbsNn)☺			*				
in3 (FiGbsFn)			*	*!			
om1 (GiOvNn)	*!		*		*		*
om2 (GiFbsNn)	*!		*		*	*	
in2 (FiGbsNn)	**DInclObj**	***FiGn**	**DNegSpace**	***FiFn**	**DHorExt**	***GiFbs**	***GiOv**
door (FiFbsGn)		*!	*		*		
in1 (FiGbsGn)		*!	*				
in2 (FiGbsNn)☺							
in3 (FiGbsFn)			*!	*			
om1 (GiOvNn)	*!				*		*
om2 (GiFbsNn)	*!				*	*	
in3 (FiGbsGn)	**DInclObj**	***FiGn**	**DNegSpace**	***FiFn**	**DHorExt**	***GiFbs**	***GiOv**
door (FiFbsGn)		*!	*		*		
in1 (FiGbsGn)		*!	*				
in2 (FiGbsNn)			*				
in3 (FiGbsFn)☺				*			
om1 (GiOvNn)	*!		*		*		*

om2 (GiFbsNn)	*!		*		*	*	
om1 (GiOvNn)	**DInclObj**	***FiGn**	**DNegSpace**	***FiFn**	**DHorExt**	***GiFbs**	***GiOv**
door (FiFbsGn)	*!	*	*		*		
in1 (FiGbsGn)	*!	*	*		*		
in2 (FiGbsNn)	*!				*		
in3 (FiGbsFn)	*!		*	*	*		
om1 (GiOvNn)☺							*
om2 (GiFbsNn)					*!	*	
om2 (GiFbsNn)	**DInclObj**	***FiGn**	**DNegSpace**	***FiFn**	**DHorExt**	***GiFbs**	***GiOv**
door (FiFbsGn)	*!	*	*				
in1 (FiGbsGn)	*!	*	*		*		
in2 (FiGbsNn)	*!				*		
in3 (FiGbsFn)	*!		*	*	*		
om1 (GiOvNn)					*!		*
om2 (GiFbsNn)☺						*	

Table 11: Tableaus to generate the Ewe and Tiriyó terms for the input of Group 2. The winning candidates are marked with a ☺.

Several things stand to be noted about these constraints and their rankings. The faithfulness constraint DInclObj does not have corresponding markedness constraints. I believe that every language expresses the distinction of which object is included. This fact is supported by the findings of Levinson & Wilkins, who say that in all the languages in their sample, the basic locative constructions express the distinction of which object is included (Levinson & Wilkins, 2006, p. 515).

The distinctions required by the faithfulness constraint DHorExt are partly neutralised by the stratum of markedness constraints *GiFbs / *GiOv. These two markedness constraints are responsible for the fact that there is only one term for both "om-situations" in Dutch.[26] However, DHorExt also requires a distinction between the Dutch terms *in* and *door*. This is fine for Dutch, which has both terms, but not for Ewe or Tiriyó, where "door-situations" are equated with in1 and in2. Theoretically, there should be two more markedness constraints of the form *FiFbs (don't express separately the feature combination 'Figure included, Figure extends to both sides') and *FiGbs (don't express separately the feature combination 'Figure included, Ground extends to both sides'). These would then prevent the distinction between on the one hand the

[26] Again, it is not technically necessary to include both markedness constraints. The reason why I do this is to avoid unwanted predictions about the typicality of "om-situations".

two “in-situations” in1 and in2 and on the other hand the “door-situation” in Ewe and Tiriyó on the basis of these situations’ different horizontal extensions. The reason why I don’t formulate these two markedness constraints, and why I can still generate the in / door category of Ewe and Tiriyó, are the markedness constraints relating to the attribute ‘negative space’. Their role for the in / door category in Ewe and Tiriyó will be explained in some more detail below, after I have elaborated on the constraints relating to negative spaces.

The faithfulness constraint DNegSpace requires there to be three separate terms, corresponding to the three values of the attribute ‘negative space’ as defined above: ‘Figure is a negative space’, ‘Ground is a negative space’ or ‘neither is a negative space’. This would mean three different terms for Dutch *in*. By formulating the corresponding markedness constraints, *FiGn and *FiFn, this effect is countered, and there is only one term for all “in-situations”. Notice that here I’m not formulating all values of the attribute ‘negative space’ as markedness constraints, other than in the strata of markedness constraints in group 1. Only the values ‘Ground is a negative space’ and ‘Figure is a negative space’ are formulated as markedness constraints. This is because I expect “in-situations” that don’t involve a negative space to be more typical for this category than “in-situations” that do involve a negative space. This prediction is backed by the fact that negative spaces are often treated apart in spatial psychology.

Notice further that in the tableaus generating the Ewe and Tiriyó pattern of categorisation, the stratum of markedness constraints relating to negative spaces *FiGn / *FiFn is split up. In Ewe and Tiriyó, only one value of the attribute ‘negative space’ is expressed separately, namely ‘Figure is a negative space’, corresponding to input situation in3. In order to mark this input situation with a separate term, the markedness constraint *FiFn needs to be ranked lower than the faithfulness constraint DNegSpace. *FiFn prevents the separate expression of input situations where the Figure is a negative space, whereas DNegSpace requires it (DNegSpace requires a separate term for all the values of the attribute ‘negative space’). In order to not also mark separately the input situations in1 and door, which both contain the feature ‘Ground is a negative space’, the markedness constraint *FiGn needs to be ranked higher than DNegSpace. *FiGn prevents the separate expression of input situations where the Ground is a negative space.

As I said above, the two markedness constraints *FiGn and *FiFn do not only neutralise the distinctions required by the faithfulness constraint DNegSpace, but also the distinctions required by DHorExt when the Figure is included. If these markedness constraints precede DHorExt in the hierarchy, they not only require one term for all “in-situations”, neutralising distinctions with respect to negative spaces, but they also equate “door-situations” into this category.

As already mentioned, the input door is ruled out by the markedness constraint *FiGn, which forbids a separate term for situations where the Figure is included and the Ground is a negative space (which is the feature combination for the input door). This allows to generate the pattern for Ewe and Tiriyó, where the "door-situation" is equated with the two "in-situations" in1 and in2.[27] The markedness constraints relating to negative spaces can therefore also be used to neutralise the distinctions required by DHorExt.

There are certain consequences of neglecting to formulate the two markedness constraints *FiGbs and *FiFbs, which would neutralise the effects of DHorExt and equate *door* and *in* into one category, regardless of the negative spaces. Even if a high rank of DNegSpace would require three terms for "in-situations" (corresponding to the three values of that attribute), the two inputs labelled door (FiFbsGn) and in1 (FiGbsGn) could not form a category by themselves, i.e. not share the same term just between themselves. This is so because the faithfulness constraint DHorExt would require a separate term for door and in1, and there are no markedness constraints to counter that effect. Given the above set of constraints, I don't allow for any language to have one term for only the input situations door and in1.[28]

There is another pattern which I don't expect to come up in any language, though my set of constraints in principal would allow for it. I don't expect there to be a language that has a separate term for situations where the Ground is a negative space, but not for situations where the Figure is a negative space. Negative spaces as the Figure are much more common than negative spaces as the Ground (which is reflected by the fact that there is no picture in the Topological Relations Pictures Series where the Ground is a negative space, only one where a negative space is "fused" into the Ground). This speaks for the fact that situations with the Figure as a negative space are cognitively more salient than situations with the Ground as a negative space.

Given the above, I allow for the following categorisations of the input of group 2:

- languages that have only two terms, expressing only the distinction of which object is included (om1 = om2 and in1 = in2 = in3 = door), generated by the ranking:

  DInclObj » (*GiFbs / GiOv) (*FiGn / *FiFn) » DHorExt » DNegSpace

[27]In the Dutch ranking, the respective higher rank of DHorExt ensures that there is a separate term *door* in Dutch, but requires no distinctions for "in-situations", because they share the same value for the attribute 'horizontal extension'.

[28]This is very abstract and probably hard to understand without illustrations. I invite the interested reader to shuffle the above constraints her- or himself to generate a language that has terms corresponding to (om1 / om2), in1=door, in2 and in3.

- languages that have three terms, like Dutch, expressing the distinctions with respect to which object is included and with respect to the horizontal extension of the objects if the Figure is included, generated the ranking:

  DInclObj » (*GiFbs / GiOv) » DHorExt » (*FiGn / *FiFn) » DNegSpace

- languages that allow four terms, always expressing the distinctions with respect to which object is included and the horizontal extension (om1, om2, in1 = in2 = in3, door), generated by the ranking:

  DInclObj » DHorExt » (*FiGn / *FiFn) (*GiFbs / GiOv) » DNegSpace

- languages that allow for four terms, like Ewe and Tiriyó, expressing the distinctions with respect to which object is included, with respect to the horizontal extension in case the Ground is included, and with respect to the presence of a negative space as the Figure, generated by the ranking:

  DInclObj » *FiGn » DNegSpace » *FiFn » DHorExt » (*GiFbs / *GiOv)

- languages that allow for five terms, expressing the distinctions with respect to which object is included, with respect to the horizontal extension, and with respect to the presence of a negative space as the Figure (om1, om2, in1=in2, in3, door), generated by the ranking:

  DInclObj » DHorExt » *FiGn » DNegSpace » *FiFn » (*GiFbs / GiOv)

- languages that allow all six terms, respecting all the distinctions, generated by the ranking:

  DInclObj » DHorExt » DNegSpace » (*GiFbs / GiOv) (*FiGn / *FiFn)

4.4.3 Group 3: Support Terminology

The choice for the subdomain of support terminology has a similar motivation as the choice for the subdomain of inclusion terminology. Support, like inclusion, has been characterised as a spatial primitive (cf. Levinson & Meira, 2003; Xu & Kemp, 2010), and it was my wish to further break down these primitives. The attributes that are formulated as constraints for this group are determined by the sub-distinctions possible in cases of support.

The attributes and values for support terminology and the distribution of the relevant Dutch prepositions[29], (*aan* (on), *op* (on) and *tegen* (against)), over the attributes are given in Table 12.

[29]As in group 2, only scenes that have been described by just one preposition are used to determine the attribute-value structure of the prepositions.

attributes / prepositions	aan	op	tegen
‘direction of support’	from same level, from above	from below	from same level
‘attachment’	yes	yes, no	no

Table 12: Attribute-value structure of the Dutch prepositions relevant for support terminology.

Concerning the Attributes and Prepositions I chose the three Dutch prepositions *aan*, *op* and *tegen* for Dutch support terminology. All of them are primarily characterised by attributes relating to support. Furthermore, it is these three prepositions that have been analysed together by researchers concerned with Dutch spatial expressions (cf. Beliën, 2002; Cuyckens, 1991).

The above attribute ‘direction of support’ could also be replaced by the attribute ‘place of contact Ground’, where the values would be ‘side’ and ‘underneath’ (for *aan*), ‘on top’ (for *op*) and ‘side’ (for *tegen*). The reason why I chose to focus on support as opposed to contact is that for this group, ‘support’ is more vital than ‘contact’ (cf. Feist, 2000). Additionally, ‘contact’ comes up throughout my groups and beyond and is therefore less informative. But whether support or contact, the analysis in this group, given my sample, would be the same in both cases.

The Input The input for support terminology are five pictures taken from the Topological Relations Pictures Series. Below I give the label for each picture (corresponding to its Dutch preposition), its number in the Series, and its characterisation in terms of feature bundles. The pictures themselves can be found in Figure 11. Again, the labels are the respective Dutch prepositions, but that is simply a matter of convenience. I take the pictures as the input, not the specific terms.

- aan1 (picture 27): Support from above, attachment (AbAt)
- aan2 (picture 25): Support from same level, attachment (SLAt)
- op1 (picture 01): Support from below, no attachment (BeNAt)
- op2 (picture 60): Support from below, attachment (BeAt)
- tegen (picture 58): Support from same level, no attachment (SLNAt)

Table 13 shows how the input of group 3 is distributed over the possible feature combinations. There is only one feature combination that is logically impossible. If there is support given from above, there has to be some attachment involved, otherwise gravity would pull the two objects apart and there would be no support.

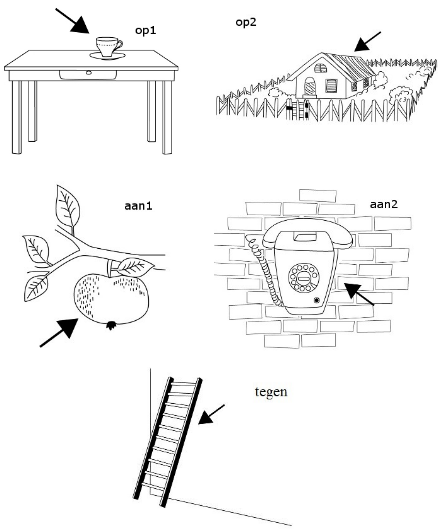

Figure 11: The input scenes for group 3.

Features	Attachment	no Attachment
Support from above	aan1 (AbAt)	n.a.
Support from same level	aan2 (SLAt)	tegen (SLNAt)
Support from below	op2 (BeAt)	op1 (BeNAt)

Table 13: Distribution over the possible feature combinations of the input of Group 3. N.a. stands for logically impossible combinations.

Analysis Group 3 The above attributes can be formulated into two faithfulness constraints and four corresponding markedness constraints.

- DSupp: Distinguish between the different directions of support
- *AbAt: Don't express separately the feature combination 'support from above, attachment'
- *SLAt: Don't express separately the feature combination 'support from same level, attachment'
- DAttach: Distinguish between attachment and no attachment
- *BeNAt: Don't express separately the feature combination 'support from below, no attachment'
- *BeAt: Don't express separately the feature combination 'support from below, attachment'

The two markedness constraints *AbAt and *SLAt counter the effects of the faithfulness constraint DSupp, and the two markedness constraints *BeNAt and *BeAt counter the effects of the faithfulness constraint DAttach. Just as in the two previous analyses (with the exception of negative spaces in group 2), I include both markedness constraints in order to avoid making a statement about typicality. The results of the analysis are unaffected by the choice of including only one or both markedness constraints. However, as in the case of the markedness constraints relating to negative spaces in group 2, the markedness constraints here do not always form a stratum, that is, they are not always ranked next to each other. In this case, this is due to some sort of family resemblance quality of this group, which I will lay out in some more detail below. The tableaus for generating Dutch support terminology are given in Table 14.

aan1 (AbAt)	***AbAt**	**DSupp**	***BeNAt**	***BeAt**	**DAttach**	***SLAt**
aan1 (AbAt)	*!					
aan2 (SLAt)☺		*				*
op1 (BeNAt)		*	*!		*	
op2 (BeAt)		*		*!		
tegen (SLNAt)		*			*!	
aan2 (SLAt)	***AbAt**	**DSupp**	***BeNAt**	***BeAt**	**DAttach**	***SLAt**
aan1 (AbAt)	*!	*				
aan2 (SLAt)☺						*
op1 (BeNAt)		*!	*		*	
op2 (BeAt)		*!		*		

tegen (SLNAt)					*!	
op1 (BeNAt)	***AbAt**	**DSupp**	***BeNAt**	***BeAt**	**DAttach**	***SLAt**
aan1 (AbAt)	*!	*			*	
aan2 (SLAt)		*!			*	*
op1 (BeNAt)			*!			
op2 (BeAt)☺				*	*	
tegen (SLNAt)		*!				
op2 (BeAt)	***AbAt**	**DSupp**	***BeNAt**	***BeAt**	**DAttach**	***SLAt**
aan1 (AbAt)	*!	*				
aan2 (SLAt)		*!				*
op1 (BeNAt)			*!		*	
op2 (BeAt)☺				*		
tegen (SLNAt)		*!			*	
tegen (SLNAt)	***AbAt**	**DSupp**	***BeNAt**	***BeAt**	**DAttach**	***SLAt**
aan1 (AbAt)	*!	*			*	
aan2 (SLAt)					*!	*
op1 (BeNAt)		*!	*			
op2 (BeAt)		*!		*	*	
tegen (SLNAt)☺						

Table 14: Tableaus to generate Dutch support terminology. The winning candidates are marked with a ☺.

The results of Table 14 are presented visually in Figure 12.

Dutch categorises the subdomain of support terminology into three terms: *aan*, *op* and *tegen*. Note that the markedness constraint *AbAt is ranked highest, and the markedness constraint *SLAt is ranked lowest. These two markedness constraints serve to neutralise the distinctions required by DSupp, which would otherwise require two terms for “aan-situations” (one where the support is given from the same level, and one where the support is given from above). Were I to rank both of these markedness constraints next to each other in positions one and two on the hierarchy, neither of the “aan-situations” would be allowed an individual term and instead be equated with “op-situations”.

In all the preceding analyses, there was always a faithfulness constraint ranked highest; DRelPos and DInclObj for projective and relative position terminology and inclusion terminology respectively. These faithfulness constraints represent important distinctions that are made in these two groups. In projective and relative position terminology, there are always at least two separate

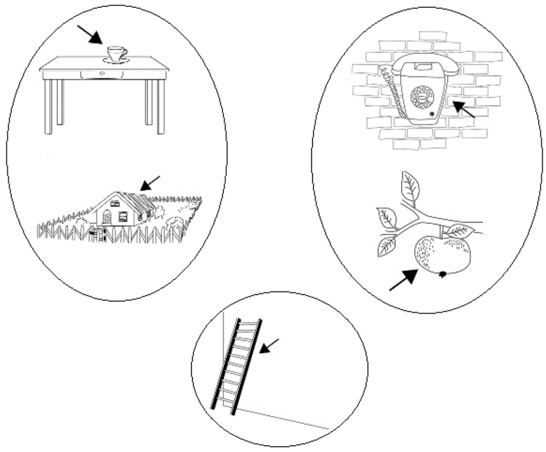

Figure 12: Dutch categories of Group 3. Terms are not given to emphasise the fact that the concrete lexical form is of no importance to the analysis here.

terms equating all situations where the Figure is higher on the one hand, and all the situations where the Ground is higher on the other hand. Similarly, in inclusion terminology, there are always at least two terms, equating all situations where the Ground is included on the one hand, and all situations where the Figure is included on the other hand.

There is no similar important distinction in the domain of support terminology. The five inputs are organised according to a family resemblance principle (recall Cuyckens, 1991, briefly presented in section 2 above, who says the same though he uses different attributes). All “aan-situations” are characterised by ‘attachment’, but so is one “op-situation”. The “tegen-situation” is characterised by a lack of attachment and support from the same level, but the former feature is shared with one “op-situation” and the latter feature with one “aan-situation”. There is no one distinction as clear as the ones required by DRelPos and DInclObj in the groups above.

This is why a markedness constraint needs to be ranked highest to generate Dutch support terminology. Dutch *tegen* and *op* categorise along the distinction of ‘direction of support’ (*op* = support from below, *tegen* = support from same level). But Dutch *aan* equates two values of that attribute (‘support from same level’ and ‘support from above’). So in order to create the category corresponding to Dutch *aan*, a markedness constraint needs to precede the faithfulness constraint DSupp and guarantee that the different directions of support are not marked in *aan*.

Notice that in the first tableau for Dutch, where the input aan1 (AbAt) is evaluated, all output candidates except the first tie on the faithfulness constraint DSupp. This is because the value for ‘direction of support’ expressed by aan1 (‘from above’) is not found in any other output candidate, meaning they all violate DSupp if the input is aan1. Yet since the distinctions with respect to direction of support are not expressed separately for the two “aan-situations”, the high rank of DSupp is irrelevant for this first tableau. The constraints relating to attachment resolve the tie. They ensure that there is only one term for “aan-situations”, disregarding direction of support, but being faithful to attachment.

The summaries of cross-linguistic data on spatial language, provided by Levinson & Wilkins, give evidence for another pattern. The languages Tiriyó and Yélî Dnye both categorise the support domain into four terms, corresponding to the input situations aan1 / aan2 (Dutch *aan*), op1, op2 and tegen (Levinson & Wilkins, 2006, pp. 560 / 561, but also Levinson & Meira, 2003, p. 497 and pp. 500 / 501). The tableaus to generate these two languages are given in Table 15.

aan1 (AbAt)	***AbAt**	**DSupp**	**DAttach**	***BeNAt**	***BeAt**	***SLAt**
aan1 (AbAt)	*!					
aan2 (SLAt)☺		*				*
op1 (BeNAt)		*	*!	*		
op2 (BeAt)		*			*!	
tegen (SLNAt)		*	*!			
aan2 (SLAt)	***AbAt**	**DSupp**	**DAttach**	***BeNAt**	***BeAt**	***SLAt**
aan1 (AbAt)	*!	*				
aan2 (SLAt)☺						*
op1 (BeNAt)		*!	*	*		
op2 (BeAt)		*!			*	
tegen (SLNAt)			*!			
op1 (BeNAt)	***AbAt**	**DSupp**	**DAttach**	***BeNAt**	***BeAt**	***SLAt**
aan1 (AbAt)	*!	*	*			
aan2 (SLAt)		*!	*			*
op1 (BeNAt)☺				*		
op2 (BeAt)			*!		*	
tegen (SLNAt)		*!				
op2 (BeAt)	***AbAt**	**DSupp**	**DAttach**	***BeNAt**	***BeAt**	***SLAt**
aan1 (AbAt)	*!	*				
aan2 (SLAt)		*!				*
op1 (BeNAt)			*!	*		
op2 (BeAt)☺					*	
tegen (SLNAt)		*!	*			

tegen (SLNAt)	***AbAt**	**DSupp**	**DAttach**	***BeNAt**	***BeAt**	***SLAt**
aan1 (AbAt)	*!	*	*			
aan2 (SLAt)			*!			*
op1 (BeNAt)		*!		*		
op2 (BeAt)		*!	*		*	
tegen (SLNAt)☺						

Table 15: Tableaus to generate Tiriyó and Yélî Dnye support terminology. The winning candidates are marked with a ☺.

The results of Table 15 are presented visually in Figure 13.

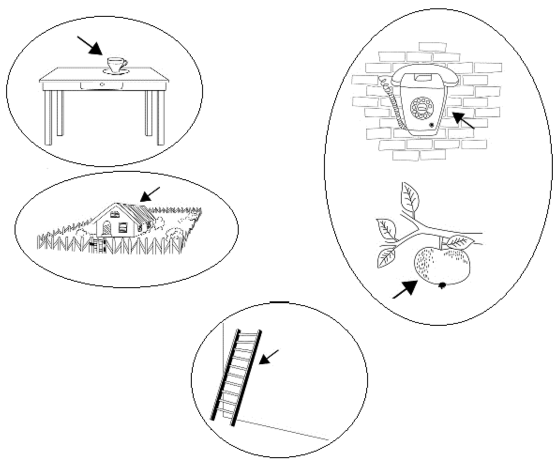

Figure 13: Tiriyó and Yélî Dnye categories of Group 3. Terms are not given to emphasise the fact that the concrete lexical form is of no importance to the analysis here.

The ranking for Tiriyó and Yélî Dnye is almost the same as the ranking for Dutch, the difference being the higher rank of the faithfulness constraint DAttach with respect to its corresponding markedness constraints *BeNAt and *BeAt. This ensures that the distinction of attachment in “op-situations” is expressed by two separate terms. Since there are no distinctions of attachment in either “aan-” or “tegen-situations”, these are unaffected by the change in the ranking.

There is no overarching distinction in this group that is respected by all languages (i.e. nothing similar to the distinction with respect to the relative position of the objects in group 1 or to the distinction with respect to the included object in group 2). Therefore, technically, all possible different rankings of the above constraints should be found in languages around the world. There should be all possible patterns present in languages, from one term for all five input situations (though I don't know if that is plausible) to five terms, one for each input situation.

Yet there is one pattern that cannot be generated by my set of constraints. In English, all "aan-" and "op-situations" are categorised together, corresponding to the English term *on*. Only the "tegen-situation" is treated apart, corresponding to the English term *against*. The reason why I cannot generate this pattern is the before mentioned family resemblance quality of this group. It is not possible to categorise all the input situations aan1, aan2, op1 and op2 together while treating tegen apart, because tegen shares with aan2 the direction of support (from the same level), and with op1 the absence of attachment. So if I try to categorise all "aan-" and "op-situations" together, either op1 or aan2 would end up being categorised with tegen, which is simply not the case in English. Out of the five pictures given in Figure 11, only picture 58, *ladder against wall*, is described by the English term *against*. All other pictures in the input are described by *on*.

There might be a way to fix this problem. If the "tegen-situation" would be conceptualised as involving only partial support of the Figure from the same level, it would be distinct from aan2 (which has full support of the Figure from the same level). This would require to either add more values to the attribute 'direction of support', to further distinguishing it with respect to full or partial support. Or one could add the attribute 'quantity of support', formulate the respective markedness and faithfulness constraints and extend the feature specifications for the input situations accordingly. In both cases, however, it would be desirable to find further cross-linguistic evidence for the extensions.

In the next section, I will briefly say something about the issue of "polysemous" spatial scenes, i.e. pictures that have been described by multiple prepositions.

4.5 The Issue of "Polysemous" Spatial Scenes

The above analyses are based on "pure" uses of the prepositions. That is, the attribute-value structure for e.g. *aan*, given in Table 12 above, is based on only those scenes that have been described solely by *aan*. This "purification", one could say, was made necessary by the fact that a lot of prepositions shared several pictures between them. *Aan* and *op*, for example, are both used to describe a subset of pictures of the Series, *aan* and *in* share pictures as well, and so on. In what follows I will try to give an explanation for these co-occurrences, based on extensions of the "core" uses of the relevant prepositions.

On Double Co-occurrences Not surprisingly, seeing as they form one category in a closely related language, the most common pair for co-occurrence are *aan* and *op*. They co-occur in pictures 07 (spider on ceiling), 12 (butter on knife), 33 (clothpin on line) and 35 (plaster on leg). Concerning the first two pictures, a tentative explanation might be that the situations underspecify the constraint system in that it is not clear from which direction the support is coming. In *butter on knife*, in any case, it is hard to judge from where the support is coming since butter has no axis and the axis of the knife is variable. Participants were forced to provide the missing information themselves, and depending on how they resolved that problem, used either *aan* or *op*. For *spider on ceiling*, there are two of frames-of-reference involved. When taking into consideration the ceiling, the support is clearly provided from above and the preposition of choice should be *aan*. However, when taking into consideration the spider and its relative axis, the support is coming from below because the spider is in contact with the ceiling feet-first (if spiders can be said to have feet). This conceptualisation of direction would favour *op*, which requires the support to come from below. There is no such straight forward explanation available for either *clothpin on line* or *plaster on leg*. Though for *clothpin on line* it can be said that the fact that the clothpin surrounds the line, and could therefore be said to be supported from the same level, favours *aan*, and that the way the clothpin is set upright onto the line favours *op*. And for *plaster on leg* one could argue that if the leg is stretched out, the plaster is support from below (requiring *op*), whereas when the person is standing, the plaster is supported from the same level (requiring *aan*). But neither of these pictures is drawn in the way that would favour *op*, so it might also be that there is some sloppiness going on, or else that the respective participants are influenced by the broader English category *on*, favouring *op* over *aan*, because it is phonologically closer.

Another co-occurrence is that of *aan* and *om* in pictures 10 (ring on finger) and 21 (shoe on foot). In both cases, the Ground is included (surrounded) by the Figure, which requires the use of *om*. However, in both cases, there is also support of the Figure coming from the same level, which would predict the use of *aan*. Depending on which attribute participants chose to focus on, they would then have used either *om* or *aan*.

Op and *in* also co-occur, in pictures 11 (ship on/in water), 62 (cork on bottle) and xx2 (hair on butter). In all of these cases, there are two conflicting conceptualisations. A ship can be said to be on (*op*) the water, if one focuses on the fact that it is supported from below and does not sink. But it can also be said to be in (*in*) the water, if one focuses on the fact that part of the lower body of the ship is included in the water (which is of great importance to professional sailors, who concern themselves with minimising drift, which requires water resistance, and maximising speed, for which water-resistance is a hindrance). The same holds for *cork in bottle* (the cork is partly included in the bottle, but also supported by it mainly from below) and *hair on butter*. Though the latter situation can be drawn to favour either *op*, if the butter is a solid block, or *in*, if the butter is depicted as soft.

Another co-occurrence of two prepositions is of *aan* and *in*, both of which come up in the descriptions of pictures 45 (apples on tree), 50 (hooks on wall) and 56 (flag on mast). The co-occurrence in the last two pictures can be explained by the fact that both Figure objects are partially included in the Ground. In order to hold on to the wall and support additional weight, parts of the hooks will have to be inside the wall. And in order to draw a flag up on a flagmast, it needs to slide up through a slit inside the mast (at least in some configurations). This favours the use of *in*. However, one can also conceptualise both pictures as primarily involving support from the same level. Both the flag and the hooks are supported from the same level by the flagmast and the wall respectively. This way to think about the scenes favours the use of *aan*. The situation of *apples on tree* is slightly different. The apples are never really included in the tree. However, if one thinks about the way in which e.g. children commonly draw trees, with a more or less round tree crown (as, in fact, the picture under concern is drawn), the apples can be said to be included in the circle made by the crown, i.e. its convex hull. This then explains the use of *in*. On the other hand, if one thinks of the apples as hanging from individual branches, being supported from above, *aan* would be the preposition of choice.

The last co-occurence of two prepositions is that of *op* and *tegen* in pictures 17 (tree on (side of) hill) and 48 (raindrops on window). In *tree on hill*, it might be the direction of support that is responsible for the choice of either the one or the other preposition. If one imagines the tree to be supported from below, *op* should be the preposition of choice. However, seeing as the tree stands on the side of the hill, one could also think of it as being supported from the same level, which would favour the use of *tegen* over *op*. The same holds for *raindrops on window*. If they are conceptualised as being supported from the same level, use of *tegen* should be preferred over use of *op*. The use of *op* for *raindrops on window*, on the other hand, is harder to explain, since in this case one cannot really speak of support from below. As to why *op* is used to describe this situation nonetheless, I have at present no idea.

On Triple Co-occurrences Several pictures are also described by three prepositions. *Door*, *aan* and *in*, for example, are all used to describe picture 69 (earring through earlobe). This picture unites core features of all three prepositions. *Door* will be used when the focus is on the horizontal extension of the

Figure, on the fact that the earring "sticks out" of the earlobe on both sides. *Aan* will be used when the focus is on the fact that the earring is support by the earlobe, with the support coming from roughly the same level of height. And *in* will be used when the focus is solely on the fact that part of the earring is included within the earlobe, disregarding both the horizontal extension of the Figure and the direction of support.

Another triple co-occurrence of prepositions is that of *aan*, *op* and *om*, all of which are used to describe pictures 22 (papers on spike) and 70 (apple on stick). Again, it can be seen how each scene allows for three different conceptualisations, each focusing on a different core aspect. Papers on a spike "include" the spike in that there are parts of the material of the spike that are surrounded by paper. This corresponds to inclusion of Ground and requires the use of *om*. When the focus is on the fact that the papers are supported by the spike from the same level of height, a feature of *aan*, this preposition will be used. And the fact that the papers need to be drawn over the top end of the spike might account for the use of *op*, though this is a slightly less forward explanation. An apple on a stick also includes parts of the material of the stick. This inclusion of the Ground would explain the use of *om*. The fact that the support of the Figure is given from the same level (from within) can again account for *aan*. The use of *op*, however, is not so easily explained. It might be that participants using *op* focus on a similar frame-of-reference as those choosing *op* in *papers on spike*. The stick in picture 70 does not stand upright, unlike the spike in picture 22, but the apple will still have to be pushed over its top end. This is a rather flimsy explanation, but I have at present no better idea of what the underlying conceptualisation for use of *op* in picture 70 might be.

The last co-occurence of three prepositions is that of *op*, *tegen* and *aan*, all of which are used to describe the situations in pictures 52 (insects on wall) and xx6 (card against card). The use of *aan* versus *op* in *insects on wall* can be explained on a par with the co-occurence of *aan* and *op* in *spider on ceiling* (picture 7), as explained above. If one focuses on the frame-of-reference of the wall, the support is being given from the same level and *aan* will have to be used. If one focuses on the frame-of-reference of the insects, however, the support is given from below, because all the insects are in contact with the wall feet-first (if any type of insect can be said to have feet). In this case, *op* should be used. As to why *tegen* is also used with this situation, I can only guess that it qualifies through the feature 'support from same level', and that maybe participants thought the insects of being too little attached to the wall to qualify for being described by *aan*. For the situation in picture xx6, *card against card*, a similar argumentation can be found. Both cards are tilted, and lean onto each other. One could conceptualise the support as being given from below, since neither card stands upright. This would require the use of *op*. If the cards are thought of as supporting each other from the same level of height, one should choose *tegen* to describe the situation. But since the cards are very clearly not attached to each other, *aan* shouldn't be used to describe this situation. However, the two participants who chose *aan* nonetheless, only did so by making use of a different configuration: *de ene kaart geeft steun aan de andere kaart* (the one card gives support to the other card). In this configuration, *aan* cannot really be said to be used to describe the relation between the two cards, but rather a situation of giving something to someone (of giving support to the card). Support can be said to be introduced as an "entity" into the setting, and we are no longer talking about the same situation that is described by *op* and *tegen*.

4.6 Interim Summary III

In this section, I have presented my own analysis, using OT to explain the meaning of Dutch spatial prepositions. I have started out by presenting earlier work on OT and spatial prepositions. I have repeated an analysis by Zwarts (2008), who focuses on the competition of a set of English prepositions in potentially ambiguous situations, explaining how the competition is resolved by drawing on a hierarchy of faithfulness constraints relating to "core" features of the prepositions.

I have explained my own approach and how I focus on the fine conceptual distinctions in the spatial domain, as represented by the Topological Relations Pictures Series. I have explained how I use this Series and some additions of my own in an online questionnaire to collect data on spatial language. I have said that I focus primarily on Dutch, due to limitations in both time and resources. I have explained briefly that both verbs and prepositions are carriers of spatial meaning in Dutch, and that I will limit myself to prepositions only, since they are primarily responsible for describing the subset of spatial meaning I'm interested in (i.e. static topological relations between two objects) (cf. van Staden et. al, 2006).

I have explained how I "translate" Jones' analysis of the kinship domain to the spatial domain. I have explained how I proceed to use his framework for my analysis, and how I circumvent a Dutch bias, despite my focus on that language. I have laid out in detail the analyses of my three groups corresponding to the subdomains of projective and relative terminology, inclusion terminology and support terminology. For every subgroup, I have explained how I formulate constraints out of relevant attributes, what I take as the input and how the Dutch terms can be generated. Based on findings in the data summaries provided by Levinson & Wilkins, 2006 and Levinson & Meira, 2003, I have also shown how a simple shuffling of my constraints can generate the pattern of terminology in other languages. For each of the subgroups, I have also given predictions concerning the relative ranking of constraints, and listed all possible rankings that I expect can be found in languages worldwide (though I lack further cross-linguistic evidence).

I have finished this section by completing the story for my set of data: I explained why some pictures can be described by several different prepositions, outlining the different conceptualisations possible for each of these pictures.

The final section will give a summary of all previous sections and some conclusions.

5 Summary and Conclusion

My above analysis presents an approach to the question of how spatial universals are coded in specific languages' spatial expressions. I introduce my decomposition of a number of pictures showing spatial situations (mostly taken from the Topological Relations Pictures Series), in which I worked out the conceptual distinctions between the basic set of spatial configurations the Series represents.

I take the conceptual distinctions found between the pictures of the Topological Relations Pictures Series as the universal building blocks from which languages can built their spatial categories. I model this process of building linguistic spatial categories by using OT, a linguistic theory that has been designed to account for language specific patterns based on a set of universals.

I choose three spatial subdomains for a detailed analysis: projective and relative position terminology, inclusion terminology and support terminology. The choice of these particular subdomains is motivated by my wish to give an account for how the fine-grained conceptual distinctions in the spatial domain feature into language. All of my subdomains correspond to a so-called spatial primitive, coarse-grained versions of spatial features that constitute early attempts at defining "spatial meaning".

My prime example of how a language utilises these universal building blocks in forming spatial categories in each of my subdomains are Dutch spatial prepositions. I collected the data through an online questionnaire, by asking participants to provide descriptions of the situations shown in the pictures of the Topological Relations Pictures Series and some additions of my own. For each subdomain, I also drew on cross-linguistic data, made available in summarised form by Levinson & Wilkins (2006) and Levinson & Meira (2003).

My sets of soft constraints marking the distinctions relevant in each of my subgroups can account for all the data on spatial language I have available, with only one exception (English support terminology). I believe that even this exception can be explained by extending the set of constraints for support terminology, so that the distinctions made in English can also be accounted for.

In principle, my analysis is intend to be able to model the process of categorisation in all languages that can be used to describe the situations I take as the input for my analysis. Since I have evidence only for a hand-full of languages, the above groups can be said to be exemplary in nature: I show how I formulate the relevant distinctions as constraints that evaluate which input situations share one term and which are categorised apart.

Further research is needed to evaluate my set of constraints against a bigger sample of languages, and, if necessary, to adjust it. Adjusting my analysis can be done simply by formulating as constraints other attributes from my rather extensive list in the decomposition, which I take as the universal building blocks.

But I expect these adjustments to be limited. For every group, I give predictions on the patterns that I expect to be found cross-linguistically. These predictions are based on the way human beings move through space and interact with objects, and the necessities resulting from that. For example, with respect to inclusion terminology, I expect languages to always have at least two terms, corresponding to whether the reference object (the Ground) or the to-be-situated object (the Figure) is included.

So, in the end, even though I have formulated sometimes quite extensive sets of constraints, based on an even more extensive list of attributes, I expect this framework to be able to generate the pattern of spatial categories in a majority of all languages. And judged against the whole variety of languages world-wide, the number of conceptual distinctions I found to be of relevance does not appear to be unnecessarily extensive.

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6 Appendix

6.1 Data and Material from the Questionnaire

6.1.1 Percentages

Table 16 below contains a list of the percentages with which prepositions have been given for each picture, and the percentages with which verbs have been given for each of these prepositions. I first give the percentages of the prepositions only, regardless of the verbs. The total number of answers considered for each picture is 40 (100%).[30] The percentages for the verbs are only considered with respect to those answers with a given preposition, not the total number of answers (i.e. 100% does not necessarily equal 40 answers, but the number of answers given with the respective preposition).

Sometimes, prepositions have been given without a verb. In these cases, the number of answers containing a preposition will add up to more than the number of verb-uses with that preposition. Answers containing only a verb are not considered in the counting for any preposition.

Alternative answers reversing the order of Figure and Ground are not considered in the counting of verbs and prepositions (but they count as an answer, setting the total amount of answers to 40 in any case).

The pictures in the table below are given with the number they have in the original Topological Relations Pictures Series and the Dutch labels I used for the questionnaire.

Picture	**preposition**	**verb**
01: het kopje XY de tafel	op: N=40, p= 100%	staat op: N=39, p=97.5%
		bevindt zich op: N=1, p=2.5%
02: de appel XY de schaal	in: N=36, p=90%	ligt in: N=36, p=100%
	op: N=4, p=10%	staat op: N=4, p=100%
03: de postzegel XY de brief	op: N=38, p=95%	zit op: N=30, p=%
		is geplakt op: N=4, p=10.53%
		zit geplakt op: N=1, p=2.63%
	bovenaan: N=2, p=5%	bevindt zich rechts bovenaan: N=2, p=100%
04: het lint XY de kaars	om: N=40, p=100%	zit om: N=38, p=95%

[30] Recall what I said in section 4.3.2 about the two excluded participants and the way I count both entry fields for each picture.

		zit gestrickt om: N=1, p=2.5%
		is gestrickt om: N=1, p=2.5%
05: de hoed XY het hoofd	op: N=40, p=100%	zit op: N=24, p=60%
		staat op: N=16, p=40%
06: de hond XY het hok	naast: N=37, p=92.5%	zit naast: N=37, p=100%
	in: N=2, p=5%	zit in: N=2, p=100%
	bij: N=1, p=2.5%	zit bij: N=1, p=100%
07: de spin XY het plafond	op: N=25, p=62.5%	zit op: N=18, p=72%
		loopt op: N=4, p=16%
		kruipt op: N=3, p=12%
	aan: N=6, p=15%	hangt aan: N=4, p=66.66%
		zit aan: N=2, p=33.33%
	over: N=6, p=15%	loopt over: N=3, p=50%
		kruipt over: N=3, p=50%
	tegen: N=1, p=2.5%	kruipt tegen: N=1, p=100%
08: het boek XY de plank	op: N=40, p=100%	staat op: N=39, p=97.5%
		ligt op: N=1, p=2.5%
09: de jas XY de haak	aan: N=40, p=100%	hangt aan: N=38, p=95%
10: de ring XY de vinger	om: N=31, p=77.5%	zit om: N=31, p=100%
	aan: N=9, p=22.5%	zit aan: N=9, p=100%
11: de boot XY het water	op: N=23, p=57.5%	vaart op: N=21, p=91.3%
		ligt op: N=2, p=8.7%
	in: N=15, p=37.5%	ligt in: N=13, p=86.66%
		vaart in: N=2, p=13.33%
	door: N=2, p=5%	vaart door: N=2, p=100%
12: de boter XY het mes	aan: N=28, p=70%	zit aan: N=26, p=92.9%
		plakt aan: N=2, p=7.1%
	op: N=12, p=30%	zit op: N=12, p=100%
13: de lamp XY de tafel	boven: N=40, p=100%	hangt boven: N=38, p=95%
14: de doos XY de tas	in: N=38, p=95%	zit in: N=36, p=94.7%
	uit: N=2, p=5%	steekt uit: N=2, p=100%
15: het hek XY het huis	om: N=30, p=75%	staat om: N=28, p=93.33%
		omheint: N=2, p=6.66%

	rondom: N=10, p=25%	staat rondom: N=9, p=90%
16: de bal XY de stoel	onder: N=40, p=100%	ligt onder: N=40, p=100%
17: de boom XY de heuvel	op: N=31, p=77.5%	staat op: N=25, p=80.6%
		staat halverwege op/op de helling van: N=4, p=12.9%
	tegen: N=5, p=12.5%	staat tegen: N=5, p=100%
	naast: N=2, p=5%	staat naast: N=2, p=100%
18: het gat XY de doek	in: N=40, p=100%	zit in: N=35, p=87.5%
		bevindt zich in: N=2, p=5%
19: de appel XY de ring	in: N=34, p=85%	ligt in: N=25, p=73.5%
		staat in: N=7, p=20.6%
	binnen: N=6, p=15%	ligt binnen: N=6, p=100%
20: de ballon XY de stok	aan: N=39, p=97.5%	zit aan: N=24, p=61.5%
		hangt aan: N=10, p=25.6%
		is vastgemaakt aan: N=1, p=2.6%
		is aangebonden: N=1, p=2.6%
	onder: N=1, p=2.5%	hangt onder: N=1, p=100%
21: de schoen XY de voet	aan: N=28, p=70%	zit aan: N=25, p=89.3%
	om: N=12, p=30%	zit om: N=9, p=75%
		past om: N=2, p=16.66%
22: de bonnen XY de prikker	op: N=23, p=57.5%	zitten op: N=19, p=82.6%
		hangen op: N=3, p=13%
	aan: N=15, p=37.5%	zitten aan: N=11, p=73.33%
		zijn aan gespiest: N=1, p=6.66%
	om: N=2, p=5%	zitten om: N=2, p=100%
23: de waterslang XY de boomstronk	op: N=34, p=85%	ligt op: N=34, p=100%
	om: N=4, p=10%	zit om: N=3, p=75%

		ligt om: N=1, p=25%
	bovenop: N=1, p=2.5%	
24: de lepel XY het servet	onder: N=40, p=100%	ligt onder: N=36, p=90%
25: de telefoon XY de muur	aan: N=40, p=100%	hangt aan: N=37, p=92.5%
		zit aan: N=1, p=2.5%
26: de barst XY het kopje	in: N=40, p=100%	zit in: N=36, p=90%
27: de appel XY de tak	aan: N=40, p=100%	hangt aan: N=35, p=87.5%
		zit aan: N=3, p=7.5%
28: het portret XY de postzegel	op: N=40, p=100%	staat op: N=32, p=80%
		zit op: N=2, p=5%
29: het tafelkleed XY de tafel	op: N=31, p=77.5%	ligt op: N=30, p=96.8%
	over: N=9, p=22.5%	ligt over: N=6, p=66.66%
		hangt over: N=2, p=22.22%
30: de pijl XY de appel	door: N=40, p=100%	zit door: N=15, p=37.5%
		steekt door: N=10, p=25%
		doorboort: N=6, p=15%
		gaat door: N=5, p=12.5%
		is door: N=2, p=5%
31: de kat XY de tafel	onder: N=40, p=100%	zit onder: N=38, p=95%
32: de vis XY de viskom	in: N=40, p=100%	zwemt in: N=28, p=70%
		zit in: N=10, p=25%
33: de knijper XY de waslijn	aan: N=35, p=87.5%	hangt aan: N=21, p=52.5%
		zit aan: N=11, p=27.5%
		is aan: N=2, p=5%
	op: N=5, p=12.5%	zit op: N=4, p=10%
34: de man XY het huis	op: N=40, p=100%	staat op: N=36, p=90%
		loopt op: N=2, p=5%
35: de pleister XY het been	op: N=35, p=87.5%	zit op: N=32, p=91.4%
		plakt op: N=2, p=5.7%
	aan: N=5, p=12.5%	zit aan: N=2, p=40%
		plakt aan: N=2, p=40%
36: de wolk XY de berg	boven: N=40, p=100%	hangt boven: N= 29, p=72.5%

		staat boven: N=3, p=7.5%
		zit boven: N=2, p=5%
		drijft boven: N=2, p=5%
		is boven: N=2, p=5%
37: de was XY de waslijn	aan: N=40, p=100%	hangt aan: N=35, p=87.5%
		wappert aan: N=2, p=5%
		zit aan: N=1, p=2.5%
38: de man XY het kampvuur	naast: N=26, p=65%	zit naast: N=22, p=91.66%
	bij: N=14, p=35%	zit bij: N=14, p=100%
39: de sigaret XY zijn mond	in: N=28, p=70%	zit in: N=18, p=64.3%
		hangt in: N=6, p=21.4%
		heeft in: N=1, p=3.6%
		steekt in: N=1, p=3.6%
	uit: N=9, p=22.5%	steekt uit: N=7, p=77.77%
		hangt uit: N=2, p=22.22%
	aan: N=2, p=5%	hangt aan: N=2, p=100%
	tussen: N=1, p=2.5%	steekt tussen: N=1, p=100%
40: de kat XY de mat	op: N=40, p=100%	zit op: N=38, p=95%
41: de blaadjes XY de tak	aan: N=37, p=92.5%	zitten aan: N=22, p=59.5%
		hangen aan: N=13, p=35.1%
	uit: N=3, p=7.5%	groien uit: N=3, p=100%
42: de ceintuur XY haar middel	om: N=38, p=95%	zit om: N=34, p=89.5%
		hangt om: N=2, p=5.3%
	rond: N=1, p=2.5%	zit rond: N=1, p=100%
43: de waterslang XY de boomstronk	over: N=27, p=67.5%	ligt over: N=19, p=70.4%
		hangt over: N=8, p=29.6%
	op: N=9, p=27.5%	ligt op: N=9, p=100%
	naast: N=2, p=5%	ligt naast: N=2, p=100%

	bij: N=2, p=5%	bevindt zich bij: N=2, p=100%
44: het schilderij XY de muur	aan: N=40, p=100%	hangt aan: N=40. p=100%
45: de appels XY de boom	aan: N=23, p=57.5%	hangen aan: N=20, p=87%
		zitten aan: N=3, p=13%
	in: N=15, p=37.5%	hangen in: N=15, p=100%
	van: N=2, p=5%	vallen van: N=2, p=100%
46: de band XY haar hoofd	om: N=38, p=95%	zit om: N=36, p=94.7%
	rond: N=2, p=5%	zit rond: N=2, p=100%
47: de hond XY de mand	in: N=40, p=100%	zit in: N=40, p=100%
48: de druppels XY het raam	tegen: N=19, p=47.5%	zitten tegen: N=6, p=31.6%
		spetteren tegen: N=4, p=21.1%
		vallen tegen: N=3, p=15.8%
		slaan tegen: N=2, p=10.5%
		komen tegen: N=2, p=10.5%
	op: N=17, p=42.5%	zitten op: N=9, p=52.9%
		vallen op: N=2, p=11.8%
		lopen op: N=2, p=11.8%
		hangen op: N=2, p=11.8%
	langs: N=6, p=15%	druipen langs: N=4, p=66.66%
		vallen langs: N=2, p=33.33%
49: de boom XY de kerk	voor: N=20, p=50%	staat voor: N=18, p=90%
	naast: N=18, p=45%	staat naast: N=18, p=100%
	bij: N=2, p=5%	staat bij: N=2, p=100%
50: de haken XY de muur	aan: N=29, p=72.5%	hangen aan: N=18, p=62.1%
		zitten aan: N=7, p=24.1%
		zijn bevestigd aan: N=2, p=6.9%
	in: N=10, p=25%	zitten in: N=10, p=100%

	uit: N=1, p=2.5%	steken uit: N=1, p=100%
51: de ketting XY haar hals	om: N=37, p=92.5%	zit om: N=18, p=48.6%
		hangt om: N=15, p=40.5%
		ligt om: N=1, p=2.7%
		draagt om: N=1, p=2.7%
	aan: N=2, p=5%	zit aan: N=2, p=100%
52: de beestjes XY de muur	op: N=28, p=70%	zitten op: N=24, p=85.7%
		klimmen op: N=2, p=7.1%
	tegen: N=6, p=15%	zitten tegen: N=4, p=66.66%
		kruipen tegen: N=2, p=33.33%
	over: N=2, p=5%	lopen over: N=2, p=100%
	langs: N=2, p=5%	lopen langs: N=2, p=100%
	aan: N=1, p=2.5%	hangen aan: N=1, p=100%
53: de kauwgom XY de tafel	onder: N=40, p=100%	zit onder: N=26, p=65%
		plakt onder: N=10, p=25%
		kleeft onder: N=2, p=5%
54: het konijn XY het hok	in: N=39, p=97.5%	zit in: N=34, p=87.2%
		staat in: N=2, p=5.1%
		springt in: N=1, p=2.6%
	uit: N=1, p=2.5%	wil uit: N=1, p=100%
55: de waterslang XY de boomstronk	om: N=38, p=95%	zit om: N=23, p=60.5%
		ligt om: N=9, p=23.7%
		slingert om: N=2, p=5.3%
		kronkelt om: N=2, p=5.3%
	rond: N=2, p=5%	ligt rond: N=2, p=100%
56: de vlag XY de vlaggenmast	aan: N=36, p=90%	hangt aan: N=19, p=52.77%
		wappert aan: N=10, p=27.77%

		zit aan: N=5, p=13.88%
	in: N=4, p=10%	hangt in: N=3, p=75%
		wappert in: N=1, p=25%
57: het medaillon XY de ketting	aan: N=40, p=100%	hangt aan: N=29, p=72.%
		zit aan: N=7, p=17.5%
		bungelt aan: N=2, p=5%
58: de ladder XY de muur	tegen: N=39, p=97.5%	staat tegen: N=39, p=100%
	voor: N=1, p=2.5%	staat voor: N=1, p=100%
59: het potlood XY het bureau	op: N=40, p=100%	ligt op: N=37, p=92.5%
		rust op: N=1, p=2.5%
60: het dak XY het huis	op: N=38, p=95%	zit op: N=24, p=63.1%
		ligt op: N=6, p=15.8%
		staat op: N=2, p=5.3%
		rust op: N=2, p=5.3%
	bovenop: N=2, p=5%	bevindt zich bovenop: N=2, p=100%
61: het handvat XY het kastdeurtje	aan: N=38, p=95%	zit aan: N=34, p=89.5%
		hangt aan: N=2, p=5.3%
62: de kurk XY de fles	op: N=23, p=57.5%	zit op: N=20, p=87%
	in: N=17, p=42.5%	zit in: N=16, p=94.1%
63: de lamp XY het plafond	aan: N=40, p=100%	hangt aan: N=38, p=95%
64: de jongen XY de stoel	achter: N=40, p=100%	zit achter: N=23, p=57.5%
		verstopt zich achter: N=8, p=20%
		hurkt achter: N=5, p=12.5%
		verbergt zich achter: N=2, p=5%
		bukt zich achter: N=2, p=5%
65: de boom XY de heuvel	op: N=40, p=100%	staat op: N=38, p=95%
66: het hengsel XY de tas	aan: N=36, p=90%	zit aan: N=32, p=88.88%
		hangt aan: N=4, p= 11.11%

	van: N=4, p=10%	maakt deel uit van: N=2, p=50%
67: de uil XY de boom	in: N=40, p=100%	zit in: N=34, p=85%
		bevindt zich in: N=2, p=5%
		schuilt in: N=2, p=5%
		woont in: N=2, p=5%
68: de letters XY het t-shirt	op: N=40, p=100%	staan op: N=40, p=100%
69: de oorring XY het oorlelletje	door: N=25, p=62.5%	zit door: N=16, p=64%
		steekt door: N=5, p=20%
		hangt door: N=2, p=8%
	aan: N=8, p=20%	hangt aan: N=8, p=100%
	in: N=7, p=17.5%	zit in: N=7, p=100%
70: de appel XY de spies	aan: N=29, p=72.5%	zit aan: N=27, p=93.1%
		hangt aan: N=2, p=6.9%
	op: N=6, p=15%	zit op: N=6, p=100%
	om: N=3, p=7.5%	zit om: N=3, p=100%
71: de hond XY het hok	in: N=40, p=100%	zit in: N=33, p=82.5%
		ligt in: N=7, p=17.5%
xx1: de man XY de ladder	op: N=38, p=95%	staat op: N=22, p=57.9%
		klimt op: N=15, p=39.5%
	af: N=1, p=2.5%	komt (de ladder) af: N=1, p=100%
xx2: de haar XY de boter	op: N=23, p=57.5%	ligt op: N=15, p=65.2%
		zit op: N=8, p=34.8%
	in: N=14, p=35%	zit in: N=10, p=71.4%
		ligt in: N=2, p=14.3%
		bevindt zich in: N=2, p=14.3%
	aan: N=3, p=7.5%	plakt aan: N=2, p=66.66%
		kleeft aan: N=1, p=33.33%
xx3: de vinger XY het gat	door: N=38, p=95%	steekt door: N=26, p=68.4%
		zit door: N=6, p=15.8%
		gaat door: N=2, p=5.3%
		komt door: N=2, p=5.3%

		past door: N=2, p=5.3%
	uit: N=2, p=5%	steekt uit: N=2, p=100%
xx4: de man XY het paard	op: N=37, p=92.5%	zit op: N=29, p=78.4%
		rijdt op: N=8, p=21.6%
xx5: de muur XY het schilderij	achter: N=24, p=60%	zit achter: N=9, p=37.5%
		staat achter: N=8, p=33.33%
		bevindt zich achter: N=4, p=16.66%
		is achter: N=3, p=12.5%
xx6: de ene kaart XY de andere kaart	tegen: N=37, p=92.5%	staat tegen: N=25, p=67.6%
		leunt tegen: N=6, p=16.2%
		steunt tegen: N=2, p=5.4%
		ligt tegen: N=2, p=5.4%
	op: N=2, p=5%	leunt op: N=2, p=100%
	aan: N=2, p=5%	geeft steun aan: N=2, p=100%
xx7: het servet XY de lepel	op: N=28, p=70%	ligt op: N=28, p=100%
	over: N=10, p=25%	ligt over: N=10, p=100%
xx8: het hengsel XY de tas	aan: N=34, p=85%	zit aan: N=31, p=91.2%
		bevindt zich aan: N=2, p=5.9%
		hangt aan: N=1, p=2.9%
	van: N=2, p=5%	

Table 16: The percentages with which the prepositions and verbs were given for the pictures.

6.1.2 Instructions

The instructions for the questionnaire were as follows:

Bedankt dat u wilt meedoen aan mijn onderzoek!

Hieronder ziet u een aantal plaatjes met steeds twee objecten, zoals een stoel en een bal, of een schaal en een sinaasappel. De bedoeling is om de ruimtelijke relatie tussen die objecten te beschrijven, b.v. “De bal ligt op de stoel” of “De sinaasappel zit in de schaal".

Het eerste object in de zin wordt in het plaatje aangewezen met een zwarte pijl en de namen van de twee objecten zijn gegeven onder het plaatje. Wat u moet doen is een volledige zin maken door de ontbrekende woorden aan te vullen. Zo ziet het eruit:

De bal _________ de stoel.

Vul altijd de ontbrekende woorden in, ook als u denkt dat de zin vreemd klinkt.

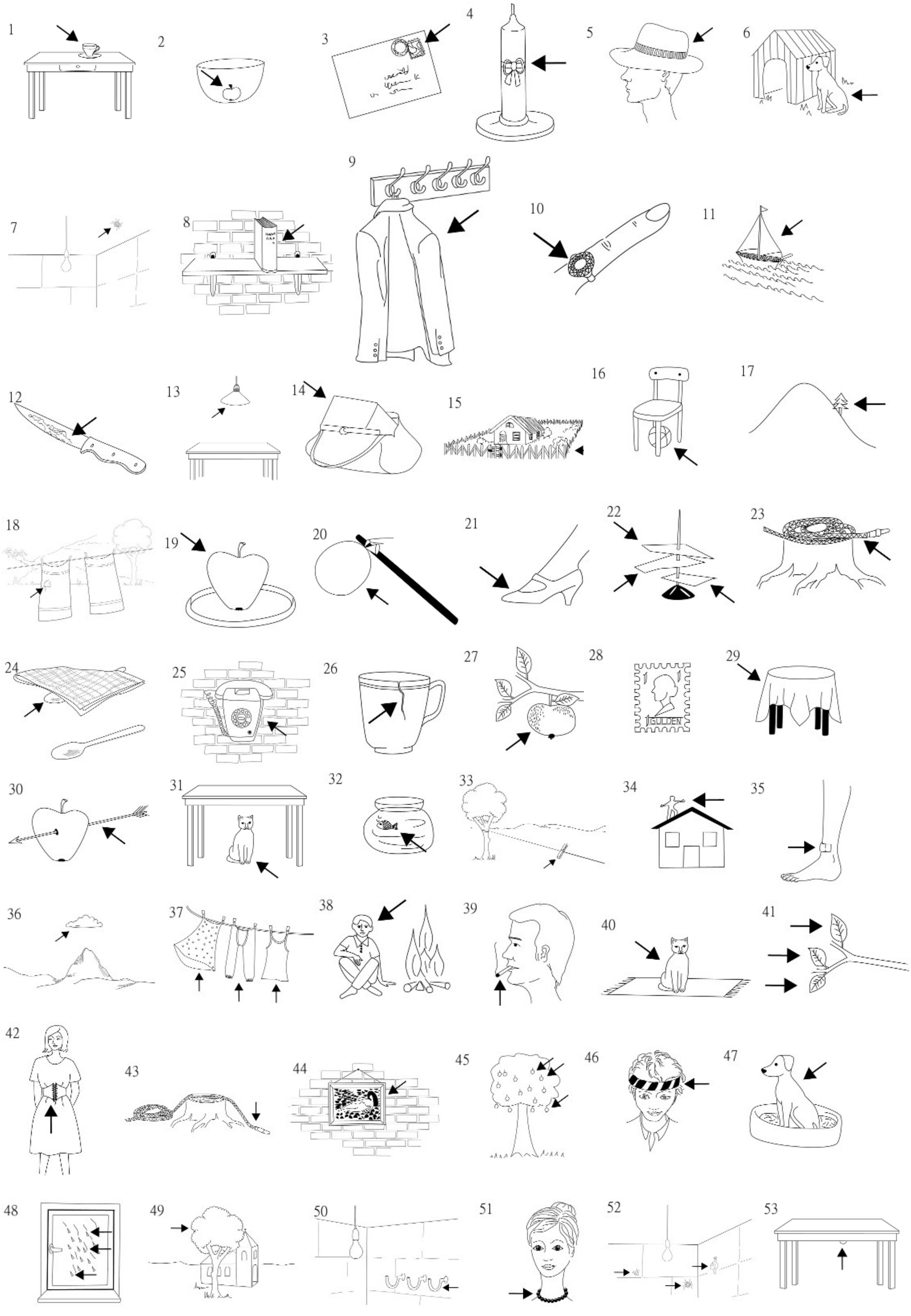
Als u denkt dat er een betere manier is om de situatie te beschrijven (b.v. "Er ligt een bal op de stoel") dan kunt u dat aangeven in een tweede stap. Er is een vrij invulveld onder elke zin. Maar u hoeft geen beter alternatief te geven! Als u het gevoel hebt dat de eerste zin goed is, dan kunt u gelijk verder. Geef alleen een alternatief als u denkt dat die echt beter is dan de eerste zin.

Schrijf op wat het eerst bij u opkomt en denk niet te lang na over een vraag. Het invullen van de vragenlijst zou niet langer moeten duren dan een half uur.

Voordat u start, wordt u gevraagd om informatie te geven over uw leeftijd en de talen die u spreekt.

6.1.3 Picture Material

In the pictures, the intended Figure object is marked by a black arrow. Due to some difficulties in compiling 79 pictures into one LaTeX compatible graphic, the pictures are generated as two separate a separate PDF document and then attached to this one. This means that they don't have page-numbers, don't appear in the table of contents, don't add to the total number of pages and only start on the next page. My apologies for any inconvenience.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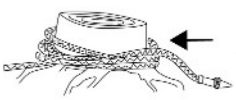

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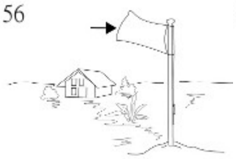

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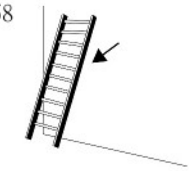

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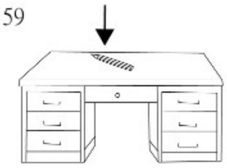

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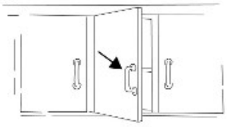

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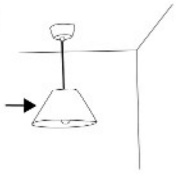

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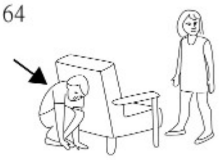

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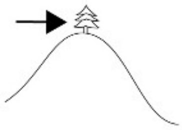

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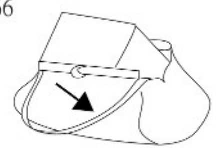

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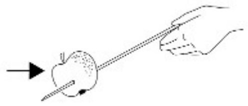

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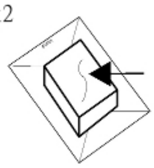
xx1


xx2


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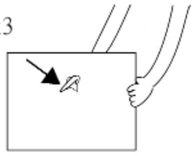

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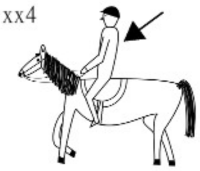

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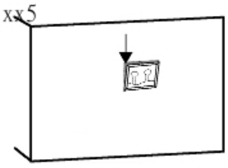

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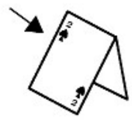

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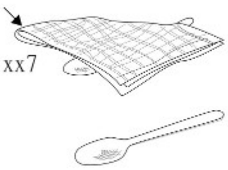

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