Vectors or Relations?

Tegenover as a problem for a compositional semantics of PPs[1]

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Abstract

A framework that proposes to analyse spatial relations in terms of a set of vectors that represent positions relative to the reference object, vector space semantics, seems to solve the problem of non-compositionality for modified PPs. A preposition that was not included in the development of this framework, is the Dutch *tegenover*, 'opposite'. The analysis that is presented in this paper concludes that *tegenover* denotes multiple properties that interact to form different meanings. However, a few problems arise when defining these properties. Most importantly, some of the properties cannot be defined without referring to the located object. This creates a new problem of compositionality, which is an indication that the framework of vector space semantics needs revision.

In natural language, an important grammatical class to express location and direction is the class of prepositions. For many prepositions, its meaning is constructed in a rather straightforward manner. This is also the case for many Dutch prepositions, that are the main subject of this paper. The preposition *voor* ('in front of') is a good example of a preposition of which its meaning can be constructed relatively easily. In this paper, however, a Dutch preposition is studied, for which the usage conditions are not as clear: the preposition *tegenover* 'opposite'. The relation expressed by the preposition seems to be symmetrical, as opposed to the preposition *voor*. Compare (1a, b) and (2a, b), repeated from Broekhuis (Broekhuis, 2013, p. 98).

[1] The research for this paper was introduced and supervised by dr. Joost Zwarts and corrected by dr. Joost Zwarts and prof. dr. Yoad Winter as an undergraduate project at Utrecht University, 2016. I would like to thank dr. Joost Zwarts for his ideas, support and thorough revision of earlier versions, as well as Roos Scharten for her insight and useful commentary.

(1)	a.	Peter staat	tegenover	Jan.
		Peter stands	opposite	Jan
	b.	Jan staat	tegenover	Peter.
		Jan stands	opposite	Peter
(2)	a.	Peter staat	voor	Jan.
		Peter stands	in.front.of	Jan
	b.	Jan staat	voor	Peter.
		Jan stands	in.front.of	Peter

The interpretation of *tegenover* seems to be dependent on the inherent orientation of the located object, as well as the referent. *Voor* does not show this symmetry. Therefore, when a speaker utters (1a), we can conclude that (1b) holds, while this is not the case for (2a) and (b).

However, this claim does not always hold. Consider example (240a) and (b) from Broekhuis (2013, p. 98), repeated here in (3).

(3)	a.	De	oude	kersenboom	staat	tegenover	de	kerk.
		The	old	cherry.tree	stands	opposite	the	church
	b.	Mijn	auto	staat	tegenover	de	kerk.	
		My	car	stands	opposite	the	church	

(3a) is acceptable, even though a tree is not considered to be an object with a front and a back. Even more so, (3b) seems to be acceptable also when the car is not facing the church. These quite different uses raise the following questions: does the preposition *tegenover* have characteristics that remain present in all spatial uses? And if so, is it possible to unite the different meanings of the preposition in one (formal) semantic model, or is it necessary to provide multiple connected definitions?

Zwarts (1997) provides a framework for a formal analysis of spatial prepositions in his compositional semantics of Modified PPs. However, his model leaves *tegenover*, as well as two other prepositions, *halverwege* (halfway between) and *aan* ('on' in the meaning of 'attached to') for further research (Zwarts, 1997, p. 4). As to analyses of the English *opposite* (Lindstromberg, 2010, pp. 97–100; Renau Renau, 2013), the formal aspect seems to be absent to this point. In this paper, therefore, I attempt to provide multiple definitions of the Dutch preposition *tegenover* in a formal semantic model in the framework of vector space semantics (Zwarts & Winter, 2000; Zwarts, 1997). I will show that *tegenover* is a problematic preposition for an analysis of PPs in the framework of vector space semantics because of the way its definition needs to refer to features of the located object.

I will do this in the following sections. Section 1 provides the definitions maintained, and gives an overview of the analyses that have been conducted on either the English prepositions *opposite* and *across* or the Dutch preposition *tegenover*. Section 2 zooms in on the different meanings of *tegenover* and provides an analysis in terms of properties. Section 3 summarises the most important concepts of the framework of vector space semantics and section 4 finally provides an introduction to the formal analysis of the preposition. Section 5 presents the issues this analysis assumes for the model-theoretic framework of vector space semantics. Section 6 reflects on former research and future research. Section 7 concludes with a short summary of the most important implications.

1. Preliminaries about prepositions

In this paper, a preposition is defined as a member of the syntactic class of words that combine with noun phrases to form phrases that express a spatial, temporal or other property, one of the functional closed categories of generative grammar (Carnie, 2013, p. 52). The prepositional phrase, PP, is assumed to cover the preposition and the noun phrase, as well as potential modifiers. The syntactic structure of a PP assumed here, is represented in figure 1.

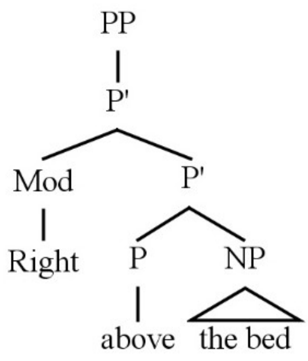

Figure 1. PP structure according to X-bar theory

When not explicitly mentioned, the term *preposition* in this paper refers specifically to a *spatial* preposition. Spatial prepositions are those prepositions that are used to describe spatial relations and movement. Non-spatial prepositions also exist, but these are not of interest here.

1.1. Typology of prepositions

The class of spatial prepositions can be divided into two groups based upon their referential properties: *locative* prepositions and *directional* prepositions. Locative prepositions typically locate one object, the *located object* (*the painting* in example 4a) relative to another one, called the *reference object* (*the table* in example 4a). Directional prepositions normally are connected to either a verb or a noun expressing movement or direction (Zwarts & Winter, 2000, p. 171). Compare examples (4a) and (b), in which *above* in (4a) is an example of a locative preposition and *towards* in (4b) is an example of a directional one.

(4) a. The painting hangs above the table.

b. Peter ran towards the building.

Furthermore, the locative prepositions can be divided into two subgroups: projective and non-projective prepositions. Projective prepositions require information about the directions from the reference object, whereas a non-projective preposition can be interpreted with only spatial knowledge on the location of the two objects (Zwarts & Winter, 2000, p. 171). Consider examples (5a) and (b), where *in front of* is an example of a projective preposition and *inside* an example of a non-projective one.

(5) a. Peter stands in front of the house.

b. Jan is inside the house.

In front of requires information about the front side of the house in order to be interpreted, while *inside* can be interpreted without further information. Of course, *inside* then requires internal knowledge of the spatial structure of the concept *house*. The classification is represented in table 1, reprinted from Zwarts & Winter (2000, p. 172).

Table 1. Typology of prepositions (Zwarts & Winter, 2000, p. 172).

Locative prepositions		**Directional prepositions**
Projective	**Non-projective**	
above/over, below/under	in/inside, outside	to, from
in front of, behind	on, at	into, onto
beside	near	across, around
	between	through

1.2. Frames of reference

Spatial prepositions establish a spatial relation between the reference object and the located object, as I have shown in the preceding paragraph. The nature of this relation is determined by the lexical meaning of the preposition. In some cases, this is quite straightforward, as in example (2b). However, this is not always the case. In fact, there are three ways of interpretation of spatial prepositions: the *deictic, inherent,* and *absolute* interpretation (Broekhuis, 2013, p. 72). In literature, these manners are also called different *frames of reference*. These are especially relevant with respect to projective prepositions, since a different frame of reference causes a different region to be referred to.

In order for prepositions to be interpreted deictically, an additional anchoring point is needed. This can be seen in example (5a). In the deictic interpretation of this sentence, the speaker's point of view actually determines the truth value of the proposition. This anchoring point need not necessarily be the speaker, however; it can also be some other participant in the discourse, as can be seen in example (6), repeated from Broekhuis (2013, p. 74).

(6) Seen from your position, Jan is standing right in front of the tree.

In an inherent interpretation, the reference object itself serves as the anchoring point. For this interpretation to be available, the reference object needs to be structured with respect to the relevant dimension(s). This means that the reference object needs to have an explicit front for prepositions such as *in front of* to be interpreted inherently (Broekhuis, 2013, p. 75). An example is seen in (7).

(7) a. Jan is standing in front of the cathedral.

b. Jan is standing in front of the tree.

In (7a) it does not matter where the speaker is standing, Jan will always be positioned at the entrance of the cathedral. This is the inherent interpretation. However, for (7b), Jan's position is determined by where the speaker is standing. This is the deictic interpretation.

Some prepositions can be interpreted both inherently and deictically. The difference is made clear in figure 2 and 3, both corresponding to the sentence *Jan staat voor de auto* 'Jan is standing in front of the car'.

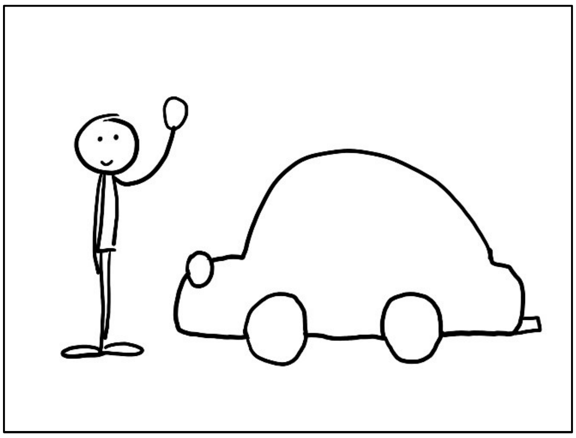

Figure 2. Inherent interpretation of *voor* 'in front of'

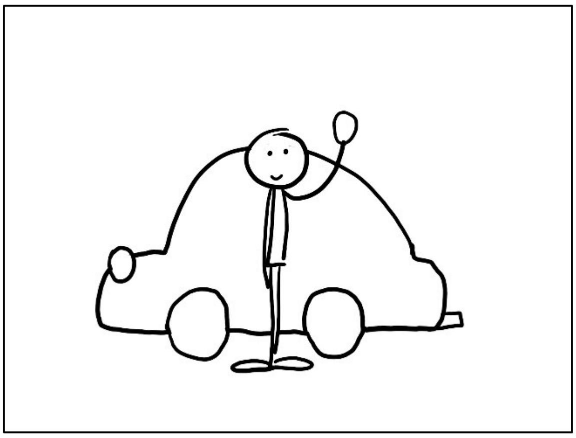

Figure 3. Deictic interpretation of *voor* 'in front of'

The absolute interpretation is available only when the preposition has neither an internal nor an external anchoring point. This means that it depends only on the natural environment such as the surface of the earth (Broekhuis, 2013, p. 75). An example of a preposition with an absolute interpretation is *above*.

(8) The poster is hanging above the table.

This statement can be interpreted independently of the orientation of the table. For example, even when the table is turned upside down, the statement remains true (Broekhuis, 2013, pp. 75–76).

1.3. Former analyses of *tegenover*

As I mentioned earlier, the preposition *opposite* and its Dutch rough equivalent *tegenover* have not yet received a formal analysis. However, it is not the case that it has not been studied at all. In this section I will outline one analysis of the Dutch *tegenover* and two analyses of the English *opposite*.

Broekhuis's short analysis of *tegenover* was already mentioned in the introduction, but for reasons of comprehensiveness, I repeat it here. According to Broekhuis, *tegenover* is an inherent preposition that differs from prepositions such as *achter* ('behind') and *naast* ('next to') in that it refers not only to the orientation of the reference object, but also that of the located object (Broekhuis, 2013, p. 97): the located object faces the front of the reference object. This relation seems to be symmetrical, as opposed to the preposition *voor* ('in front of'). I repeat the examples from the introduction in (9) and (10):

(9)	a.	Peter staat	tegenover	Jan.
		Peter stands	opposite	Jan
	b.	Jan staat	tegenover	Peter.
		Jan stands	opposite	Peter
(10)	a.	Peter staat	voor	Jan.
		Peter stands	in.front.of	Jan
	b.	Jan staat	voor	Peter.
		Jan stands	in.front.of	Peter

However, this claim does not always hold. Consider example (240a) and (b) from Broekhuis (2013, p. 98), repeated here in (11).

(11)	a.	De oude kersenboom staat tegenover de kerk.	
		The old cherry tree stands opposite the church	
	b.	Mijn auto staat tegenover de kerk.	
		My car stands opposite the church	

As mentioned, (11a) is acceptable, even though a tree does not have an inherent front or back side. Even more so, (11b) seems to be acceptable also when the car is not facing the church. Broekhuis derives from these examples that perhaps only the orientation of the reference object might be crucial (Broekhuis, 2013, p. 98).

Lindstromberg (2010) analyses *opposite (from)* in comparison to *across (from)* and *on the other side (of)*. Like Broekhuis, he concludes that a typical characteristic of *opposite* is that the reference object and the located object face each other. His analysis adds that *across*, which also translates as *tegenover* (*Van Dale Engels-Nederlands*, 2015, across), is most typically used to describe a scene where there are two orthogonal axes that represent the situation, which I will call *situational axes*. These axes can be seen as the dotted lines in figure 4.

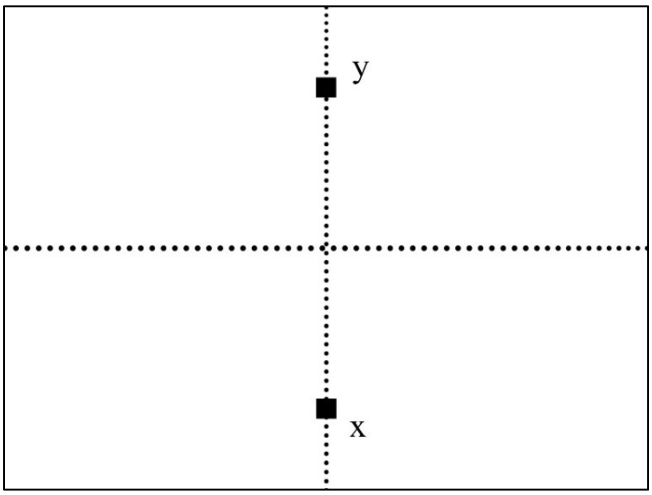

Figure 4. Situational axes as described by Lindstromberg (x is the reference object and y is the located object)

There is, however, some degree of flexibility about the angle. Two houses can also be named as standing across the street from each other, when they are not positioned in a straight line orthogonal to the situational axis represented in figure 4.

Renau Renau (2013) researches *opposite* by means of corpus analysis.[2] This analysis adds to the characteristics we have already seen that there seems to be some distance between the reference object and the located object. There is no contact between them (Renau Renau, 2013, p. 169); this conclusion is based upon examples such as (12), repeated from Renau Renau (2013, p. 169).

(12) 'It's very cold tonight,' I said politely to the passenger who was sitting opposite me.

Renau Renau (2013, p. 169) agrees that the objects need to face each other and concludes that there is a horizontal axis between the participants, as was specified by Lindstromberg (2010). Renau Renau (2013) agrees with Broekhuis (2013) by attributing to the preposition an *inherent* frame of reference (Renau Renau, 2013, p. 171).[3]

So, to conclude, these three analyses have found the following spatial characteristics of either *opposite/across* or *tegenover*:

1. Frame of reference: inherent;
2. Orientation: located object faces the front of the reference object (not always (Broekhuis, 2013));
3. Contact: no contact between located object and reference object;

[2] The way Renau Renau determines the characteristics by means of corpus analysis is not clear. These results seem to need additional proof and can only serve as an indication here.
[3] Renau Renau chooses the term *intrinsic*.

4. Separation: the objects are separated by a horizontal *situational* axis;
5. The objects are typically positioned on a second situational axis that is orthogonal the separating axis (flexible).

It is worth noting that we need to be cautious with these characteristics, as differences between the English *opposite, across* and the Dutch *tegenover* could exist. In this research, however, they provide a useful leg up towards a formal model.

2. The polysemy of *tegenover* explained

It is safe to say that *tegenover* has multiple uses (specifically two) and can therefore be considered a polysemous preposition. In this section I will demonstrate that this polysemy can be explained by four semantic properties. By doing this, I will also show that the preposition has characteristics that remain present in all spatial uses. This is not the first analysis of a polysemous preposition within the framework of vector space semantics; other analyses include Zwarts' investigation of *(a)round* (Zwarts, 2004).

Tegenover is a preposition that is frequently used reciprocally by means of the pronoun *elkaar* 'each other', as in (13a). The analysis presented below is restricted to the non-reciprocal use of *tegenover*, as illustrated in (13b).[4]

(13) a. Jan en Peter staan tegenover elkaar.

b. Jan staat tegenover Peter.

[4] The thought behind this choice is that the reciprocal use can be analysed as having the same denotation, with a different information structure. The use of *elkaar* evokes a sense of equality of the two entities involved, while in the transitive use, there is a defined reference object. The properties of the reference object and located object play a role here, but these are not studied in this analysis. I leave these for further investigation.

2.1. Properties of *tegenover*

Tegenover is a polysemous preposition with two spatial meanings, that I distilled from nine dictionaries and four Dutch native speakers' judgements:

A.	met de voorkanten naar elkaar	'facing each other'
B.	aan de overkant/zijde van	'on the other side of'

The evidence for these two spatial meanings is backed up by the existence of two English translations for *tegenover*: 'opposite' and 'across'. I will part from these two meanings in order to distil *properties*. I will show that even though the two different meanings are a necessary instrument in order to abstract the properties according to those meanings, the properties interact to form the different meanings.

2.1.1. Meaning A: Facing each other

This meaning is represented as two people facing each other and corresponds to the sentence in (14). It is depicted in figure 5.

(14)	Jan staat	tegenover	Peter.
	Jan stands	opposite	Peter

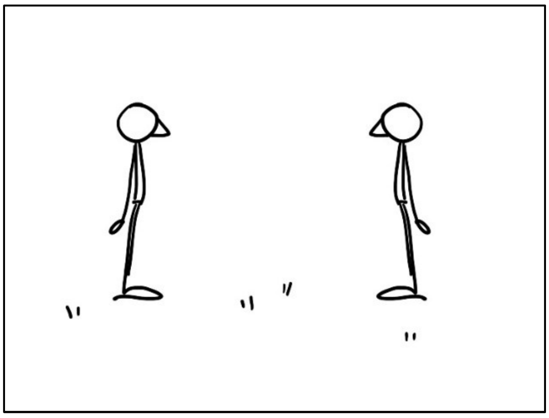

Figure 5. Prototypical depiction A of *tegenover*

The most salient characteristic we see in the situation in figure 5, is a property I will call SYMMETRY. This property means that both entities involved are oriented with their front sides towards each other.

2.1.2. Meaning B: on the other side of

This meaning is represented as two trees on both sides of a river in a sentence like (15), depicted in figure 6.[5] The presence of the river is important for its interpretation.

(15)	De	wilg	staat	tegenover	de	populier.
	The	willow	stands	opposite	the	poplar

[5] My informants described this meaning as two houses on one side of the street, but in order to completely separate the two meanings, I chose a representation with trees in this example. This because trees have no front.

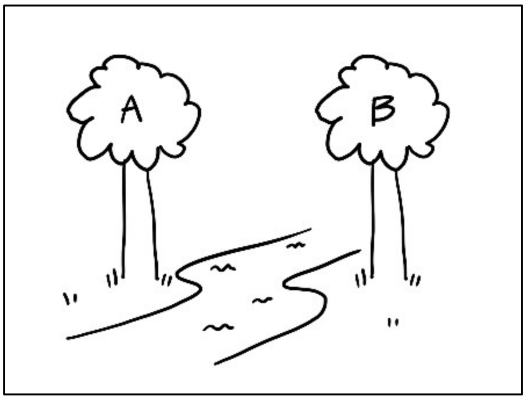

Figure 6. Prototypical depiction B of *tegenover*

This river is namely the reason for a next property that I will call BORDER. This property means that the located object is situated across a functional boundary from the reference object. In figure 6, this boundary is represented by the river. It can also be represented as a road or a square. It is a more or less flat surface with a separate function, although table also suffices. Even two rows of people standing opposite each other create a functional boundary between them. The exact nature of this boundary is left for further investigation.

2.1.3. An exploration of other meanings

These two properties, SYMMETRY and BORDER, cannot be the whole story if we assume that the two meanings of *tegenover* are connected. Obviously, there is no boundary between Jan and Peter in figure 5 and the trees in figure 6 have no front. The meanings need to be connected, though. Look at figure 7, where Jan and Peter are standing on both sides of the river. This presents a non-problematic union: Jan and Peter are facing each other and there is a boundary between them. Both BORDER and SYMMETRY are present.

So starting with the idea that SYMMETRY and BORDER cannot be the only properties, let us look at a new situation. Deriving from the fact that the trees in figure 5 have no front, we could say that when a border is present, the orientation of the objects does not matter. When only Jan turns to look the other way, as is represented in figure 7, there is no problem. This situation can still be described by *tegenover.* However, when Peter too turns his back towards the river, the use of *tegenover* no longer makes sense (figure 8). Apparently, the presence of a boundary is not enough for the orientation of both objects to become irrelevant.

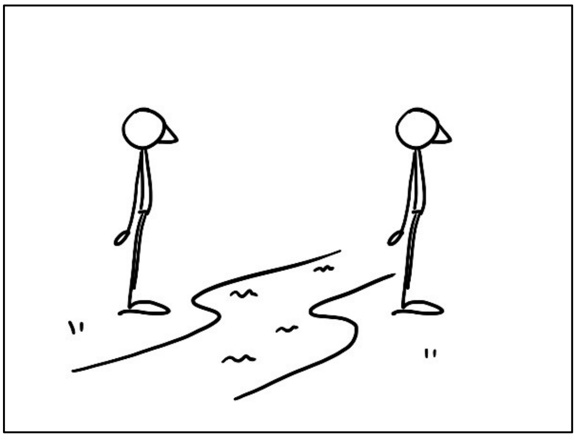

Figure 7. Jan staat tegenover Peter

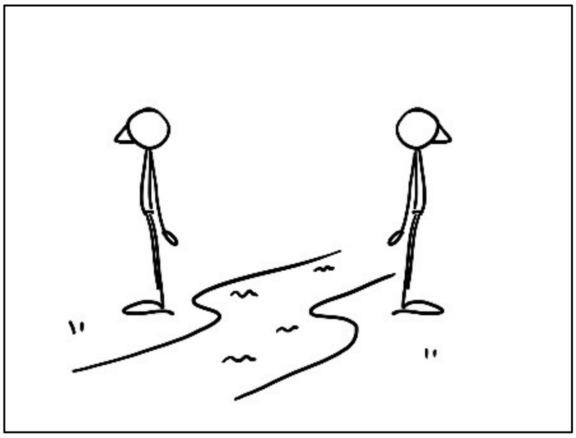

Figure 8. *Jan staat tegenover Peter

I propose to solve this problem by adding a third property: a property I will call FRONT. This property means that the reference object faces the located object. The located object can face in another direction.

We saw that SYMMETRY also included the front side of the reference object. In order to distinguish between these two properties, it is necessary to review SYMMETRY. We can say that FRONT determines the front side of the reference object and SYMMETRY copies this orientation onto the located object. In this case, for SYMMETRY to be available, FRONT needs to be present, too.

FRONT seems to be a weaker property than SYMMETRY or BORDER. Imagine a situation where only FRONT is present. This situation is presented in figure 9. Even though Peter is facing Jan, *tegenover* is not an adequate description of Jan's location.

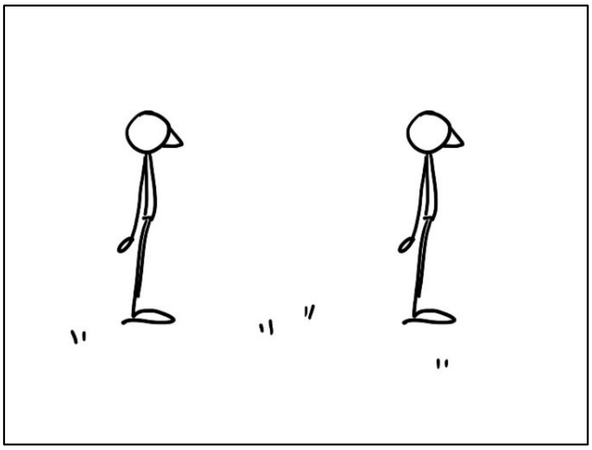

Figure 9. *Jan staat tegenover Peter.

There is no functional border, nor is the situation symmetrical. The best preposition to describe this situation is *voor* 'in front of': *Jan staat voor Peter* 'Jan is standing in front of Peter'. Compare this situation to the situation in figure 7. In figure 7, BORDER is present. From this we can conclude that the presence of only FRONT – without SYMMETRY – is enough when BORDER is present, too.

A logical question to ask next is what happens when the objects involved have no inherent front. Consider figure 10 and 11.

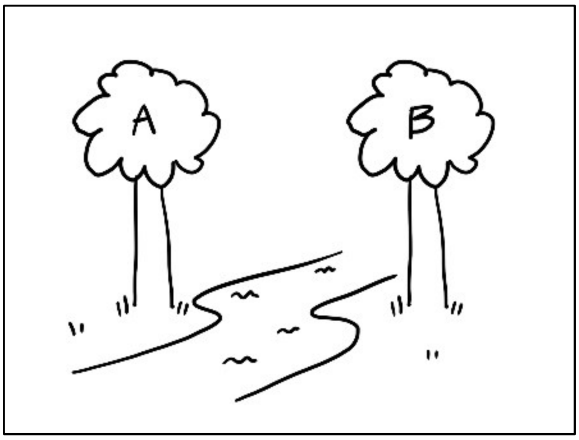

Figure 10. Boom A staat tegenover boom B

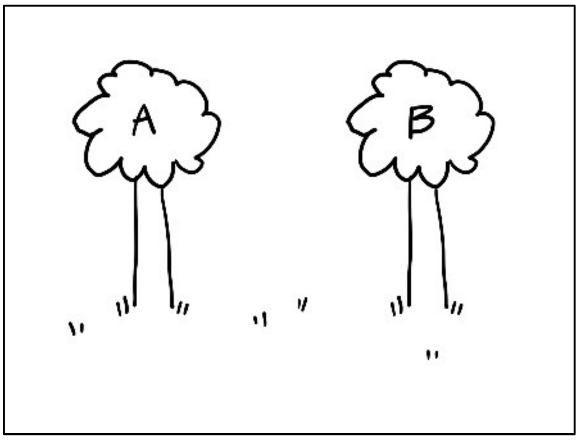

Figure 11. *Boom A staat tegenover boom B

Why is figure 10 a good example of *tegenover*, while figure 11 is not? We might attribute this to the fact that FRONT is a necessary property for *tegenover* to be adequate. In the case of figure 11, BORDER is not present. SYMMETRY and FRONT cannot be evaluated. If we assume that the functional boundary has the power to assign a deictic orientation to (at least) the reference object, this problem is solved. In this way, when a functional boundary is present, frontless reference objects can be assigned a front. This makes the property FRONT available.

We have now seen three properties: SYMMETRY, BORDER and FRONT. Together, these properties can account for most, if not all, of the situations where *tegenover* is an adequate description. This is not all, however. There is one more property. This a property I will call DISTANCE. This means that the reference object and the located object cannot touch. When, in the situation in figure 5, Jan and Peter stand against each other, the situation can no longer be described by *tegenover*. The same holds for the other situations that I have described above. We can conclude that this property is always present in situations that can adequately be described with *tegenover*.

This last property might be analysed as a weaker form of BORDER. Of course, when a border is present, there needs to be distance between the objects. We can therefore review BORDER and state that BORDER means that the space between the two objects is filled, either functionally or materially.

2.2. Interaction of the properties

To summarise, the four properties I showed in the last paragraph are:

(16)	DISTANCE	Reference object and located object do not touch
	FRONT	Reference object faces the located object
	BORDER	Space between objects is filled functionally or materially
	SYMMETRY	Reference object and located object face each other

We have already seen their interaction implicitly. We have seen that DISTANCE and FRONT need to be present in a situation, and that the additional presence of BORDER, SYMMETRY or both is required. This is summarised in table 2.

Table 2. The adequacy of the use of *tegenover* (1 = adequate; 0 = inadequate) based upon the presence of the properties BORDER and SYMMETRY (1 = present; 0 = not present) in hypothetical abstract situations.

Property	**Presence of property**			
BORDER	1	1	0	0
SYMMETRY	1	0	1	0
Adequacy	**1**	**1**	**1**	**0**

*The adequacy of this situation is not calculable.

This leads to three possible situations: a situation that contains only BORDER, one that contains only SYMMETRY and one that contains both of these properties. The situations are exemplified in (17).

(17)	1. BORDER	“De auto staat tegenover de kerk”
		The car stands opposite the church
	2. SYMMETRY	“Jan staat tegenover Peter”
		Jan stands opposite Peter
	3. BORDER, SYMMETRY	“Jan zit tegenover Peter (aan tafel)”
		Jan sits opposite Peter (at the table)

As can be seen in (17), these properties allow us to explain the problematic situation that we saw in the introduction: *de auto staat tegenover de kerk* ‘the car stands opposite the church’. The situation is shown in figure 12.

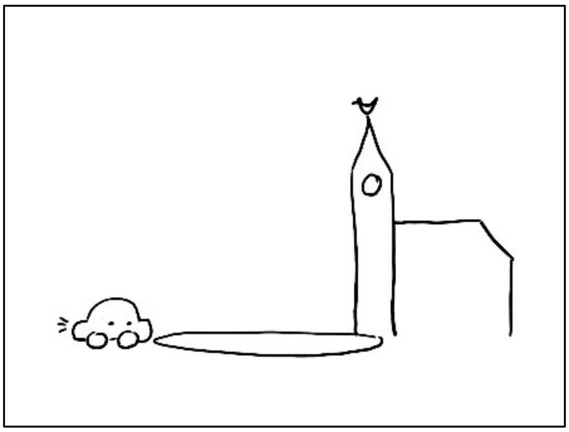

Figure 12. De auto staat tegenover de kerk

The objects do not touch each other: DISTANCE is present. The reference object, the church, is facing the located object: FRONT is present. The basis is complete. Now all that is needed, is one of the two strong properties. And, yes: there is a functional boundary between the car and the church: BORDER is present, too. The correctness of this situation can be predicted with this model.

The question whether the preposition has characteristics that remain present in all spatial uses can be answered affirmatively: the properties DISTANCE and FRONT are always present. We will explore more possibilities and problems of the properties in the sections 2.3 and in part 3.

2.3. Pragmatic property and modification issues

There is one ‘property’ that so far has only been discussed implicitly. This is in fact a pragmatic property that I will call Straight. It refers to the fact that the located object is usually positioned right in front of the reference object. When the front of the reference object is constructed deictically, this is done in relation to the functional border. Straight could then be argued to be a logical ‘side-effect’ of the property FRONT.

However, because of the possibility to cancel Straight, it needs to be separated from the property FRONT. Situations exist where the located and the reference object are in fact not positioned in a straight line, that can be described by *tegenover*. In this sense Straight distinguishes itself from the other four properties: it is always present, except when it is cancelled through modification. This is exemplified in (18) and corresponding figure 13.

(18)	Jan zit	schuin	tegenover	Peter (aan tafel)
	Jan sits	diagonally	opposite	Peter (at the table)

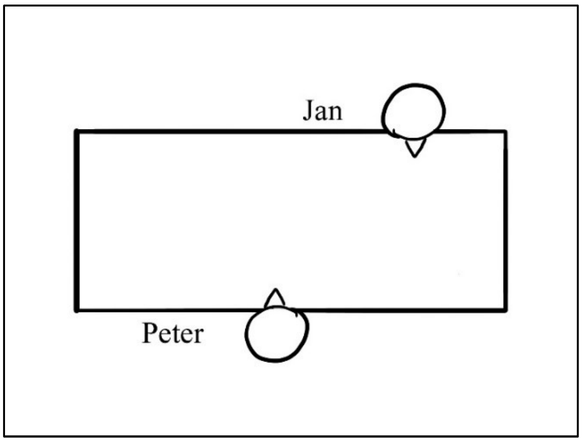

Figure 13. Jan zit schuin tegenover Peter (aan tafel)

The answer to why Straight needs to be pragmatic and cannot be another property we find in the possibility to explicitly mention it. Instead of *schuin* 'diagonally' in example (18), we also find *recht* 'straight' as a modifier of *tegenover*. An example is given in (19).

(19)	Jan zit recht	tegenover	Peter
	Jan sitsstraight	opposite	Peter

Now, a good question to ask is how to explain the orientation of the objects when they are positioned *schuin tegenover* 'diagonally opposite' each other. As is exemplified in figure 14, the objects do not face each other. Rather, they seem to be facing a virtual line separating them.[6] Notice that the objects are once again positioned *recht tegenover* 'straight opposite' each other when they face each other.

[6] This virtual line could correspond with Lindstromberg's situational axis.

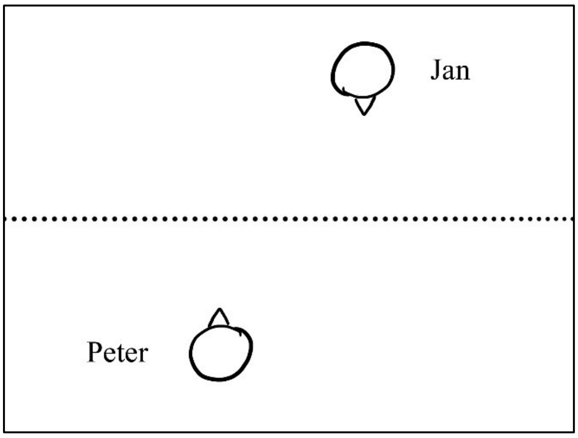

Figure 14. Schuin tegenover 'diagonally opposite'

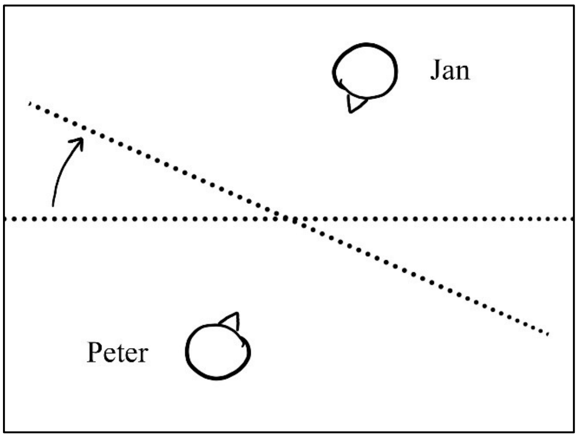

*Figure 15. *Schuin tegenover* 'diagonally opposite'

This problem can be solved without inventing a virtual separating line. In fact, it can be explained using properties we have already seen: FRONT and SYMMETRY. FRONT positions Jan within a certain pragmatically determined range at the front side of Peter (figure 16). SYMMETRY then positions Peter at the same angle from Jan, which leaves Jan and Peter not facing each other. This is illustrated in figure 17.

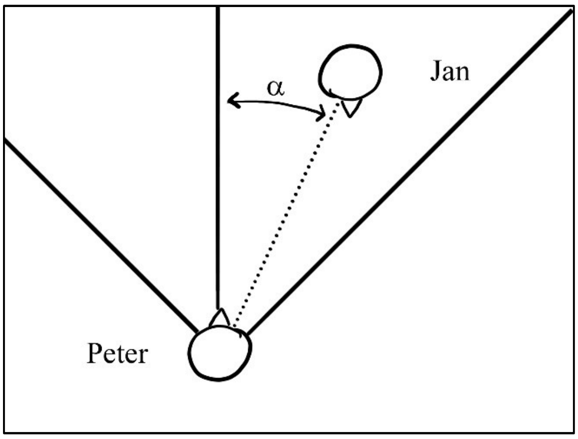

Figure 16. FRONT

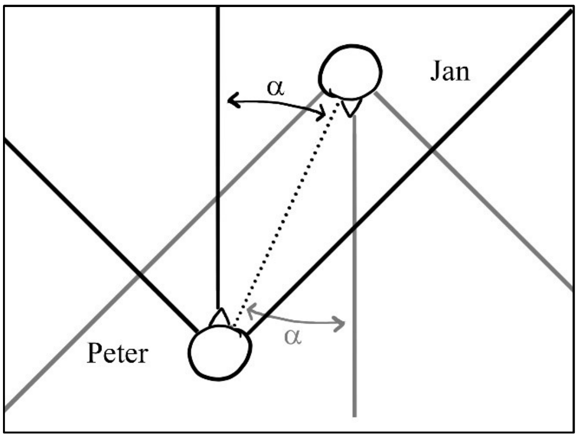

Figure 17. SYMMETRY as defined by FRONT

3. Vector Space Semantics

As mentioned in the introduction, in this paper, I will show that a formal analysis of the preposition *tegenover* in the framework of vector space semantics as introduced by Zwarts

(1997) and further developed by Zwarts & Winter (2000), is problematic. Before continuing, therefore, I will provide a necessary summary of this framework. Consider example (20).

(20) Peter staat voor het huis
Peter stands in.front.of the house

A straightforward way to treat prepositions has been as relations between sets of points (*regions*) (Zwarts & Winter, 2000, p. 172). Within the framework of Vector Space Semantics, however, a region is assumed to be a set of *vectors*: directed line segments between points in space (Zwarts & Winter, 2000, p. 173). The region denoted by example (20) is, thus, a set[7] of vectors with their starting point at the house that point forwards. The theme[8] of this PP is located at the end of one of these vectors (Zwarts, 1997, p. 11). This contrasts with the natural mathematical way to model a spatial relation, which assumes that the region corresponding to *voor het huis* is a set of points (Zwarts, 1997, p. 7).

3.1. Origin: the modification problem

This framework arose from the problems in calculating the set of points that emerge when a Dutch preposition is modified. Consider the modified preposition *naast* (next to, beside) in example (21).

(21) Vlak naast het bed
Right next.to the bed

[7] A set is informally defined as a collection of (mathematical) objects.
[8] The located object.

The region corresponding to *naast het bed* is a set of points and *vlak* corresponds to a subset of this set. Zwarts (1997, p. 8) gives the following definition of these modified PPs in an analysis in terms of points, taking into account the relativity characteristic of the modifiers,[9]

(22) $[\![vlak\ PP]\!] = \{p\ \in\ [\![PP]\!] \mid vlak\ (p, [\![NP]\!])\}$

where $[\![\propto]\!]$ represents the denotation of an expression $\propto$. A problem arises from these definitions: they are non-compositional. For the interpretation of the modified PP to be calculated, access to the reference object NP is required. However, this NP is at this point not visible to the interpretation process. This means that the interpretation of a modified PP is not a function of its immediate constituents.[10] Thus, a compositional interpretation of modified PPs is impossible when locative PPs are assumed to denote spatial regions.[11] A different account is needed.

Zwarts' proposal to analyse a region as a set of vectors solves this problem, because vectors are spatial entities that, as Zwarts (1997, p. 13) states, "[…] are by their very nature relational and that carry information about the reference object that would otherwise have only been accessible to the modifier in a non-compositional way."

3.2. Vectors as spatial relations

Let me now explain the usage of vectors to define spatial relations. A vector formalises the notion of a position specified in relation to a reference object (the spatial origin of the vector).

[9] Zwarts (1997, p. 8) explains: "they do not specify absolute properties of the points in the region, but they specify the *distance* between the point and the reference object […] or the *direction* of the point with respect to the reference object […]."
[10] The modifier and the rest of the PP.
[11] A compositional account can be given when modifiers are considered sisters of the preposition instead of sisters of PP (1997, p. 9). However, it is assumed that syntactically, modifiers inside PP are sisters of the combination of the preposition and the object (P'). There are no syntactic reasons to assume otherwise. In fact, Dutch modification of prepositions shows that it would be incorrect to assume modifiers are sisters of the preposition (see Zwarts (1997, p. 10)).

The vector concept provides the parameters of *distance* and *direction* that prepositions use to specify relative positions (Zwarts, 1997, p. 12). One vector does not represent a change of location; rather, it is a representation of position. A path, for example the denotation of the preposition *naar* ('towards'), therefore consists of a sequence of vectors starting at the referent location, gradually decreasing in length. The last vector[12] coincides with the referent location (Zwarts, 1997, p. 14) (the null vector, Broekhuis (2013, p. 78)).

3.3. The Vector Space: algebraic classification

The set of vectors denoted by the PP, all have their origin at the surface or boundary of the reference object (Zwarts, 1997, p. 18). Such a set corresponds to the algebraic notion of a real subset of a *vector space*. A vector space **V** over the set of real numbers R has closure under the following two operations (Zwarts, 1997, p. 15):

(23) a. *Vector addition*

For every pair $\boldsymbol{v}, \boldsymbol{w} \in \boldsymbol{V}$ there is exactly one $\boldsymbol{v} + \boldsymbol{w} \in \boldsymbol{V}$, the *vector sum* of **v** and **w**

b. *Scalar multiplication*

For every $\boldsymbol{v} \in \boldsymbol{V}$ and $s \in R$ there is exactly one $s\boldsymbol{v} \in \boldsymbol{V}$, the *scalar product* of **v** by scalar s

A vector space has the following axioms, as formulated by Zwarts (1997, p. 16):

[12] In some cases, the first vector of a path coincides with the referent location. For example for *bij ... vandaan* 'away', 'from'.

(24) a. $For\ all\ \boldsymbol{u}\ and\ \boldsymbol{v}\ \in \boldsymbol{V}, \boldsymbol{u}+\boldsymbol{v}=\boldsymbol{v}+\boldsymbol{u}$

b. $For\ all\ \boldsymbol{u}, \boldsymbol{v}, and\ \boldsymbol{w}\ \in \boldsymbol{V},\ (\boldsymbol{u}+\boldsymbol{v})+\boldsymbol{w}=\boldsymbol{u}+(\boldsymbol{v}+\boldsymbol{w})$

c. $There\ is\ an\ element\ 0 \in \boldsymbol{V}, the\ zero\ vector, such\ that\ \boldsymbol{v}+0=0+\boldsymbol{v}=\boldsymbol{v}$

$for\ all\ \boldsymbol{v} \in \boldsymbol{V}$

d. $For\ every\ \boldsymbol{v}\ \in \boldsymbol{V}\ there\ is\ a-\boldsymbol{v} \in \boldsymbol{V}, the$ inverse $of\ \boldsymbol{v}, such\ that\ \boldsymbol{v}+$

$(-\boldsymbol{v})=0$

e. $For\ all\ \boldsymbol{u}\ and\ \boldsymbol{v} \in \boldsymbol{V}\ and\ every\ c \in R, c(\boldsymbol{u}+\boldsymbol{v})=c\boldsymbol{u}+c\boldsymbol{v}$

f. $For\ every\ v \in V\ and\ a\ and\ b\ \in R, (a+b)v=av+bv\ and\ (ab)v=$

$a(bv)$

g. $For\ every\ v \in V, 1v=v$

The model does not just hold one vector space; rather, it holds a large set **S** of vectors, which contains for each pair of points p and q a vector pointing from p to q and back. **S** is thus the union of an infinite set of vector spaces (Zwarts, 1997, p. 16). **S** is added to the domain E of individual objects to be able to use the vectors for the interpretation of natural language expressions.

3.4. Location relation and interpretation

To determine the spatial relationships between E and **S** and between vectors of different vector spaces, the location relation *loc* is assumed, which assigns any physical entity in E its location in space. Loc is a subset of the set of pairs (E ∪ **S**) × (E ∪ **S**). The function is understood as follows:[13]

[13] Zwarts & Winter (2000) take this analysis one step further. At this point, however, their analysis goes beyond the goal of this paper.

(25)	a.	loc(x,y)	x = y
	b.	loc(**v**,x)	the beginning point of vector **v** is located at object x
	c.	loc(y,**w**)	object y is located at the end point of vector **w**
	d.	loc(**w**,**v**)	the beginning point of vector **w** is located at the end point of vector **v**

Another function that is assumed, is |**v**|. This function assigns to each **v** its length or norm. The interpretation of a locative preposition phrase, thus, has the following schematic form:

(26) $[\![[_{PP} P\ NP]]\!]_M = \{\boldsymbol{v} \in space([\![NP]\!]_M) \mid \ldots \boldsymbol{v} \ldots\}$ (Zwarts, 1997, p. 18)

in which $space([\![NP]\!]_M)$ refers to the universe of vectors determined by the reference object. In words: the denotation of the PP within this model equals the set of vectors from the universe of vectors defined by the reference object that have a determined direction and are of a (specific) length (not determined in this example).[14]

The interpretation of the vector-denotation when shifted to a property of objects is defined as the set of objects that are located at a vector from the region denoted by the PP:

(27) $\{x \in E \mid \exists \boldsymbol{v} \in [\![PP]\!]_M \wedge loc(x, \boldsymbol{v})\}$ (Zwarts, 1997, p. 19)

In words: x is an element of the set E of individual objects and there is a vector **v** that is an element of PP and x is located at the end of vector **v**. See example (28).

[14] Sometimes only direction is specified.

(28)	Peter	staat	voor	het huis
	Peter	stands	in.front.of	the house

In this example, x is Peter. Peter is located at the end of vector **v**, that starts at the boundary of the house and points forward.

3.5. Axes

In section 1.1, we saw a difference between projective and non-projective prepositions: projective prepositions require information about the directions from the reference object, whereas a non-projective preposition can be interpreted with only spatial knowledge on the location of the two objects (Zwarts & Winter, 2000, p. 171). We also saw that prepositions can (and sometimes cannot) be interpreted in three different ways: deictically, inherently and absolutely. We can incorporate these distinctions in vector theory in the following way.

Projective prepositions are based upon a particular direction.[15] Assume that this direction is determined by an *axis*.[16] Three perpendicular axes can be distinguished: a *vertical* axis, that is determined by the line of gravitation; a *horizontal front-back* axis; and a *lateral* axis, which goes side to side (Zwarts, 1997, p. 24). The horizontal front-back axis can be intrinsic to the reference object or assigned deictically. This determines if the preposition is to be interpreted inherently or not. As formulated by Zwarts (1997, p. 24), this model provides three half axes, each defined as sets of vectors:

[15] This is not to say that direction does not play any role within non-projective prepositions. For an analysis, see Zwarts (1997, pp. 21–23).
[16] In the case of *between* this direction is determined by another object (Zwarts, 1997, p. 23).

(29)	VERT	the set of vectors pointing upward	*above*
	FRONT	the set of vectors pointing forward	*in front of*
	DEXT	the set of vectors pointing rightward	*to the right of*

In (29) the prepositions corresponding to these axes are given. The antonyms of these prepositions correspond to the *inverses* of the axes in (29). The inverses denote the set of vectors pointing in the opposite direction (Zwarts, 1997, p. 24). At this point, this definition of the axes suffices.

4. An attempt at formalisation

In chapter 2, we distilled four properties that define *tegenover*: DISTANCE, FRONT, BORDER, and SYMMETRY. As you might have noticed, the only properties that are directly expressible in terms of a vector that originates at the surface of the reference object and ends at the located object, are the properties DISTANCE and FRONT. Let us first look at how we model these properties. In the second paragraph, SYMMETRY and BORDER are addressed.

4.1. DISTANCE, FRONT

The properties DISTANCE and FRONT can be united in one set of vectors:

(30) $\{\boldsymbol{v} \in space([\![x]\!]) \mid |\boldsymbol{v}_{FRONT(x)}| > |\boldsymbol{v}_{\perp FRO\quad(x)}| \;\&\; |\boldsymbol{v}_{FRONT(x)}| > 0\}$

Let’s see how the properties are visible in this definition. First of all, FRONT is represented in the first part of the specification (before the conjunction) and is stated as follows. The length of vector **v** can be defined as the sum of its projections on the inherent frontal and lateral axis, $\mathbf{v}_{\mathrm{FRONT}}$ and $\mathbf{v}_{\perp\mathrm{FRONT}}$, respectively. $|\boldsymbol{v}_{FRONT(x)}| > |\boldsymbol{v}_{\perp FRONT(x)}|$ defines a pragmatic range of possible locations for the reference object. The exact range is determined in context. The region denoted by the property FRONT, is thus as is represented in figure 18:

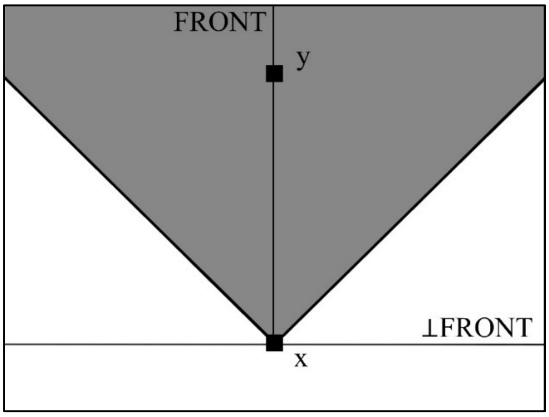

Figure 18. Schematic representation of the region denoted by FRONT[17] (x is the reference object and y is the located object)[18]

To model this, a function FRONT(x) is assumed. This function corresponds to the set of vectors originating at the surface of the reference object x pointing forward, like we saw in the previous paragraph.

For the property DISTANCE, that caused a space between the reference and the located object, the vectors need to be longer than zero. This needs to be attributed to the projection $\mathbf{v}_{FRONT}$, because the orthogonal projection can be zero; $\mathbf{v}_{\perp FRONT}$ is zero when the located object is *recht tegenover* 'straight opposite' the reference object.

Notice that this definition is a partial definition of *tegenover,* without the properties BORDER and SYMMETRY.

[17] The actual region continues where the picture ends.
[18] DISTANCE is not represented in this picture.

4.2. BORDER

Since this definition is based upon the inherent axes of an object, this definition is only valid when the reference object actually has an inherent front. For the deictic construction of FRONT, such as in case of the frontless trees, a second function is required. Recall that for the deictic construction of FRONT, the property BORDER needs to be present. This is the function FRONT1(x,y). This function corresponds to the set of vectors originating at the surface of the reference object x in the direction of b. The definition is then as follows:

(31) $\{\boldsymbol{v} \in space([\![x]\!]) \mid |\boldsymbol{v}_{FRONT\ (x,b)}| > |\boldsymbol{v}_{\perp FRONT1(x,b)}|\ \&\ |\boldsymbol{v}_{FRON\ \ (x,b)}| \geq |[\![x]\!], B_2|\}$

In this definition, b is the functional border that creates the frontal axis of the reference object, and $|[\![x]\!], B_2|$ is the distance from the reference object, $[\![x]\!]$, towards the farthest edge of the functional border, B_2. The vectors denoted by *tegenover* when the property BORDER is present need to cross the functional boundary, b, with edge B_1 on the side of the reference object and B_2 on the side of the located object. The frontal projection of the vector needs to be longer than or as long as the distance from the reference object to the farthest edge of the boundary, B2. The region denoted in this case is represented in figure 19.

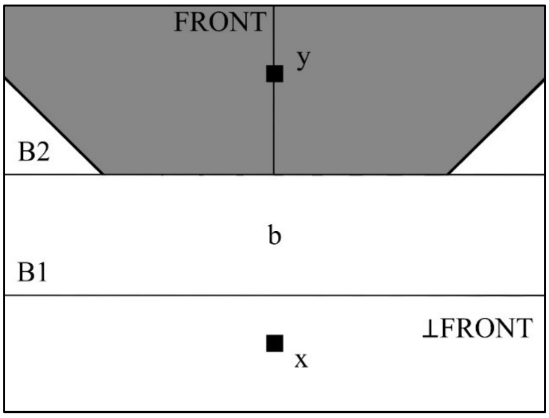

Figure 19. The region denoted for properties DISTANCE, FRONT and BORDER[19]

So, to conclude, we now have two separate formal definitions to describe the vectors corresponding to a situation: one for reference objects that have an inherent front (32a) and one for reference objects that don't (32b), where BORDER needs to be present.

(32) a. $\{\boldsymbol{v} \in space(\llbracket NP \rrbracket) \mid |\boldsymbol{v}_{FRONT(NP)}| > |\boldsymbol{v}_{\perp FRONT(NP)}| \wedge |\boldsymbol{v}_{FRONT(NP)}| > 0\}$

b. $\{\boldsymbol{v} \in space(\llbracket NP \rrbracket) \mid |\boldsymbol{v}_{FRONT\ (NP,b)}| > |\boldsymbol{v}_{\perp FRONT1(NP,b)}| \wedge |\boldsymbol{v}_{FRONT1(NP,b)}| \geq |\llbracket NP \rrbracket, B_2|\}$

(32b) corresponds to meaning B of *tegenover*: 'on the other side of'. For (32a) to correspond to meaning A 'facing each other', the last property needs to be modelled: SYMMETRY.

4.3. SYMMETRY

SYMMETRY, as we saw, means that both entities involved are oriented with their front sides towards each other. We also saw that FRONT was responsible for the front side of the reference object facing the located object and concluded that SYMMETRY had to copy this orientation onto the located object. This can be defined as a conjunction, subject to effects of figure-ground:

[19] The actual region continues where the picture ends.

object y is located at the end of a vector from (32a) applied to x and x is located at the end of a vector from (32a) applied to y.

In terms of vectors, this means that the vector at the end of which the located object is situated, has an inverse at the end of which the reference object is situated. This inverse originates at the surface of the located object and ends in the reference object. This can be formalised in the function SYMMETRY(x,y). This function denotes the set of vectors with characteristics defined in (32a) or (b) for both reference object x and located object y. The effect of SYMMETRY(x,y) is depicted in figure 20.

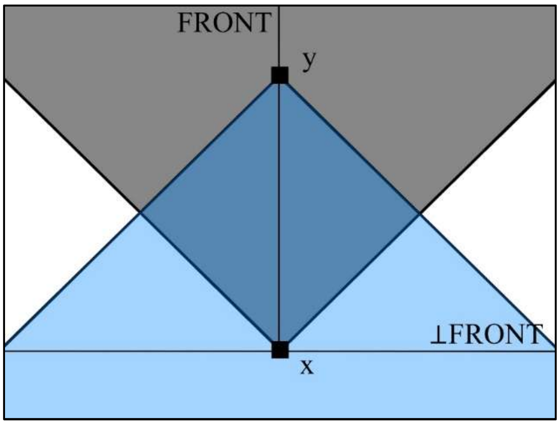

Figure 20. Schematic representation of SYMMETRY.[20]

To determine formally whether this property is satisfied, we must assume a new function:[21] FRONT2(x,y). FRONT2(x,y) positions x at the end of a vector originating at the front of y. The following can then be stated for SYMMETRY(x,y):

(33) $SYMMETRY(x,y)\ iff\ FRONT2(x,y)\ and\ FRONT2(y,x)$

[20] The actual region continues where the picture ends.
[21] The following definitions were suggested by Joost Zwarts.

Suppose the following definition of FRONT2(x,y).

(34) $FRONT2(x,y) = \exists \boldsymbol{v}[loc(x,\boldsymbol{v})\ \wedge\ v \in FRONT(y)]$

Then SYMMETRY(x,y) can be analysed as is presented in (35).

(35) $SYMMETRY(x,y)\ iff\ \exists \boldsymbol{v}[loc(x,\boldsymbol{v})\ \wedge\ \boldsymbol{v} \in FRONT(y)]\ and\ \exists \boldsymbol{w}[loc(y,\boldsymbol{w})\ \wedge\ \boldsymbol{w} \in FRONT(x)]$

4.4. Three formal types of tegenover

We might now expand the preliminary definition given in (30) to the set of vectors that correspond to a situation where SYMMETRY is present: SYMMETRY-*tegenover*.

(36) $[\![SYMMETRY - tegenover]\!] = \left[\exists \boldsymbol{v} \in \left\{\boldsymbol{v} \in space([\![x]\!]) | \left|\boldsymbol{v}_{FRONT(x)}\right| > \left|\boldsymbol{v}_{\perp FRON\ \ (x)}\right| \wedge \left|\boldsymbol{v}_{FRONT(x)}\right| > 0 \right\} \wedge loc(y,\boldsymbol{v})\right] \wedge [\exists \boldsymbol{w} \in \left\{\boldsymbol{w} \in space([\![y]\!]) | \left|\boldsymbol{w}_{FRONT(y)}\right| > \left|\boldsymbol{w}_{\perp FRONT(y)}\right| \wedge \left|\boldsymbol{w}_{FRONT(y)}\right| > 0 \right\} \wedge loc(x,\boldsymbol{w})]$

The other meaning, BORDER-*tegenover*, was defined the following way:

(37) $[\![BORDER - tegenover]\!] = \left\{\boldsymbol{v} \in space([\![x]\!]) \mid \left|\boldsymbol{v}_{FRON\ \ (x,b)}\right| > \left|\boldsymbol{v}_{\perp FRON\ \ (x,b)}\right| \wedge \left|\boldsymbol{v}_{FRONT1(x,b)}\right| \geq |[\![x]\!], B_2|\right\}$

When we look at the formal definitions, we observe a complete separation of BORDER and SYMMETRY. We can conclude that the formal definitions reflect the two basic meanings A and B. However, these definitions do not exclude the possibility of a union of the two meanings. This would give us the following definition:

(38) $$\llbracket SYMMETRY\&BORDER - tegenover \rrbracket = \big[\exists \boldsymbol{v} \in \{\boldsymbol{v} \in space(\llbracket x \rrbracket) \mid |\boldsymbol{v}_{FRON\ \ (x,b)}| > |\boldsymbol{v}_{\perp FRON\ \ (NP,b)}| \wedge |\boldsymbol{v}_{FRONT\ (x,b)}| \geq |\llbracket x \rrbracket, B_2|\} \wedge loc(y, \boldsymbol{v})\big] \wedge [\exists \boldsymbol{w} \in \{\boldsymbol{w} \in space(\llbracket y \rrbracket) \mid |\boldsymbol{w}_{FRON\ \ (y,b)}| > |\boldsymbol{w}_{\perp FRONT1(y,b)}| \wedge |\boldsymbol{w}_{FRONT1(y,b)}| \geq |\llbracket y \rrbracket, B_2|\} \wedge loc(x, \boldsymbol{w})]$$

Especially the definition of SYMMETRY has serious consequences for the framework of vector space semantics. I will address the problem in the following section.

5. Issues for *tegenover* and the model of Vector Space Semantics

The analysis presented above seems to be able to explain in many situations why *tegenover* is acceptable or not. There are, however, multiple problems: a problem for the three universals as proposed by Zwarts (1997, pp. 37, 40), a problem that considers the orientation of the objects and, most importantly, a problem of compositionality. Let us first consider the universals.

(39) Universal 1: All simple PPs are closed under shortening

Universal 2: All simple PPs are linearly *and* radially continuous

Universal 3: All PPs are linearly *or* radially continuous

Simple PPs are defined as unmodified PPs. Universal 1 means that, when you choose a random vector from a region and shorten it, the result will still be in the region. Universal 2 means that all of the vectors cover a continuous region. The meaning of a continuous region can best be explained by a counterexample, repeated from Zwarts (1997, p. 40).

(40) a. Een even aantal meter buiten x

An even number of meters outside of x

b. Schuin boven x

Diagonally above x

These modified PPs are not continuous; (40a) is not linearly continuous, and (40b) is not radially continuous. When we interpret *region* as the set of all possible denotations of *tegenover,* the preposition seems to satisfy both universals 2 and 3, but universal 1 poses a problem. In chapter 2 I concluded that a central property of *tegenover* is DISTANCE. In this case there is a clear restriction on shortening: a vector can be shortened and still be in the region, but it can never be zero. It is therefore not closed under shortening. This means that within this framework, *tegenover* cannot be analysed as a simple preposition.

The second problem comes from the property FRONT. FRONT assumes that the vectors can originate at a specific side of an object. However, as Zwarts points out in note 14, Zwarts' model is set up in such a way that all objects are oriented in the same way (Zwarts, 1997, p. 45). In my interpretation, this means that it is not possible to specify a different orientation for one of the objects. Because of the need to incorporate the orientation of the reference object, then, it is not possible to analyse *tegenover* as a polysemous simple PP within this model. The remark in note 14 leads us to believe that Zwarts saw at least some of these problems.

The most important problem arises because of the property SYMMETRY. I repeat the definition that was given in section 4 in (41).

(41) $[\![SYMMETRY - tegenover]\!] = \left[\exists \boldsymbol{v} \in \left\{\boldsymbol{v} \in space([\![x]\!]) \middle| \left|\boldsymbol{v}_{FRONT(x)}\right| > \left|\boldsymbol{v}_{\perp FRON\ \ (x)}\right| \wedge \left|\boldsymbol{v}_{FRONT(x)}\right| > 0\right\} \wedge loc(y, \boldsymbol{v})\right] \wedge [\exists \boldsymbol{w} \in \left\{\boldsymbol{w} \in space([\![y]\!]) \middle| \left|\boldsymbol{w}_{FRONT(y)}\right| > \left|\boldsymbol{w}_{\perp FRONT(y)}\right| \wedge \left|\boldsymbol{w}_{FRONT(y)}\right| > 0\right\} \wedge loc(x, \boldsymbol{w})]$

As you might have noticed, it is impossible to define this property without referring to the located object y. In the definition of SYMMETRY we find both x and y, which correspond to the reference and the located object. Of course, a property such as symmetry cannot be evaluated when the orientation of one of the two objects is unknown. This is problematic, because this analysis is not compositional. SYMMETRY, thus, is not compatible with a compositional interpretation of a *tegenover*-PP in terms of vectors. Compositionality, as you might recall, was one of the main reasons to develop the framework of vector space semantics in the first place.

This has consequences for the theory of vector space semantics as a means to analyse prepositions. This theory is based upon the idea that prepositions denote a spatial orientation of the reference object, that situates the located object. However, the impossibility to define the spatial orientation of the reference object of *tegenover* without accessing spatial information of the located object, implies that prepositions should be analysed as relations between two objects instead of a position relative to an object. This calls for a yet another approach of spatial relations in the search for a compositional semantics of PPs.

6. Final remarks

In this last section, I would like to briefly look back at the research that was summarised in the introduction of this paper and show how the model presented in this paper explains the characteristics mentioned by other researchers. Furthermore, I want to address an important question that has not yet been answered.

6.1. Reflection

Most of the characteristics of *tegenover*, *opposite* and *across* we saw in the first section coincide with or can be modelled by the properties defined in this paper. The characteristics derived from former research were the following:

1. Frame of reference: inherent;
2. Orientation: located object faces the front of the reference object (not always (Broekhuis, 2013));
3. Contact: no contact between located object and reference object;
4. Separation: the objects are separated by a horizontal *situational* axis;
5. The objects are typically positioned on a second situational axis that is orthogonal the separating axis (flexible).

The characteristics from this quite extensive list are modelled as logical consequences of the set of interacting properties. For example, with respect to the second characteristic, orientation, the importance of the front of the reference object is incorporated in this model through the property FRONT. The fact that the located object can face in another direction, as was noted by Broekhuis (2013), is accounted for through the separation of FRONT and SYMMETRY. That is to say, there are uses of *tegenover* that are characterised by FRONT, but do not involve SYMMETRY, and the other way around.

The third characteristic of contact is formally defined by the property DISTANCE. As to the fourth and fifth characteristic: the exact reason why Lindstromberg introduces the situational axes, remains unknown. In his analysis, however, the situations analysed seem to mostly correspond to situations my model would analyse with BORDER. This suggests that Lindstromberg's situational axes coincide with this property. Attributing BORDER to every situation is problematic, as we have seen in paragraph 2.1; therefore, my model contains no situational axes. While Lindstromberg's separating axis seems to coincide with BORDER, the second situational axis orthogonal to the separating axis is accounted for by the pragmatic property <u>Straight</u>.

The remaining characteristic is the frame of reference. *Tegenover* used to be analysed as an inherent preposition. Although in the model presented here *tegenover* is still partially analysed as an inherent preposition, I have shown that *tegenover* has a deictic interpretation that constructs the front of the reference object relative to functional boundary b.

6.2. Remaining questions

The connection between BORDER and the situational axes I pointed out above, brings me to an important question: what is the exact nature of this boundary? Lindstromberg mentions this boundary as an *intervening form*, and concludes that it can be substantial, like a table, or the absence of anything substantial, such as an aisle (2010, p. 98); in this paper I said that is a more or less flat surface with a separate function, although table also suffices. Even two rows of people standing opposite each other create a functional boundary between them. I concluded that BORDER meant that the space between the two objects is filled, either functionally or materially.

The first, and most important, question that needs to be answered, is: is the boundary a property or an object? If it is an object, how can we describe its characteristics, and how do we incorporate this object in a compositional definition? If it is a property, how do we describe the vectors without referring to a third entity? In this paper, I chose to give a preliminary analysis in which BORDER is represented as a sort of hybrid: a property based upon an object. Of course, this is not the most perfect definition. This definition needs revision.

It would be especially interesting to investigate differences between uses that are characterised only by DISTANCE and uses that also involve BORDER: except for the presence or absence of SYMMETRY, what are the situational differences? Which element in the environment leads to an optionality of SYMMETRY and how do we characterise this element?

7. Conclusion

From this analysis of the preposition *tegenover* we can conclude that the preposition does have characteristics that remain present in all spatial uses, namely the properties DISTANCE and FRONT. The two remaining properties, BORDER and SYMMETRY, impede the union of all of the meanings in one formal semantic model; it is necessary to provide multiple, connected definitions.

In the formal definitions of these properties it becomes apparent that the theory of Vector Space Semantics is not suitable for the analysis of *tegenover*. First of all, *tegenover* does not seem to satisfy the second universal proposed by Zwarts (1997); according to this definition, *tegenover* is not a simple PP. Secondly, it is not possible to analyse tegenover as a polysemous simple PP within this framework, because of the need to incorporate the orientation of the objects; Zwarts stated that in his model, the objects were all oriented the same way. Thirdly, it seems impossible to define *tegenover* without referring to the located object. This means that the definitions given in this paper are not compositional.

Even though the analysis presented in this paper is not at all free of flaws, especially this third problem seems to indicate that the analysis of prepositions in terms of positions relative to the reference object is not favourable; these conclusions point to an analysis based upon a spatial relation between two objects.

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