Forschungsberichte des
Instituts für Phonetik und
Sprachliche Kommunikation
der Universität München
(FIPKM) 37 (2001) 51-63

A uniform anthropomorphological approach to the human conception of dimensional relations

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ABSTRACT

Within psycholinguistics, the dimensional conception of space is described through a variety of theoretical constructs, e.g., frames of reference, perspectives, strategies, and patterns. The objective of this paper is to introduce a uniform classification of the alternatives of dimensionally conceiving of object relations, derived from the functional and morphological asymmetries of the human body which define an anthropomorphous Origo, and from our ability to mentally project the Origo into positions and orientations other than we actually occupy. Particularly, the conception of dimensional relations on the first horizontal line is explained through the princpiple of perceptual accessibility of objects; this allows for the uniform treatment of (almost) all conceptual alternatives from basic psychological principles. Finally, some implications of this anthropomorphological view for the human cognition of dimensional relations are discussed and underpinned with empirical results.

Key words: anthropomorphology, frames of reference, mental rotation, psycholinguistics, spatial relations, spatial cognition.

1. FRAMES OF REFERENCE: BETWEEN SPATIAL LANGUAGE AND COGNITION

Large parts of the research on the human conception of spatial relations originate from the linguistic investigation of the variety of verbal expressions that are suited to properly communicate about such relations. Therefore, the issue of this paper will be derived from linguistic contexts: A rather frequent goal of speakers is to verbally emphasize a particular place in order to point their hearers' attention in the right direction. Within a certain range of variation, however, such descriptions cannot simply be judged correct or false; rather, their adequacy depends on the underlying spatial interpretation, or conception, of the respective situation. Particularly with dimensional relations, most situations allow for more than one spatial conception. As long as we rely on the assumption of an unambiguous relation between someone's production, or comprehension, of language and his or her cognition (a relation that may also reflect particular constraints of the language in use; cf. Talmy, 1983), we can infer that person's cognitive conception of a spatial situation from the way he or she verbally describes, or understands a given verbal description of, this situation (cf. Tversky & Lee, 1998). In any case, the cognitive conception of a spatial situation can be considered a logical and process-related prerequisite of the use of linguistic expressions for this situation.

The question of which perspective on a spatial relation is taken in which situation or under which circumstances, has been addressed in many psycholinguistic studies on the pragmatics of spatial prepositions (e.g., Abkarian, 1982; Cox & Isard, 1990; Ehrich & Koster, 1983; Grabowski & Weiß, 1996; Grabowski & Miller, in press; Herrmann & Grabowski, 1998; Levelt, 1982; Miller & Johnson-Laird, 1976; Wunderlich, 1981). Although the empirical base for the determinants of spatial perspective-taking is strong, the theoretical underpinnings documented in the literature are neither clear nor completely convincing. There does not appear to be any overarching theory that offers a well-ordered (and, at the same time, theoretically uniform and sparing) classificiation of the *possible* ways of conceiving spatial relations or that goes beyond providing taxonomies to provide a psychological explanation for the resulting descriptive structure. Instead, we find a great variety of theoretical constructs with different theoretical status: Some determinants of the cognition of spatial relations are seen in physical properties of objects in the world (e.g., Lang, 1993), other descriptions draw on properties of linguistic elements (e.g., Talmy, 1983), some approaches concentrate on features or preferences of cognitive systems (e.g., Landau & Jackendoff, 1993; Levelt, 1982), others mix cognitive with semantic categories (e.g., Herskovits, 1986). This is not to criticize any of these approaches as such, but merely illustrates some lack of theoretical cohesion in the (admittedly interdisciplinary) field.

Particularly when it comes to the classification of the alternatives of dimensional interpretation, we apparently need, first, the distinction of the intrinsic versus extrinsic *frames of reference*, where the intrinsic (or object-centered) frame assumes inherent properties of the reference object. Intrinsically oriented objects, moreover, need to be distinguished according to their anthropomorphous or their facing *pattern* of the four sides in the horizontal plane, where the facing pattern is described through an inversion of the left-right poles relative to the front-back axis (Clark, 1973). Next, the extrinsic frame further subdivides into the environment-centered frame and the viewer-centered, or deictic, frame. The deictic frame, in turn, varies within and between cultures with respect to the applied *strategy*, which can follow either the aligning or the vis-à-vis *principle*. (See Carlson-Radvansky & Irwin, 1993; Levelt, 1996; Levinson, 1996; Retz-Schmidt, 1988; for overviews of reference systems.)

In the face of this diversity of theoretical constructs in the classification of the various systems of spatial-dimensional conception, the objective of this paper is to introduce a psychological approach that allows for the derivation of all (or at least the most important) conceptual alternatives from one uniform principle: the asymmetrical morphology of the human body. A respective specification of dimensional relations is set out in the next section. While so far a merely descriptive, though psychologically founded, taxonomy of the alternative ways of conceiving of dimensional relations will have been introduced, the final section discusses its implications for the actual human cognition of spatial relations.

2. DIMENSIONING SPACE WITH ANTHROPOMORPHOUS ORIGOS

There is ample evidence that the conception of space and its relations varies from culture to culture (Ameka, 1995; Brown, 1994; Svorou, 1994). For the present purposes, we concentrate on (mainly Western) cultures where the notion of some Euclidean-like dimensions is employed for spatial conception anyway. But where does, in a particular situation, the conception of spatial dimensions come from? As far as psycholinguistics was influenced by linguistic semantics and its search for appropriate descriptions of the core meanings of spatial expressions, it is widely assumed that the dimensional conception of a spatial situation is derived from the dimensionally qualified sides of the respective reference object.

The concept of referential frames indicates the transition from linguistic semantics to psycholinguistics: It is employed in order to describe the principles according to which reference objects get their sides assigned. Here, the basic distinction is between the intrinsic and the deictic frame: In the intrinsic frame, the reference object has its qualified sides independent of the given situation by its inherent morphological or functional features. In the deictic frame, the reference object has no inherent dimensioning features, or they are not used for the spatial conception of the situation; therefore, the reference object must have its sides assigned through an oberserver's perspective, and the dimensional qualifications of the sides change with varying positions and orientations of the observer. The principles of how sides are attributed to reference objects are elsewhere described in great detail and do not need to be repeated here (e.g., Carlson-Radvansky & Irwin, 1993; Fillmore, 1971; Grabowski, 1999; Levelt, 1996; Miller & Johnson-Laird, 1976; Retz-Schmidt, 1988).

We now turn to an answer to the question of how spatial dimensions originate in our conception of a spatial situation that tries to overcome the distinction between the sides of the reference object as the basis of conceived dimensional relations and the frames of reference which determine the assignment of sides to objects. To achieve this, we start from the basic assumption according to which the dimensions of space, as well as their poles, are always derived from the body asymmetries of the space-conceiving human being (see as early as Stern, 1936). The initial definition of the vertical line is the axis from the head (= upper pole) to the feet (= lower pole). The first horizontal axis runs through chest and back, with the positive pole being in the direction of the privileged perceptive field of the human senses. The second horizontal axis runs perpendicular to both the vertical and the first horizontal line. In the tradition of Bühler (1934), the aspect of the human body that serves the space-dimensioning functions can be called an anthropomorphous *Origo*. In our case (and unlike Bühler, whose Origo is a point without extension and directedness), the most important feature is the Origo's *orientation* (i.e., the directions it defines). If the Origo's spatial *position* is also considered—which at the same time provides the Origo's relative position to the object relation at issue—a viewpoint is defined as the basis of any dimensional conception of spatial contexts: the half

axis that points from the positioned anthropomorphous Origo towards the positive pole of the first horizontal axis. In this view, dimensional relations are always three-place relations: An object is in a specific spatial relation to a reference object from the space-dimensioning viewpoint of an instantiated Origo. (Therefore, it does not make too much sense to discuss the properties of converseness and transitivity for dimensional relations as if it were two-place relations, as does Levelt, 1996, pp. 81–83).

First, we consider the case on an *actual Origo*, in which the observer (in a given situation) sets the Origo egocentrically. This is only possible in situations where the observer, the localized object and the reference object are temporally and spatially co-present. Given an actual (egocentric) Origo, there are two manners of conceiving the poles of the two horizontal dimensions (assuming that the vertical line is given.) These ways differ with respect to the Origo being either in the place of the reference object, or outside the place of the reference object. The first case shall be called *inside perspective* (or *inside Origo*), the second *outside perspective* (or *outside Origo*).

The inside perspective: The fundamental characteristic of the inside perspective is that the Origo—which is, for the moment, functionally derived from the observer's morphology in his or her actual position and orientation—is in the same place as the reference object with respect to the relevant horizontal dimensions. This situation can occur when the reference object is a container *in* which the Origo is located or when the Origo's location differs from the place of the reference object only vertically (e. g., when sitting on a chair). With respect to a general and uniform account, it seems advantageous to carefully separate the space-dimensioning function of the Origo from the spatial anchoring of the localized object by the reference object (see Figure 1). In localizing utterances, however, from which the underlying cognitive conception is often infered, only the localized object and the reference object (and, of course, the spatial relation between the two) are verbally expressed, but not the space-dimensioning entity that is fundamental to the dimensional interpretation of the spatial situation.

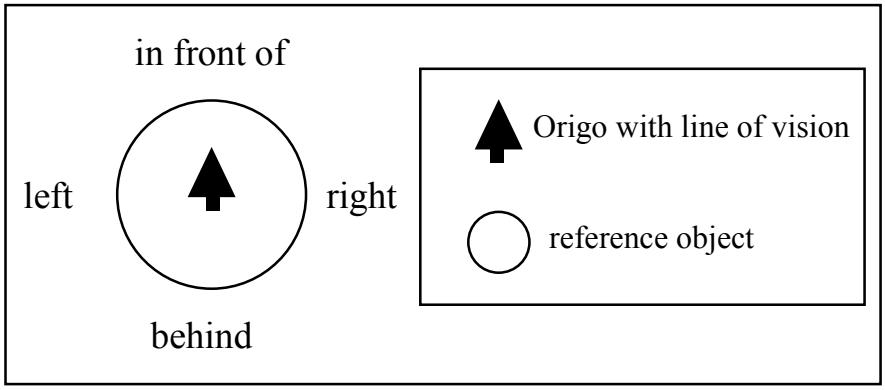

Figure 1: The conception of dimensional relations in the inside perspective.

A special case of the inside perspective is when the observer conceives him- or herself as the reference object. Again, however, there is a functional distinction between the place that the observer occupies as a physical object, and his or her body asymmetries that form the basis for the instantiation of a space-dimensioning Origo.

The outside perspective: If the Origo is not in the place of the reference object, as was described above, then it is always turned toward the reference object so that, from the Origo's point of view,

the reference object is towards the positive pole of the first horizontal axis. This is an indispensable requirement for the conception of dimensional object relations in all cases that do not come under the inside perspective. If necessary, the observer must establish this prerequisite by a change of his or her own orientation, before an object relation is interpreted dimensionally.

In other theoretical contexts, the outside perspective is, again, described so that the observer induces the reference object with a front on the side that is facing the observer; accordingly, the opposite side of the reference object is interpreted as its back. After that, the dimensioning of space and the polarization of these dimensions is put down to these acquired sides of the reference object. This principle is often justified with reference to Clark (1973), who describes the "canonical encounter" (i. e., the face-to-face position of speaker and hearer) as the typical pattern of interaction from which other cases, in which people encounter objects, are derived. However, it appears questionable as to why the definition of front and back is derived from the hearer's facing position, but not the definition of right and left. This is because the poles of the second horizontal axis correspond, under the outside perspective, again to the anthropomorphous pattern of the Origo, and not to the intrinsic left and right of the hearer on the other side (see Figure 2). These side-induction approaches have to assume a transposition of the left and right poles with regard to the front-back axis (cf. Wunderlich & Herweg, 1991). (Compare the patterns on the left-hand sides of Figures 1 and 2.)

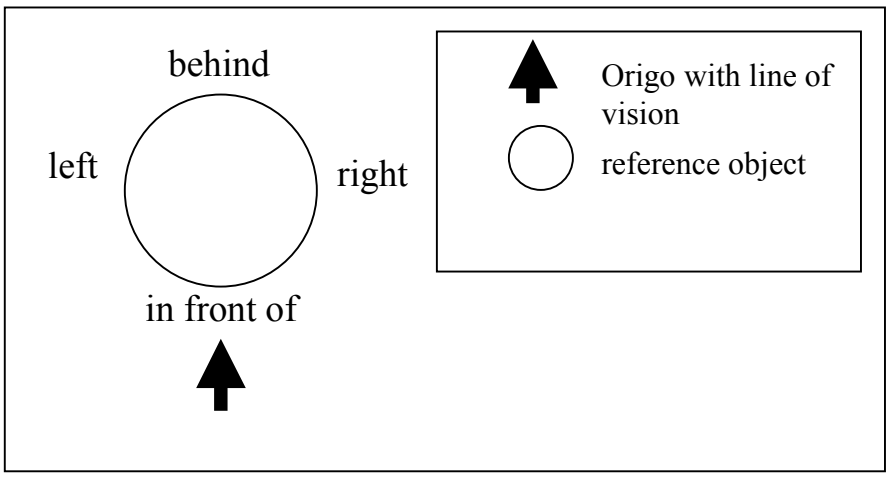

Figure 2: The conception of dimensional relations in the outside perspective.

With a uniform description of the conception of dimensional object relations in mind, the difference between inside and outside perspective is preferably understood in a way that emphasizes as far as possible what both perspectives share in common: "right of the reference object" and "left of the reference object" are defined in both perspectives through the Origo's anthropomorphous poles on the second horizontal axis. In the face of this agreement, it is now no longer the inversion of the left-right axis that needs to be explained, but the transposition of the front and back poles on the first horizontal axis in the so-called vis-à-vis perspective (as shown in Figure 2) compared to the anthropomorphous pattern of dimensional directions. However, the place "in front of the reference object" is characterized by the fact that it is part of the Origo's perceptual catchment area in both inside and outside perspectives. (Remember that, in the present approach, the Origo is derived from the anthropomorphous and anthropofunctional attributes of human beings.) If we take the visual sense as the most typical representative of human perception, we can say in simplified terms that "in front of the reference object" is a place on the first horizontal axis that the Origo can *see*; "behind

the reference object" is a place on the first horizontal axis that the Origo can't *see*. So far, this pattern holds for both inside and outside perspective.

Both perspectives, however, differ regarding the *causes* that account for the perceptual accessibility (visibility, audibility, manipulability, etc.) of the localized object. From the inside perspective, an object is either, say, visible or (at least partially) invisible, *because* it is either in the Origo's line of vision or not. From the outside perspective, an object is either visible or invisible, *because* the reference object either admits or obscures its perceptual accessibility. In the latter case, the perceptual overlap of the localized object and the reference object determines the Origo's perceptual access to the localized object. Thus, the main difference between inside and outside perspective is whether the sensory-perceptual equipment of the anthropomorphous Origo, or the position of the reference object compared to the localized object, is considered responsible for perceptual accessibility of the localized object from the Origo's point of view.

The above reconstruction of the conception of spatio-dimensional relations is solely derived from psychological conditions of human beings (and from contraints in the physical world). The results generated to reach the objective of providing a general basis for the conception of all dimensional relations (with a certain emphasis on the relations in the horizontal plane) under both perspectives seem to correspond to a goal of linguistic semantics which is, through the analysis of the usability of dimensional prepositions, to attain core meanings that are as comprehensive and as extensive as possible or, in other theoretical approaches, to attain central prototypes of prepositional usability (Brugman, 1981; Herskovits, 1986; Hottenroth, 1993; Vandeloise, 1985). However, this coincidence is neither essential nor intended.

Projected Origos: So far the discussion was restricted to Origo setting (i.e., conceiving a spatial relation from a particular Origo) via the actual position and orientation of the space-conceiving observer. However, we are capable of the cognitive processes of mental translation and mental rotation (see Shepard & Cooper, 1982), i. e. we can imagine how the spatial world looks from a perspective other than our actual egocentric perspective. In other words, we can mentally project our egocentric Origo onto another position and/or orientation. For this reason, it is possible to dimension the spatial environment from a projected Origo's perspective. As with the actual egocentric Origo, projected Origos involve both position and orientation. Origo projections always follow the anthropomorpous principle, which means that the projections preserve the anthropomorpous pattern of spatial dimensions and their poles.

The necessity of the human ability to perform Origo projections follows from the very fact that a hearer, in order to comprehend a speaker's egocentric localization, must be able to imagine the speaker's point of view in all cases in which both are not co-oriented in space. No wonder the speaker, who is also hearer in many situations, also employs this ability in the course of language production.

In principle, we can put ourselves mentally in any orientation and position, thus instantiating a projected Origo. However, particularly in communicative contexts three types of projection ‚recipients' are most important: canonically projected Origos, context-based projected Origos, and momentarily projected Origos.

Canonical Origo projection: Several objects are formed in such a way that people take a particular position and orientation towards these objects when using them. For such objects, asymmetry on at

least one dimension is required (presupposing that the object is in its normal vertical orientation; cf. Levelt, 1984). The typical position and orientation of people when handling objects of this kind can serve to define a canonical Origo's point of view, which in turn serves as a space-dimensioning entity projected by the observer. Again, an inside perspective and an outside perspective exist. Among reference objects that are typically used from the inside perspective are vehicles, garments, conference rooms, theaters, and seats. Among reference objects that are typically used from the outside perspective—where the canonical user is better refered to as a canonical observer—are grandfather clocks, closets, and TV sets.

Context-based Origo projection: Context-based projections include those cases elsewhere described as extrinsic, or environment-centered, frames of reference. Here, the observer projects the Origo into a position and orientation that people would take in a particular context because of other objects in the surrounding. For example, a house can be seen from from the viewpoint of a passer-by (= outside perspective), thus conceiving a tree as being in front of the house. Or a perfectly circular UFO may take an anthropomorphous Origo in the way a person would orientate when he or she moves in the direction of flight (= inside perspective). In contrast to the canonical perspectives, however, the context-based description of the object relation changes when the identical object constellation is put into another environment.

Momentarily projected Origo: The observer can mentally project the Origo into any arbitrary position and orientation which must, in the case of communication, be verbally explicated. However, people, in most cases, take perspectives that they could actually occupy; they do not conceive an object relation from the perspective of, say, somebody who is hanging under the ceiling. This projection category subdivides into real and fictitious Origos. Real Origo-recipients can be all entities that are present in the respective situation and that allow for an anthropomorphous projection, particularly, in the case of communication, the hearer or a third person.

When an object relation is imagined or recalled that is not part of the actual surroundings, the actual orientation is of no use as a space-dimensioning Origo. Particularly in such cases, it is possible, and sometimes necessary, to introduce a fictitious Origo. Again, fictitious Origos are always anthropomorphous Origos and come under both inside and outside perspectives.

At the end of the day, the most important cases of the dimensional conception of object relations vary according to two parameters: (a) actual (i. e., non-projected, egocentric) Origo vs. canonical (or, more precisely: canonically projected) Origo vs. context-based Origo vs. momentary projection into a real Origo vs. momentary projection into a fictitious Origo, and (b) inside perspective vs. outside perspective, where the perspective parameter merely depends on the location of the Origo relative to the reference object, thus introducing different conditions for the perceptual accessibility of places in the plane (see Figure 3). The resulting ten cases are exemplified with utterances of a space-conceiving speaker.

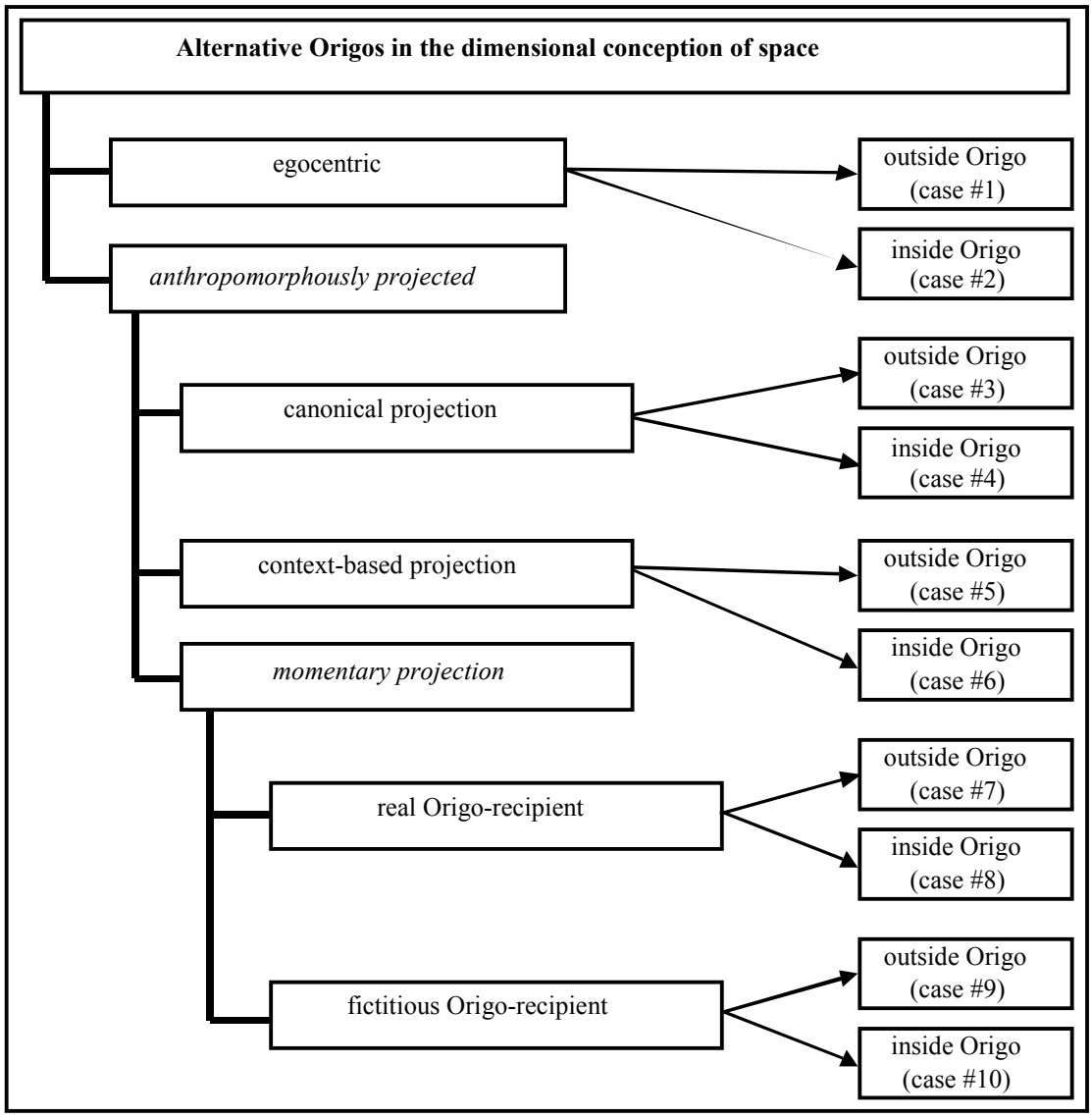

Figure 3: Important alternatives of Origo settings for the definition of spatial dimensions and their poles.

Cases #1 and #2: The egocentric Origo corresponds, as far as the outside perspective is concerned, to the typical case of the deictic frame of reference. Here, no mental projection is needed. In the case of the outside Origo, the speaker is facing the object relation: "(From my point of view) the pencil is in front of the eraser."—In the case of the inside perspective, the speaker is in the place of the reference object, e. g., sitting on a ball, and says, "There is a stain on the carpet in front of the ball." A particular case of egocentric inside Origos is to localize an object in relation to oneself: "The pencil is in front of me." But remember that also in this case the reference object "I" and its body asymmetries that provide the Origo need to be functionally distinguished.

Cases #3 and #4: These two and all further cases require a projection of the egocentric dimensional anthropomorphology into another Origo. With canonical projections, the Origo's orientation is determined by the position of typical interaction with the reference object. These cases correspond to the intrinsic frame of reference: "The cat is in front of the wardrobe" (outside Origo)—"The car behind that green mercedes is mine" (inside Origo).

Cases #5 and #6: With context-based projections, the Origo can be infered from the context of the reference object: "There is an anthill in front of the tree," where the tree is seen from an outside Origo on a forest path.—"A fighter bomber flies behind a UFO." In this example, the contextual factor of the direction of motion allows for the determination of an inside Origo.

Cases #7 and #8: With momentary projections, the Origo's position and orientation towards the object constellation is arbitrary. Real recipients of momentary Origos are the hearer or other persons or objects involved in the situation that allow for an anthropomorphous projection. The distinction between inside and outside Origo is analogous to cases #1 and #2.

Cases #9 and #10: The momentary projection into a fictitious (more precisely: a fictitiously positioned and/or oriented) Origo must regularly be verbally explicated: "If you leave central station, the hotel is behind the water-tower" (outside Origo).—If you look out of the window (of your hotel room), the Cologne Cathedral is directly in front of your room" (inside Origo).

Two concluding remarks on this taxonomy as such: It has already been mentioned that some of the described cases are elsewhere treated in terms of the deictic versus intrinsic frame of reference, where the deictic frame corresponds to the observer's actual outside perspective, whereas the canonical perspectives are combined in the intrinsic frame of reference. However, it should have become clear from the above considerations that the sole distinction between deictic and intrinsic localization is not sufficient for a differentiated description and treatment of the existing varieties of dimensional conception. Moreover, an utterance like "the ball is to the right of me" (which is, in the above taxonomy, clearly a case of an actual egocentric inside Origo) can not be clearly assigned to one of the two frames. It is deictic, since the speaker's orientation is relevant for the dimensional specification of the place of the ball. It is also intrinsic insofar as the speaker, in the role of the reference object, is intrinsically oriented. (The semantic resolution of "me" is a case of personal deixis that does not touch on the spatial descripition.) Further, all cases that fall into the category that Bühler called "Deixis am Phantasma" (which appear among the momentarily projected Origos) can not be classified according to the deictic-intrinsic distinction.

In a footnote, Hill (1982, p. 38) notes that it could be intuitively attractive to assume that we would project orientation axes from our body onto the world of physical objects, but this would only illustrate how easily our egocentric ideas lead us astray. Then, he refers to findings of Tanz (1980), according to which children learn concepts like "front" or "back" first with external objects like horses or trucks, before they are able to apply them to their own body. However, it should not be believed that the idea of anthropomorphous projection is taken in by the egocentric jack-o'-lantern. Rather, Hill's argumentation is not conclusive. In Tanz's example, children first learn, as they do with many other concepts, some prominent tokens of a concept and the corresponding linguistic expressions by heart, as it were, before they are able to make out the general invariance and to apply it productively. Again, the misconception seems to be that the attribution of fronts and backs is not considered as a phenomenon that is *derived* from the functional asymmetry of the own body, but as a *prerequisite* of dimensional conceptions. Incidentally, a uniform *anthropocentric* view, as it has been proposed above, does not necessarily imply some dominant *egocentrism*, at least in adults' actual dimensional conception of space (cf. Levinson, 1996); egocentric Origos are, altogether, rather not the majority of dimensional space conceptions in everyday situations.

3. IMPLICATIONS FOR A MODEL OF THE HUMAN COGNITION OF DIMENSIONAL RELATIONS

So far, the anthropomorphological approach has been introduced as a merely descriptive and classificatory instrument that allows for the uniform derivation of the most important alternatives of spatio-dimensional conception according to psychological factors (functional asymmetries of the human body, perceptual accessibility, and mental rotation). It is not claimed that this taxonomy provides a basis for the study of the *cognitive representation* of object relations. For example, it does not follow from the above exposition that an object constellation should be faster processed from an actual egocentric perspective than from a canonically projected Origo. Rather, research on spatial cognition suggests that canonical points of view on an object can be a more or less regular, experience-driven part of the representation of objects which do not call for extra processes of Origo transformation and rotation. However, if the Origo that a speaker takes is arbitrarily connected to the described object constellation, so that the Origo's perspective cannot be derived from the representation of the reference object, we can see from reaction time experiments on mental rotation in general, and particularly on hearer-related localization (Herrmann & Grabowski, 1994), that measurable cognitive processes are required in order to take a perspective different from the actual egocentric one, and that reaction times depend on the involved rotation angle.

The anthropomorphological taxonomy can, however, be taken as a proposal for a model of spatial cognition of dimensional relations between objects. If the assumptions hold for actual human cognition, the derived expectations for the mental processing can be tested, where the notion of perceptual accessibility as a general principle of the uniform description of both inside and outside perspective bears the most relevant implications.

One expectation says that, given an Origo, "in front of" relations should be faster processed than "behind" relations, because it is easier to find out whether something *is* the case (here: the perceptual accessibility, or visibility, of the reference object) than to notice that it is *not* the case: Positive judgements are faster than negative judgements. The advantage of judging "front"-relations compared to "behind"-relations was shown in reaction time experiments (for the egocentric inside perspective: Bryant, Tversky & Franklin, 1992; Tversky, 1996; for the outside Origo projected into the hearer: Herrmann, 1989; Herrmann, Bürkle & Nirmaier, 1987; but not with Bryant et al., 1992). A further expectation says that relations on the first horizontal axis should be faster processed (and assessed) than the left-right relations on the second horizontal axis, because the judgement of left-right relations needs an additional operation: The intended place or object is perceptually accessibile from the Origo's point of view *and* the Origo must ‚turn left or right' to perceptually fix on it which involves a decision, or an actual dimensional calculus. Again, this expectation is found confirmed (for the egocentric inside perspective: Franklin & Tversky, 1990; for the outside Origo projected into the hearer: Herrmann et al., 1987, p. 16). The results of these studies are, to some extent, co-determined by additional factors (e. g., the interference between lexical antonyms), insofar as these studies involve hearer-related localization or, more generally, the *production* of utterances. For further clarification, an experimental separation of the (cognitive) costs for the conception of object relations from the costs for the verbal expression of object relations, from a given Origo's perspective, would be useful.

Further, the notion of perceptual accessibility allows for an explanation of the fact that we have verbal expressions that specify relations on a dimension without explicating the polar direction only for the second horizontal line ("beside", "at the side of") but not for the first horizontal line. The

determination of "in front of" and "behind" relations does not imply a dimensional calculus; if the Origo ‚looks' from the place of the reference object (inside perspective) or to the place of the reference object (outside perspective), the localized object is either visible (perceptually accessible) or not. There is no sense of having an expression that leaves these alternatives open. If, however, an object is within the field of sight, but not on the first horizontal line of the Origo, it is already informative to notice that there is a transverse difference of the localized object from the reference object, even before the polar direction of this difference is specified: The localized object can be sharply seen only if the Origo, while keeping its anthropomorphous orientation, ‚turns its head' (whether in the one or in the other direction).

From the concept of perceptual accessibility, further expectations relate to the transition from the conception of a stimulus "in front" to a stimulus "back there" and its dependence on stimulus intensity and stimulus modality. These expectations, however, have not been experimentally tested so far.

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