Where is the bottle?
Cross-linguistic study on side assignment to objects and interpretation of static spatial relations by German, Polish, Italian and English native speakers

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Summary

The aim of this dissertation is to investigate the use of reference frames (absolute, relative, intrinsic) and secondary local deixes (‘in front of’, ‘behind’, ‘to the right / left of’) by German, English, Italian, and Polish native speakers to describe static spatial relations. Two experiments per language were carried out.

The first experiment investigated side assignment. Participants saw the object from the front (the canonical position) and the back (the noncanonical position). The results confirm that for side assignments to a canonical positioned vis-à-vis object most speakers of the four languages use the outside perspective. However, some variations occurred for Polish and Italian, especially while identifying the right and left sides showing significant differences between German and Italian.

Using mouse tracking, I tested the interpretation of static spatial relations of two kinds of complexity. *The simple spatial relations* included either extrinsic or intrinsic reference objects (animate; inanimate) and a bottle as localized object. *The complex spatial relations* were supplemented by an agent and embedded by indirect speech. This allows the investigation of origo shift. In all situations, participants were asked to describe the location of the bottle. German and Italian showed significant differences in interpreting simple animate and inanimate intrinsic relations. Interpreting the intrinsic complex relations, Polish speakers shifted the origo to the agent most frequently and described the relations from his point of view. All in all, for the complex relations, the choice of the intrinsic reference frame decreased significantly compared to the simple relations. That is, most participants shifted the origo to agents’ point of view and interpreted the spatial relations applying the reflection strategy.

Zusammenfassung

Das Ziel der Dissertation ist, den Gebrauch von sekundären Raumdeixes (‚vor', ‚hinter', ‚rechts / links von') und Referenzrahmen (absolut, intrinsisch, relativ) von deutschen, englischen, italienischen und polnischen Muttersparcher_innen für die Beschreibung von statischen Raumrelationen zu untersuchen. Zwei Experimente pro Sprache wurden durchgeführt.

Das erste Experiment untersuchte Seitenzuweisung. Die Proband_innen sahen ein Objekt von der Vorderseite (kanonische Position) und Rückseite (nicht-kanonische Position). Das Ergebnis bestätigt, dass die Proband_innen der vier Sprachen die Außenperspektive für die Seitenzuweisung des kanonisch stehenden vis-à-vis Objektes meistens benutzen. Einige Variationen haben die Pol_innen und Italiener_innen gezeigt, vor allem bei der Zuweisung von der rechten und linken Seite. Dabei wiesen die Deutschen und Italiener_innen signifikante Unterschiede auf.

Mit dem Mouse Tracking habe ich die Interpretation von statischen Raumrelationen von zwei Komplexitätsgraden untersucht. *Die einfachen Raumrelationen* enthielten entweder ein extrinsisches oder intrinsisches Referenzobjekt (belebt; unbelebt) und eine Flasche als lokalisiertes Objekt. *Die komplexeren Raumrelationen* wurden um einen Agenten ergänzt und mit der indirekten Rede eingebettet. Das erlaubte die Erforschung von Origo-Shift. In allen Raumrelationen wurden die Proband_innen gebeten, die Lokalisation von der Flasche zu beschreiben. Die Deutschen und Italiener_innen zeigten signifikante Unterschiede bei der Interpretation von einfachen belebten und unbelebten intrinsischen Raumrelationen. Bei der Interpretation von komplexeren intrinsischen Raumrelationen haben die polnischen Muttersprachler_innen die Origo am häufigsten zum Agenten verschoben und von seinem Blickwinkel bezüglich des relativen Bezugsrahmens die Relationen beschrieben. Im Allgemeinen, für die Interpretation von komplexeren Raumrelationen ist die Wahl des intrinsischen Bezugsrahmens im Vergleich zu einfacheren Raumrelationen signifikant gesunken. Das heißt, die meisten Proband_innen haben die Origo zum Agenten verschoben und von seinem Blickwinkel die Raumrelationen bezüglich der Spiegelstrategie interpretiert.

Acknowledgement

My time as a doctoral researcher has been a lengthy one. I have had numerous wonderful experiences and few difficult ones. To begin, I would like to thank the many people who supported me during this time and who helped make this thesis happen.

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My PhD thesis is very empirically based. I conducted the empirical studies in Berlin (for German), Wrocław (for Polish), Edinburgh and Glasgow (for English), and in Roveretto (for Italian). Thank you very much to all those who supported my experiments outside Germany: Marzena Żygis, who supported me with a DAAD grant. You made my travels possible. Many thanks to Joanna Błaszczak for hosting me and for taking care of me at Wrocław University. It was a pleasure for me to work at your institute during the time of my PhD. My next experiments were conducted in Edinburgh. My special thanks go to James Scobbie and his colleagues. Thank you very much for your support in searching for participants and for hosting me at an outstanding university in a wonderful city. After Edinburgh, I went to Glasgow, where Joanne Cleland welcomed me. It was a great pleasure for me to be hosted by you. Thank you very much for the very hospitable time with you and your team. My last journey was to Roveretto. Roberto Bottini, I thank you very much, from bottom of my heart, for hosting me in the wonderful lab center. I had the feeling of being in a big lab. It was amazing. Thank you very much for taking care of the experiment, my participants, and myself. It was a pleasure working with you, listening to your talk, and meeting your colleagues. Federica Sigsimondi, you were also a significant part of my stay in Roveretto. Thank you very much for everything. Lastly, I would like to thank to all of the participants for taking part in my experiments and for providing me with the opportunity to use their technical equipment to investigate this amazing research area.

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As mentioned above, this PhD thesis has taken a long time. This meant that I had many opportunities to interact with many researchers, especially at the Leibniz-ZAS and at conferences where I traveled to and gave talks. For their feedback, I would like to thank Jurģis Šķilters, Dieter Wunderlich, Manfred Bierwisch, Thora Tenbrink, Lera Boroditsky, Alexander Klippel, Nicole Gotzner, Norbert Fries, Gediminas Schüppenhauer, Dara Jokilehto, Dirk Wulff, and Luke Tudge (for discussions on statistics). Many thanks to Heather and Richard for proofreading this thesis.

Working on this PhD thesis has been very special for me too because I had the opportunity to become the spokesperson of doctoral researchers for the Leibniz-Zentrum Allgemeine Sprachwissenschaft and then the spokesperson for the Leibniz PhD Network and board member of N2, the Network of Networks that represents the interests of about 14,000 doctoral researchers. This was an amazing experience for me. To this end, I would like to thank Manfred Krifka, who allowed me to candidate for the position. Moreover, from the bottom of my heart I would like to thank Jan-Lucas, my co-spokesperson for the Leibniz PhD Network, for the wonderful teamwork. It was a pleasure to work with you. I learned much during this time. Furthermore, I thank the whole steering committee – you were amazing team. Many thanks to the working groups – you made the progress of the network happen. All our goals and even more were achieved. Thank you for that. I am very proud of our work. Additionally, I would like to express my great gratitude to Sabine Müller and Matthias Kleiner, who strongly supported our work. Thank you! Finally, thank you very much to Olga Naumov, Jana Lasser, Konstantin Kuhne, Martin Schmidt, Martin Grund, and many others for the teamwork and for your support during my great and hard time. It was a pleasure to work with you.

Over the course of my PhD thesis, I have been working at an IT company. Thank you very much to Alex for the considerable amount of advice – you were the first who told me that I should begin writing the thesis and should not stop. Thank you very much. My great gratitude extends to “my” wonderful customers, Angie and Timo – thank you very much for your infinitely positive energy.

Thank you to everyone who was present in my life as a doctoral researcher. I appreciate it greatly and hope I can be there for you too. I hope you enjoy reading the end product.

I dedicate the thesis to Prof. Piotr Krokowicz and Prof. Marian Grzymisławski.

Contents

[1]This part of the dissertation was already published by Stoltmann, Fuchs, and Krifka (2018).
[2]This part of the dissertation was already submitted by Stoltmann, Fuchs, and Krifka (2020).

1 The interpretation of static spatial relations by German, English, Italian, and Polish native speakers using dimensional spatial expressions

"So, tell me where should I go?
To the left, where nothing is *right*....
Or *to the right*, where nothing is *left*..."
(Itachi Uchiha, Itachi, n.d. retrieved on December 28th, 2019)

"Wie *vorne* ist *hinten*?"
Does *in front* mean *behind*?
(H.L. Gremliza in Konkret, cited in Schweizer, 1985, p. 1)

When asking the question, *Where is the bottle standing?*, we may receive a nonverbal answer that uses a pointing gesture to indicate the location of the bottle. Pointing gestures are among the first gestures produced by infants toward the end of their first year of life (Cochet, Jover, et al., 2011; Cochet and Vauclair, 2012), and they are used in very different contexts (Stoltmann and Fuchs, 2017; Fuchs and Reichel, 2016). We may also receive a verbal response (with or without a pointing gesture) that includes one of the six dimensional spatial expressions: above, below, in front of, behind, to the right of, or to the left of a reference object (4). The use and interpretation of such expressions in different languages has led to debates in various contexts about whether they are influenced by culture (Boroditsky, 2001; Levinson, 2003a; Hüther et al., 2016) or language (Olloqui-Redondo et al., 2019; Tenbrink, 2011; Grabowski and Miller, 2000; Stoltmann, Fuchs, and Krifka, 2018; Wunderlich, 1981) or whether these interpretations are independent of language and culture. Using the dimensional spatial expressions, the answer to this question may be as described below.

Hans says that the bottle is standing ***to the right of*** *the cupboard, but Thomas says that the bottle is* ***in front of*** *the cupboard.* So, where is the bottle? Can both speakers refer to the same place? Do German, English, Italian and Polish native speakers interpret the relationship between the reference object (the cupboard) and the localized object (the bottle) from their own point of view or from that of Hans or Thomas (through the origo shift)? The aim of this thesis is to explore how German, English, Italian and Polish native speakers assign sides to intrinsic objects, and how they interpret static spatial relations with animate and inanimate (extrinsic and intrinsic) reference objects. Finally, it focuses on the question to what extent the interpretation depends on, for example, inherently distinguishable sides or animacy.

Spatial relations between entities – as mentioned above – can be produced and interpreted with respect to the three reference frames: absolute (environment-centered), intrinsic (object-centered), and relative (viewer-centered; e.g. Levinson, 2003a; Olloqui-Redondo et al., 2019; Tenbrink, 2011; Tenbrink and Dylla, 2017). In the languages investigated, native speakers apply the relative and intrinsic reference frames in everyday situations. The relative reference frame can additionally be split into three strategies – *translation*, *reflection*, and *rotation* (e.g. Hüther et al., 2016; Levinson, 2003a; Levinson, 2006) – and the intrinsic one into *inside* and *outside* perspectives (e.g. Grabowski, 1999; Grabowski and Miller, 2000).

Most research on spatial cognition has investigated how humans interpret spatial relations between the reference and the localized object (3). For side assignment, there are many assumptions (e.g. Grabowski, 1999), though, in contrast to the interpretation of spatial relations, there is a lack of empirical evidence (Schole et al., 2018).

Entities can be divided into *animate* and *inanimate* objects (2). *Animate* entities possess clear intrinsic properties for the vertical axis (*up–down*) and for both horizontal axes (*front–back*; *right–left*). *Inanimate* objects can be further divided into *extrinsic* and *intrinsic* objects; this means that they possess different properties, for instance, inherently distinguishable sides. People allocate sides to intrinsic objects using one of two strategies: the *inside* – in case of vehicular objects (e.g. a car) – or the *outside* perspective – in case of vis-à-vis objects – (e.g. Grabowski, 1999; Grabowski and Miller, 2000; Grabowski and Weiß, 1996). An extrinsic object, such as a ball, is not oriented according to the vertical (*up–down*) or the first (*front–back*) or second (*right–left*) horizontal axis. That is, they are symmetrical in relation to all axes. However, in a spatial relationship, we can assign intrinsic properties to such objects spontaneously using one of the three strategies of the relative reference frame (e.g. Hill, 1982, p. 16; Herrmann, 1990, p. 136; Levelt, 1986, p. 199).

This thesis demonstrates how native speakers of four languages (German, English, Italian, and Polish) identify the sides of a cupboard when seeing it from the front (the canonical position) and the back (the noncanonical position). To this end, I follow the assumption of Grabowski (1999) that cupboards are vis-à-vis objects, because we use them from the outside and that people assign sides to them using the outside perspective of the intrinsic reference frame. More specifically, this means that people mentally rotate by 180° to identify its *front* and *back*. The *right* and *left sides* are transferred egocentrically when the cupboard is being used. The results of the task serve as a baseline for the analysis of data from further tasks that involve the cupboard (5).

Using mouse tracking as an experimental method, I tested 178 participants on their interpretation of static spatial relations (5). Two-hundred and eighty-eight sentences and scenarios were designed to verify the participants' mouse movements. This method allows the investigation of decision-making behavior, specifically to interpret it with respect to origo shift. The experimental scenarios included either *extrinsic* (inanimate: table) or *intrinsic* objects (animate: dog; inanimate: cupboard) as reference objects in order to analyze *simple* spatial relations. In these situations, participants were asked to describe the location of the bottle. *Complex* spatial relations involved a cupboard or table and were supplemented by an artificial agent (Hans). In this part of the experiment, participants were asked to interpret situations that included a complex sentence, such as, *X says that the bottle is standing. . . .*

This study extends the results of my master's thesis. For that thesis, I tested 561 participants using a questionnaire as the experimental method. In that study, I investigated the interpretation of dimensional spatial expressions by German, English, Italian, and Polish native speakers for spatial relations described by verbs of dynamic semantics (e.g. *stellen* in German). The results from these questionnaires demonstrate that the interpretation of the dimensional spatial expressions examined depends on the language and the situation. The most significant differences in the interpretation of *in front of* and *behind* were found between German and English native speakers (in spatial relations with an extrinsic reference object). For intrinsic spatial relations with a cupboard, Italian native speakers deviated most frequently from the expected outside perspective when interpreting *to the right of* and *to the left of* (see Perużyńska, 2012a). It was the first evidence for the different interpretation of *right* and *left* between the German and Italian native speakers to my knowledge. In the present thesis, I investigated how German, English, Italian, and Polish native speakers identify sides of cupboards to find out, whether these differences appear in the side identification too or only in the interpretation of spatial relations described by dynamic verb. To complete the possibilities, I also investigated the static spatial relations.

This thesis also explores how animacy influences the interpretation of spatial relations for the first and second horizontal axes. Do German, English, Italian, and Polish native speakers describe spatial relations with animate entities more precisely than with inanimate ones by using the intrinsic reference frame more frequently?

In previous research, scientists have shown how important animacy is for the description of several spatial relations in different languages. Feist (2000, p. 92), Feist and Gentner (1997) and Feist and Gentner (1998) state that there is evidence that the animacy of both reference and localized objects affects the choice of the preposition used for particular spatial relations. More specifically, Feist (2000, p. 122 f.) points out that spatial relations with an animate reference object are more frequently described using the preposition *in* than are spatial relations with inanimate reference objects because the animate reference object better serves as a container. Bowerman (1996) indicates that the animacy of a localized object influences the use of the spatial preposition, for instance, in case of *aan* ('in' in Dutch). Using an acceptability rating experiment, Baltaretu et al. (2016) explored preferences for specific reference objects. The participants of that study mostly preferred descriptions of spatial relations in which the animate reference object was mentioned first. In their investigation of the influence of animacy in generic and medical (animal) contexts, Hüther et al. (2016) indicate that medical students more frequently interpreted medical situations (with a human as the reference object) in terms of the intrinsic reference frame than did law students; only 44.2% of the beginner and 49.8% of the advanced medicine students chose the intrinsic reference frame. The present thesis serves as further evidence for the influence of language on spatial thinking.

2 Objects

The various entities in the world possess different properties. First, humans may distinguish between *animate* and *inanimate* entities. In my experiments, I employed higher animate entities – a human and a dog. For this reason, here, I focus only on the higher animate objects group, especially on these two representatives. The second objects group I used for my experiment were inanimate objects. Here, I focus especially on their representatives: a cupboard and tables.

In our everyday life, we use inanimate objects continuously. Writing minutes on a sheet of paper, we use two extrinsic objects: a pen and the paper. Here, the single sheet of paper does not provide information about any of its sides like *front-back* or *right-left* (as with a ball or a cube). It possesses only four vertexes, which could indicate sides in spontaneous situations but not in general. Neither does it have a front or back, or an up or down side. However, the pen differs from the sheet of paper: in the middle, it is mostly cylindrical (similar to a tree; cf. observations about objects with an asymmetry vertical axis by Grabowski (1999, p. 100)). Therefore, in general, it has neither a right and left side nor a front and back. But it clearly possesses a top and a bottom. The upper end of the pen is where we click it to reveal and conceal the point, and the bottom end is for writing on the sheet of paper. Sitting at a table while writing the minutes, we again use a different type of object – different especially in terms of size though not really in terms of the identification of the sides. The table is significantly larger; however, it does not have more sides than the pen. It clearly possesses a top and a bottom. The top is where we put our sheet of paper to write and the bottom, where the legs are, is what the table usually stands on (except when it is in storage or while being relocated). However, the table does not have a front or back or a right or left side. Nonetheless, it is possible to assign sides to the table spontaneously for a particular spatial relation. However, by rotating the table by a few degrees, the assignment of the sides can change in relation to the particular parts of the table. We can also sit at a desk and write our minutes, for instance, during a web meeting or a phone call. A desk with drawers is distinguished from a table in terms of intrinsicality and functionality. As with the table, it clearly possesses a top and a bottom. Additionally, it also has a front and back, and a right and a left side. The front is where the drawers are. The back is the opposite of the front. The right drawer and the right side of the desk usually is understood as where our right hand opens the drawer. Finally, we are usually sitting on a chair while writing our minutes. As an object, the chair differs from the others mentioned above. As with the table, the chair clearly has a top and a bottom. The upper part of the chair is the top of the seat and the backrest, and the lower is the part on which the chair stands (as with the desk and table). The front is the part of the backrest and the seat that we are directly touching when sitting on the chair. The right and left sides may have armrests – the right armrest is that which our right arm touches and the left armrest that which our left arm touches.

In a final step, imagine that your pet is sitting on the desk or table facing you. Your pet is a higher animate entity. Higher animate entities possess clear intrinsic sides according to their body's anatomy. Hence your cat, dog, or other pet possesses a front where its eyes (and mouth) are, a back where its tail is, and, of course, it has right and left paws (usually – exceptions would be cases of amputations). You may also be watching a colleague, friend, or relative. We identify the sides of humans' bodies in a manner similar to those of other higher animals – according to their anatomy. This means that humans possess an upper end and a lower end, a front and a back, and a right and a left side. In contrast to other higher animals, humans are used to moving in an upright position (vertically) while animals move horizontally.

We can also communicate the particular spatial constellation of the objects to an absent person because we know what these look like and we know their features (Leßmöllmann, 2002, p. 100). For instance, we can tell a person that the chair from example above is to the right of the desk.

In the following sections, I explain which types of object are commonly identified in cognitive science and psycholinguistics, how we recognize objects in Western culture, and what this depends on. What exactly is the difference between the abovementioned objects: the sheet of paper, pen, table, chair, desk, and the higher animals such as humans or pets? Furthermore, I summarize the evidence from research on the assignment of sides to objects in non-canonical spatial constellations (e.g. an upside down table). Additionally, I explain the strategies people undertake to spontaneously assign sides to extrinsic objects and whether this depends on culture and language (see 2.1.1 and 2.2).

The order of the subsections corresponds to the hierarchy of objects proposed by Hill (1982, p. 14), who states that objects are more often oriented along the vertical axis (*up–down*) than along first horizontal axis (*front–back*). Furthermore, Hill assumes that there are more objects that possess front–back orientation than right–left orientation (objects' properties: up-down > front-back > right-left). Lang (1990, p. 64) explains that the vertical axis is more dominant (primary) than the first horizontal axis (secondary), and that the second horizontal axis is the least dominant (tertiary; it derives features from both of the first two axes). I first explain extrinsic objects, then inanimate intrinsic objects (entities), and, finally, higher animate entities.

Harris and Strommen (1972) point out that there are at least two possibilities for the spontaneous identification of sides. The results of the empirical study of Harris and Strommen (1972) reveal this for American native children. More precisely, the results of that study showed that around 25% of the participants investigated used the align strategy (here, *translation strategy*). Harris, Strommen, and Marshall (1974) asked 670 undergraduate students how they assign front and back to geometrical objects. In one of the tasks, the students saw a simple rectangle supplemented by one or two small circles (see 2.1) and were asked to draw a line dividing the figure into front and back.

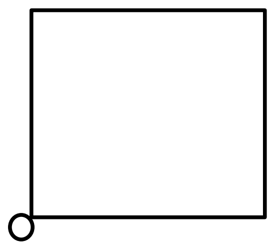


Figure 2.1: Geometrical figure used for front and back identification by American English speakers (Adapted from Harris, Strommen, and Marshall, 1974)

Harris, Strommen, and Marshall (1974) reported that there are many strategies for assigning the polar sides of the first horizontal axis. The results of their study indicate that the front is the part of the object that catches most of the attention of the participants. Furthermore, the front is that part of the objects that is closer to the participants (the facing strategy in Hill's, 1982, terminology, or reflection in the terminology of Levinson (2003b), see 2.1.1.1). However, it may also be the opposite side, with the part of the objects closest to the participant being interpreted as the back (the align strategy in the terminology of Hill (1982), or the translation strategy of Levinson (2003b)). In sum, the results of their studies demonstrate that English native speakers use their own body coordinates when assigning and identifying the sides of extrinsic objects. A part of the objects can be also interpreted as the front when it is interpreted as most moving (Harris, Strommen, and Marshall, 1974, p. 579).

Following Ehrich (1992, p. 10), the ambiguity of side assignment occurs with intrinsic objects – vehicle and vis-à-vis objects – in the European languages too. Referring to Ehrich (1992), the ambiguity in the assignment of sides to extrinsic objects does not occur with speakers of European languages – in contrast to the speakers of the Hausa language.

As Levinson (2003b, p. 85) has already stated, there are at least three possibilities for how do people in Western culture assign sides to extrinsic objects or how they assign these spontaneously to conceptually inherent objects. People can, for instance, translate their egocentric axes to the ground object (the axes are shifted across without rotation or reflection). People can also translate their egocentric axes by means of a mental rotation of 180°. Moreover, people can also translate the egocentric axes using reflection. These three strategies explain in greater detail the variety of the judgments of English native speakers as revealed by the results of the empirical study of Harris, Strommen, and Marshall (1974).

In fact, the strategies are usually defined in the research as strategies for the description of spatial relations between objects. However, in my opinion, if we use an object as a reference, we first assign sides to it and then describe a spatial relation between it (more precisely, between the regions of it) and localized objects. Here, I explain this procedure first. In the empirical component of this thesis, I also present the results of experimental tasks that show how German, English, Italian, and Polish native speakers first identify the sides of an object (a cupboard) and how they subsequently interpret spatial relations with the same object as a reference. The results indicate that the participants derive the identified sides in order to describe a spatial relation (see 5). This assumption corresponds with that of Miller and Johnson-Laird (1976, p. 49) who state that humans first isolate individual objects in a scene. The identification of those shapes is the beginning of the process of describing the scene as a whole (ibid.). Carlson-Radvansky and Logan (1997, p. 436) came to the conclusion after their two experiments. In both of these cases, the researchers investigated the use of *above* and *below* in spatial relations. Carlson-Radvansky and Logan define the assignment of sides to an object as one of the "basic steps for using spatial relations" (ibid.).

2.1 Object types

2.1.1 Extrinsic objects

According to Piaget (1937), humans acquire the ability to recognize objects within the first two years of life (cf. Landau, 1994). Objects can be characterized, for instance, according to color, size, edge vertexes, surface, texture, shape, and weight (Miller and Johnson-Laird, 1976, p. 39). In this subsection, I explain what extrinsic objects are and how we know that an object is extrinsic (non-intrinsic) [1].

One of the common features for extrinsic objects is that they do not possess any inherently distinguished sides. Looking at a ball, a cube, or a piece of paper how could we say that the one side is the *front* and another *right* or *left* – in general and not spontaneously? This is impossible of course.

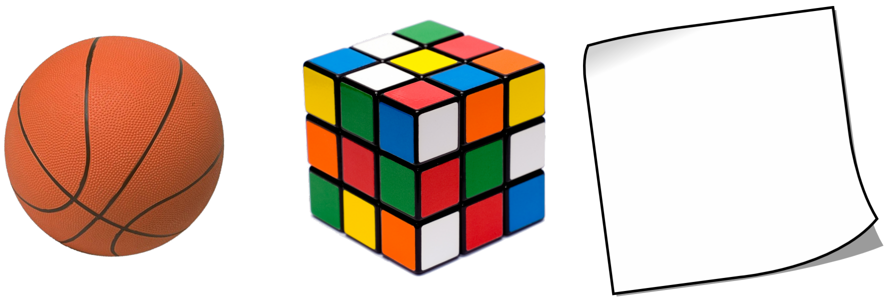


Figure 2.2: Examples of extrinsic objects (source: hadiaaltaf, 2019a, hadiaaltaf, 2019b, dmwqdw, 2019)

All the objects in the 2.2 belong to the so-called *extrinsic* group of objects although they look very different. All of them are symmetrical in terms of all of their dimensional axes: their vertical axis (*up–down*), first horizontal axis (*front–back*), and the second horizontal axis (*right–left*). This means that extrinsic objects are oriented in relation to neither the vertical nor the first or second horizontal axes. It follows that these are symmetrical in terms of all their axes.

Nevertheless, based on their features – as defined by Miller and Johnson-Laird (1976, p. 39), we can distinguish between these objects: The ball is characterized by its round form. It does not possess any edges or vertexes – in contrast to the cube and sheet of

[1] Thank you very much to Manfred Krifka for this indication that actually extrinsic objects are those that are not intrinsic. They can be assigned sides by reference to other objects in an "extrinsic" way. Usually, these are called "extrinsic", even though "non-intrinsic" would be better, because extrinsic is not a particular property of the object itself.

paper. Both the cube and the sheet of paper have edges and vertexes and yet we can distinguish between the one object and the other. Their surfaces and colors differ. Some researchers would also say that the cube and the sheet of paper differ in terms of their dimensionality: The sheet of paper is defined as a two-dimensional object and the cube as a three-dimensional one (cf. Miller and Johnson-Laird, 1976, p. 40; Bierwisch, 1967, p. 13 ff.).

Overall, the two objects *cube* and *sheet of paper* have edges and corners. Following Miller and Johnson-Laird (1976, p. 51), the perception of edges and corners plays the most important role in the shape perception of objects. These researchers define a *corner* as an intersection of three faces and an *edge* as an intersection of two faces. In these terms, a *face* of an object is an extended continuously varying part of the objects' surface that is bounded by relatively abrupt edges (Miller and Johnson-Laird, 1976, p. 51). For instance, the faces of the cube above are the six planar squares bounding the object. In contrast, the face of the ball is round and does not have any edges. The face of the sheet of paper is flat.

For all symmetrical objects, inherently distinguished side assignment is impossible (Grabowski, 1999, p. 99). Therefore, three strategies have emerged in research for spontaneously assigning sides to extrinsic objects: reflection, rotation, and translation [2] (e.g. Hüther et al., 2016; Levinson, 2003b; Tenbrink, 2011; Tenbrink and Dylla, 2017; Stoltmann, Fuchs, and Krifka, 2018).

2.1.1.1 Side assignment to extrinsic objects: the reflection strategy

The *reflection strategy* was introduced into linguistics by Hill (1982) for the different interpretation of spatial relations with extrinsic objects (Hill refers to it as the *facing strategy*). Hill observed cross-linguistic differences between Hausa and English native speakers. (This diversity has been also found for English native speakers by Harris, Strommen, and Marshall (1974) – as shown above.)

Regarding the reflection strategy, the speaker (the viewer or third person) – in our case, Hans – assigns sides to the objects as if they were seen in a mirror. Thereby, the objects' front is the closest part of the object to Hans. The back is the opposite side – the side that is furthest from Hans. The right and left sides are transferred in egocentric manner (translation, in the terminology of Levinson (2003b)). The right side of the table is where the right hand of Hans is when he is lifting up the table. Analogous to the right side is the left side, which is transformed from the left hand of Hans on the table when he is lifting it up. It is important to stress that the Hans' point of view plays the role in defining the origo when assigning the sides in the scene 2.3 (see 3.2.2).

[2] The *translation* and *reflection* strategy are also called align and facing strategy.

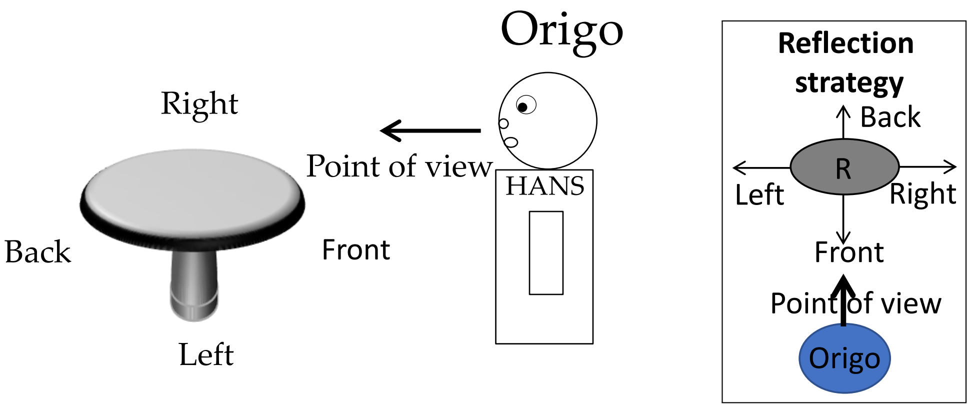


Figure 2.3: Side assignment using the reflection strategy in a spontaneous situation

Levinson (2003b, p. 85) explains this procedure as a shift of the egocentric axes in relation to the object and then rotation of them so that *the front* of the object is facing the speaker / viewer or a third person. However, only the *front* and *back* are rotated, the *right* and *left* of the person (viewer / speaker / third person) remain the *right* and *left* of the object – as would occur in a mirror.

It is interesting that the vertical axis is ignored in the strategy. In the case of a table, which is asymmetric on the *up–down* axis, it is clear where *up* and *down* are. However, regarding the vertical axis in the case of a symmetrical object, people assign up and down according to gravity (a geocentrically defined axis), which coincides with people's *up-down* axis in the canonical position (an anthropomorphically defined axis, e.g. Grabowski, 1999, p. 100).

2.1.1.2 Side assignment to extrinsic objects: the rotation strategy

Several empirical studies suggest the *rotation strategy* – one of these is my very first study of description (survey) and interpretation (video recordings) of spatial relations with 596 participants (see Perużyńska, 2012a). This strategy was analyzed by Hüther et al. (2016) – as has the production and interpretation of spatial expressions when describing spatial relations between at least two objects (more precisely, between their regions). However, as explained above, I transfer it for the spontaneously assignment of sides first because this is an earlier process in the course of the description of spatial relations.

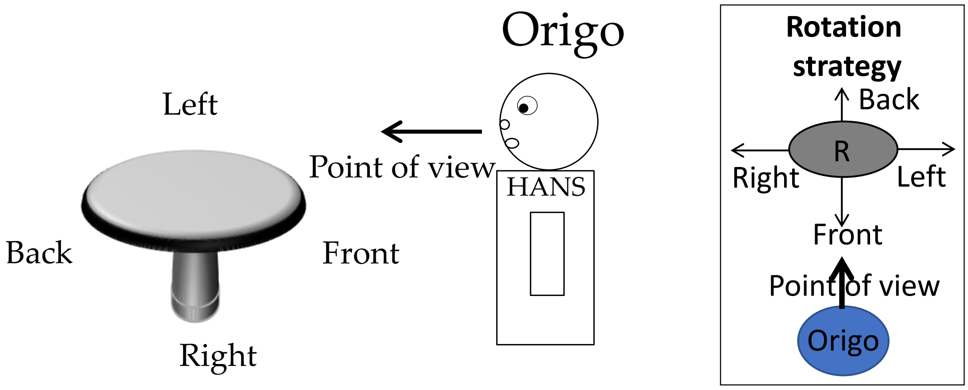


Figure 2.4: Side assignment along the rotation strategy in a spontaneous situation

Referring to this strategy, people transfer sides of objects by conducting a mental rotation of 180° for all sides, not only the *front* and *back*, as in the reflection strategy above, but also *right* and *left* (see Shepard and Cooper, 1982, for further detail on mental rotation and Parsons (1987), for imagined body rotation). Considering again the table as our object, when lifting it up, we assign the *front* to the part of the object that is closest to us – to our viewpoint. The opposite side is the *back*. In contrast to the reflection strategy, the side where our right side is in the course of lifting up the table is the *left* side of the object. More precisely, considering the object, we are conducting a mental rotation of 180° and are aligning the object as we would when we sit on it or merge with it. In a last step, we are transferring the sides from our body to the object (cf. Levinson, 2003b, p. 86 ff.; Hüther et al., 2016).

This strategy of side assignment resembles the inside perspective for the identification of the sides of intrinsic objects (see section 2.1.2). Moreover, it also applies to spatial relations containing more objects – Grabowski (1999, p. 114) calls this strategy the *contextual conditional perspective* (see also Retz-Schmidt, 1988; Wunderlich and Herweg, 1991). Using this strategy, the localized object is assigned (environment-centered) due to derivation of the sides from the neighboring (reference) object. For instance, a symmetrical basket on a bicycle takes the orientation of the bicycle it is on (see 2.5). It is important to emphasize that the basket – similar to the table above – possesses a *front*, *back*, *right*, and *left* side as long as it is located on the bicycle. When we rotate the basket or the table, other parts of the particular object are assigned to the same sides. This is in contrast to intrinsic objects (see section 2.1.2).

However, I have neither investigated this effect in my experiments nor observed such an effect (for instance, the environment-centered side assignment to the table as a reference objects resulting from the constellation of the room). Therefore, I do not analyze it any further here.

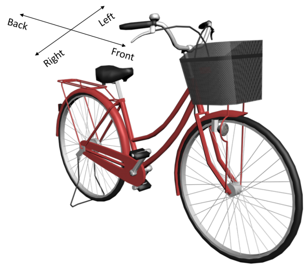


Figure 2.5: Contextual side assignment following Grabowski (1999, p. 114 f.), source for bike PNGStock, 2019a

2.1.1.3 Side assignment to extrinsic objects: the translation strategy

The *align strategy* is also called the *translation strategy* (e.g. Hüther et al., 2016; Levinson, 2003b) and is the third possible strategy of the relative frame of reference – without any order. This strategy was introduced into linguistics by Hill (1982), together with the facing / reflection strategy (see above). For this strategy too, Harris, Strommen, and Marshall (1974) found empirical evidence.

In contrast to the two strategies discussed above, when assigning sides to objects using the translation strategy, people do not conduct any mental rotation (see 2.6). Quite the contrary, they transfer the sides of their body to the object as they are considering it and looking at it. Considering the example above with the objects being lifted up, the side that is closest to the person and her / his viewpoint during this activity is the *back*. The opposite side is the *front*. The *right* side is derived from the right hand of the person and

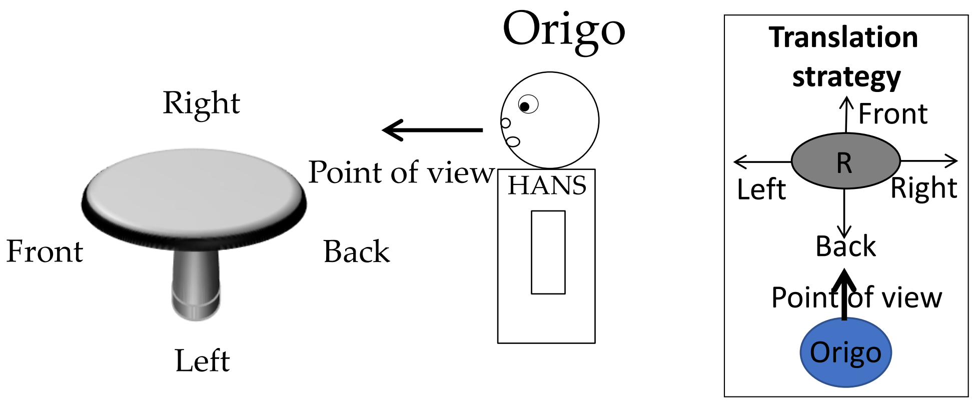


Figure 2.6: Side assignment using the translation strategy in a spontaneous situation

the *left* side from the left hand. This means that people assign sides to an object using this strategy by aligning themselves with the object. They identify the object according to their own position. In the next step, they derive sides from their body and transfer these to the object (e.g. Levinson, 2003b; Grabowski, 1999).

There are further possibilities for spontaneously assigning sides to an object, for instance, according to its direction of the motion. However, such strategies are not important for the current experiment and are therefore not discussed in detail here (see Grabowski, 1999, p. 115 f.; Levinson, 2003b, p. 95 ff.; Tenbrink, 2011, p. 708 ff.). The *front* of a symmetrical moving object is usually shown to be in the direction of movement and is achieving the aim as first. In case of a rolling ball, the *front* is continuously changing – in contrast to that of a toy trailer. The remaining sides are assigned to a moving object according anthropomorphic principles (see Grabowski, 1999, p. 115).

2.1.2 Inanimate intrinsic entities

As mentioned above, Hill (1982, p. 14) defines a hierarchy for objects' intrinsicality, which can be represented by implicational scale *up-down* > *front-back* > *right-left*. This hierarchy assumes that there are more objects that are oriented along the vertical axis (*up–down*) than the first horizontal axis (*front–back*). Furthermore, there are more objects possessing a *front–back* orientation than a *right–left*. Moreover, the hierarchy also implies that if an object possesses an orientation in terms of the first horizontal axis, it is also oriented along the vertical axis (Wunderlich, 1986, p. 218). If an object is asymmetrical with respect to the *right* and *left* orientation, it is usually also asymmetrical regarding the *front* and *back* and *up* and *down*.

Allan (1995) explains that the intrinsic orientation of an object, which is independent of the viewpoint of observer, is not a physical fact – rather, it is a psychological one. The *front* or *back* are not inherent features of the object – these are attributed to it by people (cf. Grabowski and Miller, 2000; Miller and Johnson-Laird, 1976; Herrmann, 1990). According to the assumptions of Grabowski and Miller (2000), Miller and Johnson-Laird (1976) and Herrmann (1990), humans identify the *front* of a particular object according to the following rules:

1. For humans, higher animals, statues and the like, people recognize the body part that contains the perceptual apparatus as *front*. For humans, this part corresponds to the face, for cameras, to the lens, and for cars, the eyelike headlights.
2. The *front* of a mobile object is that which aligns with the direction of movement and hence reaches a destination first. This means, in case of a car, it is again the headlights. Grabowski and Miller (2000, p. 522) point out a wheelbarrow falls into this object category too: The *front* is lower part of the object when it is being emptied.

3. It is the side that is used by humans to handle an object – the first side between the person and the object in the case of vis-à-vis objects (2.1.2.1) such as *cupboards*, *desks*, and *notebooks*. The other possibility when using an object and assigning sides to it automatically is the tandem strategy (Grabowski and Miller, 2000, p. 522). Grabowski (1999) and Levinson (2003b) refer to this as the vehicle objects group and assign to it, for instance, *cars*, *bicycles*, *chairs*, and *clothes* (see 2.1.2.2).
4. In addition to permanent side assignment, there is also spontaneous side identification, which is, for instance, assigned to extrinsic objects – as shown above (e.g. Hill, 1982, p. 16; Herrmann, 1990, p. 136; Levelt, 1986, p. 199; Grabowski and Miller, 2000; Grabowski, 1999; Jackendoff and Landau, 1991).

Tenbrink (2005b, p. 18 f.) points out that time plays an important role in the assignment of the front too. This is especially feasible with objects or entities that are going to achieve an objective – for instance remaining in a queue or driving in a driving competition. Such situations are conceptualized as linear. Following the identification of front, the assignment of back follows analogously as the opposite side. As Tenbrink (2005b) indicates, events involving motion and route descriptions also belong to the entities group. However, I have not analyzed such cases in the current experiments and therefore I do not go into further details here. It is only important to keep in mind that time plays an important role in the side identification of an object and in the perception and description of spatial relations.

In addition to strategies of assigning *front / back* orientation, several theories regarding object side identification have been developed. Levinson extends one of these using the example of the Tzeltal language (Mayan): the theory of vision proposed by Marr and Nishihara (1978) and Marr (1982). In accordance with Levinson (1994b, p. 813 ff.), people recognize objects and assign sides to them in the following way:

1. Object segmentation;
2. Finding the main or “model axis,” and mapping generalized cone structures along this generating axis;
3. Determining the directedness of the model axis;
4. Using the expressions for the two poles of the model axis;
5. Locating secondary projections based on the model axis, analyzing these secondary axes for their angles in relation to the main axis, and finding their associated volumes;
6. Naming these projections with respect to the shape; and
7. Assigning names to the surface features or protrusions (Levinson, 1994b, p. 813) based on the theory of vision developed by Marr (1982).

Object segmentation is the first process that occurs when assigning sides to an object. First, the viewer has to identify the particular object based on the other parts of the particular spatial relation. Furthermore, the viewer has to recognize the object by means of its partial aspects. It is usually the case that a viewer can see an object only partially. An example from my experiments for this thesis: Looking at a canonically positioned cupboard, the viewer can only see the *front*, *right*, *left*, and *upper* sides of the object (see figure 2.7).

Leßmöllmann (2002, p. 122) emphasizes that while we can see only part of an object, we assume that the rest also exists. Considering the example from the experiment: We cannot see the *back*, but we assume that the cupboard has one.

In the second step of assigning sides to an object, the viewer is looking for the primary axis of the object. Following Levinson (1994b, p. 814), the primary axis of an object is a main internal coordinate of an object. There can only be one main axis. In contrast, there can be more generating axes. The main axis is usually the longest axis. For instance, the vertical axis serves as the main axis for a bottle – considering the bottle in a canonical position – as does the horizontal for a pipe (see also Grabowski, 1999, p. 99 f.). However, the main can sometimes be the shorter one (e.g. the vertical axis of a coffee table). These procedures can be also applied for more than one dimension, for instance, German native speakers assign length, width, and height to a brick (Grabowski, 1999; Lang, 1990; Lang, 1993).

In the third step, the viewer determines the directedness of the model axis. Levinson (1994b, p. 816) defines the direction of an object as a directed arc. A directed arc is the intrinsic orientation of a particular object. Levinson (1994b, p. 816 f.) explains the process based on the theory of Leyton (1989).

In the fourth step, the viewer or speaker applies the linguistic terms to the ends of

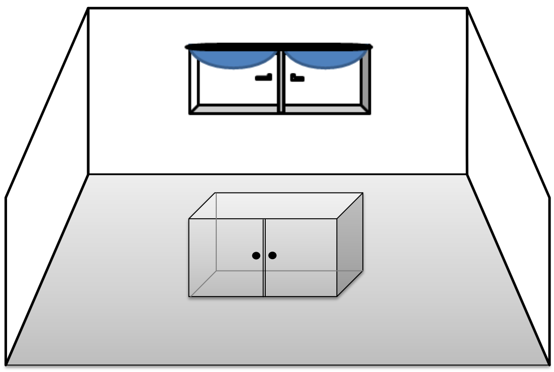


Figure 2.7: Example of spatial relations for a cupboard

the model axis (Levinson, 1994b, p. 819). In this step, speakers or viewers linguistically identify the two ends of the model axis. For instance, in case of the bottle and its main – vertical – axis, speakers or viewers would assign *up* and *down* to the axis.

In the next step, speakers or viewers find and name sides of the central volume (Levinson, 1994b, p. 821). In this part of the process, it is important to linguistically assign a name to the axis that is orthogonal to the main axis. The axis can be drawn around 360° – for some objects (intrinsic), the procedure is unique and for some not (extrinsic – as shown above 2.1.1). Considering a cupboard as an intrinsic object and a bottle as an extrinsic object, this unity can be recognized as in 2.8.

After finding the axes, the relevant linguistic terms are assigned to the two ends of the axes.

Secondary volumes and their axes are defined subsequently (Levinson, 1994b, p. 829). "The axis of a projecting part may come off the model axis at any angle; nevertheless, orthogonal projections are frequent enough to be the main thing to look for" (Levinson, 1994b, p. 829).

Following Levinson (1994b, p. 834), the canonical orientation does not play any important role when assigning sides to objects. Moreover, it "plays little or no role in the application of body-part terms to objects." Levinson (1994b, p. 834)

In my experiments, I focused on intrinsic objects of two kinds – vis-à-vis objects and higher animate entities (see 2.1.3). In the case of the latter, in Western cultures, people identify the sides of animate entities in the same way as they do for vehicular objects. Retz-Schmidt (1988, p. 98) explains:

> *"Human beings and other animate beings (with a perceptual apparatus that defines their fronts) as reference objects are also treated as if they were seen from the inside."*

Vehicle and vis-à-vis objects form the main groups of intrinsic objects. In Western

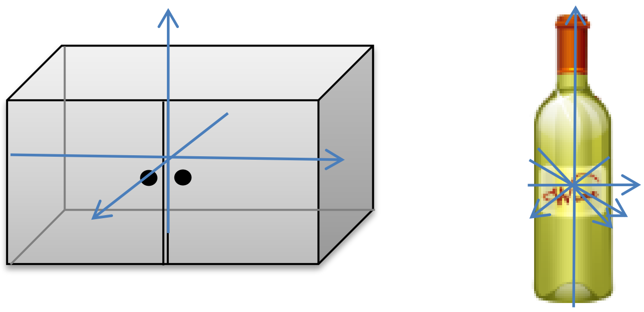


Figure 2.8: Finding and naming the orthogonal axis to the main axis for extrinsic and intrinsic objects

cultures, we assign sides to these objects not only due to their inherent features and asymmetry but also due to their functionality – how humans apply / use them (e.g. Tenbrink, 2005b; Levinson, 2003b; Herrmann and Grabowski, 1994; Retz-Schmidt, 1988). In addition, Wunderlich (1990, p. 45) states, that head, top, front, and back are functional nouns that define the parts of objects.

Grabowski (1999)'s account yields the same as that of Retz-Schmidt (1988). The only difference between them is the order of the assignments (in the outside and inside perspectives). For Retz-Schmidt, the assignment of the *right* and *left* sides plays the most important role. However, for Grabowski, the *front* is the most important (see Tenbrink, 2005b, p. 19). In this thesis, I follow Grabowski.

Grabowski (1998, p. 25) argues that the intrinsicality of objects is derived from the human body (the anthropomorphic origo). He refers to this as *secondary intrinsicality.* As Grabowski (1999, p. 99) explains, people assign intrinsic sides to entities by considering asymmetry and based on the dimensional distinctions of anthropomorphic spatial axes. The poles of the recognized and assigned axes serve as sides. All three dimensions do not have to be asymmetrical – they can be derived from other axes (e.g. Grabowski, 1999; Herrmann, 1990; Miller and Johnson-Laird, 1976).

When an object is asymmetrical along one axis (e.g. a table along the vertical axis), which coordinates, for instance, with people's vertical axis, and it can be used functionally by humans, then to that part of the object the vertical axis is transferred from the human body to the objects. The positive pole "top" is assigned to that part of the object that is closer to the user's head and the negative one "bottom" to that part that is closer to the user's feet. Of course, the gravity is also considered when assigning (e.g. Grabowski, 1999, p. 101).

In the case of intrinsic objects with only one asymmetrical axis – the first horizontal one (*front–back*), people derive the axes' poles from their bodies too. The same applies as for the vertical one. Examples of objects belonging to this group are *arrows* and *traffic lights.* The objects share the feature that they are used by humans in accordance with the first horizontal anthropocentric axis (*front-back*). In case of the traffic lights, when "using" these, people can only see or perceive the front; the back is hidden (e.g. Miller and Johnson-Laird, 1976, p. 403; Grabowski, 1999, p. 103).

When an object is characterized by at least two axes, the sides for the third axis will be automatically transferred to it in accordance with the two axes. Such objects possess a pronounced vertical (*up-down*) and first horizontal axis (*front-back*). The identification of the second horizontal axis follows one of the strategies – inside or outside – depending on how people use the objects. Due to the order of side assignment, an order of axes was suggested: the vertical axis as the primary axis for side assignment, the first horizontal axis as the secondary axis for side assignment, and the second horizontal axis as the tertiary axis (Grabowski, 1999; Lyons, 1977).

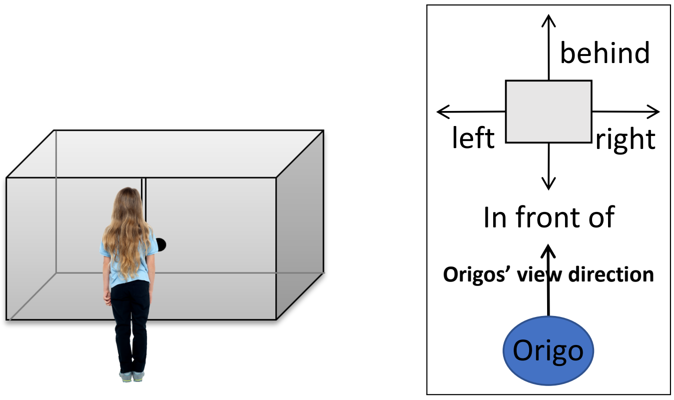


Figure 2.9: Side assignment to a canonically positioned vis-à-vis object (source for girl: Moomhan, 2019a)

2.1.2.1 Vis-à-vis objects

Vis-à-vis objects are, for instance, *cupboards*, *desks*, and *mirrors*. These objects are asymmetrical in relation to the vertical (*up–down*) and first horizontal (*front–back*) axes and symmetrical with respect to the second horizontal (*right–left*) axis. However, in my opinion not all the objects are asymmetrical along the vertical axis. For instance, wall cabinets are vis-à-vis objects but are symmetrical along the vertical axis. As stated above, I agree with Levinson (2003b) and other researchers that the functionality of the objects is one of the most important aspects when identifying their sides. Native speakers of European languages assign sides to vis-à-vis objects according to the way they use or observe them in everyday situations. Grabowski and Miller (2000) refer to this as the outside perspective because people use the objects from outside. However, Clark (1973) refers to the side identification as the *canonical encounter*.

Using or viewing the objects, people face the *front* of the vis-à-vis object. This part of the object is also its most pronounced side that is also connected with its functionality (e.g. Grabowski, 1999, p. 108 f.; Klein, 1990; Levinson, 2003a, p. 41 f.; Herrmann, 1990). Hence, the side of the TV that we can watch is the *front*. That part of a cupboard we access it from is the *front*. The side opposite to the front is the *back*. In the canonical situation this is one of the parts of the object the user cannot see when using it. The *right* and *left* sides are translated egocentrically from our hands or other parts of the body that use the particular object. It is important to emphasize that side assignment to the intrinsic object is independent on the current position of the speaker / hearer / third person. Moreover, it is also independent of the environment.

Nonetheless, people sometimes identify the sides of vis-à-vis objects in a different way (e.g. Grabowski, 1999, p. 110). How exactly German, English, Italian, and Polish native speakers identify the sides of a cupboard is revealed in the results of the first part of my empirical study (the survey). These also show whether the same participants use side identification to interpret spatial relations with the same cupboard as a reference object. In other words, whether they derive the sides and their regions for the prepositional phrase.

As Grabowski (1999, p. 110) indicates, some objects can belong to different object types. A church serves as a well-known example of this in the literature. People identify the sides of a church according to the outside or inside perspective, depending on where they consider the object from. When walking into the church, people identify its sides according to the outside perspective – where the door is at the *front*. The *back* is the opposite side, and the *right* and *left* sides are translated egocentrically according to their functionality. In contrast, sitting in the church, humans identify the sides of the church according to the inside perspective because they are sitting or remaining in it. They transfer their sides anthropomorphically beginning with the altar, which serves as the *front*; the (main) door is usually on the opposite side and we identify this as the *back* (see also 4.8).

2.1.2.2 Vehicle objects

The second main group of three-dimensional intrinsic objects is represented by *vehicle objects*. Humans assign sides to these objects according to the inside perspective because we use them from the inside (e.g. Grabowski, 1999; Grabowski and Miller, 2000; Herrmann, 1990; Levinson, 2003a). Examples of vehicle objects are *lecture halls*, *chairs*, *clothes*, *cars*, *trains*, *aircraft*, and the like.

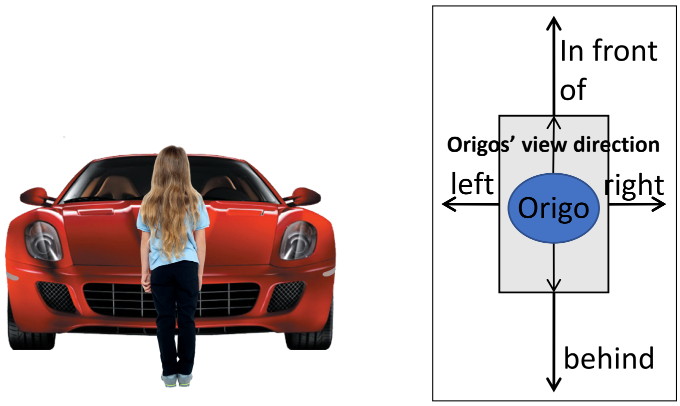


Figure 2.10: Side assignment to a canonically positioned vehicle object (source for girl: Moomhan, 2019a; source for car: PNGStock, 2019b)

These objects are asymmetrical along all of their spatial axes. We assign these objects spatial features as if we were considering them from the inside perspective because we use them from the inside. People transfer sides to these objects anthropomorphically from the body of the canonical user of the object. Hence, for instance, sitting on a chair in a lecture hall, we transfer our anthropomorphic axes to the chair and the lecture hall. Thereby, the *front* is where the lecturer is standing and the *back* is the opposite (the wall behind our backs if we are sitting on a chair canonically facing the lecturer). The right and left sides are where our hands are. These sides are also derived from our body. The *front* coincides with our point of view while using the object; the *back* is not visible for us (e.g. Grabowski, 1999, p. 107 f.).

Of course, in addition to the functional aspects there are also other – secondary – reasons for why we categorize an object as a vehicle object. For instance, a car has headlights that are similar to humans' eyes (an aspect of the front), moves forward (an influence for the front), and the right door is opened from inside using the right hand and the left door using the left hand. However, I agree with Grabowski (1999, p. 110), who explains that all these points are merely secondary and support the functional use of the object by a person.

2.1.3 Higher animate entities

How do we assign sides to ourselves, to other human beings, or our animals that accompany us in everyday situations? The bodies of both human beings and animals are three dimensional and asymmetrical. However, the last point is controversial in the literature – for instance, Franklin and Tversky (1990) argue that the human body, as with many intrinsic objects, is asymmetrical along the vertical (*up–down*) and first horizontal (*front–back*) axes but not along the second horizontal axis (*right–left*) or the second horizontal axis is perceived as symmetric (see Freyd and Tversky, 1984). In my opinion, the human body is asymmetrical along all three axes. In this regard, let us consider the hands of a human – are these symmetrical? Do the fingers look same on both hands, like the sides of a cupboard, for instance? I think that the asymmetry of the vertical and first horizontal axes is more pronounced than that of the second horizontal one, yet the latter looks asymmetrical to me. The body of humans is also characterized by the internal differences – the heart is on the left side. The same applies to our animals, such as dogs. A dog served as representative in my experiment on higher animate entities. For this reason, here, I concentrate on human beings and dogs only.

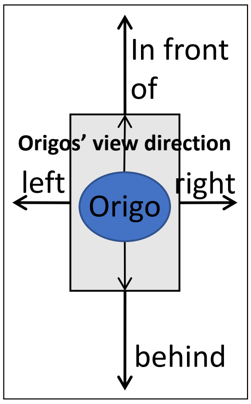


Figure 2.11: Higher animate entities – the example of a dog

As stated above (2.1.2.2), humans assign sides to higher animate entities according to the inside perspective (e.g. Grabowski, 1999; Grabowski and Miller, 2000; Retz-Schmidt, 1988). But how do we know where the front is in order to assign all six sides to an animate entity? For this, there are several clues because animate entities are characterized by several features. For instance, eyes play important role in recognizing the *front*. Following Landau (1994, p. 273), "eyes are a perceptual property, they clearly are powerful in suggesting animate beings." Additionally, humans recognize the body part as the front that contains the perceptual apparatus – not only the eyes. The front is also linked to the sense of smell – the nose is in the front. Lastly, Grabowski (1999) points out that the ears are directed to the front. In addition to the perceptual apparatus, which is perceived as front marker for higher animate entities, the canonical direction of motion indicates the front – canonically, higher animate entities move forward. Regarding the asymmetry of the second horizontal axis, we recognize which hand is right and which left. Several acquaintances of mine in Germany use the "L" sign as memory aid to recognize the left hand. This is possible only with the left hand (from the viewpoint of the performer) – trying the same with the right hand, we receive a mirrored sign (see 2.12).

Figure 2.12: Recognizing one's own right and left hands using thumb and index finger (source: Moomhan, 2019b)

2.12 indicates that people assign sides to higher animate entities from the inside perspective – otherwise, we would recognize the right hand as the left.

In my experiment, I investigated how English, German, Italian, and Polish native speakers interpret spatial relations with dog (as in the 2.12) and a bottle as localized objects – seeing the dog once from the front and once from the back. I focused on considerations of *front*, *back*, and *right* and *left* sides by the participants – whether they take into account the anthropomorphic sides of the dog when interpreting spatial relations with it. Hüther et al. (2016) have shown that even medical students (German native speakers) do not always take into account the anthropomorphic sides of a human in interpreting spatial relations when that human is the reference object.

The assignment of sides to higher animate entities succeeds in accordance with parts of our own bodies. Humans can translate their anthropomorphism to other humans, statues, and animals. It does not depend on the position of the entities in relation to each other. Humans can also conduct a mental rotation to transfer the sides (e.g. Grabowski, 1999; Graf, 1994; Shepard and Metzler, 1971; Stoltmann, Fuchs, and Krifka, 2018). Grabowski (1999, p. 105) refers to this process as *kanonische Projektionsperspektive* (canonical projection perspective).

However, other higher animate entities are characterized by different morphologies relative to humans – they move horizontally and not vertically as humans do. The head is in the front and not at the top and the back is up (cf. Grabowski, 1999, p. 105). Nonetheless, Grabowski (1999, p. 105) argues that humans do not have any problems in empathizing with them.

2.1.4 The influence of motion

One further aspect influencing the identification of the sides of an object is *motion*. An object can either be considered while moving or merely in terms of possessing the possibility of movement. Objects that can be moved by someone or something but not by themselves are not considered here because there is no indication of their sides. All kinds of objects – extrinsic and intrinsic – can be moved. Tenbrink (2005b, p. 33) explains:

> *"Objects in motion (or potentially in motion) induce a further kind of perspective that is independent of intrinsic fronts or perceptual organs. The perspective adopted can be described as though the moving object was viewed from the inside, so to speak, looking in the direction of motion. Thus, even completely symmetric objects, such as a ball, can be ascribed front, back, right and left sides when in motion" (Tenbrink, 2005b, p. 33).*

This can be seen in 2.13. As I did not investigate the influence of motion on the assignment of sides in my experiment, I do not analyze this aspect here any further – I only wished to point out that (potential) motion can also influence the identification of sides (please refer to the following sources for further details: Eschenbach, 2005; Levinson, 2003a; Miller and Johnson-Laird, 1976; Retz-Schmidt, 1988; Talmy, 2000a; Tenbrink, 2005b; Tenbrink, 2011; Winterboer et al., 2008; etc.)

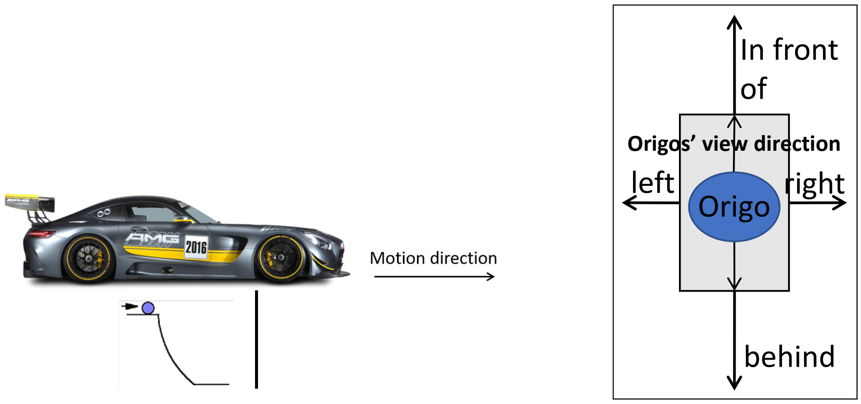


Figure 2.13: The influence of motion on the assignment of sides (source for car: datsvs, 2019)

2.2 Identification of the sides of objects in other cultures

It is important to emphasize that side assignment is language and culture specific (e.g. Brown, 1994; Brown and Levinson, 2000; Fedden and Boroditsky, 2012; Leßmöllmann, 2002; Levinson, 1994b; Levinson, 2003a). The side identification discussed above is the one dominant for European native-language speakers but it can be found in many other speech communities as well. However, there are other systems. Here, I focus only on one very famous example from Levinson (1994b) and Levinson (2003b) just to show how different side assignments to objects can be. Levinson (2003a) indicates that Tzeltal native speakers transfer the name of human body parts to inanimate objects. According to the researcher, the body parts establish one special form class that possesses its own morphology and own particular semantic properties. Moreover, there are even primary body parts for spatial descriptions (see Levinson, 1994b, p. 804). Overall, Levinson (1994b, p. 807 f.) distinguishes three source domains for spatial metaphors in Tzeltal:

1. Human body parts
2. Animal body parts
3. Parts of plants

Levinson characterized the inanimate physical objects as the target metaphorical domain. This means that the meaning of the human and animal body parts as well as the plant parts are transferred to these objects, in 2.14.

Levinson (1994b, p. 808) explains that it is impossible for the inanimate physical objects to be considered as the source domain and the animate ones as the target domain. The most important aspect of metaphor theory (see 4.1) is that when building metaphors, speakers transfer the meaning of more concrete terms to less concrete ones (Levinson, 1994b, p. 808).

Furthermore, Levinson (1994b, p. 808) defined criteria for source and target domain identification:

1. "more exact application:" eye of an animal vs. marked patch on a piece of furniture;
2. "restricted number of identical parts:" humans have only one head; however, for instance, tables have two; and
3. when the "source combines two or more schema, targets choose [the] subset".

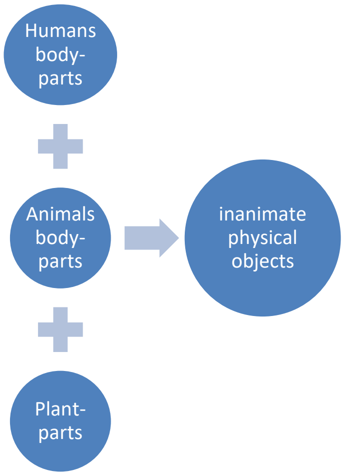


Figure 2.14: The three source domains of spatial metaphors in Tzeltal for inanimate physical objects according to Levinson (1994b, p. 807)

2.3 Summary

In this chapter, I focused on animate and inanimate objects and how native speakers of European languages assign sides to these objects. I focused on the representatives of these objects I used in my experiment – a *table* (inanimate extrinsic object), *cupboard* (inanimate vis-à-vis intrinsic object), and *dog* (animate entity). Additionally, using the example of Tzeltal native speakers, I briefly showed that native speakers in the non-Western cultures may assign sides to objects in different ways than in Western culture.

Harris, Strommen, and Marshall (1974) have shown that research on the phenomenon of side assignment is very important because even speakers of the same language (in this case, English) indicate diversity in recognizing the everyday concepts of *front* and *back*. Herrmann (1990) points out that the sides can be assigned to objects in terms of the way people interact with them.

As regards side assignment to higher animate entities, I agree with Grabowski (1999, p. 106), who assumed that side assignment to humans and higher animate entities does not succeed in accordance with the perceptual apparatus or the direction of movement. It involves more than this – the whole morphology of the body complemented by other aspects such as the direction of movement.

This diversity of side assignment to objects in different cultures was researched by, for instance, Levinson, who argued that objects do not have inherent features – these "features" depend on the culture (Levinson, 2003a, p. 76 ff.). Moreover, Levinson (2003a, p. 76 ff.) emphasized that when assigning sides to an object, several factors are considered: the orientation of the object, perception, and its features and functions (cf. Tenbrink, 2005b, p. 25).

In this chapter, I have not referred to evidence from brain experiments on object recognition by humans (for information on this, refer, for instance to Supp et al. (2007), who conducted an EEG experiment or to Kaiser et al. (2019) for a review of object vision in a structured world).

3 Spatial relations

In the interpretation or description of spatial relations, *perception* plays an important role. As Bellebaum et al. (2012, p. 31) has explained:

Wahrnehmung "bedeutet, die Umwelt in all ihren Eigenschaften mit den zur Verfügung stehenden Sinnen zu erfahren, Ereignisse und Dinge zu erkennen und zu klassifizieren und sich auf Reaktionen vorzubereiten" Bellebaum et al. (2012, p. 31). (Perception means to experience all the features of the environment with all the senses, to recognize events and objects and to classify them and prepare for the reactions).

In perception, the localization of an object in space plays a very important role. Perception of spatial relations is one of the best-investigated domains as regards linguistic differences between native speakers of different languages (e.g. Li et al., 2011; Brown and Levinson, 1992; Brown and Levinson, 1993a; Brown and Levinson, 1993b; Levinson, 1996; Levinson, 2003a).

In the previous chapter, I explained what kinds of objects exist and how native speakers of European languages assign sides to these. I have also indicated that the identification of sides depends on culture using the example of Tzeltal native speakers.

In this chapter, I focus on spatial relations. A *spatial relation* involves at least two objects (of any kind) and can be described and perceived regarding relation to at least three frames of reference, depending on the reference object, spatial constellation, and culture. Imagine that you want to describe the example of the spatial relation from the previous chapter, where you were writing with a pen sitting at a table or a desk. Considering the spatial relations between the pen and a sheet of paper, the pen can be located in relation to the sheet of paper, though the relation the other way around would not be intuitive. How would one interpret a spatial relation involving the pen between you and the sheet of paper? Would you say that the pen is *in front of* or *behind* the piece of paper? Would you express the spatial relation in the same way in all the languages you speak or would you change the strategy or the preposition depending on the language or perhaps the addressee? What about the two other positions, *right* and *left*? How would you interpret these when hearing one of the following sentences?

- *The pen is to the right of the sheet of paper.*
- *The pen is to the left of the sheet of paper.*

Which aspects may influence your interpretation of the spatial relations? In this chapter, I present some aspects that may influence the interpretation and description of spatial relations with a *table* or *desk* or *chair* as reference object. To this end, let us consider the following description of a spatial relation:

- *The bottle is in front of the table.*

German, English, Italian, and Polish native speakers use different strategies to interpret the previous examples compared to the following ones:

- *The bottle is in front of the desk.*
- *The bottle is in front of the chair.*

Lastly, in this chapter I also focus on the influence of a third person on a particular spatial relation – how her or his presence may affect the interpretation or description of a spatial relation by means of indirect speech, such as in the following examples:

- *Hans says that the pen is in front of the sheet of paper.*
- *Hans says that the bottle is in front of the table.*
- *Hans says that the bottle is in front of the chair.*

To explain how spatial relations can be interpreted or described, I first explain how the space can be defined (what kinds of spaces are distinguished in linguistics and cognitive science), that is, what exactly contains a spatial relation. In a final step, I explain the frames of reference applied to the description and interpretation of spatial relations in different languages.

3.1 Space

What is *space* actually and how do humans perceive it? *Space* is everything around us. The theories of space had already been discussed by Euclid and Aristotle and are still being researched and extended. As Aristotle explained:

> *"These are the parts and kinds of place: above, below, and the rest of the six dimensions. These are not just relative to us, they – above, below, left, right – are not always the same, but come to be in relation to our position, according as we turn ourselves about, which is why, often, right and left are the same, and above and below, and ahead and behind. But in nature each is distinct and separate." (Physics, book 4, cited in Levinson, 2003a, p. 7)*

This idea of Aristotle was extended by Newton (relative and absolute space), Leibniz, Kant, Helmholtz, and recently by Levinson (2003a) for external spatial relations and by Tenbrink (2011) for both internal and external spatial relations. The models of the two later researchers are the focus of the current thesis.

Following, for instance, Piaget and Inhelder (1957), Clark (1973), Miller and Johnson-Laird (1976), Lyons (1977), and Levinson (2003a), human spatial thinking is mostly egocentric. Moreover, it is also anthropomorphic – this means that humans derive the spatial coordinates *front–back*, *right–left*, and *up–down* from the body. If we were creatures with another symmetry, like starfish with a pentalateral structure, our spatial terms would likely be different. The statement on anthropomorphic derivation of spatial coordinates had already been suggested by Kant (1991 [1768]) (see also: Levinson, 2003a; Clark, 1973; Miller and Johnson-Laird, 1976; and Lyons (1977)).

> *"In physical space, on account of its three dimensions, we can conceive three planes which intersect one another at right angles. Since through the senses we know what is outside us only in so far as it stands in relation to ourselves, it is not surprising that we find in the relationship of these intersecting planes to our body the first ground from which to derive the concept of regions in space. . . .*
>
> *One of these vertical planes divides the body into two outwardly similar parts and supplies the ground for the distinction between right and left; the other, which is perpendicular to it, makes it possible for us to have the concept before and behind. In a written page, for instance, we have first to note the difference between front and back and to distinguish the top from the bottom of the writing; only then can we proceed to determine the position of the*

> *characters from right to left or conversely" (Kant, 1991 [1768], p. 28 f. cited in Levinson, 2003a, p. 11).*

Following Miller and Johnson-Laird (1976, p. 394), the first spatial reference entity humans learn is *ego*. Spatial thinking is a fundamental part of our everyday routines. Using spatial memory, we navigate, for instance, in buildings (at our employer and at home) or on the way (from) home. Humans acquire new local experiences while moving through new environments. It is assumed that a spatial mental representation is linked to a particular experience – for instance, after a walk, humans have a mental representation of the route they took (of course, only if they paid attention to the route and did not get sidetracked, for instance, by a smartphone). Moreover, repeatedly passing the same way helps humans to orient themselves, and over time they become more familiar with the environment or with the building of their new employer. In the course of time, the mental representation of the route or of the particular building contains even more features that characterize it and help humans to categorize it as well as to distinguish it from other categories or entities of the same category (Wang et al., 2012).

Analysis of a geographical map may also lead to a mental representation of the environment, retrieval of which supports us by means of memory recall while passing through an environment (e.g. Tower-Richardi et al., 2012; Tolman, 1948; Jeffery and Burgess, 2006).

According to Tower-Richardi et al. (2012), humans with high spatial navigation capabilities focus on coordinate systems while moving through space. In contrast, humans with low(er) spatial capabilities concentrate on local landmarks while moving through space.

This corresponds with Gosztonyi (1976, p. 1035), who states that there are two possibilities for perceiving space – the anthropocentric, which assumes that humans perceive the space from the basis of their body, and the object-centered. With the latter, humans perceive space by means of objects.

In contrast to time, which is represented on only one axis, space contains three axes. According to Tenbrink (2005b, p. 15), this fact makes the representation of space more complicated. However, time is more abstract than space, as shown in metaphor theory. In this thesis, I follow the statement of Boroditsky (2001) that the representation of time is more complicated because it is more abstract and because we still do not know much about time, for instance, the direction in which it flows. As regards space, in most literature and experiments only two spatial axes are considered – mostly the horizontal ones (*front-back* and *right-left*; this also applies in the current study), and the vertical one is often ignored (*up-down*; e.g. Herskovits, 1986, p. 76; Tenbrink, 2005b, p. 15).

According to Klein (1990, p. 12), space consists of three dimensions: the vertical, horizontal, and transversal. The structure of the referential area depends on the particular spatial relation – it does not have to be the same for all spatial relations. However, the different structures refer to one another. The two structures may be different so that one of these, for instance, the second horizontal (transversal) can be ignored when describing a spatial relation (Klein, 1990, p. 13).

Tversky, Bauer Morrison, et al. (1999, p. 516) distinguish between three *spaces* of spatial cognition linked to a mental representation:

- The navigation space
- The space surrounding the body
- The space of the body

Humans allocate different properties to each of the spaces. However, Tversky, Bauer Morrison, et al. (1999, p. 517) emphasize that these are definitely not all spaces. According to Tversky and her colleagues, the three spaces differ in the way humans represent them mentally. Later on, Tversky (2000) introduced a fourth kind of space – *the space of graphics* (see also Tversky, 2003a); however, I do not discuss this further in the following subsections because it is not linked to my dissertation. In the following subsection, I briefly explain the first three kinds of spaces, though I focus especially on the space around the body as it is this component of spatial relations that I investigate in this study.

3.1.1 Navigation space

"The space of navigation is the space we explore, the space we inhabit as we move from place to place, typically a space too large to be seen at once," explains Tversky (2003b, p. 71).

Furthermore, Tversky (2003b, p. 72) adds that

> *"[i]n the case of the space of navigation, several reference frames are possible, primarily based on viewer, object, or environment (e.g., Taylor and Tversky, 1996). Directions and axes are not represented analogically or metrically in exact degrees or meters but rather somewhat categorically. It is this schematization into elements and paths relative to reference frames ... that allows integration of fragments into a whole."*

Humans perceive navigation space in different ways. The prototypical way is by exploring the environment. In the course of time, particular parts of the environment change their salience as a result of experience.

Several studies have shown that the mental representation is schematized. Landmarks, paths, frames of reference, and perspectives play important role in establishing a schematization (Tversky, Bauer Morrison, et al., 1999, p. 517; see 3.2). Tversky, Bauer Morrison, et al. (1999) emphasize various aspects that influence the mental representation of navigation space. An influence on the representation of a particular navigation space may, for instance, be other elements and the direction between the elements. The main building of the Humboldt University in Berlin and the university's Linguistics department building can serve as an example. To remembering the location of the building, people usually put them into relation and direction with each other. Tversky, Bauer Morrison, et al. (1999, p. 518) indicates that humans do not remember a location with respect to an absolute frame of reference (see 3.3.1). However, I leave the statement on that position open due to there being different cultures. It may be that Tzeltal or Mian (Papua New Guinea, e.g. Fedden and Boroditsky, 2012) native speakers remember a location using an absolute frame of reference because that is their predominant reference frame.

Nonetheless, Tversky and colleagues make a very interesting point, namely that "locations and direction seem to be schematized so that group elements are drawn closer" (Tversky, Bauer Morrison, et al., 1999, p. 518). One of the interesting results refers to an experiment that tested how humans perceive maps. Participants were asked to choose one of a number of maps that illustrated continents with manipulated distinctions between them. The study results indicate that most of the participants selected a map on which South America was closer to North America than it is in reality (Tversky, Bauer Morrison, et al., 1999; Tversky, 1981).

One of other effects influencing the mental representation of navigation space is the effect of the frame of reference. This can also influence humans' judgment on the direction of and distance between locations. For instance, according to Tversky, Bauer Morrison, et al. (1999, p. 518 f.), humans remember cities that are east or north to each other more quickly if the two belong to different geographical entities, such as countries or states.

A very important effect for the three spaces is the effect of viewpoint. Tversky, Bauer Morrison, et al. (1999, p. 519) refer to this as perspective (similarly to Tenbrink, 2011). In other studies it has been shown that humans schematize navigation space in terms of its elements, the frame of reference, and perspective (e.g. Gramann, 2013; Holyoak and Mah, 1982; Levinson, 2003a; Taylor and Tversky, 1996). Holyoak and Mah (1982) results show that judgment of the distance between cities or locations depends on the location of the assessor. Holyoak and Mah (1982) investigated students in Ann Arbor. They asked participants to imagine themselves once having been on the east coast and once on the west coast. Their task was to judge the east–west distance between city-pairs. The results reveal that students who imagined themselves on the east coast judged the east–west distance between the cities to be larger than those who imagined themselves on the west coast. The question that arises here is: Did the actual location of the participants have an impact on their judgment?

Pfuhl and Biegler (2011) investigated whether humans consider the precision of a map when they are looking for a location (of an entity marked on the map). According to them, an accurate map is a map on which the average values correspond to the real values. The reliability of a map concerns how well a place is correctly identifiable on the map. Pfuhl and Biegler (2011) conducted a study that tested 11 participants using a map. The map included various special symbols. The participants received a map at the start and were asked to find as many objects as possible. They did not know how many were hidden. The participants were allowed to use a compass only. In the real calculation, the objects were at the place, where they were labelled on the map. To determine the route the participants took to find the objects, they received a GPS. The assumption was that the less an object is characterized the more difficult it is to find it. Most of the participants found all the objects (four of the objects labelled on the map did not exist). The results indicate that the imprecision of a map plays an important role for experienced map users – in contrast to the unexperienced ones. The influence was observed in relation to "the actual behavior of reduced running speed, as well as in the verbal description they gave when asked which controls they found difficult" (Pfuhl and Biegler, 2011, p. 4).

König et al. (2019) tested participants using interactive maps in virtual reality. Their results show that the more the participants were familiar with the map and the environment, the more accurate their orientation was.

3.1.2 Space around the body

Tversky (2003b, p. 71) defines the space around the body as follows:

> *"In short, mental representations of the space around the body appear to be three-dimensional, with the dimensions defined by extensions of the axes of the body. Times to retrieve objects in directions from the body can be accounted for by perceptual and functional asymmetries of the body axes and the axes of the world."*

This sort of space plays very important role in this dissertation. Humans perceive space by observing the objects around them. Without looking at something, we know where each object is located. For instance, crossing the apartment of a friend for the first time, we know where the table and cupboard are located and the relation of these objects to us. The space around the body is considered from a single place along three dimensions (Tversky, 2003b, p. 68).

Tversky, Bauer Morrison, et al. (1999) distinguish between three models for the analysis of perception of the space around the body:

- Mental transformation: the model originates with Shepard and Podgorny (1978) and assumes that the front of an object – the side facing the viewer – is retrieved fastest, followed by all directions at the angle of 90° – right, left, down – and finally the one at 180° – behind.

- Equiavailability, which assumes that the retrieval time for all directions of the reference object is the same; the idea comes from Levine et al. (1982).
- Spatial framework: the model originates with Franklin and Tversky (1990) and assumes that the up–down axis is retrieved fastest, followed by the front–back axis, and the right–left axis last. According to Tversky, Bauer Morrison, et al. (1999), this order applies only if the up–down axis corresponds with the direction of gravity. When the viewer is lying down, the head–feet axis no longer correlates with gravity. In such a case, the front–back axis assumes retrieval primacy.

3.1.3 Space of the body

The third and last space defined by Tversky, Bauer Morrison, et al. (1999) is the *space of the body.* According to Tversky, Bauer Morrison, et al. (1999, p. 520), humans' body parts are reflected in mental maps (cf. Morrison and Tversky, 1997). Morrison and Tversky (1997) investigated how humans access particular body parts, beginning with the assumption that a few of them are used more frequently: head, arms, hands, legs, and feet. According to Tversky, Bauer Morrison, et al. (1999), these particular human body parts are characterized by a shorter reaction time for access. In relation to the space of the body, further models were defined in the research:

- Imagery theory predicts that larger body parts are named more quickly than smaller ones. The theory is derived from Kosslyn (1980). Following this theory, the head and back would be more quickly detected than an eye or a finger.
- Object recognition theories: One of the theories predicts that the objects are recognized by the contours. According to Tversky, Bauer Morrison, et al. (1999, p. 521), "it could be predicted that parts with greater contour discontinuities would be identified faster. Thus, for example, foot should be identified faster than chest".
- Part-significance theory: This theory predicts that inside and outside body parts are perceived in the same way (cf. Reed and Farah, 1995). Employing this theory in relation to the human body, it would mean that the chest is identified more quickly than the leg.

Tversky (2003b, p. 67 ff.) indicates that humans apply the perceptual features of the objects in order to derive their functions (perceptual salience as a sign of functional significance). The mental representation of the body is organized in accordance with the body parts. It would be of interest to investigate the reaction time for body parts in different cultures and cross-linguistically – for instance, West European culture vs. Tzeltal or German vs. English (because English native speakers use body parts – e.g. hand expressions – more frequently; see Tenbrink, 2005b).

3.2 What contains a spatial relation?

A spatial relation can be either *static* or *dynamic*. With static spatial relations, the entities involved are motionless or their motion is not relevant in the particular context. In contrast, a dynamic spatial relation involves a *route*, *source*, and *goal*, or the *direction of a path* (Pribbenow, 1991, p. 609).

Both static and dynamic spatial relations involve at least one *localized* and *reference object*. In the literature these are referred to as the reference object [1] and localized object (cf. Svorou, 1994, p. 9; see also Tarasevic, 2003, p. 67; and Grabowski (1999, p. 32), *Bezugsobjekt* and *lokalisiertes Objekt*), *relatum* and *locatum* (e.g. Tenbrink, 2011),*Ground* and *Figure* [2] (cf. Talmy, 1983, p. 230 f.; Talmy, 2000a; Talmy, 2000b), and *landmark* and *trajector* (cf. Langacker, 1987: 217 ff.). The localized object can also be referred to as the *indirect* or *target object* (e.g. Grabowski, 1999, p. 32).

The terms *Ground* and *Figure* derive from gestalt psychology, though their features differ in linguistics. It is for this reason that Talmy (2000a, p. 312) changed the notation to capitals. For their application in linguistics, he defines the two concepts in the following manner:

> *"The Figure is a moving or conceptually movable entity whose path, site, or orientation is conceived as a variable, the particular value of which is the relevant issue. The Ground is a reference entity, one that has a stationary setting relative to a reference frame, with respect to which the Figure's path, side, or orientation is characterized" (Talmy, 2000a, p. 312).*

As explained above, some of the spatial properties that characterize an object are *size*, *gestalt*, *position*, and *place* (that is, where it is positioned). The following qualitative properties provide support when selecting one of the objects as a reference object in a spatial relation: size, gestalt, inherent and functional properties, dimensionality, mobility, and ontological belonging (see Maciejewski, 1996, p. 39; Perużyńska, 2012a).

However, as has been emphasized by Klein (1990, p. 29), spatial relations are between places and not between objects. More precisely, in the description or interpretation of a spatial relation, the region of the localized object is put into relation with the region of

[1] Wojaczek (2006) labeled the reference object as "Verweisobjekte" and the region as subspace "Teilraum". She defined objects as following: Concrete items ("Gegenstand") like a bottle, table or cupboard; Beings: humans, animals; Places (buildings) like house, museum, institute; Abstract spatial concepts like events, panic conditions (Wojaczek (2006: 199)).

[2] The concepts of *Ground* and *Figure* were introduced by Talmy (1983). Theme and relatum, or the more recent *trajector* and *landmark*, are defined by Langacker (1987).

reference object. Humans use these regions for the indirect description of the relations between the objects.

Wunderlich (1990, p. 43) supports the idea that spatial relations are described as being between the places that the objects occupy at a particular time. This means that, in the spatial relation, *The bottle is to the right of the table*, the spatial relation *to the right of* expresses the relation of the place of the bottle (at that particular time) to the place of the table (at the same time; Wunderlich, 1990, p. 43). Moreover, Wunderlich (1990, p. 43) explains that the place of the bottle is an element of the structured set of many *to the right of* – spaces that can be used as a reference to the place of the table.

According to Klein (1990, p. 34), the viewpoint defines the perceptual dimensions of a particular spatial relation. In this manner, the dimensionality and polarization of spatial relations are related to the (functional) bodily asymmetry of the person who comprehends the particular spatial relation and are derived from the body (e.g. Grabowski, 1998, p. 25).

In the following subsections, I explain the semantic elements of a spatial relation: reference object, localized object, origo, and region. However, *motion*, *path*, *manner*, and *cause* are not explained because these were not included in the experiment.

3.2.1 Reference and localized objects

The choice of an object as a *reference object* depends on the object's properties and on its discursive properties (see Klabunde, 1998, p. 47). In the research, numerous properties emerged as typical for a reference object. I explain these together because they always occur together in a spatial relation:

1. The reference object (relatum or Ground) serves as a reference entity with known properties that can be provided to determine the properties of the localized object / Figure (Talmy, 2000a, p. 315 f.).
2. The reference object is usually larger than a localized object (e.g. Ehrich, 1985, p. 141; Grabowski, 1999, p. 35 f.; Maciejewski, 1996; Svorou, 1994, p. 8; Perużyńska, 2012a, p. 6; Fortis, 2010, p. 1), therefore it is common to say *The bottle is located to the right of the table* and not *The table is located to the left of the bottle.* However, there are exceptions to this rule – for instance, when an object is culturally more important but smaller it will serve as a reference object (cf. Svorou, 1994, p. 11).
3. Additionally, Grabowski (1999, p. 36 f.) argues that the choice of reference object does not depend on the language – this rather occurs situationally. This means that there are situations in which a smaller object can serve as the reference object for a particular spatial relation. Sometimes, this depends on who is focusing on what. For instance, going shopping with a partner, it is possible to say, "The table

behind the pink vase." When the wife indicates the pink vase to her husband, she might say, "Look at that pink vase over there." The husband may add, "It looks nice – but look at the table behind the pink vase. That would go well in our living room." This contradicts the assumption of Retz-Schmidt (1988, p. 96) that some combinations of objects are impossible in natural language.

4. The reference object is more permanently located if only one of the objects is mobile (e.g. Grabowski, 1999, p. 35; Ehrich, 1985, p. 141; Svorou, 1994, p. 11; Perużyńska, 2012a, p. 6; Fortis, 2010, p. 1).

5. The reference object serves as a *comment* in a sentence. Using the sentence from above, *The bottle is located to the right of the table*, as an answer to the question, *Where is the bottle?*, the table takes the role of the *comment* and the bottle is the *topic* (e.g. Grabowski, 1999, p. 32; Perużyńska, 2012a, p. 6).

6. The reference object has intrinsic and functional properties if only one object is intrinsic and has functional properties (see 2.1.2). Therefore, in the following sentence, the cupboard and not the bottle is considered the reference object: *The bottle is standing to the right of the cupboard* and not *The cupboard is standing to the left of the bottle.* Nonetheless, size can be more important than an object's functionality and intrinsicality. For instance, it is more common to say *The bicycle is located to the left of the tree* than it is to say *The tree is located to the right of the bicycle* (e.g. Svorou, 1994, p. 12). Talmy (2000a, p. 315 f.) adds that the localized object is geometrically simpler and the reference object more complex.

7. Following on from the statement above, the reference object is either visually or perceptively more salient than the localized object. Therefore, it is possible to say *The cupboard is located to the right of a painting*, if the painting culturally or traditionally plays an important role for the sender and recipient (e.g. Weiß, 2005, p. 93 ff.; Timova, 2010, p. 17). It may also just be more familiar to the sender and the recipient (Fortis, 2010, p. 1).

8. According to Fortis (2010, p. 1), the reference object can also be more independent (see also Talmy, 2000a, p. 315 f.).

9. From a grammatical point of view, the reference object (the Ground according to Talmy, 2000a) is used as the obligatory object in a sentence and the localized object (Figure) as the subject. Therefore, it is common to say *The bottle is in front of the table* and not *The table is behind the bottle.* Nonetheless, there are also a few exceptions:

   > *"In an agentive clause, where the Agent is the subject, the Figure is direct object and the Ground is oblique object. When applied to the clauses in a complex sentence, the precedence principle yields the Figure as the*

main clause and the Ground as the subordinated clause" (Talmy, 2000a, p. 334).

10. Grabowski (1999, p. 31 f.) and Stutterheim (1990, p. 105) separate the reference and localized objects as *Thema* and *Rhema* (*topic* and *focus*).
11. Talmy (2000a, p. 335) points out that a Ground / reference object can be also represented by a complex constituent, as in the following sentence: *The pen (Figure) has fallen off the table* (Ground1 / reference object 1) *onto the floor* (ground 2 / reference 2). Here, the reference object is represented by two objects with a path between them.

As I investigated a stationary simple reference and localized object in my experiment, I do not analyze other kinds of Ground or Figure in any further detail here. See Talmy (2000a) and Talmy (2000b) for further details on Figure and Ground, for instance, as regards a *self-referencing event* and *complex Ground* and *Figure* in a complex constituent.

In my experiment, which object serves as the reference and which as the localized object was given.

3.2.2 Origo

In its Euclidean meaning, the *origo* is the zero-point on the coordinate system. The spatial axes are derived and defined from the zero-point/origo (e.g. Bühler, 1934; Grabowski, 1999). The first person (speaker), second person (addressee), or a third person (or entity – e.g. a higher animate entity or object) can serve as an origo for a spatial relation. All the options for origins are reflected in the grammatical distinction (cf. Herrmann, 1990, p. 131; Tenbrink, 2005b, p. 21). However, considering the origo more precisely, it is not represented by the person or the animate entity but rather by her or his viewpoint (e.g. Levinson, 2003a). The origo can also serve as a gestural zero point of reference (e.g. Fricke, 2007; Quek et al., 2001). A gestural origo can become a key organizational locus around which discourse may be built (Quek et al., 2001).

Tenbrink (2011) introduces a difference between an origo and a perspective. According to Tenbrink (2011), the origo can serve as the basis for the direction of the view and can be represented by an entity. In contrast to the origo, the perspective is not merely an entity due to its ontological differences – following Tenbrink (2011, p. 705), it is rather a direction (e.g. of a viewpoint). This is partly in contrast to the assumption of Vorwerg and Rickheit (2000, p. 24), who states that the origo of a frame of reference is defined by the reference object and the orientation of the directions' reference by the viewpoint. The assumption of Tenbrink can be explained by means of following example: Hans is sitting at a desk with his back to the door of a room. A person comes in and asks: Where is the bottle standing? Hans turns to the person and answers: To the right of the table (the table is between Hans and the door). In this situation, Hans' body is the origo and his viewpoint is the perspective. However, in my opinion, the point of view is the origo, which can be shifted to the pointing gesture. In this regard, imagine again that Hans is sitting at the desk and cannot turn his head to the person because he is busy with a phone call. Rather, he can indicate it with a pointing gesture. It means that origo does not only (and necessary) define a point of view but also three directional axes. In my experiment, the artificial agent, *Hans*, takes the canonical position, which means that he does not look to his right or left.

Additionally, Grabowski (1998) defines three anthropomorphically projected origos:

1. The canonical projected origo:

   > *"The speaker is projecting the origo in a position and orientation, which is fixed – independent of the situation – associated with the particular reference object: the typical spatial position of it users or observer" (Grabowski, 1998, p. 27).*

   In case of a cupboard, the user is usually on the side of the doors. The position and the orientation of a canonical origo is fixed by the reference object.

2. Context-based origo projection: The origo is derived from the speaker in a situated position and orientation, which can be derived from the relative context-based position of the reference object.

3. The current projected origo: This kind of origo is divided into fictive and real. There are two classes for the position of the current or projected origo (see Grabowski, 1998):

   - The PLACE of the origo corresponds to that of the reference object.
   - The PLACE of the origo does NOT correspond to that of the reference object.

3.2.3 Region

Every object has a characteristic *region* (which partially belongs to the object). Speakers use such region when they express the location of an object, the position of the particular condition or event (Wunderlich, 1990, p. 44f.). German, English, Italian, and Polish speakers use spatial prepositions to express localization in a particular region (see 4.3.3). The term region in relation to a spatial relation was introduced by Miller and Johnson-Laird (1976, p. 59). According to the authors, a *region* of an object is an indefinite place encircling the particular object.

> *"The advantage between of region over place as perceptual predicate is that regions overlap can be seen in spatial relation to each other. We will say that*

> *object x is in the region of object y when x is spatial close enough to y to have the sort of interactions with it that normally occur between x's and y's."*

The authors added: "The definition of region is deliberately vague, because the perceptual attributes of a region are correspondingly vague" (Miller and Johnson-Laird, 1976, p. 59).

The concept of region depends on the spatial context. For a person, a region around her or him, expressed by means of the primary local deixis, *here*, is different from that around an object, which is expressed using secondary local deixis, for instance, *to the right of the object* (see 4).

Miller and Johnson-Laird (1976, p. 59) provide several reasons for the ambiguity of the concept of region (based on the statements of Howard (1973)). Initially, researchers saw a region as a concept of personal space in which humans feel comfortable performing with a trusted person. However, the person does not feel comfortable when a stranger is passing by. As emphasized by Miller and Johnson-Laird (1976, p. 59), this region depends very strongly on personality, culture, and on the relationship between the particular people. Therefore, the region that we transfer to inanimate objects is vague too. It also depends on our relationship to the object, more precisely on how familiar we are with it. This point can be illustrated by an example from language acquisition but also very simply from conceptual knowledge and from brain plasticity. Conceptual knowledge can vary across an individual's life span (Claus, 2016, p. 16): A child seeing a tractor for the first time is not familiar with the regions of it. The child does not know how to deal with it – how to describe relationships between it and another object. In contrast, an adult knows about the functionality of the tractor and its characteristic features. Therefore, it is no trouble for her or him to assign the region to the tractor. In contrast, today, children are more familiar with technology than are some adults. Hence, they can recognize and allocate regions to particular technological gadgets that some adults cannot due to their lack of experience.

There are further extending functions, such as *inclusion* and the like. However, I do not focus on this here because my experiment did not investigate it. In everyday situations, it is important to recognize that the regions of different objects perform a wide range of activities. For instance, when we are asked to *put the bottle in front of the cupboard*, first, we allocate the *front* to the cupboard, then we define the region of the cupboard, and, in the end, we are performing the task we were asked to do and place the bottle in front of it. The same thing happens when we are looking for an object and receive the hint that *the bottle is to the right of the cupboard.* First, we assign the side to the cupboard, then the particular region. As a last step, we hopefully find the object we were looking for.

Additionally, not only the region of the reference object but also the region of the localized object has to be recognized in order to express a spatial relation between two particular objects (Miller and Johnson-Laird, 1976, p. 384). However, as Carstensen (2002, p. 7) indicates, the meaning of the dimensional prepositions and the regions is extended.

"The three principal axes can be viewed as extending from the center of the reference object to provide six possible directions. Centered around each half-axis is a region that defines the acceptable space for different prepositions" (Landau and Jackendoff, 1993, p. 230). Tenbrink (2005b, p. 17) adds:

> *"The acceptable space (the region of applicability) of dimensional terms is based on the relationship of the referent to the relatum with respect to one of the basic axes. The gradedness of acceptability then concerns the degree of deviation from these axes" (Tenbrink, 2005b, p. 17).*

3.3 Frames of reference

Humans can localize both themselves and objects in space. But how do humans describe spatial relations and do all cultures describe a particular spatial relation in the same way? If not, what does it depend on? In the previous section, I showed that native speakers of different languages identify sides in different ways. As several researchers have demonstrated, this also applies to the description of a particular spatial relation due to the application of various frames of reference by different cultures.

Vorwerg and Rickheit (2000, p. 19) explain a *frame of reference* as a cognitively represented set of values to which a particular stimulus can be referred. The researchers argue that the perception of vertical and horizontal axes is superior to the perception of diagonal axes. As Eschenbach and Kulik (1997, p. 217) have shown, spatial frames of reference are derived from the reference object (its intrinsic / functional features – existing or non-existing). However, a spatial relation comprising an intrinsic reference object can be interpreted with respect to the *absolute*, *intrinsic*, as well as the *relative* reference frame (e.g. Talmy, 2000a, p. 226 ff.) – for instance, because of the lack of a reference frame in a particular language. I explain this step by step in the subsections that follow.

Frames of reference [3], as system for describing and interpreting spatial situations have emerged as a significant topic in research. The reference frames used in a particular language determine how its speakers describe or interpret spatial relations. They do not specify the linguistic coding but the nonlinguistic one (Levinson, 2003a, p. 170). I focus on three main frames of reference that have emerged in the literature: absolute (environment-centered), intrinsic (object-centered), and relative (viewer-centered) [4] (e.g.

[3] Please refer to Levinson (2003a, p. 24 ff.) for a historical overview on development of frames of reference in the philosophy, neuroscience, linguistics, and psychology. The author goes through the ideas by Newton (relative vs. absolute space), Kant (1991 [1768]), O'Keefe and Nadel (1978), Miller and Johnson-Laird (1976). These are followed by Piaget and Inhelder (1957) (egocentric vs. allocentric), Acredolo (1988), Tolman (1948) as well as Leech (1970), and Clark (1973) for the deictic vs. intrinsic frames of reference that emerged for the linguistic application especially.

[4] In accordance with the linguistic application, Carlson-Radvansky and Irwin (1993, p. 224) summed the reference frames as "[t]hree distinct classes of reference frames exist for representing the spatial relationships among objects in the world . . . : viewer-centred frames, object-centred frames, and environment-centred frames of reference. In a viewer-centred frame, objects are represented in a retinocentric, head-centric or body-centric coordinate system based on the perceiver's perspective of the world. In an object-centred frame, objects are coded with respect to their intrinsic axes. In an environment-centred frame, objects are represented with respect to salient features of the environment, such as gravity or prominent visual landmarks. In order to talk about space, vertical and horizontal coordinate axes must be oriented with respect to one of these reference frames so that linguistic spatial terms such as 'above' and 'to the left of' can be assigned".

Schole et al., 2018; Levinson, 1994b; Levinson, 2003a; Tenbrink, 2005b; Tenbrink, 2011; Carlson-Radvansky and Irwin, 1993; and Schmidt and Lee (2006), for the ego and allocentric reference frames). [5] I am mostly convinced by the ideas of Levinson for external spatial relations; these were supplemented by Tenbrink for internal spatial relations and the temporal frame of reference (see e.g. Levinson, 2003a; Tenbrink, 2011). Tenbrink refers to her theoretical extension as a toolbox:

> *"The resulting ''toolbox" of basic roles and relations is suitable for representing abstract relational concepts conveyed by linguistic descriptions across discourse contexts and languages, and may thus serve as a framework for comparing lexicogrammatical as well as pragmatic structures of language in the ubiquitous domains of space and time" (Tenbrink, 2011, p. 705).*

In this way, Tenbrink (2011) (similar to Levinson(2003a; 1996)) distinguished between the three abovementioned main spatial reference frames: absolute, intrinsic, and relative. The interpretation of the relative reference frame depends on the viewpoint of the viewer and the intrinsic or absolute do not. Additionally, in her model, Tenbrink (2011) considers motion as well. As indicated by Levinson (2003a), the same reference frames can be employed for the interpretation and description of both static and dynamic spatial relations.

Previously in linguistics, it was common to divide the frames of reference into *deictic*, *intrinsic*, and *absolute*; the *deictic* was replaced by the relative in the theory of Levinson (2003a) though the correspondence is not one to one. For this purpose, Levinson presented – in my opinion – very persuasive examples. I demonstrate this in relation to analogous sentences (Levinson, 2003a, p. 36):

1. The bottle is to the right of me.
   Coordinates: **Deictic**
   Origo: Speaker
   Reference object: Speaker
2. The bottle is to the right of the tree.
   Coordinates: **Deictic**
   Origo: Speaker
   Reference object: Tree
3. The bottle is to the right of the cupboard (on the cupboard's right).
   Coordinates: **Intrinsic**
   Origo: Not the speaker, but the cupboard
   Reference object: Cupboard

[5] The absolute and the relative terms go back to the Newton – Leibniz controversy on the nature of space. "Intrinsic" reference frame was introduced by Clark (1973) (cf. Fortis, 2010, p. 8).

4. The bottle is to the right of you.
   Coordinates: **Intrinsic**
   Origo: Not the speaker, but the addressee
   Reference object: Addressee
5. The bottle is in front of the tree, from your viewpoint.
   Coordinates: **Intrinsic**
   Origo: Not the speaker, but the addressee
   Reference object: Tree

As Levinson (2003a, p. 36) states, the locus of the origo of the coordinate system depends on which spatial relation is considered *intrinsic* and which *deictic* – in other cases, the spatial relations described in (2) and (3) would belong to the same group of non-deictic reference objects. Analyzing the last two sentences, it appears clear that the traditional distinction between *intrinsic* and *deictic* is not suitable. As Levinson (2003a, p. 36) points out, spatial relations that include a person as a reference entity should be grouped together. Moreover, all spatial relations with the same kind of object as reference object should be grouped together – in this case, sentences (2) and (5).

Levinson (2003a, p. 37) suggests another analysis of spatial relation based on the coordinate system of the reference object (if this is available). He groups examples (1), (3), and (4) together. Furthermore, as also stated by Levinson, the logical structure is the same in the three sentences – it is binary. More precisely, the binary spatial relations comprise two arguments – the *localized* and *reference objects*. Levinson emphasizes that the two other sentences – (2) and (5) – are distinct from the three others: There, the spatial relations consist of a nonintrinsic reference frame. Therefore, these spatial relations are logically considered to be ternary relations that additionally consist of the localized and reference objects of a viewpoint as the origo of the coordinate system. For these reasons, Levinson (2003a, p. 37) labels the binary spatial relations as intrinsic and the ternary ones as relative. Regarding the differentiation Levinson provides, the example sentences above can be grouped as follows:

1. The bottle is to the right of me.
   Coordinates: **Intrinsic**
   Origo: Speaker
   Reference object: Speaker
2. The bottle is to the right of the cupboard (on the cupboard's right).
   Coordinates: **Intrinsic**
   Origo: Cupboard
   Reference object: Cupboard

3. The bottle is to the right of you.
   Coordinates: **Intrinsic**
   Origo: Addressee
   Reference object: Addressee
4. The bottle is to the right of the tree.
   Coordinates: **Relative**
   Origo: Speaker
   Reference object: Tree
5. The bottle is in front of the tree, from your point of view.
   Coordinates: **Relative**
   Origo: Point of view of addressee
   Reference object: Tree
6. Thomas put the bottle to the right of the table.
   Coordinates: **Relative**
   Origo: Third person (Thomas)
   Reference object: Table

Levinson (2003a, p. 38) emphasizes that spatial relations should be divided into *intrinsic* and *relative* and not *intrinsic* and *deictic*:

> *"Hence deictic and intrinsic are not opposed; instead we need to oppose (a) coordinate systems 'intrinsic' vs. 'relative', on the one hand, and (b) origins 'deictic' and 'non-deictic' (or, alternatively, egocentric vs. allocentric) on the other. Since frames of reference are coordinate systems, it follows that, in language, frames of reference cannot be distinguished according to their characteristic, but variable, origins". Levinson (2003a, p. 38)*

Humans need two instances to describe and perceive a frame of reference of a particular spatial relation: the reference object and the point of view (Vorwerg and Rickheit, 2000, p. 24). The direction of the localized object in relation to the reference object depends on the viewpoint of the viewer. This means that the spatial expression cannot be interpreted without the viewpoint. However, this statement applies only for the relative reference frame (ternary relation), not for intrinsic or absolute ones (binary relation). The latter are based on fixed directions (either of an object or the environment) and are not influenced by the viewpoint.

Vorwerg and Rickheit (2000, p. 31) point out that the choice of the strategy of the relative frame of reference (see 3.3.2; 3.3.3; 3.3.1) for the production and interpretation of dimensional spatial relations depends on:

- Prepositional inventory (cf. Grabowski and Weiß, 1996);

- Living conditions (e.g. the Cora language in Mexico, see Casad, 1988);
- Level of education (see Pederson, 1995); and
- Tradition.

Additionally, Grabowski (1999) also shows in his habilitation that one's profession can influence the choice of the frame of reference for the production and interpretation of dimensional spatial relation descriptions (taxi drivers vs. no taxi drivers). Also Hüther et al. (2016) shows the influence of profession on interpretation of spatial relations (law students vs. medicine students) as well as Zarina et al. (2018) (students of STEM vs. humanities/social sciences). Šķilters et al. (2018) pointed out that even hobby can influence the spatial skills of an individual.

Levinson and his group at the Max Planck Institute in Nijmegen conducted an immense cross-linguistic analysis of frames of reference, investigating more than 20 cultures (recorded on video and sound). Brown and Levinson (2000, p. 168) suggest four theses (see also Pederson et al., 1998; Levinson, 2003a):

> - *"Languages differ, sometimes fundamentally, in the spatial concepts they encode.*
> - *Spatial concepts in a specific language correlate with the kinds of spatial coding used in nonlinguistic thinking in the community that speaks that language.*
> - *Language appears to play a causal role in that correlation.*
> - *Consequently, language- and culture-specific concepts play a role in the conceptual development of the child, and, specifically, they may affect the order or rate of development of particular concepts in "representational" thought." (Brown and Levinson, 2000, p. 168)*

One of the research group's findings is very important for my dissertation: Following Brown and Levinson (2000, p. 169), the description of the locations of the horizontal axes differs systematically across cultures (*left / right / front / back; north / south / east / west; uphill / downhill / across*). The aim of this thesis is to determine whether English, German, Italian, and Polish native speakers apply the same reference frames for different spatial relations.

The three frames of reference have one common property: Using one of the systems, speakers express the relation between the regions of localized and reference objects – their angular relation (Brown and Levinson, 2000, p. 169). For instance, the following region could be perceived as (3.1):

- The bottle is *behind* the cupboard (from Hans' point of view; rotation or reflection strategy of the relative frame of reference);

- The bottle is *to the left of* the cupboard (intrinsic frame of reference); or
- The bottle is *to the west of* the cupboard (absolute frame of reference).

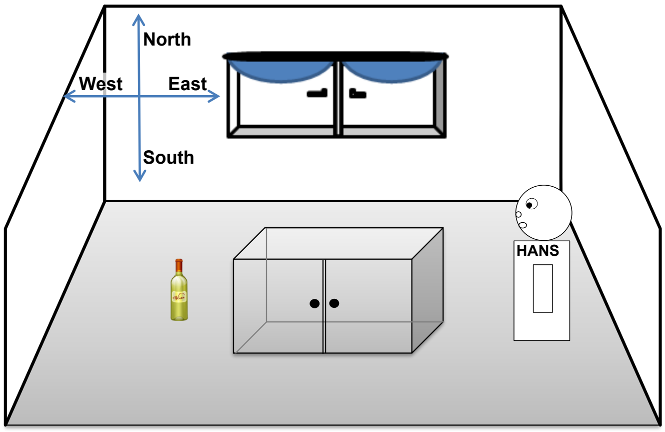


Figure 3.1: Spatial relation with Hans and a cupboard

Furthermore, Brown and Levinson (2000, p. 170) point out that there are languages that use only one frame of reference to describe spatial relations. As examples, they provide:

Intrinsic	Intrinsic / relative	Intrinsic / relative / absolut	Absolute	Absolute / intrinsic
Mopan	Japanese, Dutch	German, English, Italian, Polish	Guugu-Yimithirr	Tzeltal

Table 3.1: Languages and their possible frames of reference according to Brown and Levinson (2000, p. 170)

However, for languages with only one reference frame constraints apply. If a language has only one frame of reference, it has to be either the *absolute* or the *intrinsic* one. According to Brown and Levinson (2000), it is impossible for a language to have only the relative frame of reference as a system for describing or interpreting spatial relations. The relative frame of reference is derived from the intrinsic frame of reference. This means that the intrinsic frame of reference is a condition for the relative one. However, it does not imply its existence in a language, as in the Tzeltal language. A language can also have only two frames of reference (as shown in the 3.1).

In the following subsections, I focus on the assumptions of the three main reference frames: absolute, relative, and intrinsic. To clarify the differences between the three reference frames, I illustrate these using figures showing similar spatial relations, beginning with the absolute one.

3.3.1 The absolute frame of reference

The absolute (environment-centered) reference frame is based on a fixed coordinate system such as *compass, river, or mountains directions*. In the four languages investigated by the current thesis, this reference frame is preferably applied in the context of large-scale space such as a geographical location rather than to indoor scenarios (e.g. Tenbrink, 2005b, p. 25). For instance, using the absolute reference frame, the location between two entities would be expressed as follows: Germany is to the west of Poland, or Berlin is to the east of Hannover. It is of interest that the absolute reference frame has two axes and the intrinsic or relative three. Brown and Levinson (2000, p. 169) explain *north* and *south* as expressions of the horizontal dimension and Toward-Richardi et al. (2012) state that the up–down axis correlates with *north–south* axis. I agree with the latter statement.

When analyzing the spatial relation in relation to the absolute reference frame, it is important to keep in mind that Hans' point of view is not considered in the latter (3.2). What are important are the cardinal directions (*north*, *south*, *east*, and *west*) that serve as anchor directions (Tenbrink, 2005b, p. 24). The absolute frame of reference can also be based on the direction of a river or hill. It is important that the directions do not change with respect to the position of the speaker, addressee, or a third person. Additionally, a description or interpretation using the absolute frame of reference does not change with the rotation of the reference or localized object. In terms of the absolute reference frame, the spatial relations between the bottle as localized object and the round table as reference object would be described as follows:

1. Spatial relation A:
   The bottle is *to the south of* the table.
2. Spatial relation B:
   The bottle is *to the north of* the table.
3. Spatial relation C:
   The bottle is *to the east of* the table.
4. Spatial relation D:
   The bottle is *to the west of* the table.

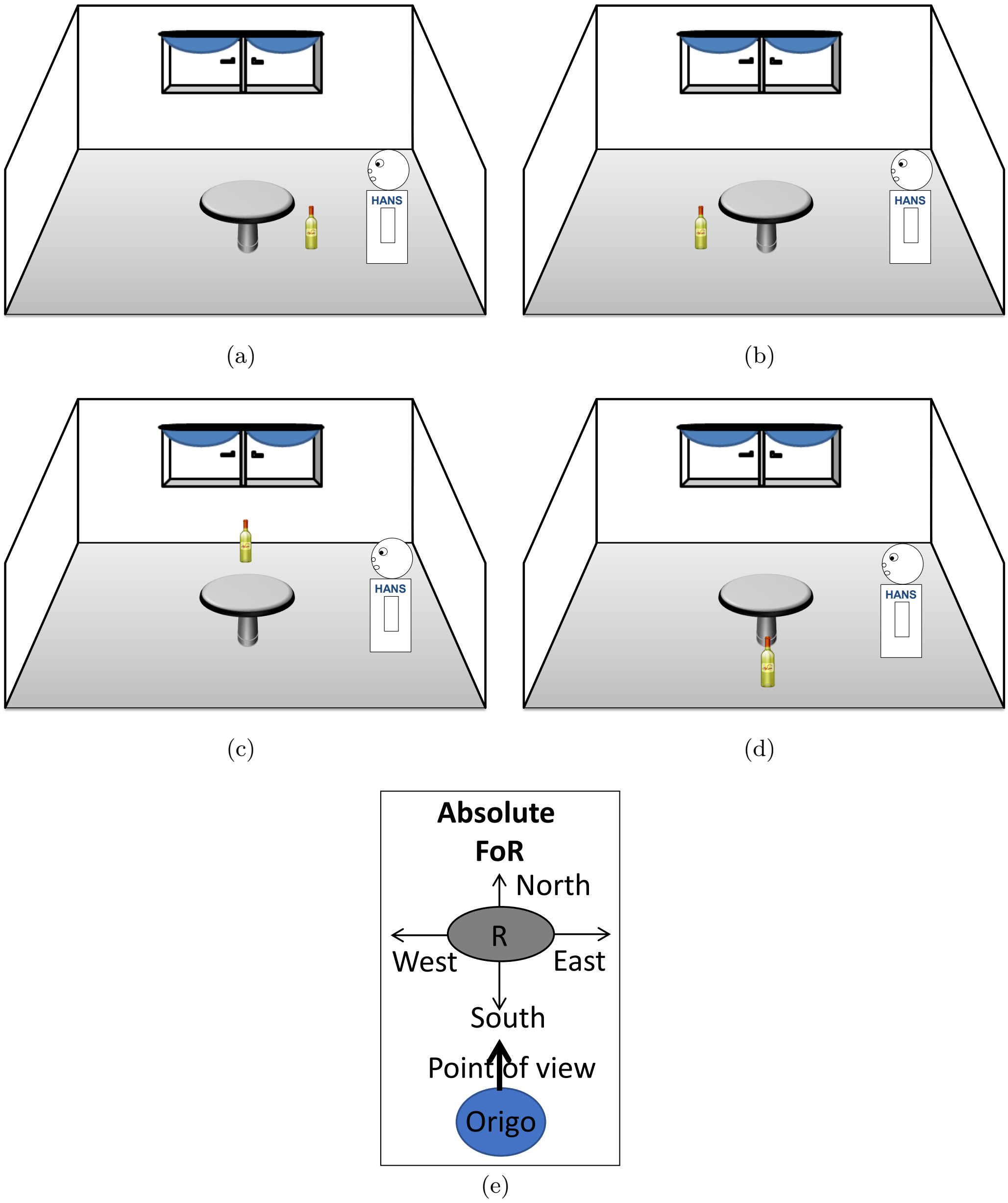


Figure 3.2: Spatial relations between the reference and localized objects in north–south and east–west directions

The description of the four spatial relations is independent of the location of Hans. As with the intrinsic reference frame, the absolute one also has a binary logical structure. The origo of the interpretation of spatial relations is centered on the reference object. The reference object can be represented by any entity in the absolute reference frame – there are no restrictions. However, the geometry of the coordinate system depends on language and culture. The coordinate systems (e.g. of the directions of the compass or of a river or mountains) can differ regarding the degrees (e.g. 90° in the case of the compass for north–east–south–west) that the system is projecting from the reference object (Levinson, 2003a, p. 50).

As per Brown and Levinson (2000, p. 192), the absolute frame of reference is supported by very accurate pointing gestures in the Tzeltal language. The systematic use of gestures and absolute termini supports children in the acquisition of the absolute system (which is successful earlier in Tzeltal than the acquisition of the intrinsic reference frame is in the European languages – see e. g. Levinson, 2003a).

Tenbrink (2011, p. 706 f.) emphasizes that the linguistic expressions belonging to the absolute reference frame when describing a spatial relation differ from those used for the interpretation of the relative or intrinsic reference frame:

> *“this linguistic difference reflects a fundamental difference concerning the conceptual basis for direction assignment. Projective terms rely on an underlying (view) direction for interpretation of the intended spatial relationship; this direction is determined independently of the actual choice of spatial term and is not expressed by it. In contrast, in absolute reference systems the intended direction is chosen from the (culturally or situationally) available orientation system and directly expressed by the spatial term” (Tenbrink, 2011, p. 706 f.).*

Pederson (2003) suggests a sub-type of the absolute reference frame based on the local environment, such as: *The bottle is towards the window from the door.*

3.3.2 The relative frame of reference

The relative reference frame is derived from the human body of the viewer, speaker, or a third person determining polar half-axes *up–down*, *front–back*, *right–left* (e.g. Herrmann, 1990; Grabowski, 1999). However, as has already been shown, the way humans derive their body parts for the interpretation of spatial relation between reference and localized objects may depend on the language used or the kind of the spatial relation (see e.g. Hill, 1982; Levinson, 2003a). Hill (1982) divided the relative reference frame into *facing* and *align* strategies (*reflection* and *translation* in the terminology of Levinson, e.g. Levinson (2003a)). These strategies differ in terms of the interpretation and production of spatial relations along the *front–back* axis (see sections 3.3.2.1 and 3.3.2.2, for further details on the individual strategies). The reflection strategy is more common in English and the translation strategy is more common in Hausa; however, it depends on the kind of the spatial relation. [6] Additionally, there is also a *rotation strategy.* This differs from the reflection strategy as regards the *right–left* axis (see 3.3.2.3). But what does it mean to interpret or describe a spatial relation in terms of the relative reference frame?

In the interpretation or production of spatial relations using the relative frame of reference, the spatial properties of the reference object do not play any important role. This means that the relative reference frame is applied for spatial relations with either an extrinsic reference object or the intrinsicality and functionality of the reference object are ignored. It is not possible to assign fixed sides to an extrinsic object and derive from these sides the regions to describe a spatial relation, than it is necessary to assign sides to the object to use it as a reference object of a particular spatial relation (Grabowski, 1999, p. 98).

In contrast to the intrinsicality and functionality of the particular reference object, the viewpoint of the speaker, viewer, or third person plays a very important role in the description and interpretation of spatial relations according to one of the strategies of the relative reference frame. Moreover, as explained above, the direction of the viewpoint or a pointing gesture is considered to be the origo. Nevertheless, for the interpretation or description of a spatial situation with respect to the relative reference frame, a localized and a reference object are required (similar to the absolute reference frame), supplemented by the origo (and perspective in terms of e.g. Tenbrink, 2011). Both the reference and the localized objects have to be different from the origo. To describe or interpret a spatial relation in terms of the relative frame, the viewer, hearer, or the third person derives and maps body coordinates onto the reference object. The mappings of the coordinates can succeed in terms of three abovementioned strategies. With the translation strategy, the person translates all the polar axes onto the reference object (without the rotation of sides). When interpreting a spatial situation using the rotation strategy, the person conducts a mental rotation for all sides and then maps these onto the reference object. With the reflection strategy, the person conducts a mental rotation for the *front–back* axis only and maps it onto the reference object. These three strategies are presented and explained in greater detail in the subsections that follow (see also e.g. Levinson, 2003a, p. 43 ff.; Tenbrink, 2011, p. 706).

Additionally, the interpretation of a spatial relation using the relative reference frame causes difficulties because the point of view, which is used for the description, is not

[6] In English, static visible and invisible spatial relations should be interpreted and described in accordance with the reflection strategy and the dynamic visible relations regarding the translation one. In contrast, in Hausa the static visible and dynamic visible relation should be interpreted and described in accordance with the translation strategy and the static invisible relation in accordance with the reflection strategy (Hill, 1982, p. 23).

usually expressed, as in the example below (and in 3.3.2.3, 3.3.2.2, 3.3.2.1, e.g. Tenbrink, 2005b, p. 22; Herrmann and Grabowski, 1994):

> The bottle is standing *in front of / behind / to the right of / to the left of* the table (from X's point of view).

To describe or interpret a particular spatial relation, the speaker can consider not only her or his own point of view but also shift it to that of a viewer or a third person, and this for several reasons, for instance politeness to develop a clearer understanding for a child (Herrmann and Grabowski, 1994, p. 121), hierarchy (e.g. Grabowski, 1999, p. 117), or cognitive load (e.g. Mainwaring et al., 2003).

Not only one individual object but also several objects together can serve as a reference object, such as in the case of group-based reference (Moratz and Fischer, 2000). Group-based reference usually includes objects of the same kind, as in:

> *The bottle is located in front of the tables.*

The interpretation of spatial relations using group-based reference objects was not investigated in the current experiment. Refer to Tenbrink (2005b, p. 23) for further details on the linguistics of group-based references.

In contrast to the intrinsic reference frame, the relative one has inferential potential (e.g. Levelt, 1986, p. 191; Fortis, 2010, p. 8):

(a) **Transitivity principle:** The table is to the right of the bottle and the ball is to the right of the table. This implies that the ball is to the right of the bottle.

(b) **Converseness principle:** The bottle is to the left of the table and the table is to the right of the bottle.

Figure 3.3: The principles of *transitivity* and *converseness*

Transitivity and conversion in spatial dimensional expressions depend on the intrinsic and extrinsic orientation and the positioning of the objects in the particular spatial relation (Lang, 1990, p. 91).

According to Levinson (2003a, p. 43 ff.), the *viewer-centered* label of this reference frame is misleading because this perceptual basis is not a necessary condition for it. However, in contrast to the 'deictic' one (shown above), the label is not incorrect.

3.3.2.1 The reflection strategy

Considering the spatial relations in the 3.4 with regard to the reflection / facing strategy from Hans' point of view, the spatial relation between the *bottle* as localized object and the *round table* as reference object would be described as follows:

1. Spatial relation A:
   The bottle is *in front of* the table.
2. Spatial relation B:
   The bottle is *behind* the table.
3. Spatial relation C:
   The bottle is *to the right of* the table.
4. Spatial relation D:
   The bottle is *to the left of* the table.

In accordance with this strategy, the origo of the reference system is the viewpoint of the viewer, speaker, or third person. Here it is from the point of view of Hans. The person conceptualizes the regions from her or his point of view around the reference object and assign sides (Tenbrink, 2005b, p. 24). This means that if Hans changes his position, the description of the spatial relation also changes (e.g. Grabowski, 1999, p. 117).

3.3.2.2 The translation strategy

The translation strategy differs from the reflection strategy with regard to the conceptualization of the *front–back* regions of the reference object (from the point of view of the speaker, viewer, or third person). This is depicted and explained in the 3.5, as in the section for the reflection strategy above.

With regard to the translation strategy from Hans' point of view, the spatial relation between the bottle as localized object and the round table as reference object would be described as follows:

1. Spatial relation A:
   The bottle is *behind* the table.
2. Spatial relation B:
   The bottle is *in front of* the table.

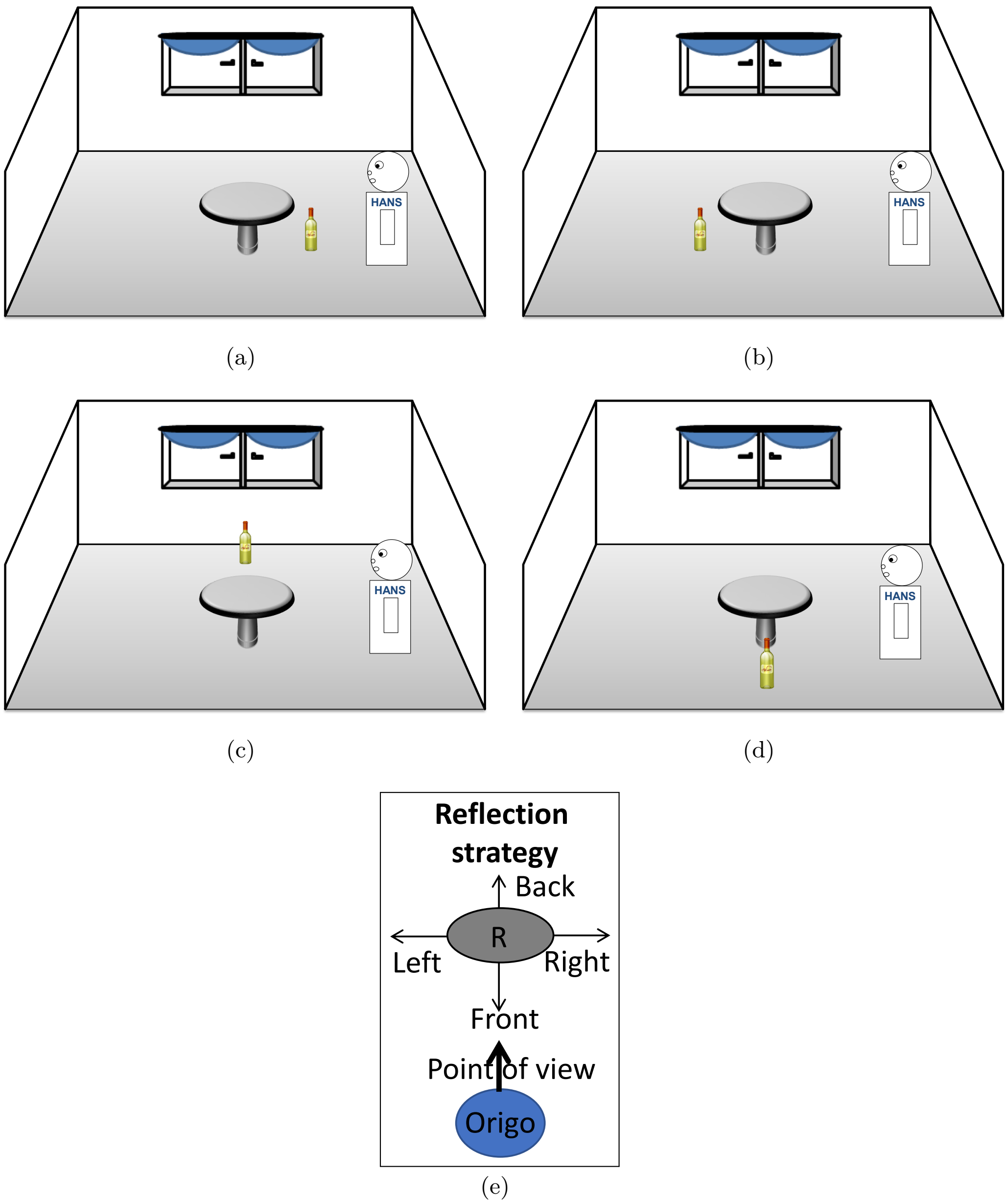


Figure 3.4: Spatial relations between reference and localized objects along the front–back and right–left axis (reflection strategy)

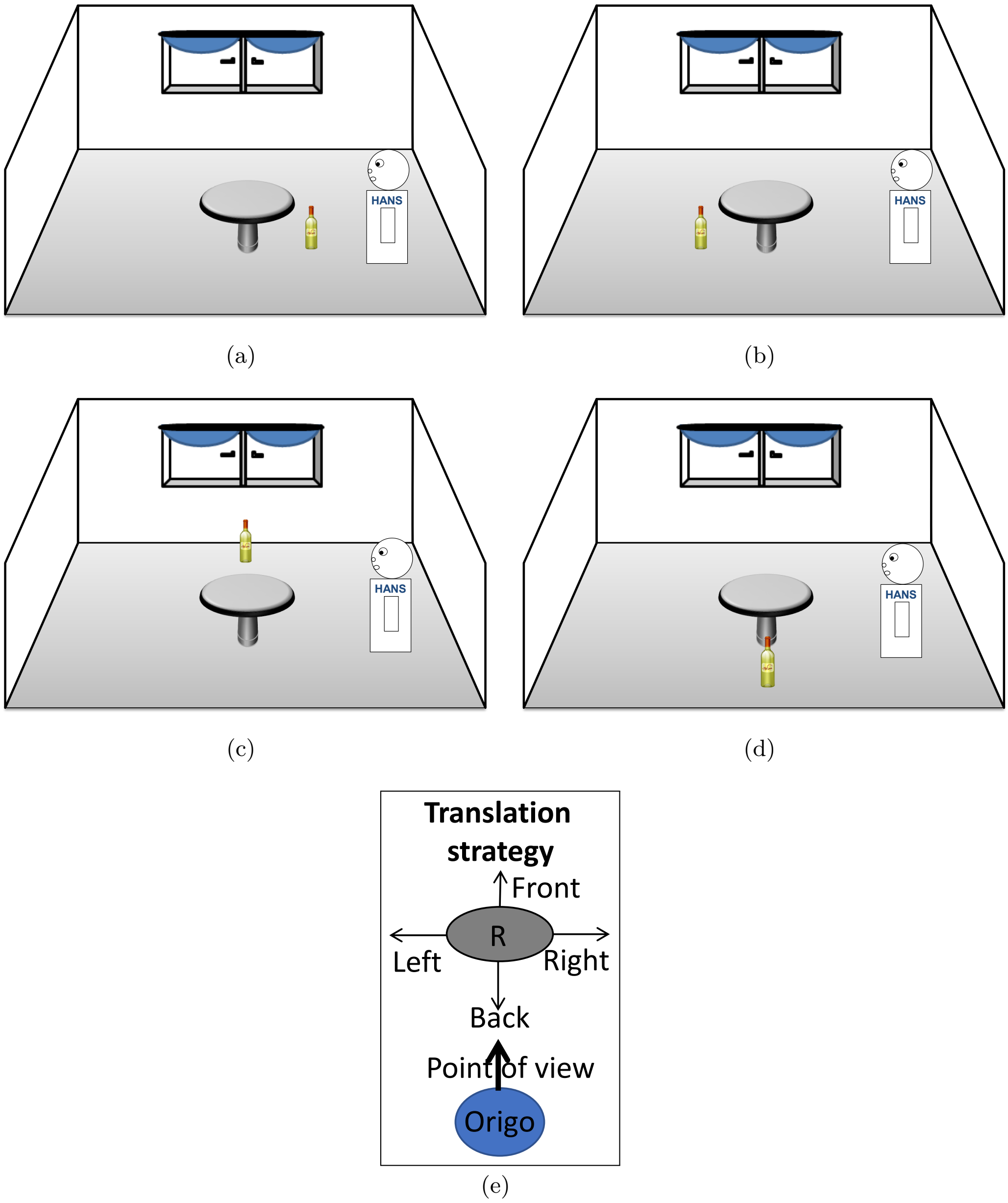


Figure 3.5: Spatial relations between the reference and localized object along the front-back and right-left axis (translation strategy)

3. Spatial relation C:
   The bottle is *to the right of* the table.
4. Spatial relation D:
   The bottle is *to the left of* the table.

We can imagine that when ascribing sides to an object using the translation strategy, the origo (speaker, viewer / addressee, or third person) is "identifying" with the relatum – as if imagining sitting on it and translating the sides to the object (this is similar to side identification using the inside perspective). Again here, the person conceptualizes the regions around the reference object from her or his point of view and can apply these to the relationship between the locations of the localized and reference objects.

The aim of the study is to explore which strategy the German, English, Italian, and Polish participants apply in the interpretation of analogous spatial relations. According to Tenbrink (2005b, p. 24), the translation strategy is used exceptionally only in these four languages:

> *"If the entities involved are part of a queue, then interpretation would be based on the functional front end of the queue rather than X's point of view, which would then lead to similar results as [with the align strategy] .... Similar effects arise if the entities are in motion ..., where the direction of motion induces a perspective on the situation". Tenbrink (2005b, p. 24)*

This also applies for the translation strategy; if Hans changes his position, the description of the spatial relation also changes (Grabowski, 1999, p. 117). However, if the table rotates, the description remains the same.

3.3.2.3 The rotation strategy

The rotation strategy differs from the translation and reflection strategy as regards the right–left axis. Moreover, it also differs from the translation strategy as regards the front–back axis. Let us consider the following four spatial relations – the same as above – but using the rotation strategy (3.6).

With regard to the rotation strategy from Hans' point of view, the spatial relation between the bottle as localized object and the round table as reference object would be described and interpreted as follows:

1. Spatial relation A:
   The bottle is *in front of* the table.
2. Spatial relation B:
   The bottle is *behind* the table.

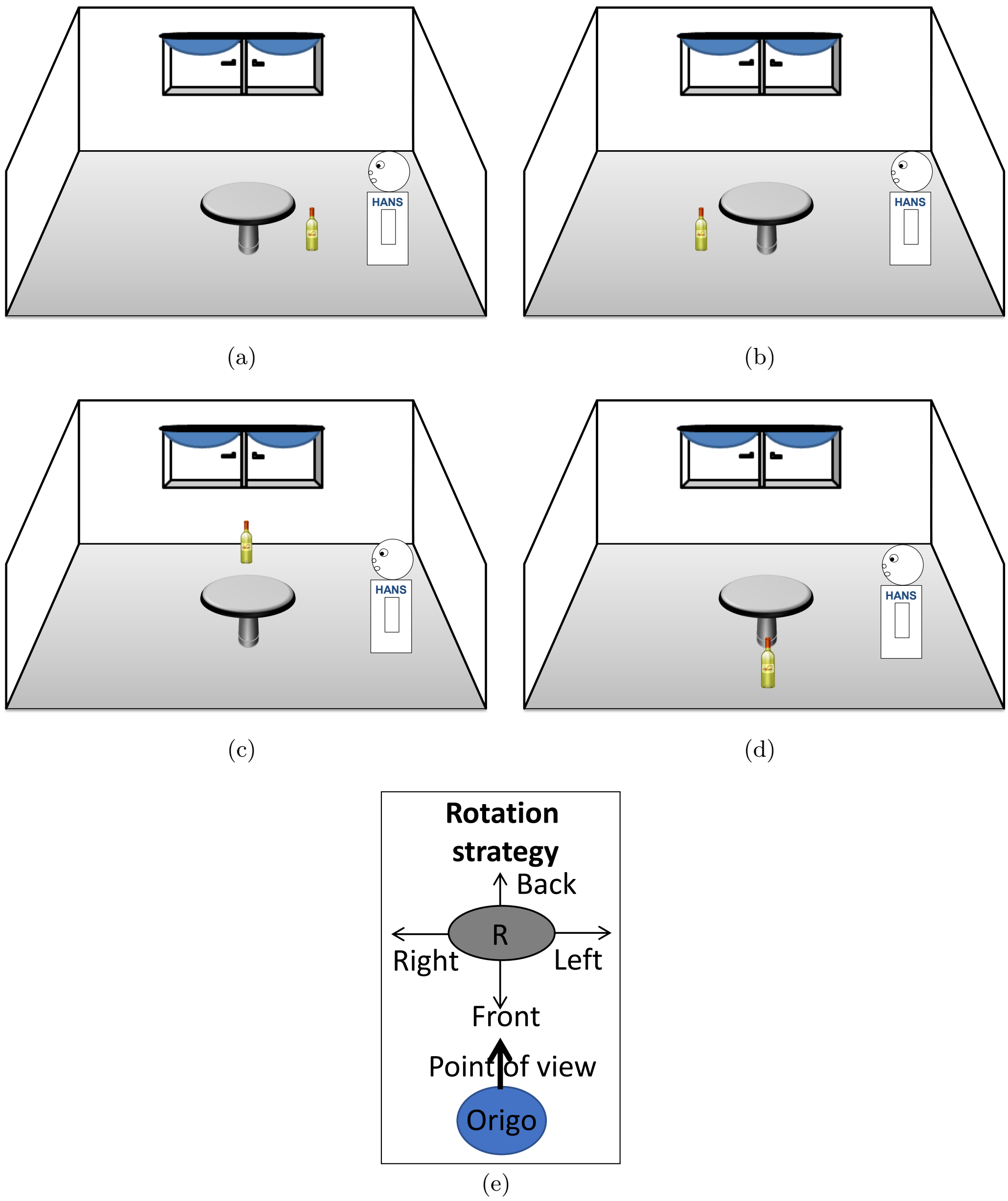


Figure 3.6: Spatial relations between the reference and localized objects along the front–back and right–left axis (rotation strategy)

3. Spatial relation C:
   The bottle is *to the left of* the table.
4. Spatial relation D:
   The bottle is *to the right of* the table.

As with the two previous strategies of the relative reference frame, with the rotation strategy, if Hans changes his position (and his point of view), the description of the spatial relation also changes (Grabowski, 1999, p. 117). However, if the table rotates, the description remains the same.

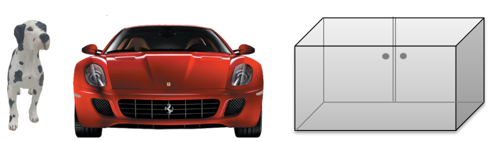
3.3.3 The intrinsic frame of reference

The properties of the reference object play an important role in the interpretation or production of spatial relations using the intrinsic frame of reference. One of the conditions for this reference frame is the intrinsicality and functionality of the reference object. That is, the reference object has to be intrinsic and functional [7] in order to apply this reference frame for the interpretation or description of a spatial relation within it. Overall, an intrinsic spatial relation has to include a localized object and a reference object (as well as a perspective, according to Tenbrink, 2011). However, in contrast to the relative frame, in the intrinsic one, the viewpoint of the speaker, hearer, or a third person does not play as important role as it does in the relative one. As the reference object has its own sides, the coordinate system is derived from the reference object and the poles of its axes are mapped onto regions within the intrinsic reference frame (Grabowski, 1999, p. 98; Levinson, 2003a, p. 41, also refers to this as the "object-centred" coordinate system). This means that any entity that provides a direction can be applied as a reference object for the description or interpretation of a spatial relation following the intrinsic reference frame (e.g. Herrmann, 1990; Tenbrink, 2011). A third entity is not required in an intrinsic spatial relation; as a result, it is also referred to as binary by Levinson (2003a, p. 42) with arguments F and G (Figure and Ground), and as two-point localization by Herrmann (1990). Moreover, Levinson (2003a, p. 42 f.) adds that

> *"[a]n intrinsic relation R(F,G) asserts that F lies in a search domain extending from G on the basis of an angle or line projected from the centre of G, through an anchor point A (usually the named facet 'R'), outwards for a determined distance. F and G may be any objects whatsoever (including ego), and F may be a part of G. The relation R does not support transitive inferences, nor converse inferences"*

[7] It can also possess a particular shape (side identification in Tzeltal, Levinson, 2003a, p. 41).

(see 3.7(a) and 3.7(b)). Unlike the relative reference frame, the intrinsic one has weak inferential potential (e.g. Levelt, 1996, p. 84; Fortis, 2010, p. 8; Levinson, 2003a, p. 50 ff.):



(a) The dog is to the right of the car and the car is to the left of the dog. Because the car and the cupboard have their right and left side adjacent, in this case it is also possible to say: The dog is to the right of the cupboard.

(b) Unlike in this situation: The dog is to the right of the car visible from front and the car is to the left of the dog; this does not imply that the dog is to the right of the car visible from back.

Figure 3.7: Transitivity principle (source for the cars: PNGStock, 2019b)

(a) In the intrinsic reference frame, converseness does not imply automatically. Considering this figure, it is possible to say: The car is to the right of the dog. But this does not imply that the dog is to the left of the car – it is to the right too.

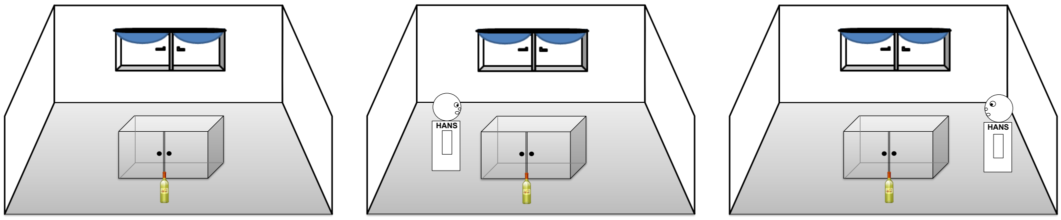
(b) However, for this figure, the following statement applies: The dog is to the right of the car and the car is to the left of the dog.

Figure 3.8: Converseness principle (source for the cars: PNGStock, 2019b)

The relationship between the localized and reference objects can be influenced by several factors (Tenbrink, 2011; also see above 3.2.1). Some of them are:

- size (e.g. Talmy, 2000a);
- the functional relationship between the objects (e.g. Carlson-Radvansky, Covey, et al., 1999); and
- the situational context (e.g. Bateman et al., 2007).

According to Tenbrink (2011, p. 21), the identification of the bottle's position in the following spatial relation – in relation to the cupboard – is unambiguous (3.9).



(a) (b) (c)

Figure 3.9: The bottle is standing in front of the cupboard

1. The bottle is in front of the cupboard.

In this spatial relation, the localization of the speakers and hearers does not count – the identification of the front of the intrinsic object plays the most important role. Of course, there are intrinsic spatial relations in which the intrinsic properties of the speaker / hearer or third person count; this is the case when the speaker / hearer or third person takes the role of origo:

2. The bottle is to the right of me / you / her / him.

To make the theory clearer, I explain the interpretation of spatial relations in terms of the intrinsic reference frame by means of examples from the experiment conducted for the study. Consider these three spatial relations (3.9) – where is the bottle standing?

In accordance with the intrinsic reference frame, all of these intrinsic spatial relations A–C are interpreted as *The bottle is (standing/located) in front of the cupboard* due to the intrinsic and functional properties of the cupboard as reference object (in the European languages). This spatial relation represents the outside perspective of the intrinsic reference frame (Grabowski, 1999). As I have already shown (2.1.2), the inside perspective of the intrinsic reference frame is also possible with vehicle objects as reference.

(a) (b) (c)

Figure 3.10: The bottle is (standing/located) to the right of the car (source for the cars: PNGStock, 2019b).

All these spatial relations (A–C) with the car (vehicle) as reference object are interpreted and described as *The bottle is to the right of the car* in accordance with the intrinsic reference frame (3.10).

Brown and Levinson (2000, p. 179) indicate that Tzeltal native speakers can use an intrinsic frame of reference when the localized and reference objects are close to each other. To describe such spatial relations, Tzeltal native speakers employ body parts, such as *head*.

3. "Kotol ta sjol karo te tz'i'e.
   'The dog is standing at the „head" of the car (i.e., directly in front of it, at its front end).“ (Brown and Levinson, 2000, p. 178)

Following Miller and Johnson-Laird (1976), intrinsic spatial relations are usually interpreted and described using the intrinsic frame of reference (see also Grabowski and Miller, 2000; Abkarian, 1982). However, as Grabowski and Miller (2000) indicate, this is the case in noninteractive situations, where the speaker and the hearer are considered individually. The question that arises for such an interpretation is whether the sender and the recipient interpret the particular reference object as intrinsic or not. Therefore, in my experiment, I asked the participants to identify the cupboard's sides first and then to interpret the spatial relations including it. According to Grabowski and Miller (2000), people from the same culture, which applies to the participants in this study, usually agree on the intrinsic orientation of many objects. The empirical component of this thesis shows that this is not always the case for higher animal entities or vis-à-vis objects.

But why have humans developed the intrinsic reference frame and do they not express all spatial relations using the relative one (Levelt, 1982)? Grabowski and Miller (2000, p. 526) point out the one of its advantages that it is observer and speaker independent.

In addition to the categorization of the intrinsic reference by Levinson (1996) and Levinson (2003b), Tenbrink (2011) introduced the categorization of external and internal spatial relations. Tenbrink distinguishes between the absolute, relative, and intrinsic internal frames of reference, which are analogous to the external ones. The external spatial relations are characterized by spatial relations between objects that are separate: they do not include one another. In contrast, with internal spatial relations, the localized object is included in the reference object. Tenbrink (2011, p. 707) emphasizes that "language sometimes distinguishes between these two topological kinds grammatically (Miller and Johnson-Laird, 1976; Talmy, 2000a):"

4. The bottle is in the front of the cupboard. (internal)
5. The bottle is in front of the cupboard. (external)

In general, Tenbrink (2011, p. 707) explains that

> *"[i]n internal relationships, the relatum is conceptually ascribed part regions that are described by projective terms, sometimes explicitly so by referring to sides (such as 'on the left / right side', Carroll, 1997). As with external relationships, the perspective or direction underlying such a description may come from different sources."*

However, the assumptions for the interpretation and production of external spatial relations are transferred from the external to the internal ones. As I investigated the interpretation of external spatial relations, I do not go into any further detail or discussion of internal reference frames here.

3.3.4 The temporal frame of reference

As with spatial expressions, a temporal relation comprises a reference and a localized object as well as a perspective. Temporal reference frames are analog to the local one (e.g. Tenbrink, 2011). First, these can be divided into A and B series following the theory of McTaggart (1908) (e.g. Tenbrink, 2011, p. 714). In general, the temporal A-series is represented by deictic concepts based on the viewpoint of the observer, and the B-series by non-deictic concepts based on two events relating to each other (cf. Tenbrink, 2011).

McGlone and Harding (1998) has shown that ambiguity is influenced by temporal and spatial concurrence:

1. "Next Wednesday's meeting has been moved forward two days" (Tenbrink, 2011, p. 718).

This famous sentence was used in several experiments to investigate how the spatial thinking can influence temporal thinking (e.g. Boroditsky, 2000; Kranjec, 2006). The idiosyncrasy of the sentence is that it can be interpreted as meaning that the meeting will take place either on Friday or on Monday.

In contrast to the ambiguity expressed by the temporal A-series, the concepts expressed by the temporal B-series are more unambiguous to interpret. The temporal relations expressed by the temporal B-series are directional. While directionality is defined as change, in the temporal meaning it is represented by the change from past to future or other way around (e.g. Galton, 2011; Moore, 2011; Tenbrink, 2011).

Tenbrink (2011) points out that most but not all languages interpret the future as moved forward. For instance, Aymara speakers, an Amerindian language spoken in the Andean highlands of Bolivia, Peru, and Chile, express the future as being behind them – because they cannot see it. In contrast, because they have already seen the past, they express it as being in front of them. In Mandarin, the time can be expressed on the vertical axis (Boroditsky, Fuhrman, et al., 2011).

3.4 Summary and discussion

In this chapter, I have shown what *space* is and which *kinds of space* can be distinguished. However, the main part of this chapter was dedicated to spatial relations, how spatial relations can be conceptualized, because the experiments for the current thesis focused on the interpretation of spatial relations in German, English, Italian, and Polish. Therefore, first I explained what comprises an external static spatial relation because only this kind of relation was investigated. Overall, to interpret or describe a spatial relation in any language, the following inventory of primitives is required: a reference object, a localized object, the viewpoint of the observer / speaker / third person or the direction of the reference object (origo) as a coordinate system (e.g. Levinson, 2003a, p. 39). Not all of these entities have to be present individually in a spatial relation. In a binary spatial relation, only reference and localized objects are necessary. In these, the origo and the perspective are determined by the reference object. In ternary spatial relations, all the entities are necessary; it can either be represented by a spatial relation with an extrinsic reference object or an intrinsic one where the intrinsic and functional properties are ignored.

To describe a spatial relation between objects, the speaker, hearer, or third person has to choose one of the three main reference frames – the *absolute*, *intrinsic*, or *relative*. The *absolute* one is based on a fixed coordinate system such as a compass or river direction; the *intrinsic* one is based on the coordinate system of the reference entity; and the *relative* is based on the coordinate system of the speaker, viewer, or third person. For the latter reference frame, the coordinate system is derived from the human body and is mapped onto the reference object in accordance with one of the strategies of *translation*, *rotation*, or *reflection*.

Levinson (2003a, p. 53) points out that there are languages that use only one or two reference frames. However, there is no language that applies only the relative reference frame. Moreover, Levinson argues that linguistic expressions are connected with the reference frames; therefore it is impossible to say that the language does not affect the choice of the reference frame.

According to Miller and Johnson-Laird (1976, p. 399), humans initially assume intrinsic interpretations:

> *"In interpreting spatial indications, people first determine whether the landmark has intrinsic parts. If it does, they try to interpret the spatial relation intrinsically unless they are explicitly informed to the contrary. If the landmark does not have intrinsic parts relevant to the spatial indication, they must rely on context to provide a deictic interpretation. If both strategies fail, they*

may ask for more explicit information". Miller and Johnson-Laird (1976, p. 399)

Similarly, Ehrich (1985) states that intrinsic reference frame is more common than the "deictic" (relative) ones. However, the results of the experiments conducted for this study show that this statement does not always apply.

Not all researchers agree with these statements, however; for instance, Levinson (2003b) and Tenbrink (2005a) state that

> *"in English or Dutch, both relative and intrinsic frames of reference are available and colloquially used, but the relative frame is clearly predominant for most kinds of spatial description. In the case where more than one frame of reference is available, one may find one frame of reference preferred for one situation, and another for another situation" (Levinson, 2003b, p. 179).*

Tenbrink (2005b, p. 28) indicates that German native speakers use their own perspective more frequently. In contrast, English speakers use the intrinsic reference frame. Additionally, Taylor, Naylor, et al. (1999) show that the intrinsic reference frame is activated first and the relative one is derived from this (see also Tenbrink, 2005b, p. 28).

Finally, Ehrich (1985) investigated German native speakers. She asked the participants to describe a room. Her results indicate that speakers apply the reference frame in a particular spatial relation that seems to be more explicit. For this reason, speakers apply temporal order (then, after) instead of a spatial term (to the right / left of). Moreover, the results reveal that if an intrinsic reference frame is possible, it was applied constantly by 95% of participants.

In sum, in the previous sections, I have shown how humans perceive objects and identify their sides. Subsequently, I explained which options they have for the perception of a spatial relation containing objects. In the next chapter, I explore which linguistic strategies speakers can apply to describe a spatial relation. In a final step, I discuss the results of some studies that have investigated the description, interpretation, and perception of spatial relations in different languages.

4 The coding of spatial relations

> *"Spatial language is used primarily to indicate where things are; indicating where things are is frequently an important aspect of identifying or referring to them; identification and reference are critical aspects of linguistic communication." (Miller and Johnson-Laird, 1976, p. 410; Tenbrink, 2005b, p. 1)*

In the previous chapter, I explained how humans perceive objects and identify their sides. Then, I explored what options viewers of a spatial relation have to perceive it, including the objects. In this chapter, I explain how humans encode spatial relations linguistically. To this end, I build on theoretical assumptions and empirical evidence. Subsequently, in the following chapter, I explain my empirical study and analyze the results of it.

Talmy (1985, p. 61) introduced a universal typology of motion event. In terms of the theory, a motion event includes a localized object moving or located with respect to a reference object (e.g. Slobin, 2006, p. 60). Talmy (1985) and Talmy (2000a) distinguishes between *verb-framed* and *satellite-framed languages. Verb-framed languages* express a location or a movement using a verb – the main verb of the particular clause. In contrast, the *satellite-framed languages* encode a location or motion using a satellite – an element associated with the verb (e.g. Slobin, 2006, p. 61). The languages investigated for this study are representatives of the both groups: verb-framed languages are represented by Italian (a Romance language) while satellite-framed languages are represented by German and English (Germanic languages), and Polish (a Slavic language).

Slobin (2004) extends the typological classification of verb- and satellite-framed languages with equipollently-framed languages. However, the Germanic, Slavic, and Romance languages do not belong to this group.

According to Slobin (2006, p. 72 f.), native speakers of satellite- and verb-framed languages possess different mental imagery. He sums this up as follows:

> *"Such findings suggest that the actual conceptualizations of motion events may differ for speakers of typologically different languages – at least when conceptualizations are evoked by the verbal experiencing of such events through narrative" (Slobin, 2006, p. 73).*

For the current experiment, this is a very interesting statement because languages from both groups were investigated – both *verb-* and *satellite-framed languages* (see 4.1).

<table>
<tr><th>Language type</th><th>Peferred means of expression</th><th>Typical construction type</th><th>Examples</th></tr>
<tr><td>verb-framed</td><td>expressed by finite verb, with subordinate manner expression</td><td>$\text{verb}_{\text{PATH}}$ + subordinate $\text{verb}_{\text{MANNER}}$</td><td>Romance, Semitic, Turkic, Basque, Japanese, Korean</td></tr>
<tr><td>satellite-framed</td><td>path expressed by non-verb element associated with verb</td><td>$\text{verb}_{\text{MANNER}}$ + $\text{satellite}_{\text{PATH}}$</td><td>Germanic, Slavic, Finno-Ugric</td></tr>
<tr><td rowspan="3">equipollently-framed</td><td rowspan="3">path and manner expressed by equivalent grammatical forms</td><td>serial verb: $\text{verb}_{\text{MANNER}}$ + $\text{verb}_{\text{PATH}}$</td><td>Niger-Congo, Hmong-Mien, Sino-Tibetan, Tai-Kadai, Mon-Khmer, Austronesian</td></tr>
<tr><td>bipartite verb: $[\text{manner} + \text{path}]_{\text{VERB}}$</td><td>Algonquian, Athabaskan, Hokan, Klamath-Takelman</td></tr>
<tr><td>generic verb: $\text{coverb}_{\text{MANNER}}$ + $\text{coverb}_{\text{PATH}}$ + $\text{verb}_{\text{GENERIC}}$</td><td>Jaminjungan</td></tr>
</table>

Figure 4.1: Typology of motion event constructions (Slobin, 2004; adapted from Slobin, 2006, p. 64)

4.1 Metaphor theory

> *"The essence of metaphor is understanding and experiencing one kind of thing in terms of another ... metaphor is not just a matter of language, that is, of mere words. We shall argue that, on the contrary, human thought processes are largely metaphorical. This is what we mean when we say that the human conceptual system is metaphorically structured and defined. Metaphors as linguistic expressions are possible precisely because there are metaphors in a person's conceptual system" (Lakoff and Johnson, 1980, p. 5 f.).*

In their famous book, Metaphors We Live By, Lakoff and Johnson (1980) explain step by step what a metaphor is and which kinds of metaphors are represented in languages. The researchers distinguish between several types of metaphors. For instance, *structural metaphors* are "where one concept is metaphorically structured in terms of another" (Lakoff and Johnson, 1980, p. 14). *Orientational metaphor* is metaphor that

> *"organizes a whole system of concepts with respect to another ... since most of them have to do with spatial orientation: up–down, in–out, front–back, on–off, deep–shallow, central–peripheral. These spatial orientations arise from the fact that we have bodies of the sort we have and that they function as they do in our physical environment. Orientational metaphors give a concept a spatial orientation" (Lakoff and Johnson, 1980, p. 14).*

In this section, I do not focus on all kinds of metaphors but rather on *conceptual metaphors* because these demonstrate the important role space plays in our everyday life. The theory assumes that a conceptual metaphor is based on a domain of experience – the *target domain*, which is typically abstract – in terms of another – the *source domain*, which is typically concrete. This definition captures conceptual metaphors both as a process and a product. We can imagine conceptual metaphors as they are presented in the following figure (see 4.2), where the meaning of the source domain is derived and mapped onto the target domain.

According to Lakoff and Johnson (1980), the source domain is the spatial domain. The meaning of the target domain – for instance, *time* – is derived from the spatial one. Moreover, the most important concepts that humans can understand are spatial concepts, such as *below* or *above*. Humans developed the concept of *below* through their experience with space. This is that the result of every person having a body and walking upright. Human body orientation is of central importance for every physical activity according to Lakoff and Johnson (1980, p. 70). While walking, it corresponds to gravity, while sleeping, it does not. The researchers point out that the human body includes

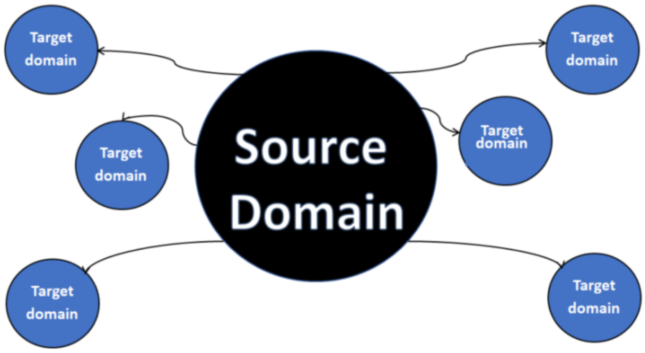


Figure 4.2: Source and target domain

orientations such as *above–below*, *front–back*, and *inside–outside*. In addition, the body also has a *left–right* orientation. In the opinion of Lakoff and Johnson (1980, p. 71), the structure of our concept of space derives from our experience with space. It follows that the meaning of *(in) front* or *above* or *below* is derived from permanent motor actions that are influenced by gravity. However, as Lakoff and Johnson (1980, p. 71) point out, culture also plays an important role in conceptual metaphors and can influence them because all experiences depend on how we culturally perceive space (as is explained in the previous chapters).

Lakoff and Johnson (1980, p. 72) argue that humans perceive each other as entities that are surrounded by the world and separated from it. In other words, humans perceive each other as CONTAINERS – with an interior and exterior. We also experience objects as entities – with an interior and exterior. We map also it onto the perception of time or events as a CONTAINER (Lakoff and Johnson, 1980, p. 73).

The evidence for the derivation of time from the spatial domain also comes from language changes. Namely, the current meaning of the word "time" emerged from the meaning "space marked off" in early Latin and was used as a reference to the sky:

> "The word [tempus] referred originally to space; the meaning 'time' is later, and came about in this way: the quarters of the heavens are thought of as corresponding to and standing for the parts of the day and year; east is morning, south noon, and so on" (Allen, 1880, p. 140, cited in Casasanto, Fotakopoulou, et al., 2010, p. 389).

Additionally, over time, metaphor theory has been confirmed empirically for numerous languages and cultures. Several studies have shown that humans spatialize time. It happens naturally and automatically (e.g. Boroditsky, 2000; Boroditsky and Ramscar, 2002; Boroditsky, 2008; Boroditsky, Fuhrman, et al., 2011). Evidence for this comes from Boroditsky, Fuhrman, et al. (2011) who have empirically shown that mental representations of time differ across cultures and groups.

Boroditsky (2000) provided some of the first empirical evidence for metaphorical structuring using the example of time and space. In the English language, it is possible to express space and time using two metaphors. For time, either MOVING TIME or MOVING EGO is applied. Similarly, for space, it is possible to express it employing moving ego or moving objects. It is worth mentioning that the two metaphors vary in terms of the assignment of *front* and *back* to a timeline. In the ego-moving metaphor, the future is in the front; in the time-moving metaphor, the future is behind.

Investigating 453 participants, Boroditsky (2000) showed that spatial priming influences temporal thinking. Casasanto and Boroditsky (2008) tested how monolingual English native speakers think about time – more precisely, they examined whether English native speakers use the spatial domain to think about time. To this end, Casasanto and Boroditsky (2008) conducted six experiments. In these, they used, for instance, lines of different length for different time durations. The results of their studies (which are similar to many other studies by Boroditsky and Casasanto) reveal that the spatial domain influences the temporal domain but not vice versa. Thus, the results support the assumptions of metaphor theory.

Moreover, Casasanto (2005, p. 3) argues in his dissertation that "the structure of abstract domains such as time appears to depend, in part, on both linguistic experience and on physical experience in perception and motor action." In one of the experiments, Casasanto (2005) explored how often English, Greek, Indonesian, and Spanish native speakers use distance and quantity metaphors for time. The results of the research in Google search machine reveal that the English and Indonesians apply distance expressions for time (e.g. "long time") significantly more frequently than quantity expressions (e.g. "much time"). In contrast, Greek and Spanish native speakers use quantity expressions significantly more frequently than distance expressions (Casasanto, 2005, p. 50). Additionally, the results of another of Casasanto's (2005) studies indicates that quantity interference influences the estimation of duration (for Greek and Spanish native speakers) and distance interference influences the estimation of time (for English and Indonesian native speakers).

In another experiment, Tversky, Kugelmass, et al. (1991) show that American children localize the temporal event from left to right (where *left* is past and *right* is the future). In contrast, Arabic native speaking children follow an order from right to left, where *right* corresponds to the past and *left* to the future. These directions coincide with the time axes, which are common in both these cultures as well as in writing directions.

A very interesting experiment was conducted by Casasanto and Jasmin (2012). They investigated co-gestures using for the temporal and spatial domains. According to the researchers, the direction of deictic space–time metaphors is coded by the first horizontal axis using *in front of* or *behind*. Exceptionally, it is also coded vertically (*up–down*) in English, German, Polish, and Italian. The up–down axis is more specific for Mandarin. It is of interest that the coding of space–time metaphors based on the second horizontal axis (*right–left*) is lacking. However, as Tversky, Kugelmass, et al. (1991) showed American children localize temporal events from left to right. Casasanto and Jasmin examined whether the second horizontal axis dominates gestures about time in English. To this end, they posed questions about events and asked participants to respond to the questions. The researchers recorded the orientation and direction of the gestures that participants used. In another study, the participants were asked to retell a story to their interlocutors. The results of both studies reveal that the participants used gestures along the *right-left* axis more frequently than along the *front–back* axis when talking about space. In particular, they used *right–left* gestures to mark the length of an event. The researchers point out that the co-gestures along the *front–back* axis were rather associated with deictic language (Casasanto and Jasmin, 2012, p. 656; see also Clark, 1973).

Miles, Betka, et al. (2010) employed a dynamic method to investigate spatiotemporal mapping using the dynamics of hand movements during time classifications (past or future). The results of their study show that movement to the right was linked to the future and movement to the left indicated the past. Miles, Betka, et al. (2010) conclude that their study result "affirms that spatiotemporal processing is grounded in the sensory-motor systems that regulate human movement" (Miles, Betka, et al., 2010, p. 213). They used mouse tracking software to investigate how English native speakers match the future and the past with the spatial location (*right* and *left*). The mouse tracking experiment results reveal that English native speakers tended to the right when they were asked about the future and to the left when asked about the past (Miles, Betka, et al., 2010, p. 216 f.).

In my study, I did not investigate language acquisition. However, in this field there is evidence that children acquire the spatial meaning of prepositions before their temporal meaning. Later on, they derive the meaning of the spatial prepositions for the temporal meaning as metaphor (Clark, 1973). According to Clark (1973)'s explanation for English acquisition by children, the children perform it by applying the properties of people's innate perceptual apparatus, which is the starting point for the properties of spatial expressions (Clark, 1973). For instance, children use the local meaning of *in* more frequently than the temporal one (Casasanto, Fotakopoulou, et al., 2010; Clark, 1973). Furthermore, children acquire *here* and *there* more quickly than *now* and *then*. Moreover, children use the question marker *where* earlier than they do *when*.

However, Tenbrink (2011, p. 705) indicate that the conceptual transfer from the local to the temporal domain is not plausible in language. For this claim, Tenbrink (2011) characterized numerous reasons. She provides an extensive overview of the literature focusing on the topic of temporal and local frames of reference and the transfer from the source (main) to the target (aim) domains. First, Tenbrink (2011, p. 705) emphasizes that temporal concepts can actually be expressed in a different way linguistically – for instance, using the grammatical system or the pragmatic principle of order (cf. Reichenbach, 1947; Klein, 1994; Halliday and Matthiessen, 1999). Moreover, there are also lexical items that are employed more frequently in the temporal domain than in the local one such as *earlier / later / before* (Tenbrink, 2011, p. 715). Another important aspect is that the temporal and local properties differ from structural properties – for instance, *dimensional asymmetry* (cf. Traugott, 1978; Galton, 2011). Furthermore, temporal and local descriptions are semantically extremely underspecified regarding the semantics of a particular context. According to Tenbrink (2011, p. 704), the choice of frame of reference in a particular context depends on pragmatics, for instance:

- Perspective choice, which could be specified by "from my point of view," usually remains implicit and is not expressed (cf. Tenbrink, 2011; Levinson, 2003a);
- Dimensional expressions, such as *in front of/behind/to the right of/to the left of* can be applied using two frames of reference – the *relative* and the *intrinsic* (3.3). For this reason, its interpretation can lead to ambiguity. However, Tenbrink (2011) indicates that the ambiguity does not apply as often in the temporal domain as in the local one. In contrast, Boroditsky presents evidence for ambiguity in temporal dimension too (see above). Nonetheless, it is important to keep in mind that the deictic reference points of "perspective" also occur in the temporal domain – for instance, in the expression "move the meeting forward" (Tenbrink, 2011, p. 705; Langacker, 1999).

Overall, there are two possibilities for differentiating temporal expressions:

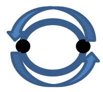
- Deictic (regarding the context) vs. nondeictic (cf. Traugott, 1978; Tenbrink, 2011); and
- Metaphoric: MOVING TIME and MOVING EGO (cf. Clark, 1973; Tenbrink, 2011; Miles, Betka, et al., 2010). According Lakoff and Johnson (1980, p. 53), this observation came from Fillmore during a conversation.

Galton (2011) extended metaphor theory by introducing an important aspect that limits the spatialization of time: Time flies but the space does not. According to Galton (2011), the main important attributes of time are *extension*, *linearity*, *direction*, and *transience*. Following Galton, the *extension* applies as an attribute to time but not to space. However, Galton also emphasizes that the spatial metaphor of transience can be expressed only by the meaning of time by motion. More precisely, no pure spatial transience metaphor is transferred to the domain of time. Therefore, in Galton's opinion, time and space have only the following two attributes in common *linearity* and *direction*. In this manner, transience metaphors are based on a change as a source. Galton (2011, p. 703) emphasizes that many metaphors that are presented in the literature as spatial metaphors for time expression are not spatial but change-based metaphors. These metaphors cannot be considered to be purely spatial. Time seems even to be like space – or like even a kind of space. This means that time and space together form a unified space-time continuum. However, as Galton indicates, this assumption does not consider important attribute of time: transience.

The statement is also partially confirmed by the empirical results of Casasanto, who shows that: "(a) people not only talk about time in terms of space, they also think about it that way, (b) people who use different spatiotemporal metaphors also think about time differently, and (c) learning new spatial metaphors can change the way you mentally represent time" (Casasanto, 2005, p. 12).

It is noteworthy that time can also have a cyclical shape, as in (e.g. Radden, 2011, p. 10):

1. Historia lubi się powtarzać
   (History likes to repeat itself).



In Aymara, the future is behind and the past in the front. As has been explained, the past has been seen and the future not (e.g. Radden, 2011, p. 15). More in detail, "[i]n Aymara, *nayra*, the word for 'front/eye/sight,' is also used to express past time, and *qhipa*, the word for 'back/behind,' also expresses future time (Núñez and Sweetser, 2006, p. 402)" (Radden, 2011, p. 15). The same applies to the spatial preposition *za* ("behind") in Polish, which can express both the future and the past.

In the South American Indian languages Toba, Taos, Jaqaru, Kawki Quechua, and few more, the future is also behind and the past in front. As Radden (2011, p. 16) points out, this arrangement is very well motivated by the metaphor KNOWING IS SEEING.

Metaphor theory also found a few contradictions, for instance, theory of magnitude (ATOM), introduced by Walsh (2003). This proposed that time, space, and quantity are part of a generalized magnitude system in contrast to metaphor theory, which assumes that the spatial domain influences the temporal one. Therefore, the spatial and temporal domains are asymmetrical (e.g. Bottini and Casasanto, 2010).

In this thesis, I investigate whether the temporal meaning of a preposition can influence the spatial one. For example, the German and Polish prepositions *przed* ("in front of", "before"), *za* ("behind" – local, "in" – temporal) and *vor* ("before" and "in front of,") can be used both temporally and locally, in contrast to the English preposition *in front of*, which is mostly used spatially.

4.2 Linguistic devices for the coding of spatial relations

In the previous parts of the thesis, I have explained what kinds of objects exist and how humans identify their sides. I have also explored the fact that side assignment can succeed when different strategies are used. The application of a particular strategy depends, for instance, on culture or context. Then, I explained what comprises a spatial relation and how humans can integrate an object into a context using it as a localized or a reference object. I examined the three main frames of reference (absolute, intrinsic, and relative). Which reference frame a speaker chooses to describe a particular spatial relation can be influenced by the objects involved – their intrinsic, functional, and geometrical features, or merely their shapes. However, how do humans describe a spatial relation linguistically? This is the final matter I explain before reporting the data of my empirical study.

Every experience in our lives is linked to space and time. As Ehrich (1992, p. 1) clarifies, everything that we do and perceive, all our experiences in life, is linked to a particular place and particular time. The localization of an object can be expressed for several reasons, for instance, to describe its spatial relation to the reference object or to focus on one of the objects (e.g. Grabowski, 1999, p. 26; Klein, 1990).

The location of an object can be expressed verbally or nonverbally (e.g. Ehrich, 1992, p. 1; Stoltmann, Fuchs, and Krifka, 2020). Humans use deixis in different ways in everyday situations starting within a few months after birth we use nonverbal deixis such as pointing gestures (Cochet, Jover, et al., 2011; Cochet and Vauclair, 2012) in very different contexts, for example, indicating the location of an object or just playing around with counting rhymes (Stoltmann and Fuchs, 2017; Fuchs and Reichel, 2016). Pointing gestures can be performed in different ways, using the arm, finger, head (Ehrich, 1992, p. 1), palm (Rohlfing, 2019) or eyes. Later on, native speakers of European languages also use deixis verbally in the form of adverbs, adpositions, and pronouns. They begin with the acquisition and use of the topological prepositions between the ages of two and four years and continue with the acquisition of projective prepositions such as *in front of* and *behind*. The acquisition of dimensional spatial expressions is completed at around 11–12 years by native speakers of European languages (e.g. Brown and Levinson, 2000, p. 173; Johnston and Slobin, 1979; Piaget, 1928-primary source in Text in Brown and Levinson, 2000).

Linguists use the term spatial reference frames (or frames of reference) to cover research on linguistic expressions of the spatial circumstances (e.g. Vater, 1996; Grabowski, 1999). They distinguish three linguistic phenomena for spatial frames (e.g. Vater, 1996, p. 45):

Positioning: Positioning is usually expressed by prepositional phrases (e.g. *vor dem Schrank*, "in front of the cupboard") or adverbs (e.g. außen, "outside") (Vater, 1996,

p. 45). This expresses the relationship between the reference and localized objects. However, in English, positioning is marked by the verb and by the prepositional phrase or adverbs. In German, Polish, and Italian, the verb usually marks the kind of the positioning of the localized object (e.g. “stand” or “be located”). Overall, *positioning* expresses where the particular localized object is located, where an event takes place, or in which way the object is located. The position of a localized object can be requested in German by *wo* (“where”) and in Polish by *gdzie*, its equivalent. However, in English, *where*, and Italian, *dove*, can also be applied to motion, that is directionalization, as in: *Where did you locate the bottle?*

Directionalization: The spatial change of a place (in a particular direction) is referred to as *directionalization*. Furthermore, the indications of spatial paths that are followed by changes are referred to as directionalization. The manner of the directionalization is coded by verbs (e.g. *stellen*, “put” or *fahren*, “drive”). According to Vater (1996, p. 45), the source and the goal of the directionalization are expressed by prepositional phrases (e.g. *vor den Schrank*, “in front of the cupboard”) or adverbs (e.g. *vorwärts*, “forward”). However, Klein (1991, p. 89) points out that the term is confusing because the expressions belonging to the group do not have to code a direction – compare *nach Berlin*, “to Berlin.” There are several directions that lead to Berlin (e.g. to the right/left/north/south) (see Grabowski, 1999, p. 23). Directionalization can be requested in German by *wohin* (“where”). According to Levinson (2003a, p. 64), all languages can encode where-questions and use at least one of the three reference frames to describe or interpret a spatial relation.

Dimensioning: Dimensioning refers to the spatial properties of objects or object categories that imply spatial properties. Dimensioning is mostly coded by adjectives (e.g. *lang*, “long” or *klein*, “small”) or nouns.

Along with the definitions of Vater (1996), the current thesis focuses only on positioning (“Positionierung”). However, as pointed out by Levinson (2003a, p. 98), this categorization is misleading and refers to European languages in particular. Levinson shows, for several languages, that it is not always the case that a spatial relation is encoded by one word class, the adpositions. I agree with Levinson (2003a, p. 98) that the spatial information for the description of a spatial relation is distributed throughout a sentence. The relationship between regions of objects can be expressed by more than merely one word class. Levinson (2003a, p. 99) created a structure for the grammar of space.

Nonetheless, the four languages I investigated in the empirical studies are European languages, therefore the statement above is correct. Moreover, there are three conditions for successfully communicating spatial relations (see e.g. Grabowski, 1999, p. 38; Grabowski and Miller, 2000, p. 518; and Klein, 1994, p. 165):

1. Both the speaker and hearer have to possess the same or at least almost the same conception of the spatial area that is referred to in the expression. This condition relates to the general spatial conception of the speaker and hearer as well as to their conceptions of the particular spatial relation.
2. Both the speaker and hearer have to know the semantics of the applied/used spatial expressions. More precisely, both have to know how to associate the relations between the objects and the spatial expressions.
3. Both the speaker and hearer have to complement the description of the particular spatial relation with contextual information. It is important for the speaker – as a condition for production – and for hearer for the interpretation of the description of the spatial relation. Moreover, it is important that the contextual information associated with the description and interpretation of the speaker and hearer match. This contextual information plays an important role for the situational spatial conceptions.

In the following subsections, I explain what *deixis* is and what its meaning depends on. Subsequently, I illustrate how to use deixis in context – depending on the reference frame. In this way, I focus on the ambiguity of interpretation between the reference frames, which is rather an exception than a rule and can be replaced by unambiguous expression according to Levinson (2003a, p. 74).

4.2.1 Deixis

The term *deixis* was introduced into linguistics by Bühler (1934). The linguistic phenomenon distinguishes the shift of meaning. Bußmann (2002, p. 149 f.) extends the definition, explaining that deixis can be a process of pointing, referring to situational elements by gestures or linguistic expressions, which are language specific (e.g. Ehrich, 1992, p. 1; Klippel and Montello, 2007 show the influence of language on the conceptualization of turn directions). The meaning of linguistic deictic expressions depends on their context: *when*, *where*, and *by whom* they are used (Weissenborn and Klein, 1982, p. 2). Three types of deixes are distinguished in linguistics: personal (pronouns, e.g. *I, me, your*), temporal (temporal adverbs, e.g. *now, later, and tomorrow*), and local. Local deixis is divided in *primary* (*here, there*) and *secondary*. The primary local deixis *here* indicates the position of the speaker as the origo of the particular situation. According to Rauh (1983, p. 26), *here* refers to the coding place too. The second primary local deixis in English is *there* and can refer to all possible locations except that of the speaker. Three of the languages I investigated in this dissertation are characterized by two primary local deixes: English, Italian, and Polish. In contrast, German has three primary local deixes: *hier*, *da*, and *dort* (e.g. Ehrich, 1982). Levinson (2003a, p. 70) deepened the idea of deixis and explained that due to the lack of angular specification in primary deixes, expressions are often accompanied by gesture. Gesture can provide finer degrees of angular arc than any linguistic specification. The spatial deixis *here* and *there* are the most direct spatial deixis (Levinson, 1994a, p. 855) – *here* indicates a region around the speaker (including her- or himself) and *there* indicates a region at a distance from the speaker. Overall, Levinson (1994a, p. 853) defines *deixis* as a word for pointing, which

> *"refers to a particular way in which the interpretation of certain linguistic expressions ('deictic' or 'indexicals') is dependent on the context in which they are produced or interpreted. For example,* I *refers to the person currently speaking,* you *to the intended recipients or addresses,* now *to the time of speaking,* here *to the place of speaking,* this finger *to the currently indicated finger, and so on. These deictic expressions introduce a fundamental relativity of interpretation: uttering* I am here now *will express quite different propositions on each occasion of use. This relativity makes clear the importance of the distinction between sentence-meaning and utterance-meaning or interpretation: in large part because of deixis, one cannot talk about sentences expressing propositions – only the use of an affirmative sentence in a context expresses a determinate proposition." Levinson (1994a, p. 853)*

Levinson (1994a, p. 854 f.) continues to the effect that "[l]inguistics normally think of deixis as organized around a 'deictic center,' constituted by the speaker and his or her location in space and time at the time of speaking". In opinion of Levinson – this is an oversimplification. He argued that

> *"the identity and location of the addressee are also normally presumed, forming a two-centered system. A further normal assumption is that where linguistic expressions exhibit both deictic and non-deictic uses, the deictic ones are basic, and the non-deictic ones derived (or transposed, as Bühler put it). Thus here and now normally refer to the place and time of speaking, but in What should he do here now, Harry wondered?, the deictic center has been shifted or transposed from writer to the protagonist, Harry". Levinson (1994a, p. 854)*

As I focus on secondary local deixis in this work, I do not further analyze primary local deixes here. *Secondary local deixis* is represented by *adverbs*, *adjectives*, and *adpositions* (primary and secondary; see Skibicki, 2007, p. 219; Helbig and Buscha, 2001, p. 359); *local adverbs* can be considered "einstellige" prepositions (see Bierwisch, 1988). This study focuses on the interpretation of secondary local deixes in German, English, Italian, and Polish. *Secondary local deixes*[1] expresses the relationship between the reference and

[1] In accordance with Miller and Johnson-Laird (1976), the secondary local deixes are labelled as secondary

the localized object. In particular, it expresses the region between the localized object and the region of the reference object (Ehrich, 1992, p. 17). Therefore, secondary local deixes are analyzed as a *region-constituting function*.

Moreover, Klein (1990, p. 21) distinguishes between *structural* and *global contextual* dependency. According to Klein (1990, p. 21), all natural languages have expressions, which meaning demands systematically a specific supplement from the context, the *origo* (Bühler, 1934; Klein, 1990, p. 21). The origo can be shifted as a result of different processes:

- The position of the hearer: Here, the viewpoint of the hearer is considered the origo (compare this with the “complex” spatial relations in the empirical study). However, it is dependent on a speech act.
- The fixed (frozen, “gefrorene”) origo: Here, the intrinsic object is considered the origo but only if it is canonically positioned (compare this with the spatial relations in the empirical study with the dog or cupboard in this thesis: Where is the bottle standing?)
- Gestural shift: The origo can be shifted by means of pointing gestures (see also Fricke, 2002; Fricke, 2014; Stoltmann and Fuchs, 2017).
- Deixis phantasma: Instead of a real position, a fictive position can be considered the origo. This phenomenon was referred to as “deixis am phantasma” by Bühler (1934). In this case, the origo shift has to be marked by an additional contextual embedding (Klein, 1990, p. 22).

Components of secondary local deixis are also referred to as dimensional prepositions. This term was introduced into linguistics by Wunderlich and Herweg (1991, p. 778):

“Eine geschlossene Klasse von in der Regel sechs Ausdrücken bilden die dimensionalen Präpositionen: vor, hinter, über, unter, rechts, links.”[2] (The six dimensional prepositions build a closed class: in front of, behind, above, below, to the right of, to the left of.)

The dimensional prepositions are referred to as dimensional[3] because they express the relation between at least two entities along a particular spatial dimension of a coordinate system (x, y, or z; e.g. Klabunde, 1998; Van der Zee and Slack, 2003; Tenbrink, 2005b). As they are deixes, their application often depends on the context (as shown above). The

because those are applied intrinsically usually (e. g Grabowski (1999, p. 126)). However, it requires intrinsic (reference) object. Following Pribbenow (1991, p. 614), the intrinsic usage is preferred if the reference object is intrinsic and the context of the analyzed expression does not suggest the relative application.

[2]Klabunde (2000, p. 193) called these “prototypical dimensional prepositions”.

[3]The dimensional prepositions are also called projective prepositions (e.g. Herskovits, 1986) and directional prepositions (e.g. Van der Zee and Slack, 2003). In this work, I will use the name dimensional prepositions – analogous to Thora Tenbrink because it is most unambiguous.

interpretation of a particular dimensional preposition is influenced by the verb that is employed in the construction (Coventry and Garrod, 2004, p. 10 f.).

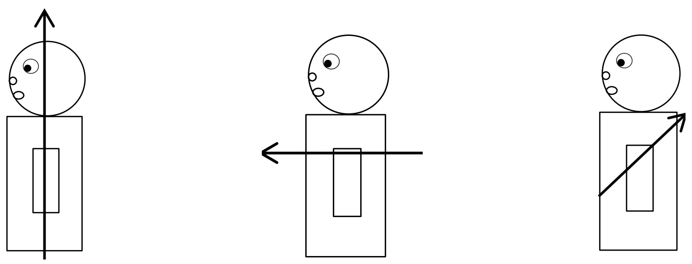
The semantics of dimensional spatial expressions is derived from the three axes (x, y, and z), where the origo serves as a zero point. The human body thereby serves as a pattern for the directionality. The axes and expressions are derived from them – in particular from the corporeal axes: The *front* is where the eyes are and the *back* is the opposite. The *left side* is where the heart is and the *right* is again the opposite. The upper side is where the head is when the body is positioned canonically, and down is again the opposite. The directions of the current egocentric space perception are derived from this asymmetry (2.1.3 for side assignment; Grabowski, 1999, p. 72; Clark, 1973; Klein, 1994; Levinson, 2003a, p. 43; Miller and Johnson-Laird, 1976, p. 381 ff.; Perużyńska, 2012a; Stoltmann, 2014; Tyler and Evans, 2003, p. 155; see Figure 4.3).

Vertical axis (up–down) The vertical dimension arises out of the axis that goes through head and feet (in a stretched body posture). The positive pole is *up* and negative *down*. The meaning of the poles is derived from metaphor theory.

1st horizontal axis (front–back) The first horizontal axis is also referred to as the sagittal. It arises from the axis that goes through the back and the chest. The positive pole of the axis is *front* (at the chest) and the negative *back* (at the back). The positive direction of the dimension is characterized by the sensory organs – eyes and ears as well as mouth and nose.

2nd horizontal axis (right–left) The second horizontal dimension arises from the axis that goes through the shoulders. The positive pole is *right* and the negative *left*.

All of the dimensional prepositions can be interpreted ambiguously, as can the vertical ones. This may happen when the body or the intrinsic object is not in the canonical



(a) Vertical axis (up–down) (b) 1st horizontal axis (front–back) (c) 2nd horizontal axis (right–left)

Figure 4.3: Derivation of corporeal axes

position. Klein (1990) explains this using the example of a bed: when lying on a bed, *down* is where the feet are. This means that gravity does not match the body's orientation. According to Klein (1990), in spatial relations in which the body's orientation does not match gravity, the body's orientation dominates. Carlson-Radvansky and Tang (2000) explored the use of the spatial preposition *above* by English native speakers. To this end, the researchers conducted an acceptability experiment using a scale from 1 to 7 which was shown to the 80 participants investigating pairs of pictures and sentences. The results of the study reveal that "function also influences how the orientation of the axes of a reference frame is set" (Carlson-Radvansky and Tang, 2000, p. 812). The results of this study extend previous research on the role of the functional relationship between objects in a particular spatial relation. For instance, Carlson-Radvansky and Radvansky (1996) have shown that a functional relationship between objects plays an important role when selecting a reference frame. Moreover, Carlson-Radvansky, Covey, et al. (1999) show "an influence of function on where the origin of a reference frame was imposed" (Carlson-Radvansky and Tang, 2000, p. 812). Tenbrink demonstrated a prototype of her upcoming experiment during the 7th International Conference on Spatial Cognition in 2018. In this experiment, Tenbrink will investigate the perception of people while they are walking vertically on a wall or window.

Some dimensional spatial prepositions in German and Polish can also be considered to be so-called *Wechselpräpositionen*, because these use different cases (e.g. Klabunde, 1998, p. 43). Depending on the case, the described spatial relation can either be positional or dynamic/directional. The first codes the position of the localized object with respect to the reference object. For this purpose, the *dative* is used as case. It determines the region (the static location):

- *Die Flasche steht vor dem Schrank.*
  "The bottle is standing in front of the cupboard."

The dynamic spatial relation is expressed using accusative and specifies a positional change of the localized object with respect to the reference object:

- *Stelle die Flasche vor den Schrank.*
  "Put the bottle in front of the cupboard."

The axes and the region of the reference object are considered the baseline for the descriptions (Klabunde, 1998, p. 43). However, in German, it is interesting that the prepositions of the second horizontal axis *rechts von*, "to the right of" and *links von*, "to the left of" connect with the dative only because of *von*, "of." This means that the directionality has to be encoded by other linguistic devices, for instance, a verb in the case of German:

- *Stelle die Flasche links vom Schrank.*
  “Put the bottle to the left of the cupboard.”

In contrast to *rechts von* and *links von*, *neben* “next to” can be linked either with the dative or accusative and belongs to the same axis as the *right of* and *left of* do (Klabunde, 2000, p. 195). In this manner, *neben* has a nonspecific meaning and can express either the right or the left side. Overall, it can be summed up that dimensional spatial prepositions are used to describe a spatial relation between the regions of the reference and localized objects. The meaning of the particular preposition specifies the kind of relation (Grabowski, 1998, p. 13).

Ehrich (1992, p. 11) points out a very interesting and important difference between primary local deixis (which Ehrich refers to as “positional deixis”) and secondary local deixis (which she refers to as “dimensional deixis”) which is particularly relevant for my experiment. It applies for primary local deixis: Embedding primary deixis from direct speech into indirect speech, the deixis has to be shifted. This can be observed in the following example:

1. Thomas: The bottle is standing here. (Direct speech)
   Kasia: Thomas said that the bottle is standing there. (Indirect speech)
   Kasia: *Thomas said that the bottle is standing here. (Indirect speech)

According to Ehrich, the last example is impossible, though of course only when Thomas and Kasia do not share the same region. Following Ehrich (1992, p. 11), personal deixis demonstrates similarities with primary local deixis:

2 Thomas: The bottle is to the right of me. (Direct speech)
  Kasia: Thomas said that the bottle is standing to the right of him. (Indirect speech)
  Kasia: *Thomas said that the bottle is standing to the right of me. (Indirect speech)

In contrast to primary local deixis and to personal deixis, secondary local deixis does not change between direct and indirect speech:

3 Thomas: The bottle is standing to the right of the cupboard. (Direct speech)
  Kasia: Thomas said that the bottle is standing to the right of the cupboard. (Indirect speech)
  Kasia: *Thomas said that the bottle is standing to the left of the cupboard. (Indirect speech)

I agree with Ehrich (1992, p. 11) that personal and primary local deixes are far more bound to the distribution of roles in a particular situation than are secondary local (dimensional) deixis. The latter are more independent of the persons and objects involved in particular situations. These can be bound only indirectly using personal pronouns.

Carstensen (2002, p. 1) explains that, in contrast to dimensional spatial expressions, adjectives and measurement phrases are applied to specify the distance between objects. I agree that the adjectives can express the distance between objects. However, I do not think that dimensional adjectives express distance. I follow the assumption of Svorou (1994, p. 166) and Sadowski (1998, p. 166) that dimensional adjectives express the spatial features of particular objects. Leßmöllmann (2002) conducted an analysis on dimensional adjectives that shows that their meaning depends on the orientation of an object. For instance, a pen that is lying horizontally can be described as long. When the pen is upright, it is possible to assign to it the adjective *high* (Leßmöllmann, 2002, p. 118 f.). Additionally, Klabunde (1998) notes that *adverbs* refer to interior space and *prepositions* to exterior space (see also Carroll, 2012, for a deep meaning analysis encoded by case and verbal particles).

4.2.2 Description of spatial relations

> "Spatial language, properly analyzed, can shed light on spatial thinking" (Landau and Jackendoff, 1993, p. 217).

Within the scope of description of spatial relations, Levelt (1982) considered the phenomenon of *linearization.* Levelt (1982, p. 199) defined *linearization* as the information order that speakers use in discourse. According to Levelt, only exceptional reports – such as accident reports and meal descriptions – contain an intrinsic linear order. Usually, reports or descriptions do not possess intrinsic linear order. A description of an apartment containing numerous objects can serve as an example. Following Linde and Labov (1975), a description of an apartment consists of a two-dimensional structure due to the layout, and this has to be mapped onto a linear order. This process is referred to as a *linearization strategy* by Linde and Labov (1975) (cf. Levelt, 1982). Ullmer-Ehrich (1982) extended the work on apartment descriptions, asking participants to describe the living room. Ullmer-Ehrich (1982) found out that the participants located themselves in the doorway of the room and used a gaze tour. They described the objects one by one either from their left to their right or the other way around. A few participants even forgot to mention the furniture in the middle of the room, probably because it was not part of the gaze tour. However, spatial descriptions are more linearized than many others, for instance, explanations of games, which are significantly less structured. As in my work, I focus on the interpretation of simple spatial relations – with already introduced descriptions – I do not further consider the model here. The results of the empirical study of Levelt (1982) with 53 participants who were asked to describe a network, reveal that 33 participants were “jumpers.” This means that they jumped between the nodes when explaining the network. Nineteen participants turned out to be movers. More precisely, they moved between the nodes while explaining the network. The rest showed a mixed structure of motions and jumps (Levelt, 1982, p. 214).

Eschenbach and Kulik (1997, p. 207)

> *“argue that the relations given by* in front of *and* behind *can be modeled on the basis of linear orders and on the basis of axes, whereas the relations given by* left *and* right *can be modeled as planar and on the basis of regions. The explicit characterization of the means necessary to specify the intrinsic and deictic uses thereby sheds light on the structures contributed by different frames of reference and therefore contributes to understanding the deictic/intrinsic-distinction”.*

But which linguistic devices do speakers need to express a spatial localization and what are their features? Let us repeat a few steps from the previous sections. A region is described by referring to another region, which is considered as a known place in the particular situation or at least as identifiable (Klein, 1990, p. 11). To describe a spatial relation, humans usually need numerous linguistic devices, as shown in the previous sections:

- Adpositions (prepositions, postpositions, circumposition)
- Verbs
- Adverbs
- Case
- Nouns (e.g. Klein, 1990, p. 9; Levinson, 2003a, p. 99).

With a verbal description of spatial relation, all the linguistic devices affect one another. Additionally, a particular expression is influenced by different factors: syntactical, semantic, and pragmatic (Klein, 1990, p. 9). As a result, numerous difficulties arise when describing a spatial relation: reference area, the meaning of the expression (e.g. deixis), and contextual integration. To understand a description of a particular spatial relation, the sender and the recipient have to command the same or at least a similar spatial imagination. Moreover, the sender and the recipient have to know the meaning of the applied expressions as well as the rules for their application and interpretation. This fact can cause difficulties for interlocutors of different cultures and with different native languages. In addition, the sender and the recipient have to properly connect the meaning of the individual expressions with the contextual information (Klein, 1990, p. 9 f.).

Due to the contextual information, the viewpoint of the speaker/hearer or third person plays a very important role in the coding of a particular spatial relation. Furthermore, for distance coding, humans use experience (see above 3.1). The physical position of the viewer serves as an important factor for the coding of dimensional spatial relationships (ibid.). Moreover, Vorwerg and Rickheit (2000, p. 11) point out that when the position or the viewpoint of the viewer changes, the description of the spatial relationship changes too. In contrast, a physical change in the viewer or her/his point of view does not change the distance between the two objects. Considered in greater detail, it can change the estimation of the distance because the relationship can be clearer or less clear. It is worth mentioning that the point of view of the viewer plays an important role only when dimensional prepositions and not topological ones are used (cf. Vorwerg and Rickheit, 2000, p. 12).

1 Dimensional spatial expressions:
The bottle is standing to the right of the table.

2 Topological spatial expressions:
The bottle is standing on the table.

As I have shown above, viewpoint also does not affect the description of an intrinsic spatial relation with a dimensional spatial expression (as long as the assumptions for the intrinsic reference frame are considered); therefore, I cannot fully agree with the statement of Vorwerg and Rickheit (2000).

3 Dimensional spatial expression: The bottle is standing to the right of the cupboard.
The bottle is standing to the right of the table (pointing it out).

4 Topological spatial expressions: The bottle is standing on the cupboard.

Janzen and Katz (2000, p. 53) extend this point. Following their assumption, the hearer and speaker have to possess approximately the same viewpoint of the spatial relation and the spatial arrangement. They both have to consider the particular situation from the same viewpoint to describe and interpret it in exactly the same way. For this purpose, the simplest option for the speaker is to use the egocentric strategy and expect that the hearer empathizes with the role of the speaker. Janzen and Katz (2000, p. 53) based on the statement of Herrmann and Grabowski (1994, p. 123 ff.), who point out that an egocentric description of spatial relations is applied most commonly. However, there are few exceptions: sometimes the speaker shifts the perspective to that of the hearer while describing a spatial relation. There are further reasons for such shifts, such as *politeness* and *poor language competence* of the hearer (Janzen and Katz, 2000, p. 53 f.; Herrmann and Grabowski, 1994, p. 121; see also 3.3.2).

Furthermore, Leßmöllmann (2002, p. 101) follows the assumptions of the viewpoint. She indicates that the form of a reference object does not play an important role in encoding the relationship between the reference and localized objects. She points out that usually the viewpoint accounts for this. When the viewpoint changes, the speaker employs a different preposition. In my opinion, this only counts for two more general cases:

- An extrinsic object as a reference object (only in verbal expressions); and
- Ignorance of the reference object's intrinsicality and functionality.

Leßmöllmann (2002, p. 101) explains her assumption by means of two examples with an extrinsic reference object, though she does not limit her statement to this object group alone. Carroll and Stutterheim (1993) argues that English speakers apply the intrinsic reference frame most frequently based on the intrinsic object's properties, and German native speakers deviate from this strategy when describing or interpreting a spatial relation with an intrinsic object and instead apply the relative reference frame. This means that German native speakers tend to split the regions from their point of view and ignore the intrinsic features of the reference object. This means that the assumption of Leßmöllmann (2002) coincides with that of Carroll and Stutterheim (1993) but only for German native speakers.

In contrast to these statements, Levinson (2003a, p. 74) indicates that the ambiguity of interpretation between reference frames is rather an exception than the rule (this is in contrast to the statements of, e.g., Miller and Johnson-Laird, 1976, p. 404, Carlson-Radvansky and Irwin, 1993, p. 242 and Svorou, 1994, p. 23).

"The English ambiguity in *The dog is in front of the truck* reflects the diachronic origin of many relative systems from intrinsic systems, and disappears in related constructions, like *in the front of the truck*, at the truck's front etc. which have only the intrinsic interpretation" (Levinson, 2003a, p. 74).

Carroll and Stutterheim (1993) demonstrate the difference between transitive and intransitive expressions. Transitive ones can be applied in the context of the external parts of the reference object. This means that the region that can be expressed using transitive expressions begins at the outer boundary of the reference object (cf. Carroll and Stutterheim, 1993, p. 1021; Becker and Ward, 1991). However, intransitive expressions can be used for the internal description of the reference object. These do not have to be employed for the expression of spatial relations at the outer boundary. Intransitive expressions are *in front of/at the back* and express the global spatial regions of a reference object, which begin in the middle of a reference object and end at the outer boundary (cf. Levinson, 2003a). Intransitive expressions in English refer to the object's sides and can be represented by *at the top* or *at the front*. These expressions rely on the intrinsic parts of reference object. In contrast, spatial expressions applied without a reference object are interpreted egocentrically. In general, transitive expressions are mostly prepositions and are used to describe spatial relations including those of a reference object. Transitive expressions are used linearly and are structured point by point (at least in German and English).

It follows that there are contradictory assumptions regarding the use of dimensional spatial expressions – they are only or mostly unambiguous following the expectations of intrinsic reference frame and ambiguous following that of the interlocutor's viewpoint extended by relative reference frame (one of its strategies). Kessler (2000) established a simulation model for the use of dimensional spatial prepositions. It is based on the empirical evidence. When hearing the sentence "Put the bottle to the left of the table," the hearer has to decide on one of the frames of reference. Thereafter, the frame of reference will be used for the three spatial dimensions. Kessler (2000, p. 160 f.) mentions two possible frames of reference; however, in my opinion only one is possible – the relative (due to the reference object, which does not possess any intrinsic or functional left side). However, the relative frame of reference provides three possibilities regarding the three strategies of reflection, translation, and rotation. Kessler (2000, p. 160 f.) points out that the difference between self-rotation and the rotation of an object is linked to a different form of mental effort and also depends on the angle of rotation. The effort involved in object rotation continuously increases proportionate to the angle. The effort involved in self-rotation increases significantly after 90° and increases proportionate to the angle of the rotations.

In the simulation of Kessler (2000, p. 170), the expressions for the second horizontal axis (*right-left*) are processed more quickly than those for the first horizontal axis (*front-behind*) in spatial relations where the second horizontal axis of the reference object and the speaker or hearer coincide. I also investigated this; the results for each language can be found in the following chapter (5). For the first horizontal axis, the assumption is the opposite: The reaction time is the longest for relations of less than 90°. The greater the angle, the lower the reaction time. The lowest reaction time for *in front of* and *behind* is expected for a spatial relation in which the hearer or speaker has to conduct a mental rotation of 180° (Kessler, 2000, p. 171).

Now, let us return to the four languages investigated in this study – German, English, Italian, and Polish. In these languages, local nouns and prepositions form prepositional phrases. Speakers of these languages apply the prepositional phrases to describe local relations (Wojaczek, 2006). In German and Polish, case distinguishes between *directional prepositional phrases* and *locative* ones (e.g. Wunderlich and Herweg, 1991, p. 762; Tenbrink, 2005b, p. 5). However, this only applies for the Wechselpräpositionen, which can be used with more than one case (e.g. in German *vor* "in front of" but not *rechts von* "to the right of"). In English and Italian, the motion is encoded by the verb or by the preposition as in the case of the vertical axis with *on* and *onto* in English. Verbs encode the kind of the spatial relation as positional or directional (e.g. Buchgeher Coda, 1995, p. 229; Perużyńska, 2012a, p. 7). Let us compare a few examples from the experiment in order to understand the role of the verb:

- *Put* the bottle in front of the table (directional spatial relation encoded by a dynamic verb – also referred to as a causative positional verb by Wunderlich (1990, p. 54) and as a directional verb by Klein (1990, p. 27) – that expresses a change of place).
- The bottle *is standing* in front of the table (positional spatial relation encoded by a static verb).

In the last step, let us analyze the expressions most relevant to this thesis, the dimensional spatial expressions:

German	English	Italian	Polish
vor	in front of	davanti a	przed
hinter	behind	dietro di/a	za
rechts (von)	(to the) right of	a destra	(na) prawo (od)
links (von)	(to the) left of	a sinistra	(na) lewo (od)

Table 4.1: Dimensional spatial expressions in German, English, Italian and Polish adapted from Perużyńska (2012a, p. 9)

As I showed in Perużyńska (2012a), the syntax of the secondary local deixis in German, English, Italian, and Polish is different. This is illustrated in Table (4.1). One of the reasons for the differences is the word structure: Considering the prepositions of the first horizontal axis (*front–back*), the spatial expressions of both Polish and German are primary prepositions (e.g. Wunderlich, 1982, p. 10). In contrast, the English and Italian prepositions of the positive pole of the first horizontal axis (*front–back*) are secondary prepositions and the expression of the negative pole is in English a primary preposition and in Italian secondary (Helbig and Buscha, 2001, p. 353; Skibicki, 2007, p. 219; Hentschel, 1998, p. 156 ff.).

The German preposition *vor* can be used with both cases dative and accusative. In the local meaning, the dative indicates the positional application of the spatial relation and the prepositional phrase expresses the vertical region of the front side of the reference object on which the localized object is localized (see example 5). In contrast, the use of *vor* with the accusative refers to the vertical axis of the reference object that the localized object reaches as the target in the particular spatial situation (see example 6; e.g. Perużyńska, 2012a, p. 9; Schröder, 1990, p. 209 ff.).

5 Dative:

Die Flasche	steht	vor	**dem** Tisch.
The bottle	is standing	in front of	the table.

6 Accusative:

Thomas	stellte	die Flasche	vor	**den** Tisch.
Thomas	put	the bottle	in front of	the table.

Moreover, the German preposition *vor* can also be used with a temporal meaning (see examples 7 and 8).

7 Dative:

Die Vorlesung	findet	vor	**dem** Seminar statt.
The lecture	takes place	before	the seminar.

8 Accusative:

Die Vorlesung	wurde	vor	**das** Seminar verschoben.
The lecture	was moved	before	the seminar.

Finally, *vor* can be also used as a *particle* in phrasal verbs (Partikelverb) such as ***vor**gehen*.
Similar to the preposition *vor*, also *hinter* can be used with either dative or accusative to describe a spatial relation. The positional use of *hinter* (with dative) refers to the back of the vertical region of the reference object on which the localized object is positioned in the particular spatial constellation (see example 9). The directional application of *hinter* (with accusative) indicates the vertical region of the reference object, which is the local target of the localized object in the particular spatial relation (see example 10; e.g. Perużyńska, 2012a, p. 10; Schröder, 1990, p. 123 ff.).

9 Dative:

Die Flasche	steht	hinter	**dem** Tisch.
The bottle	is standing	behind	the table.

10 Accusative:

Thomas	stellte	die Flasche	hinter	**den** Tisch.
Thomas	put	the bottle	behind	the table.

In contrast to *vor*, *hinter* is not used temporally, or only rarely, as in *hinter sich bringen*. *Hinter* can also be concatenated with a verb, as in **hinter**gehen, but without a local or temporal meaning. According to Levelt (1986, p. 197), the preposition *vor* expresses "closer to the speaker" and *hinter* "further away from speaker."

The Polish *przed* and *za* prepositions are among the most frequent Polish prepositions according to Boguslawski (2003). *Przed* has three principal meanings: the spatial area closer to the speaker, hearer, or third person (the localized object is positioned between the person and the reference object, e.g. Klebanowska, 1971, p. 74; Perużyńska, 2012a, p. 10); the vertical region of the front side; and the prospective meaning (e.g. Weinsberg, 1973, p. 31). Used with the accusative (see example 12), *przed* refers to the vertical region of the reference object, which is the local target of the localized object in the particular spatial relation (second possibility). Applied with the instrumental case (see example 11), *przed* refers to the vertical region of the front of the (static) reference object.

11 Instrumental:

Butelka	stoi	przed	stoł**em** (instrumental for stół “table”).
The bottle	is standing	in front of	the table.

12 Accusative:

Postaw	butelkę	przed	stół (accusative for stół “table”).
Put	the bottle	in front of	the table.

The preposition *za* is very special in Polish. It is the only Polish preposition that can be connected with three cases (accusative, genitive, and instrumental). Locally, it can be used with the accusative or instrumental case. Applied with the accusative (see example 14), *za* refers to a target that is located on the vertical axis behind the reference object. Used with the instrumental (see example 13), *za* refers to a target of an act that is located behind the reference object (e.g. Perużyńska, 2012a; Skibicki, 2007, p. 240, 247).

13 Instrumental:

Butelka	stoi	za	stoł**em** (instrumental for stół “table”).
The bottle	is standing	behind	the table.

14 Accusative:

Postaw	butelkę	za	stół (accusative for stół “table”).
Put	the bottle	behind	the table.

Both local possibilities recall the meaning of the German prepositions *vor* and *hinter*. However, in contrast to *hinter*, *za* can also be used to express a temporal relationship (see examples 15, 16, 17, 18, and 19):

15 Immediate outcome of events:

Brama	otwiera się	**za**	nacisnieciem tego przycisku.
Das Tor	öffnet sich	**nach**	dem Drücken der Taste.
The gate	opens	**after**	pressing the button.

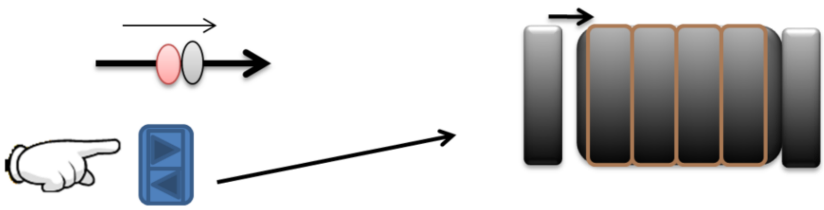


Figure 4.4: Za as immediate outcome of events

16 The trajector (the localized object in spatial meaning) is always a consequence of a landmark (the reference object in spatial meaning, e.g. Przybylska, 2002, p. 357) – similar to the German preposition *nach* or the English *after*.

17 The landmark will be repeated until the trajectory is reached (like *beim* in German, e.g. *beim dritten Mal*, "on the third occasion").

18 Recursively:

	"Taksówka	**za**	taksówką	podjeżdża pod hotel." (Przybylska, 2002, p. 358)
Local:	Taxi	**hinter**	Taxi	fährt ans Hotel.
	Taxi	**behind**	taxi	is driving to the hotel.
Temp.:	Taxi	**nach**	Taxi	fährt ans Hotel.
	Taxi	**after**	taxi	is driving to the hotel.

Is it possible to separate time and space from each other?

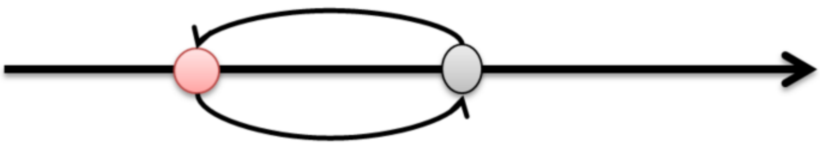


Figure 4.5: *Za* used recursively

19 Future (za + accusative):

"Zaczynam pracę	**za**	godzinę." (Przybylska, 2002, p. 375)
(Ich) Beginne die Arbeit	**in**	einer Stunde.
(I) Start the work	**in**	one hour.

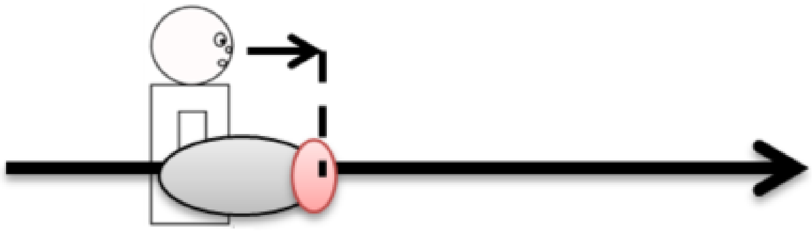


Figure 4.6: *Za* expressing future

These are only few examples for the temporal use of *za* – refer to Przybylska (2002) and Perużyńska (2012b) for detailed analyses of the preposition. It is of interest that both the prepositions *za* and *przed* can express the same result temporally and locally.

The Italian prepositions of the first horizontal axis (*front–back*) are secondary prepositions due to their structure. These comprise the adverb *davanti* (front) vs. *dietro* (behind) and a grammatical preposition (e.g. Schwarze, 1995, p. 305).

English is the only language of the four investigated languages with a primary and a secondary preposition of the first horizontal axis (*front–back*). The positive pole of the axis is represented by the secondary preposition and the negative by the primary. The preposition *in front of* consists of two prepositions, *in* and *of*, and a noun *front*. The preposition *in* expresses the localization of the localized object regarding the front side of the reference object. The preposition *of* connects the localized object with the front of the reference object – more precisely, with the front of the vertical region of the reference object (e.g. Lindstromberg, 2010, p. 105; Perużyńska, 2012a, p. 10). *Behind* has historically developed from *be* + *hind* (e.g. Tyler and Evans, 2003, p. 169). In static spatial situations, which are the focus of this thesis, the preposition prototypically expresses a position at the back of the reference object (either in accordance with the intrinsic reference frame with an intrinsic entity or in accordance with one of the three strategies of the relative frame of reference).

The spatial expressions of the second horizontal axis (*right–left*) in English, German, Italian, and Polish are represented by secondary prepositions. In none of these languages can be the spatial expressions of the second horizontal axis concatenated on the verb. In Polish and German, these expressions can be used with only one case and are characterized by narrower semantics than the primary prepositions (e.g. Skibicki, 2007, p. 220). Both German prepositions include adverbs that feature the right vs. left side and a preposition, *von*, that expresses the relationship between the region of the reference object and the region of the localized object (e.g. Perużyńska, 2012a, p. 11).

Similar to the German prepositions, the Polish prepositions of the second horizontal axis also include adverbs and prepositions. The local adverbs indicate the regions on the second horizontal axis of the reference object on which the localized object is located (in the positional spatial relation). The region on the second horizontal axis of the reference object can be also expressed to indicate the target position of the localized object.

The structure of the English prepositions of the second horizontal axis deviates from one of the German or Polish prepositions. The English prepositions comprise a determined noun, which expresses the side of the reference object (the region in which the localized object is positioned). Here too, the preposition *of* connects the localized object with the particular side of the reference object – more precisely, with the region of the reference object.

The Italian prepositions have the same structure as the German ones – each of them consist of one grammatical preposition and one local adverb (e.g. Perużyńska, 2012a, p. 11; Schwarze, 1995, p. 306).

4.3 Previous experimental evidence for spatial perception

In the previous sections, I explained the theoretical background of this study. The aim of this section is to relate it to empirical evidence. I report on selected relevant empirical results regarding *space perception*, *language acquisition of dimensional spatial expressions*, and *metaphor theory*. I will start with the metaphor theory, following by experiment on motion through space and description as well as interpretation of spatial relations. The latter comes last, because it is a perfect transition from the previous empirical evidence to the current one from the thesis. These experiments are mostly related to the one of the current thesis.

4.3.1 Metaphor theory

In section (4.1), I explained what metaphor theory is and what its most important assumptions are. Here, I present some empirical evidence for it.

Boroditsky (2001) investigated how one's native language can shape the mind by testing Mandarin and English native speakers. She used metaphor theory – in particular following the question how the spatial domain (as the primary domain) influences the time domain (as the secondary domain). Boroditsky also investigated whether knowledge of additional languages can shape the way humans perceive the world. Boroditsky referred to Slobin, who had shown that language can influence the way we think and speak (Slobin, 1987; Slobin, 1996; Boroditsky, 2001). Boroditsky (2001) investigated the influence of the native language on the coding of the temporal domain in a foreign language. For this purpose, Boroditsky (2001) tested 26 English native speakers and 20 Mandarin native speakers. The Mandarin native speakers used Mandarin only in their early childhood and grew up in the United States. The participants were asked to answer temporal questions, though the prime tasks were spatial (e.g. "The bottle is in front of the table") and appeared before the target tasks (e.g. "January comes before/earlier than April," Boroditsky, 2001, p. 9). The experiment was conducted in English. Its results reveal that the participants were influenced by the spatial (prime) tasks: The English native speakers answered "earlier/later" more quickly after viewing horizontal spatial pictures. In contrast, the Mandarin native speakers were influenced by the vertical spatial (prime) tasks when answering the questions with "earlier/later" – they answered these more quickly. *Before* and *after* did not reveal any differences between the English and Mandarin native speakers investigated (Boroditsky, 2001, p. 10). Boroditsky concluded that language can shape thought.

To underpin this conclusion, Boroditsky (2001) conducted a second experiment on reaction time. For this purpose, she tested Mandarin–English bilingual native speakers in a manner analogous to the first experiment. The results of this study show that the Mandarin–English bilingual native speakers who acquired English later were more strongly influenced by the spatial vertical axis when judging the temporal sentences. Furthermore, Boroditsky (2001, p. 15) indicated that the earlier the participant acquired English, the less the vertical axis influenced his/her temporal thinking. In the third and last experiment, Boroditsky asked 70 English native speakers to learn the vertical axis as a temporal one. The results of the participants – after the training – resembled those of the Mandarin–English native speakers. The *earlier/later* answers were judged more quickly after vertical priming questions and the *before/after* ones after the horizontal priming questions, similar to what occurred with the Mandarin native speakers. Boroditsky (2001, p. 20) summed up as follows:

> *"Language can be a powerful tool for shaping abstract thought. When sensory information is scarce or inconclusive (as with the direction of motion of time), languages may play the most important role in shaping how their speakers think."*

Later, Casasanto, Fotakopoulou, et al. (2010) again showed that the relationship between spatial and temporal domain is asymmetrical – the representation of time depends on that of space. It means that the author again refuted the assumptions of the theory of magnitude. The latter assumes that *time, space*, and *numbers* are represented in the brain analogously to the magnitude system and are symmetrical. It means that none of these dimensions depend on one another. Casasanto, Fotakopoulou, et al. (2010) researched whether the spatial and temporal domains are symmetrical during language acquisition. For this purpose, they tested 99 children (aged 4–6 and 9–10 years old) in Thessaloniki. The children were asked to perform three tasks: called "Racing Snails (the main Distance–Time interference task), Jumping Snails (a task to test children's ability to judge duration independent of spatial interference), and Static Lines (a task to test children's ability to judge distance independent of temporal interference)" (Casasanto, Fotakopoulou, et al., 2010, p. 392). The results of this study reveal that children performed better at judging distance accompanied by temporal interference than duration accompanied by spatial interference. This means that this study results demonstrate the same cross-dimensional asymmetry previously found with adults, as reported above (Boroditsky, 2000; Casasanto and Boroditsky, 2008). The authors conclude: "It appears that space and time are asymmetrically separable dimensions (Garner, 1976) in children's minds" (Casasanto, Fotakopoulou, et al., 2010, p. 397 f.).

This study's results disproved the assumptions of ATOM theory (e.g. Walsh, 2003), namely that the temporal and spatial domains are symmetrical (see above).

Boroditsky, Fuhrman, et al. (2011) explored whether English and Mandarin speakers think differently about time. The background to their study was the different use of spatial prepositions in the temporal domain and the baseline for the study was the results of Boroditsky (2001). In both English and Mandarin, the native speakers used *front* and *back* to express temporal relationships. However, Mandarin native speakers have also the option to express time using the vertical prepositions, *up* and *down*. With the preposition *up*, Mandarin speakers relate an earlier event and with *down*, a later one. According to Boroditsky, Fuhrman, et al. (2011), up to 36% of vertical metaphors are employed temporally. However, they point out that it is also possible to use vertical spatial prepositions as metaphors for temporal meaning in English, though it is very rare. The authors hypothesized that Mandarin speakers think more frequently about time vertically than do English ones, as had already been suggested by Boroditsky (2008). Boroditsky, Fuhrman, et al. (2011) tested 181 students at Stanford University, 118 English and 63 Mandarin–English bilingual speakers. The participants had successively seen pictures with the same person at a different time of life. They were asked to answer on whether the picture was taken earlier or later in the life of the particular person. For this purpose, they were asked to press an arrow button that was either horizontal or vertical.

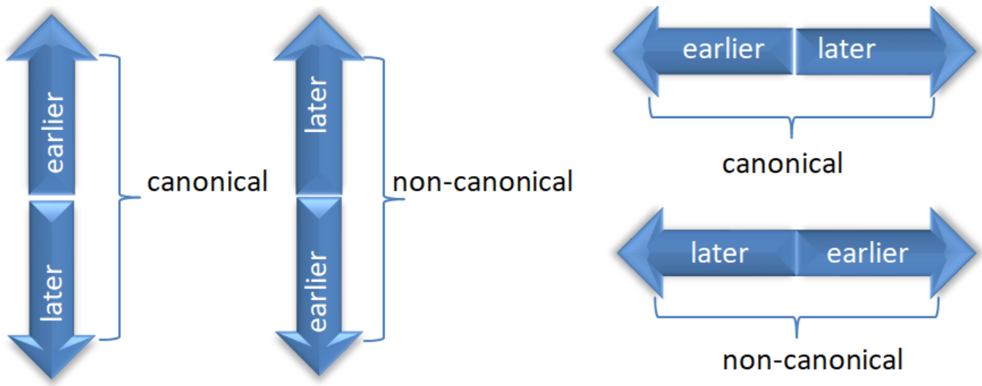


Figure 4.7: The orientation of the buttons in the experiment of Boroditsky, Fuhrman, et al. (2011). (Horizontal and vertical order in canonical and non-canonical orientation.)

The results of the study reveal that both English and Mandarin speakers were faster when the buttons were in the canonical horizontal orientation. However, the vertical orientation influenced only the reaction time of Mandarin bilingual speakers. The English native speakers achieved similar reaction times for the canonical and non-canonical vertical button orientation. The authors explain the differences between the monolingual English native speakers and bilingual Mandarin–English speakers as linguistic distinctions in spatiotemporal metaphors. The results reveal that "speakers of different languages automatically activate different culturally-specific spatial representations when reasoning about time" (Boroditsky, Fuhrman, et al., 2011, p. 128).

Fuhrman et al. (2011) conducted an experiment to examine metaphor theory. More precisely, they explored how the spatial domain can influence the temporal domain in nonlinguistic tasks. Fuhrman et al. (2011) point out that the following factors should be considered when investigating spatial or temporal perception:

1. The language used in the experiment;
2. The direction of the orthography; and
3. Knowledge of other languages.

All these aspects can influence the spatialization of time perception. This had already been evidenced in numerous empirical studies (e.g. Boroditsky, 2000; Boroditsky, 2001; Boroditsky, Fuhrman, et al., 2011; Casasanto, Boroditsky, et al., 2004). In addition, age and experience can shape the way we spatialize time perception (e.g. Carstensen, 2007; Ji et al., 2009).

As with the previous experiments by Boroditsky and colleagues, here too Fuhrman et al. (2011) tested English and Mandarin speakers. In the first experiment, they tested 59 English native students from the Stanford University and 75 bilingual Mandarin–English speakers from Shanghai University. The participants had seen different pictures and were asked which of them showed an earlier event and which a later event. The pictures included, for instance, famous actresses at different ages. This idea was extended with, for instance, a banana being eaten (Fuhrman et al., 2011, p. 1310). Here too the pictures were presented either horizontally or vertically (canonically and non-canonically – see 4.7).

The results of the study of Fuhrman et al. (2011, p. 1311 f.) reveal that English native speakers are faster when the response alternatives were ordered horizontally (from left to right: earlier–later). In contrast, the Mandarin native speakers responded to the same questions more quickly when the pictures were ordered vertically from the bottom-up: earlier (bottom)–later (up).

In a second experiment, Fuhrman et al. (2011) tested 377 participants. Of these, 330 were tested in English (134 of these were instructed and investigated in English). 243 participants were Mandarin–English bilinguals who were tested in a different geographic area (the USA and Taiwan). During the experiment, the experimenter showed the participants, for instance, "today" and asked where tomorrow was. Participants were asked to indicate the day spatially. Overall, participants were asked three questions about days, months, and the time of the day (breakfast, lunch, and dinner).

The results of the study indicated that the English native speakers decided horizontally more frequently – from the left to the right (97.5%). In contrast, the English–Mandarin bilinguals applied both strategies – the horizontal and the vertical for the order of the responses.

> *"In addition, participants who spoke Mandarin often produced vertical arrangements for time. The proportion of vertical representations of time depended on participants' proficiency in Mandarin and also on whether participants were tested in Mandarin or in English. Participants who were more proficient in Mandarin and participants who were tested in Mandarin were more likely to represent time vertically, suggesting that both long-term language experience and proximal linguistic context can shape people's representations of time. Differences in vertical time representations were not explained by differences in writing direction. Writing direction did emerge as an important predictor on the left/right axis; participants who always read text arranged horizontally from left to right were more likely to arrange time from left to right than participants who at least sometimes read text arranged in other ways" (Fuhrman et al., 2011, p. 1322).*

Miles, Betka, et al. (2010) conducted a similar experiment for Mandarin and English bilinguals and English monolinguals. In their first study, participants saw pictures of famous cities. These showed the cities at different times presented either vertically or horizontally. The results reveal that monolingual English speakers are quicker than Mandarin and English bilinguals when seeing pictures that were compatible with the horizontal orientation. In contrast, the Mandarin and English bilinguals are quicker than the English monolinguals at judging the compatible vertical pictures. In the second experiment, 32 Mandarin and English bilinguals (from Singapore) were asked to temporally order pictures of Brad Pit and Jet Li. Pictures of the two famous actors at different ages were presented to them. The results of the study indicate that the participants more frequently arranged photographs of Brad Pit horizontally (62.5%) and of Jet Li more frequently vertically (65.6%; Miles, Tan, et al., 2011, p. 600). Following, the results the ethnicity of the face "may have served as a cue that caused activation of one of the two existing spatio-temporal mappings in bilinguals" (Wu, 2012, p. 1).

Wu (2012) also conducted an empirical study of spatiotemporal metaphors, testing English–Mandarin bilingual speakers living in the USA. The motivation was the same as that of Boroditsky, Fuhrman, et al. (2011) and of Miles, Tan, et al. (2011). Wu (2012) tested 27 Mandarin–English bilinguals by showing them pictures of 20 Asian and 20 Caucasian faces (that is, not only two faces as had been undertaken by Miles, Tan, et al. (2011)). Wu (2012, p. 2) hypothesized that the Caucasian faces would be arranged only along the horizontal axis and that the Asian faces would be arranged along both the horizontal and vertical axes. The results of the study indicate that the Mandarin–English bilinguals judged the Caucasian faces in the horizontal arrangement more quickly than those in the vertical arrangement. However, the participants did not show any significant differences regarding the judgment of Asian faces. Their reaction time for the vertical and horizontal arrangements was almost the same. At first glance, this means that the results of Wu (2012) did not confirm the results of Miles, Tan, et al. (2011) or the assumption of Boroditsky, Fuhrman, et al. (2011). However, as was admitted by Wu (2012), the pool of participants used by Miles, Tan, et al. (2011) and Wu (2012) was different. This aspect may have caused the differences because Miles' participants were Singaporean Mandarin–English bilinguals and Wu's were American Mandarin–English bilinguals. As stated by Wu, the Singaporeans may have been more influenced by the vertical writing direction than were the American ones. Wu (2012)'s participants were also tested in English; the task was written horizontally, which may also have influenced their metaphorical interpretation and mapping.

ATOM theory was also rejected by Bottini and Casasanto (2010) in favor of metaphor theory (e.g. Lakoff and Johnson, 1980). For this purpose, Bottini and Casasanto (2010) conducted two experiments testing Dutch native speakers. In the first experiment, they showed the participants nouns of seven letters and asked them to estimate for how long the particular noun appeared on the screen. The nouns displayed were names for objects of different lengths: cigarettes, pencils, motorways, and the like. The results of the study reveal strong differences between the shorter and the longer objects. That is, the length of the named object influenced the temporal perception of it (all of the words were displayed for the same length of time). Words that named shorter objects were estimated to be displayed for a shorter time. In the second study, Bottini and Casasanto displayed to Dutch native speakers words pertaining to different events of different duration (breakfast, January, etc.). All words were shown on the screen for the same amount of time, but their physical length (the number of letters) differed. The results of this study reveal that the spatial length of an event noun did not influence the estimation of spatial length (Bottini and Casasanto, 2010, p. 152).

The spatialization of time was also the focus of Fedden and Boroditsky (2012) study. These authors examined the Mian language (Papua New Guinea). In this language, the spatial system is based on the direction of the rivers, *Hak* and *Sek*, and the surrounding landscape. Fedden and Boroditsky (2012) showed that the native speakers of Mian apply two reference frames for the temporal representation – from left to right (relying on the second horizontal axis) and from east to west (relying on the absolute reference frame, which correlates with the rivers' directions). Moreover, they indicated that the more years of formal education the Mian native speakers had the more frequently they applied the body-relative reference frame from *left to right* (the researchers tested nine participants). As an experimental method, they used pictures of an apple being eaten or a man at different ages. "The results of our study extend previous work on spatial representations for time to a new geographical region, physical environment, and linguistic and cultural system" (Fedden and Boroditsky, 2012, p. 8).

Merritt et al. (2010) showed that the opposite is applicable to monkeys. These researchers tested humans and two rhesus monkeys and showed that, for monkeys, ATOM theory applies and not metaphor theory. How did the researchers accomplish this? They replicated the experiment of Casasanto and Boroditsky (2008) in which the participants were asked to learn to classify lines on the basis of duration and spatial extent first. Thereafter, they estimated the time duration; the object or the length of the object was displayed on the screen.

The authors concluded that spatial and temporal information strongly influenced each other. It follows that the results are in favor of not metaphor theory (which was shown to the humans) but ATOM, which assumes that both of the domains of space and time are represented by a common metric according to magnitude. The results indicate “the possibility that the capacity to represent abstract magnitudes metaphorically may be uniquely human” (Merritt et al., 2010).

4.3.2 Motion through space

Janzen and Katz (2000) investigated how humans perceive their own motion and the motion of others. For this purpose, the authors conducted an experiment with simulations of the own motion and an object’s motion. They tested 45 participants. The participants watched a movie about a virtual museum. The museum had a form of a U and contained office furniture. The participants never saw the whole museum. They always saw only individual objects. The participants were split into three groups. Each of them saw different arrangements (bright – during the day, semi-darkness, and darkness). After watching the movie, the participants were asked to describe what they saw. The results of the study reveal that the participants perceived the spatial relations as would they move in the bright light through the museum (using descriptions such as “I was going”). In contrast to the constellations in the bright light, the participants had the feeling that the objects moved in the constellations of semi-darkness and darkness (using descriptions such as “it appeared;” Janzen and Katz, 2000, p. 60). Overall, the results of the experiment indicated that background information plays an important role in spatial relation perception and in motion. It follows that the representation of their own and object’s motion is distinguishable with respect to viewpoint and motion. Conversely, the spatial constellations I used for my experiment were static and bright.

Tversky, Kim, et al. (1999, p. 43) point out that human mental representation is usually derived from the experience of the particular individual (see also Clark, 1973; Miller and Johnson-Laird, 1976). Tversky, Kim, et al. (1999) investigated 24 participants, exploring the *moved room* and the *moved participant* effect. They asked the participants to read a text about a large space museum. 12 participants read a text with about moving room and the other 12 were asked to imagine themselves moving in it. Thereafter, they were asked to respond to questions about the objects in the room. The results of the study reveal that participants in the *moved participant* condition were faster in reorienting themselves than those in the *moved room*. Moreover, researchers reported that "[f]or both conditions, larger reorientations to 180 degrees were faster than reorientations to 90 degrees" (Tversky, Kim, et al., 1999, p. 248). Overall, "[p]articipants were faster to locate objects to head and feet, next to front and back, and slowest to left and right" (Tversky, Kim, et al., 1999, p. 249). These results confirm the assumption of the spatial framework model: The up–down axis is perceived the fastest. It is followed by the perception of front–back axis. The right–left axis is perceived the slowest. In a second experiment, Tversky, Kim, et al. (1999) investigated the participants in different planes: upright, reclining, and upside down, using the same texts as in the first experiment and the same two conditions (*moving person* vs. *moving room*). The results of the study confirmed the results of the first experiment, namely that the reaction time in the *moving person* condition was faster than that in the *moving room*. Furthermore, the results confirmed the assumption of the spatial framework model and indicated that exploring spatial imagination using description can be technically simpler than exploring spatial imagination through experience (Tversky, Kim, et al., 1999, p. 252).

Hölscher et al. (2011) investigated whether speakers would follow their own route description. To this end, it is important to consider *wayfinding strategies*, *route description strategies*, *prospective planning*, and the *elements for the conceptualization of the city* (because Hölscher et al., 2011 investigated routes in a city). The five fundamental elements of a city as conceptualized by humans are: paths, edges, districts, nodes, and landmarks. All the elements are interrelated to yield a complex, connected urban network. Both planning and describing a novel route through a well-known urban environment is an everyday spatial task. The study's results reveal that the routes generated while navigating were more efficient (shorter) than those developed when planning ahead. Additionally, the results indicated that routes are usually planned ahead and then updated in the course of performance because of "sensory (visual) feedback from the environment" (Hölscher et al., 2011, p. 17).

4.3.3 Description and interpretation of spatial relations

Hayward and Tarr (1995) conducted three empirical studies on spatial language and spatial representation. The authors show that humans use language to describe visual entities. However, there are many linguistic boundaries: not all visual entities can be described by language. For instance, people have difficulties in describing differences in faces. The reason for this is that language cannot express all visual information. A further issue concerns recognition of a particular spatial preposition: on, above, along, below, to the right, and to the left.

Franklin and Tversky (1990) explored which axis is experienced first while listening to spatial relations between objects. For this purpose, the authors tested three models that predict reaction time in the course of spatial perception: spatial framework, equiavailability, and the mental transformation model (see 3.1). The spatial framework model predicts that the perception of dimensions depends on the body and is derived from it. The vertical axis emerges as the predominant axis and the axis that is perceived quickest in terms of reaction time. The first horizontal axis – represented by *in front of* and *behind* comes second. The second horizontal axis (*right-left*) perceived last with respect to reaction time. The equiavailability model assumes that all dimensions – the vertical axis and first and second horizontal axes – are perceived at the same time. The mental transformation model presumes that the second horizontal axis and the vertical axis are perceived at the same time because they are about 90° from the front. In general, this model assumes that the higher the angle from the front, the slower the side is perceived (see also 3.1.2). Franklin and Tversky (1990) explored which of these models is best suited to various everyday situations. For this purpose, they conducted five experiments; in one, the participants were standing and listening to a text and in one they were lying down. First, the participants read texts (either staying or lying down) written from the viewer's perspective about the localizations of objects. Thereafter, they were asked where a particular object was positioned – exploring "head, feet, front, back, left and right." Their reaction time of the responses was measured with a computer.

The results of the studies confirmed the assumptions of the spatial framework model. That is, that the perception time depends on the accessibility of the object by the person and this relies on the asymmetry of the body. For the standing participants, the order of axis perception over the reaction time was as follows: vertical axis (fastest), first horizontal axis (second), second horizontal axis (last). For the participants who were lying down, the order was different due to their position: the first horizontal axis was perceived the quickest, then the vertical axis (second), and the second horizontal axis (slowest).

Vorwerg and Rickheit (2000, p. 12) investigated how German native speakers describe the localization of a cube relating to a bar. The results from the 35 participants reveal that:

1. 22% used dimensional spatial prepositions: *vor* "in front of," *hinter* "behind," *rechts* "to the right of," *links* "to the left of," and *neben* "next to;"[4]
2. 60% used dimensional adverbs: *vorne* "in front," *hinten* "behind," *links* "left," and *rechts* "right;"
3. 24% used dimensional prepositional adverbs: *davor* "in front," *dahinter* "behind,"

[4] However, in my opinion ‚next to' does not belong to the dimensional prepositions.

and *daneben* “alongside;” and

4. 2%used dimensional adjectives: *vordere* “front,” *hintere* “rear.”

Vorwerg and Rickheit (2000, p. 14) stressed that the participants used individual strategies to describe the spatial relations. For instance, there were participants who preferred dimensional spatial prepositions or expressions belonging to another group. Moreover, the study results indicated the more the spatial relation looks like a prototype, the more frequently is it described using dimensional prepositions and not by means of other linguistic devices.

Tappe (2000) investigated how humans produce texts describing a spatial outline. In particular, how do linear propositional structures arise (Tappe, 2000, p. 71). As baseline for the empirical study, the empirical evidence from Taylor and Tversky (1996) was used; the latter tested participants by showing them a spatial sketch first. Thereafter, they asked the participants to reproduce it either verbally or nonverbally (by drawing). The results of the study of Taylor and Tversky (1996) reveal three different perspectives:

1. Gaze,
2. Route, and
3. Survey.

Each of these perspectives is a natural means of obtaining an overview of the environment (Tappe, 2000, p. 74). Tappe (2000) tested 12 German native-language students. She asked them to describe a route as a support for a route sketch. The participants had the option of describing the route with public transportation. For the verbalization task, the students viewed the route step by step online and were asked to describe it (online description). At the end of the first task, they saw the whole route as a picture. After the first task, they were asked to describe the route again, without being able to see it on the screen anymore (offline description). The results of the study were analyzed analogously to those of Taylor and Tversky (1996). Tappe (2000)’s results were significantly different from those of Taylor and Tversky (1996). The differences indicate the cross-linguistic differences between English and German native speakers. For the offline description, the German native speakers used the viewer perspective less frequently for *front–back* and *right–left* (49%) than the English speakers did (71%). The English native speakers used the absolute perspective – using expressions such as *to the north*, *south*, *east*, and *west* – more frequently in the online experiment than the Germans did (82% vs. 47%). Tappe (2000, p. 83) concludes that it is impossible to determine one perspective for the description of dynamic routes. Neither is it possible for static routes.

Carroll (2012) tested 12 German and 12 English native speakers. The participants were asked to retell animated movies. The results of her study indicated that:

1. 63.1% of German native speakers applied the location in terms of the localized object;
2. 36.8% of German native speakers used the location in terms of reference object;
3. 34.1% of English native speakers employed the location in terms of localized object; and
4. 65.2% of English native speakers utilized the location in terms of reference object.

According to the author, the differences arise due to language-specific differences in grammaticalization. More precisely, Carroll (2012, p. 115) states:

> *"Both languages have the means to differentiate the separate phases of an event, and locate them within the relevant places, but there is a preferred option in each case which may be linked to the means grammaticized. Aspectual distinctions which allow segmentation into phases are grammaticized on the verb in English but not in German."*

In German, case is grammaticized but in English it is not.

Carroll and Stutterheim (1993) investigated German (74) and English (45) native speakers, asking them to produce spatial texts. The results of the study reveal that German native speakers applied the relative perspective more frequently than did the English ones. The English native speakers employed the intrinsic reference frame most frequently. This means that the spatial descriptions produced by the German participants were more speaker-centered and those of the English ones were more object-centered (Carroll and Stutterheim, 1993, p. 1020). This contrasts with the results of Tappe (2000), who showed that German native speakers used viewer perspective less frequently for front–back and for right–left (49%) than did the English (71%) ones. This indicates that the differences between the native speakers of these languages depend on the kind of spatial relation.

Grabowski and Miller (2000) tested American English and German native speakers: How do they employ spatial prepositions of the first horizontal axis (*front–back*)? They reported on the results of 16 experiments by means of which they investigated the production and interpretation of spatial prepositions in German and in American English and not the semantics of the particular expressions (similar to the current thesis). Grabowski and Miller (2000) tested 369 German native speakers and 207 American English native speakers. The participants were asked to maneuver a toy car and park it either *in front of* or *behind* a reference object. The reference object was either a tree (extrinsic) or a car (intrinsic). The first study results for the German native speakers reveal that they interpreted *vor* "in front of" using the relative reference frame more frequently and *hinter* "behind" using the intrinsic reference frame (Grabowski and Miller, 2000, p. 530 f.). That is, these participants interpreted *hinter* and *vor* as the same parking bay. In the spatial relation with a tree, the German native speakers applied the reflection strategy most frequently. Later, the researchers manipulated the situations and asked the participants to participate in a driving test; the task was the same: parking a car *in front of* or *behind* a car. In this situation, most German native speakers maneuvered the car and parked it using the intrinsic reference frame for the both spatial prepositions. In contrast, the participants showed less consistency in the parking situation with the tree as a reference object in the driving license condition. Grabowski and Miller (2000, p. 532 f.) concluded that the interpretation patterns for *vor* "in front of" and *hinter* "behind" are not symmetrical: *vor* is more often understood with respect to the relative reference frame and *hinter* more according to the intrinsic one (Grabowski and Miller, 2000, p. 533). In the production experiments, the participants described the spatial relation inconsistencies too. The results of the production experiments reveal that the German native speakers mostly applied the reflection strategy of the relative reference frame (in the spatial relation with the tree as reference object). In spatial relations with the car as reference object, the descriptions deviated from each other, depending on the kind of spatial situation. In the rather formal situation of a driving test, participants applied the intrinsic reference frame, and in the informal situation they used the relative one more frequently and ignored the intrinsic and functional features of the car as a reference object (Grabowski and Miller, 2000, p. 536 f.). Grabowski and Miller (2000, p. 540) state that one of the possibilities for cross-linguistic diversity may be the temporal interpretation of *vor* by the German participants – this links to interpretation/production in accordance to the relative reference frame. Nonetheless, the temporal interpretation of *vor* does not explain the interpretation of *hinter* with respect to the relative reference frame (in accordance with Grabowski and Miller, 2000, p. 540).

In contrast to the German native speakers, all the English native speakers interpreted the informal spatial relations with the car as a reference object and both spatial expressions *in front of* and *behind* using the intrinsic reference frame. In addition, unlike the Germans, the English native speakers showed inconsistency in their interpretation of spatial relations with the tree – the preposition *in front of* was interpreted using the facing/reflection strategy more frequently, whereas for *behind* they used the align/translation strategy (Grabowski and Miller, 2000, p. 542). Furthermore, all American English native speakers interpreted the spatial relation with the car as a reference object in the driving license exam condition using the intrinsic reference frame. In the extrinsic spatial relation with the tree, most of the American participants interpreted the situation using the translation strategy not the reflection one (Grabowski and Miller, 2000, p. 543). In summary, the American participants interpreted all of the tested relations consistently.

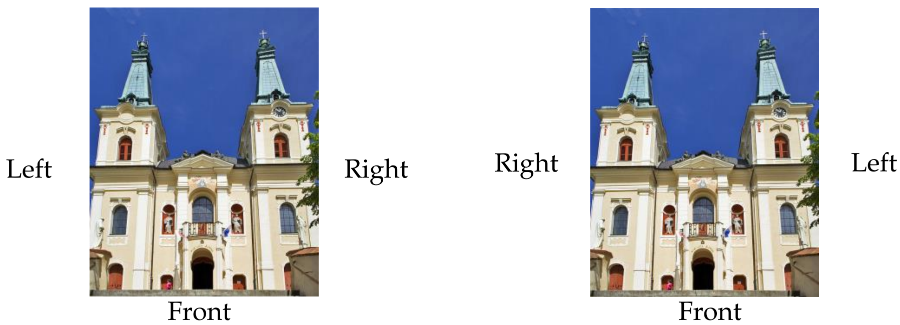
The American English native speakers also produced spatial expressions consistently in the informal as well as the formal spatial relations with the car as a reference object.

The driving test situation description with the tree was consistent. It can be summed up that the American English native speakers produced intrinsic spatial relations using the intrinsic reference frame independent of situational formality. Only the informal spatial relation with the tree as a reference object caused inconsistency among the participants (Grabowski and Miller, 2000, p. 546).

As indicated by Grabowski and Miller (2000, p. 548),

> *“[b]y conducting similar experiments in other languages whose spatial and temporal prepositional systems equal either the German pattern (Dutch) or the English pattern (French, Italian, and Swedish), it could be shown that it is, indeed, not the individual language but the described prepositional patterns of a language that cause the observed distributions of prepositions with subspaces.”*

This leads to one of the hypotheses I investigated with the German, English, Italian, and Polish native speakers for this thesis. Thereby, the prepositional inventor deviates even more from these two groups (see 5).



(a) German (b) English

Figure 4.8: Possibilities of side assignment to a church; Source [2, retrieved on 31.12.2019; photographer Tomek Zuk, Zuk, 2019]

Carroll and Stutterheim (1993) also tested German and English native speakers. Unlike Grabowski and Miller (2000), Caroll tested British rather than American English speakers. Her study showed that the German and English native speakers perceived a church in different ways – the Germans identified the sides of the church using the outside perspective (of the intrinsic reference frame) from the church’s door, and the English speakers identified the sides using the inside perspective (of the intrinsic reference frame), also from the church’s door (but from the inside). The results indicate that the *front* and *back* of the church were interpreted in the same way by both participant groups, though they deviated from each other with regard to the interpretation of the *right* and *left* sides of the church (see chapter 5).

Tower-Richardi et al. (2012) used mouse tracking to explore whether the expressions of absolute reference frame are associated with those of the relative reference frame: north = up, south = down, east = right, west = left. The researchers tested 100 English native speakers in the first experiment – all were right-handed. First, they applied a masked prime procedure with a 4x4 within participants design (prime type: north, south, east, west, center, and nonword; target: up, down, right, left).

In this experiment, participants were asked to "move the mouse as quickly as possible to the box that correctly corresponds with the word presented on the screen" (Tower-Richardi et al., 2012, p. 3). The results of the experiment revealed "dynamic and directionally specific effects of abstract primes on movement trajectories toward concrete target directions" (Tower-Richardi et al., 2012, p. 6).

In the second experiment, Tower-Richardi et al. (2012) tested 59 English native speakers (the data from nine participants were excluded). The design matched the previous experimental design apart from the target words. These were replaced by arrows.

The results of the second experiment showed that movement trajectories can explain cognitive operations, which are otherwise hidden. More precisely, the mouse tracking data supported this assumption with consistent directionally trajectory biases toward orthogonal primes (Tower-Richardi et al., 2012).

Gorniak and Roy (2004) conducted a production and perception study (with six participants and 268 sentences), in which two participants were involved in parallel. The participants had seen the same pictures at the same time; the task was for the one participant to describe the spatial position of a cone and for the other to select the correct cone. The cones were different colors. The participants developed three strategies for successful communication: color, local regions and extremes, group building, spatial relations between objects (groups), and anaphora.

Gorniak and Roy (2004) generated a model basing on the results of their study. As the authors state: "the system selected correct object in responses to utterance for 76.5% of the development set data, and for 58.7% for the test set data" (Gorniak and Roy, 2004, p. 444). In my opinion, this is a very important indication that the interpretation and production of spatial prepositions should be investigated more precisely in order to improve the communication between machines and humans while additionally considering language.

Peters et al. (2011) paid attention to human–robot interaction in terms of the production and interpretation of spatial expressions. The authors indicate that there are already different types of robots. First, there are robots that conduct one task only, for instance, in hospitals. Such robots do not interact with humans and are used to undertake one particular task. Unlike these robots, there are others that interact with humans (human–robot/machine–interaction). Such robots are used in museums, hospitals, and for medicine (e.g. dental medicine). Peters et al. (2011) conducted an experiment with eight scenarios to determine how the robot should behave when passing humans in a corridor. The participants were asked to judge the particular reaction of the robot: which of the reactions were adequate, what would they change, and what would not they change. The results of the study reveal that humans interact with faster-moving robots better, with longer signalization, and at a lateral distance of 0.4 meters. It would be of interest to conduct an extended study using verbal communication, for instance, where the participant (native speakers of different languages) instruct the passing robot to pass the human to the right or to the left. In the next step, the participant could be asked whether she or he expected the side the robot has taken or the other one.

Kessler and Rutherford (2010) researched the differences between the VPT-1 (level 1 of visual perspective taking) and VPT-2 (level 2 of visual perspective taking). VPT-1 "reflects understanding of what lies within someone else's line of sight, VPT-2 involves mentally adopting someone else's spatial point of view."

In the first experiment, the participants were asked whether the target was visible or hidden. In the next experiment, the participants were asked to verbally indicate where the targeted object was located (*in front of/behind/to the left of/to the right of*). The results of the study indicated that the participants are quicker in the VPT-1 condition than in the VPT-2. It follows that the participants recognized the former more quickly, whether or not the localized object was visible to the avatar than when it was positioned to the right/left of the reference object (Kessler and Rutherford, 2010, p. 4 f.).

In the second experiment, the researchers also tested the conditions *visible* vs. *invisible* and *in front of* vs. *behind*. The results of this experiment revealed an analogy between *in front of* and *behind* vs. *visible* and *invisible*. Nonetheless, the reaction time for *in front of* and *behind* was higher than for *visible* or *invisible* (Kessler and Rutherford, 2010, p. 9).

Hüther et al. (2016) investigated the influence of animacy in generic and medical (animate) contexts, testing medical and law students in different semesters. In an online survey, attendees were asked to select one of the situations fitting the description. The results show that the medical students interpreted the medical situation with humans as reference objects more frequently using the intrinsic frame of reference than did the law students. Given the importance of spatial descriptions in medicine, it is surprising that only 44.2% of the beginners and 49.8% of the advanced medical students chose the intrinsic perspective. The second most dominant strategy for this group was the facing/reflection strategy. Furthermore, the results show that only 26% of all the law students interpreted the spatial relations with a human as reference object using the intrinsic frame of reference, while 58.6% selected the facing/reflection strategy.

Tenbrink (2005a) conducted an internet study to investigate cross-linguistic discourse strategies for spatial expressions, especially for the first (*front–back*) and second (*right–left*) horizontal axes. One hundred and eighty German and 200 English native speakers participated in the experiment. The results of the study reveal that English native speakers use significantly greater linguistic variety in describing a spatial location than German native speakers do. More precisely, the results showed that the German participants mostly used adjectives and adverbs to describe a spatial location and only occasionally used spatial prepositions. In contrast, the English participants used adjectives, nouns, prepositions, hand terms, and undetermined expressions such as *left.* The most significant difference between the languages revealed nouns in prepositional phrases such "to my right" (*zu meiner Rechten* in German). These were used by 42.7% of English native speakers and only by 1.3% of German native speakers. According with Tenbrink, linguistic choice depends on the spatial constellation, on the presence of other people and objects as well as on the location of the objects. For this study, it is important to explore whether the participants of both languages interpret spatial prepositions in the same way for particular spatial situations.

4.4 Summary and discussion

German, English, and Polish are satellite-framed languages whereas Italian is a verb-framed language. This means that the Italian language encodes motion or location using a verb while German, English, and Polish use satellites. It points out that speakers of these languages conceptualize locations and events in different ways (Slobin, 2006).

Lakoff and Johnson (1980)'s metaphor theory explains the important role played by the spatial domain. According to this theory, space is the source domain and all other domains, for example, *time*, are the target domains. This means that temporal meaning is derived from spatial meaning. This dependency between space and other domains such as time has also been investigated within language acquisition – children acquire spatial prepositions first and temporal ones thereafter. Considering this by means of an example, this means that children apply the spatial meaning of the preposition *vor* "in front of/before" in German first and the temporal afterwards. It is of interest to determine how the temporal meaning of a particular expression can influence the spatial one.

In this chapter, I have shown how a spatial relation can be encoded by linguistic devices, both verbally and nonverbally. To encode a spatial relation verbally, speakers can use *adpositions, verbs, adverbs, case*, or *nouns* (e.g. Klein, 1990; Levinson, 2003a). As regards the linguistic devices, I focused on descriptions and interpretations of spatial relations encoded by the adpositions used in my experiments (for German, English, Italian, and Polish). In doing so, I used only the explicit spatial frames of reference, such as the following:

- Hans says that the bottle is standing...
  - *To the right* of the reference object.
  - *To the left of* the reference object.
  - *In front of* the reference object.
  - *Behind* the reference object.

The meaning of dimensional spatial expressions is derived from our bodies. In the next chapter, I demonstrate how German, English, Italian, and Polish native speakers interpret spatial expressions in different contexts. Thereby, I will base on empirical results from my study.

The interpretation of anaphoric frames of reference was not a focus of this chapter. (see below for an example for anaphoric frame of reference):

- “[The adults]i in the picture are facing away from us, with the children placed behind themselves$_{\{i,*j\}}$”. (Sundaresan and Pearson, 2014, p. 4; example 4)

In my experiment, I investigate static spatial relations. For this reason, I have not discussed the influence of motor execution on perceived orientation (see Manera et al., 2012, for an overview of this topic and experimental indications). The results of Manera et al. (2012, p. 1)’s experiments indicate that the perception of the point-light body’s’ movement depends on the task the participant is performing. Specifically, when the point-light body is walking and the participant is too (on a treadmill), the participant perceives the movement of the point-light body as facing the viewer more frequently than when performing another task, such as cycling vs. walking.

5 Empirical studies for German, Polish, Italian and English

As I have already shown in the previous chapter, there is a large body of empirical evidences about how do native speakers of different languages perceive space. I have pointed out that speakers of different cultures can describe a particular spatial relation in different ways, for instance transferring the parts of the body on the objects like *nose*, *eyes* or *ears* instead of *right*, *left*, *front* or *back* (intrinsic reference frame). Moreover, speakers can also describe the same spatial relation in terms of a fixed coordinate system like the *compass*, *river* or *mountains directions* (absolute reference frame). Additionally, time can play an important role for the description of a spatial relation: For instance, a particular position can be reached in terms of time earlier than another one and considered as *in front of*.

The current thesis focuses on the perception of spatial relations in German, English, Italian and Polish. In the research, there are already several cross-linguistic results for the description and interpretation of spatial relations. For instance, it was shown that the German native speakers use the viewer point of view less frequently for *front*, *back*, *right* and *left* than the English native speakers. Moreover, the results of the German native speakers revealed that they interpret *vor* "in front of" in terms of the relative reference frame more frequently than *hinter* "behind". The latter is interpreted with respect to the intrinsic reference more frequently. Considering the production of *vor* "in front of" and *hinter* "behind" it turned out that it depends on the situational context (official vs. unofficial). Here, *vor* was produced with respect to the relative frame, what could be caused by the temporal meaning of the expression. However, it indicates the relative production of *hinter* indirect only (Grabowski and Miller, 2000). In contrast to the German native speakers, American English native speakers interpreted and produced the spatial relations consistently. In contrast to German native speakers, American English speakers used the translation strategy for the interpretation of extrinsic spatial relations most frequently and not the reflection one (Grabowski and Miller, 2000).

The diversity in interpretation and production of spatial expressions has been already also shown for the German native speakers with respect to their profession as well as the animacy of entities (as reference object). Medicine students applied the intrinsic reference frame more frequently than the law students in spatial relations with a human as reference object (Hüther et al., 2016).

Due to the diversity in interpretation and production of spatial relations I have investigated the side identification of objects by German, English, Italian and Polish native speakers first. This step is essential to understand how the participants investigated interpret spatial relations with these objects.

5.1 Questionnaire study: motivation and experimental design

The survey was designed to provide evidence of whether participants recognize a cupboard as a vis-à-vis or vehicle intrinsic object or as an extrinsic object by assigning names for the sides according to the *align / translation, reflection / facing*, or *rotation strategy* (e.g. Levinson, 2003a; Levinson, 2006; Hüther et al., 2016). Furthermore, it provides a baseline for the question of whether participants conduct a mental rotation (e.g. Shepard and Metzler, 1971) in assigning terms to the front and back, and whether they assign the positive (right) and negative (left) sides of the second horizontal axis egocentrically – as would be expected with respect to the outside perspective of the intrinsic frame of reference (see Grabowski, 1999; Grabowski and Miller, 2000; Grabowski and Weiß, 1996).

In the questionnaire study, I sought to obtain a general baseline for the assignment of spatial locations to an intrinsic reference object (see Stoltmann, Fuchs, and Krifka, 2018). Participants were asked to identify the four sides of a cupboard in a simple drawing. The drawing matched the reference object and the general situation in the later experiment. The cupboard was placed in two conditions. In the first, the cupboard was placed canonically, that is, with the front towards the participants; in the second, it was placed non-canonically, that is, with the back towards the participants (5.1).

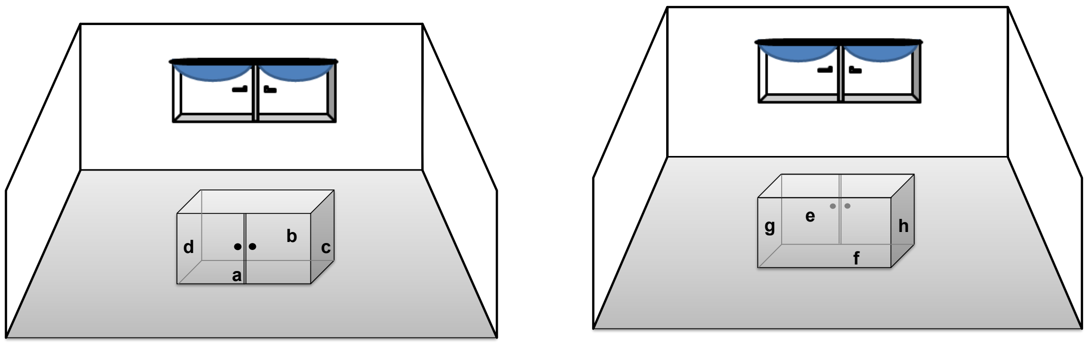
It was expected that for a canonically positioned cupboard, the participants would assign the following terms to the sides of the cupboard with respect to the outside perspective of the intrinsic frame of references (see Grabowski, 1999; Herrmann and Grabowski, 1998; Grabowski and Miller, 2000):

Canonically positioned cupboard

a. Front side
b. Back side
c. Right side
d. Left side

Non-canonically positioned cupboard

e. Front side
f. Back side
g. Right side
h. Left side.



(a) canonical (b) non-canonical

Figure 5.1: Illustrations of the cupboards with the front (left image) and the back (right image) towards the viewer

The aim of this task was to explore how do native speakers of the four languages assign sides to an intrinsic object, whether they use the same strategy or a different one.

5.2 Mouse tracking experiment: motivation

The results of a mouse tracking experiment are presented in this chapter as well. This online experiment (with respect to processing not internet) served as an extension of an offline experiment conducted by me in the course of the master thesis (see Perużyńska, 2012a; Stoltmann, 2014). The results of questionnaires with 561 participants indicate that the interpretation of the dimensional spatial expressions examined depends on the language and the situation. For this, I investigated German, English, Italian, and Polish. The most significant differences in interpretation of "in front of" and "behind" were found between German and English native speakers. In the extrinsic spatial relations with a table, almost all German native speakers decided for the reflection strategy of relative reference frame, whereas the English native speakers deviated from the strategy and interpreted extrinsic spatial constellations according to the translation strategy. In intrinsic spatial relations with cupboard, Italian native speakers deviated most frequently from the egocentric assignment of sides in the interpretation of "to the right of" and "to the left of." They conducted a mental rotation of 180° in interpreting these dimensional spatial expressions, in effect aligning their own front with the front of the cupboard, as if they were inside the cupboard, looking out. In this their answers differed significantly from the answers of English, German, and Polish native speakers, who did not perform this mental rotation (see Perużyńska, 2012a). It is important to emphasize that these spatial relations were directional.

The current experiment investigates the interpretation of positional spatial constellations. It was designed and developed to have participants' answers to questions by mouse movements that are tracked and analyzed. This method allows for a more fine-grained observation of the decision process than simply recording answers, or reaction times and answers, because one can observe the influence of possible distractors. This is especially important in situations where more responses are possible. One of examples from the study is the investigation of the origo shift. Mouse tracking supports in better observation the competition between a shifted and a non-shifted assignment of values. Origo shift might depend, for instance, on sentence constructions (that the speaker uses), the semantics of embedding as well as embedded predicates, or the spatial expressions of the first and second horizontal axes (*in front of – behind* vs. *to the right of – to the left of*). To discover whether origo shift takes place in spatial relations, a mouse tracking experiment comprising 248 sentences was implemented and conducted.

The experiment was composed of both *simple* and *complex sentences*. An example of a simple sentence is: "Where is the bottle standing?". It introduced simple spatial relations. In this case, participants were asked to choose one of four answers: "to the right of / to the left of / in front of / behind the cupboard / table / dog." In the second part of the experiment, participants were asked to judge more complex spatial situations supplemented by an artificial agent (*Hans*) and described by a complex sentence (indirect speech), such as: "Hans know that the bottle is standing. . . ."

The aim of the experiment was to discover which reference frame native speakers of German, English, Italian and Polish apply to interpret simple spatial situations. In particular, I wanted to find out whether the participants shift the origo when interpreting complex spatial relations (supplemented by an artificial agent, Hans). That is, whether participants interpret these complex situations from their own point of view and consider themselves as origo, or from the artificial agent's point of view and thus shift the origo (as expected from the theory of mind, e.g. Perner, 1999). Additionally, it is relevant when the origo shift takes place and, whether the shift depends on the complexity of the spatial relation. It is particularly important whether native speakers of these four languages interpret such situations using the same reference frame. All the null hypotheses investigated in this experiment on the four languages are defined in section (5.3).

The following sections contain a description of the experimental method, some details of the participants and laboratory, the hypotheses, and the results. In the result section, the margins include the respective discussed spatial relations supplemented by visual frames of reference and its explanations of strategies. This approach should support the reader's comprehension. All the null hypotheses are accompanied first by general data analysis, then by a detailed data analysis, and, at the end, by a brief summary and discussion. The detailed analysis shows step by step how the particular native speakers interpret spatial relations. The chapter concludes with a summary and a more general discussion in which a comparison with the hypotheses is made. Finally, the results for the all languages investigated are compared (see 5.10).

5.3 Mouse tracking experiment: null hypotheses

For the current studies, the null hypotheses listed below were formulated. They are based on the literature discussed in the chapters above as well as on the author's own observations.

First null hypothesis: The presence of a third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift.

Factors: simple (without Hans) vs. complex spatial relation (with Hans) × Dimensional spatial expression (in front of, behind, to the right of, to the left of); MAD.abs / AUC.abs

Second null hypothesis: The interpretation of dimensional spatial expression does not depend on the semantics of embedding predicates.

Factors: Embedding predicates (positive vs. negative) × Dimensional spatial expressions (in front of, behind, to the right of, to the left of); MAD.abs / AUC.abs

Third null hypothesis: The animacy of reference objects does not affect the interpretation of spatial relations.

Factors: Animacy (animate reference object vs inanimate reference object) × Dimensional spatial expression (in front of, behind, to the right of, to the left of); MAD.abs / AUC.abs

Fourth null hypothesis: The choice of the reference frame does not depend on the native language.

Factors: Dimensional spatial expression (in front of, behind, to the right of, to the left of) × reference object (table, cupboard, dog) × language (DE, EN, IT, PL); MAD.abs / AUC.abs

5.4 Mouse tracking experiment: procedure

Before beginning the experiment, I explained the experimental procedure and method as well as the purpose of the study to the participants. Each participant was asked to read, complete, and sign the *information sheet* and the *consent form* (see the appendix for both).

Following this, participants were asked to move to the computer station, where the experiment leader explained the procedure in detail (see research protocol in attachment). Before commencing the actual experiment, participants were asked to take part in a practice mouse tracking experiment, which showed them the methodology; they thus became familiar with mouse tracking as an experimental method. The practice experiment consisted of three different trials concerning fruit and vegetable classification, which were not linked to the topic of space and language. During this task, the experiment leader explained the experimental methodology to them step by step. During this component, participants could ask questions about the methodology. Before the experiment, each participant was asked whether she or he clearly understood the procedure and the task and whether she or he was ready to begin the experiment. Only thereafter the participants were asked to start the experiment session.

After the experiment, participants were additionally asked to complete a questionnaire in order to correctly assign them to a particular group (pursuant to their metadata). In this questionnaire, participants were also asked to identify the *right*, *left*, *front*, and *back* of the cupboard and assigning these, as outlined above.

5.5 MouseTracker as experimental method

Freeman, Dale, et al. (2011) found evidence that trajectories, that is, hand movements, during mouse tracking experiments, visualize ongoing dynamics of processing. The authors describe the process as “capturing the mind in motion with fine-grained temporal sensitivity” (Freeman, Dale, et al., 2011, p. 1). This statement was already known for the eye-tracking; however, there are also several benefits in applying each investigative method (hand- and eye-tracking) individually (see Magnuson, 2005). One of advantages of mouse tracking is being able to visualize the continuous streams of motor actions. More specifically, as per Magnuson (2005, p. 9996), mouse tracking enables the simultaneous investigation of graded locations among multiple response locations. Freeman and Ambady (2010) indicate that mouse tracking can be used to draw conclusions regarding the actual mind in motion. They describe this principle as “Hand in Motion reveals Mind in Motion” (Freeman and Ambady, 2010, p. 226).

The trajectories of arm reaching movements are steadily updated by means of perceptual-cognitive processing over time, as has already been proven in numerous studies (e.g., Abrams and Balota, 1991; Tipper et al., 1998; Gold and Shadlen, 2001; Song and Nakayama, 2006; Freeman and Ambady, 2010, p. 226 f.; Spivey et al., 2005). It has been demonstrated that continuous motor responses, such as the movement of a hand in the case of mouse tracking, are not simply the endpoints of sensory and cognitive subsystems. More specifically, Freeman and Ambady (2010) describe the dynamics of the movement as an indicator of the dynamics of perception and cognition. For this reason, researchers conclude and emphasize that online motor responses that are sampled quickly enough may be informative about the duration of perceptual-cognitive processing (Freeman and Ambady, 2010, p. 227). Spivey et al. (2005) demonstrated that the trajectory of a mouse can reveal the accumulating relative activation of response options, with proximity of each point on the trajectory to the options reflecting the activation of the options. As far as this author is aware of, this was the first study in the field of linguistics processing that used mouse trajectories as an experimental method.

However, this mouse tracking method has also been criticized in the literature. Kieslich, Wulff, et al. (2018) explained that, due to temporal resolution, neither mouse nor eye tracking are insufficiently strong methodologically to track the cognitive process closely enough to uncover its precise nature. Therefore, these researchers recommend simultaneous mouse and hand tracking. According to the authors, using mouse and hand tracking simultaneously enables the recording of the position of the hand while it moves to select one of the possible response alternatives. However, a problem may arise here due to different sampling frequencies: the mouse tracking achieves a resolution between

60-100 Hz and the hand tracking up to 1,000 Hz. Hence, approximately 10 data points of hand tracking are found between two mouse tracking data points.

Despite the criticism, mouse tracking tools have been used with increasing frequency as an experimental method in the last decade. Many researchers have applied this method to investigate cognitive processes in numerous research fields, including linguistic processing (e.g. Spivey et al., 2005; Morett and MacWhinney, 2013; Tomlinson, Gotzner, et al., 2017; Sauerland et al., 2017), cognitive conflicts (e.g. Weis and Wiese, 2017), food choice (e.g. Gillebaart et al., 2016), memory (e.g. Abney et al., 2014; Papesh et al. (2012); Tomlinson, Bailey, et al., 2013), numerical cognition (e.g. Faulkenberry, 2014), social cognition (e.g. Freeman, Dale, et al., 2011; Smeding et al., 2016), and many more.

As regards cross-linguistic and spatial cognition, as far as I am aware, the current study is the first experiment that uses mouse tracking as an investigative methodology (despite the experiment of Galati et al. (2019) and Tower-Richardi et al. (2012), who investigated the influence of abstract spatial concepts on the concrete egocentric body axes – as well as Wang et al. (2012)). Nonetheless, some finely grained experiments have already been conducted; these investigated spatial perspective-taking (for instance Duran and Dale, 2014; Duran, Dale, and Kreuz, 2011).

The free mouse tracking software, MouseTracker [1], by Freeman and Ambady (2010), is widely used. A statistical evaluation shows that over 3,000 researchers had used the method for their research during the period from August 2009 to August 2016 (5.2; adapted from *MouseTracker* (n.d.)).

For my work, this software was selected as an experimental tool to investigate the interpretation of spatial expressions of the first and second horizontal axis. This free available software does not directly provide a powerful scripting interface, therefore fine-tuning for adaptation for experiments is almost impossible. Due to the fact that it is closed-source software, it cannot easily be extended. The last disadvantage of the software is it can only be run on the Windows operating system (see also Kieslich, Wulff, et al., 2018).

Despite some technical weaknesses, the tool can be used to conduct mouse tracking experiments. During experiments, the MouseTracker software records the mouse movements of the participants throughout their answer process (see Freeman and Ambady, 2010 for more details on the software package; and Hehman et al. (2015), and Calcagnì et al. (2017) for an explanation of advanced mouse tracking analytical work). The mouse movements recorded are referred to as mouse trajectories. Figure 5.3 serves as an example of the mouse trajectories of all participants in one randomly selected task of the current study.

[1] The MouseTracker can be downloaded from the following address: http://www.mousetracker.org/download/ after filling in a short clarification document. (Retrieved on 11th of October 2017.)

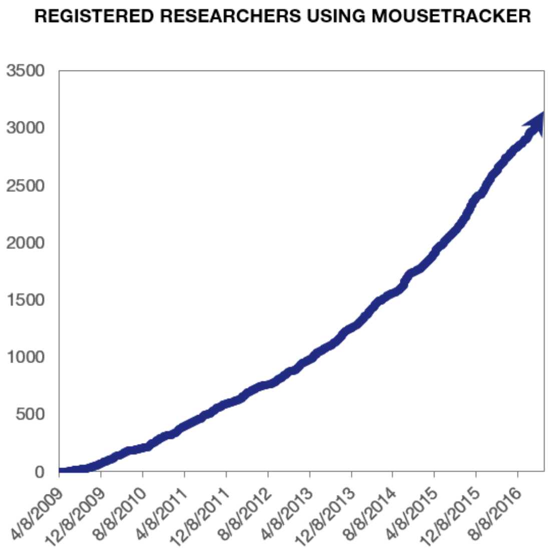


Figure 5.2: Number of registered researchers using Mouse Tracker (Source: http://www.mousetracker.org/user-base/)

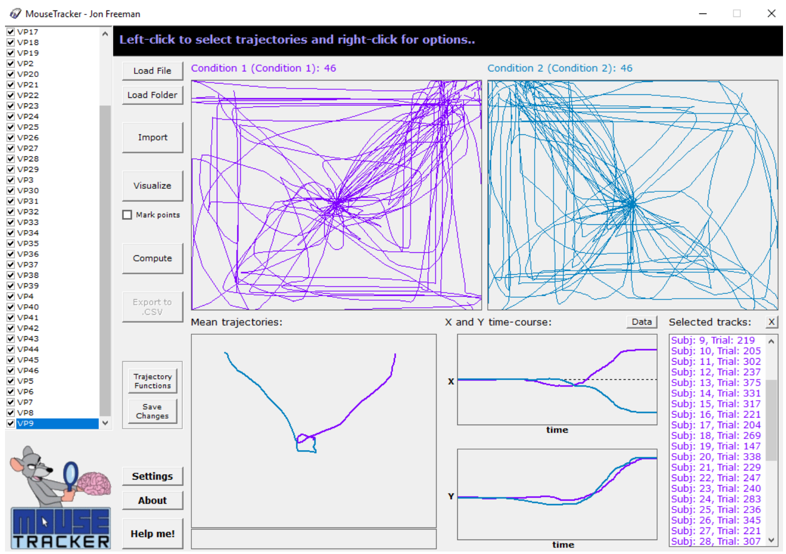


Figure 5.3: Mouse tracking trajectories using Analyzer program in the MouseTracker suite

Considering the trajectories in 5.3, the actual mouse trajectories from the start button to the response button indicate an extensive process as per the assumptions of Freeman and Ambady (2010), Magnuson (2005), Tomlinson, Gotzner, et al. (2017), and others. In contrast, mouse trajectories that lead straight from the start button to one of the response button indicate minimal processing. Trajectories visualize incremental sentence interpretation by participants. The change of their mouse paths indicates the change of their interpretation of the sentence (see Tomlinson, Gotzner, et al., 2017).

For this experiment, mouse tracking was chosen as a method for several reasons. It provides a very good way for investigating a lexical decision visualizing the participants' reaching arm movements when choosing one of multiple response alternatives. Furthermore, it depicts the trajectories during the response time very clearly. In contrast to surveys, this method illustrates the route to the response. Therefore, it provides more explicit data for the questions of *why* and *how* the participants decided on their responses. Furthermore, this experimental method provides reaction times, information about cognitive processes between stimulus and completed action (e.g. Tomlinson, Bailey, et al., 2013; Tomlinson, Gotzner, et al., 2017) as well as a measure of incremental sentence interpretation (e.g. Tomlinson, Gotzner, et al., 2017). Finally, it is portable; hence, mouse tracking experiments investigating languages can be conducted in different countries/places – as was required for this work. As a result of the numerous positive aspects, some of the negative ones can be balanced.

5.5.1 Technical settings in the MouseTracker software

The experiment was conducted using the Runner program available in the MouseTracker suite, in addition to the Designer (see 5.4) and Analyzer (see 5.3).

The screen resolution was set to 1366 x 768 pixels for the experiment. The start button was placed in the coordinate system with the parameters $x = -0.1$ and $y = 0.75$. It was 0.1 high of the particular measurement unit. The location of the visual stimuli was set at $x = 0.01$ and $y = 0.69$ (see 5.4).

The response font size was set at *19* and colored *black*. The response font was *Arial*. In contrast, the stimuli font size was set at *44*. As defined by the software authors, Arial was selected as the font for black stimuli. START is the button visible before each trial; it appeared in font size 18 as black Verdana text. After every 20 trials, additionally "break" appeared as an image (png) on the screen – at this time, participants were asked to take a short break if required and press enter when they were ready to continue. The experiment closed with acknowledgement (also a png image).

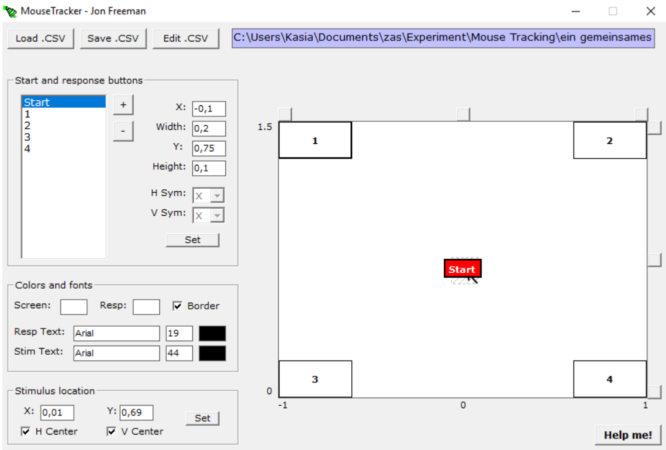


Figure 5.4: Design of the mouse tracking experiment

The sentences appeared automatically with the following time settings:

1. interrogative – 500 millisecond
2. subject (the name of the artificial agent *Hans*) – 500 milliseconds
3. predicate in simple sentence – 500 milliseconds
4. predicate and conjunction of the matrix sentence – 700 milliseconds
5. predicate of embedded sentences – 500 milliseconds
6. object – 500 milliseconds
7. Where (500ms) is (500 ms) the bottle (500 ms) standing? (500 ms)
8. Hans (500 ms) says that (700 ms) the bottle (500 ms) is standing... (500 ms)

As per Gangl et al. (2018) and Landerl et al. (2013), this is more than enough time to read and understand the words presented (see also Brem and Maurer, 2015 on the neurobiological processes of reading; Hauk and Pulvermüller, 2004 on visual word processing; Friederici et al., 1996 and Kutas and Hillyard (1983) for reading processing and the influence of syntax).

The data were preprocessed with mousetrap, an integrated, open-source mouse tracking package that allows the data from all participants to be merged and several parameters to be calculated while providing the source code (Kieslich, Wulff, et al., 2016; Kieslich and Henninger, 2017), for instance: the response (left, right, in front of, behind), the Maximum Absolute Deviation (MAD), and the Area under the Curve (AUC) of the hand trajectories. For each computation of continuous measures, the normalized time data was set by default to 101 steps due based on the definition on Spivey et al. (2005).

5.5.2 Experimental design

5.5.2.1 Linguistic stimuli

This within-participants experiment included 248 sentences in total (see appendix). In addition to these sentences, another 113 sentences (≈ 31%) were added as filler items. Based on the research question and on the number of sentences, the proportion between filler and stimuli are not 1:3, which is more usual in psycholinguistics (see e.g. Nikolayeva et al., 2015). Had this been the case, the experiment would have lasted more than one hour and hence the participants' concentration would have been impaired or limited (see e.g. Khromovskikh, 2003, p. 58; Myers and Hansen, 2011, p. 431). Furthermore, participants were asked to interpret spatial expressions that they use in everyday situations. Before each trial, participants were asked to press START to continue the experiment. After every 20 trials, an additional break appeared – in this time, participants were asked to take a short break if needed and press enter if they were ready to continue.

The presentation of each trial began with the showing of the START button in the center of the screen and four responses in the four corners of the screen (see 5.5.2.3). After pressing the button, the particular sentence was presented on the computer screen followed by the picture. Each trial started with words presented chunk by chunk. Once the whole sentence had appeared, the picture was shown on the screen. This methodological approach was proposed by Stanfield and Zwaan (2001).

The 248 sentences were split into two groups: interrogative simple sentences (without a supplemented artificial agent as subject), and complex declarative sentences supplemented by the artificial agent *Hans* as a subject.

The simple interrogative sentence in the particular languages were:

Language	**Interrogative sentence**
German	Wo steht die Flasche?
English	Where is the bottle standing?
Italian	Dove sta la bottiglia?
Polish	Gdzie stoi butelka?

Table 5.1: Interrogative sentences for the simple spatial relations in the particular languages investigated

In this case, the sentences did not include any syntactic or semantic differences. The interrogative sentence was the same for all the simple spatial relations. The response alternatives were the same for all the simple spatial relations too though their order was randomized. This means that, for each spatial relation, the order of the response differed; however, for a particular relation, the order was the same for all participants.

With the simple spatial relations, participants saw the following four response alternatives, depending on the reference object (see 5.5.2.2 for more details on the reference objects):

- *In front of / behind / to the right of / to the left of / the cupboard.*
- *In front of / behind / to the right of / to the left of / the table.*
- *In front of / behind / to the right of / to the left of / the dog.*

The task was to investigate the interpretation of the spatial expressions for different spatial relations; these can be ordered hierarchically according to the objects' intrinsicality (see 5.5.2.2).

The complex spatial relations were first split into two semantic groups: positive vs. negative. To the positive group belong complex sentences, including the following verbs as embedding predicates:

- behaupten, twierdzić, affermare ("claim" – as representative of the verbs of retaining knowledge, see Karttunen, 1977, p. 6)
- denken, myśleć, pensare ("think" – as representative of verbs of retaining knowledge, see Karttunen, 1977, p. 6)
- glauben, wierzyć, credere ("believe" – as representative of verbs of conjecture, see Karttunen, 1977, p. 6)
- meinen, sądzić, ritenere ("reckon" – as representative of verbs of communication, see Karttunen, 1977, p. 6)
- sagen, mówić, dire ("say" – as representative of verbs of communication, see Karttunen, 1977, p. 6)
- wissen, wiedzieć, sapere ("know" – as representative of the verbs of retaining knowledge, see Karttunen, 1977, p. 6).

The negative group comprises sentences embedded with the following predicates in the matrix sentence:

- bezweifeln, wątpić, dubitare ("doubt"), and
- leugnen, przeczyć, negare ("deny").

Relative to the interrogative sentences, all the complex sentences were supplemented by Hans. All had the same syntactic structure (see table 5.2).

Language	Subject	Embedding predicate	Conjunction	Bottle	Predicate
DE	Hans	sagt,	dass	die Flasche	steht…
EN	Hans	says	that	the bottle	is standing…
PL	Hans	mówi,	że	butelka	stoi…
IT	Hans	dice	che	la bottiglia	sta…

Table 5.2: Example for description of complex spatial relations in individual languages investigated

All these complex spatial relations included the bottle as the localized object, the cupboard or one of the tables as the relatum and the artificial agent (Hans). Hans was placed on either the left or the right side of the reference object and participants saw the following four response alternatives:

- *In front of / behind / to the right of / to the left of / the cupboard*
- *In front of / behind / to the right of / to the left of / the table.*

The following chart depicts the experimental design of the study in its entirety (see 5.5):

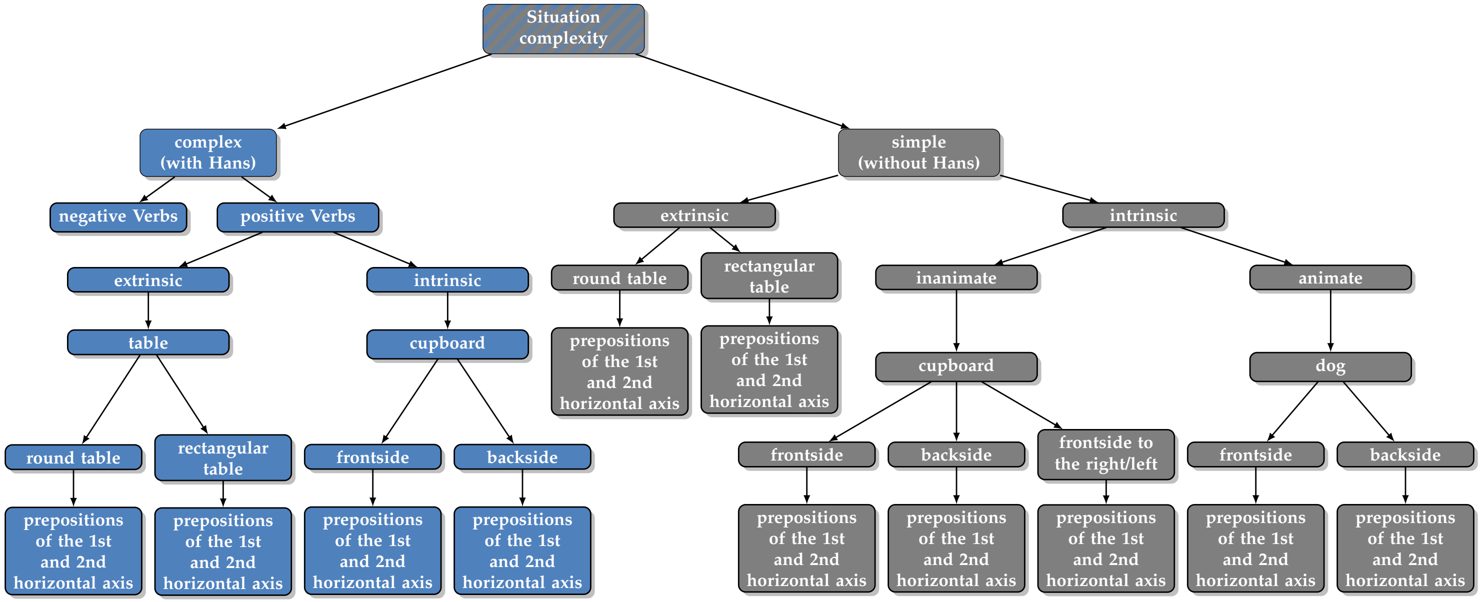


Figure 5.5: Experimental design

5.5.2.2 Visual stimuli

As stated above, I used different objects as reference objects. The reference objects included in the investigation of spatial relations can be ordered hierarchically according to the object's intrinsicality:

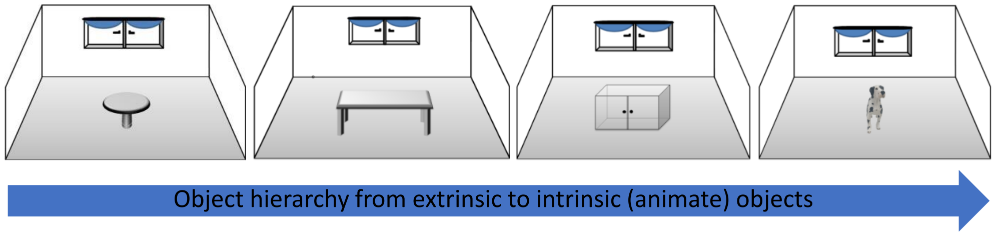


Figure 5.6: Hierarchy of objects (stimuli) according to object intrinsicality

Considering the hierarchy (5.6) in ascending order, the *round table* comes as first (within the investigated spatial relations and its objects). It has no edges. It only possesses a pronounced vertical axis, *up* and *down*. In contrast, neither the sides of the first horizontal axis nor of the second axis are pronounced. One of the reasons for this is that it does not possess any edges, which may at least indirectly indicate some directions (see e.g. Perużyńska, 2012a, p. 35; Stoltmann, 2014).

The *rectangular table* appears second in the selected object hierarchy. It does not possess any fixed pronounced sides (contrary to a desk) but still possesses four corners, which may indirectly lead to stronger side assignment in spontaneous situations than in the case of spatial relations with round table (see the results of the surveys by Perużyńska, 2012a, p. 44 ff. on German, Polish, English, and Italian native speakers for spatial relations with round, rectangular, and triangular tables).

The *cupboard* appears third in the hierarchy as representative of vis-à-vis objects and last as the representative of inanimate stimuli. According to Grabowski, we assign sides to the cupboard with respect to the outside perspective (s. e.g. Grabowski, 1999, p. 109; Miller and Johnson-Laird, 1976, p. 403) because we use the cupboard from the outside and not from the inside as we do with, for instance, vehicle objects (e.g. cars, armchairs, garments).

The *dog* appears as fourth and last in the hierarchy. In contrast to the three above mentioned objects, the dog represents the only animal entity, in particular, a higher animate entity (see Stoltmann, Fuchs, and Krifka, 2018). We assign the animate objects with intrinsicality in a manner similar to the way we do for humans or vehicle objects (2). Within the scope of the study, I investigated whether native speakers of the four languages describe spatial relations according to the intrinsicality to animate entities. There are several reasons to assume that the animacy of a reference object influences the description of spatial relations, which were shown in different previous studies (see e.g. Baltaretu et al., 2016 for the preference of the choice of spatial relations with animate reference object as first; Bowerman, 1996, p. 153, Feist, 2000, p. 121 ff., Feist and Gentner, 1997; Feist and Gentner, 2003, p. 2 f. for the influence of animacy on preposition choice while description of spatial relations; Hüther et al., 2016 for choice of reference frame).

5.5.2.3 Responses

This experiment employs a more advanced sort of mouse tracking experiment, with four response alternatives (see 5.7). Usually, the response alternatives are not randomized in mouse tracking experiments (see Monaro et al., 2017; Calcagnì et al., 2017; Sauerland et al., 2017). Nonetheless, in this experiment, the response alternatives were randomized – otherwise their local order could have influenced the participants' responses.

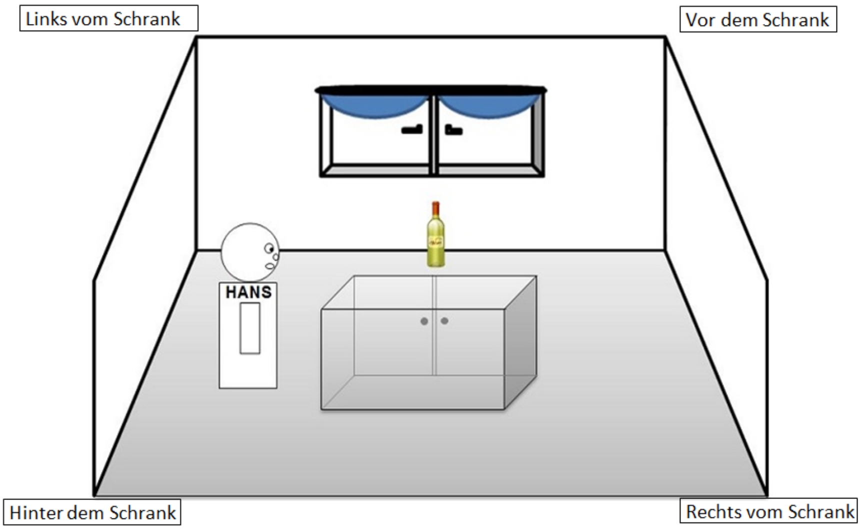


Figure 5.7: Design of response alternatives for the mouse tracking experiment

The proposed distribution design of response alternatives for the mouse tracking experiments corresponds to the following coordinate system (5.8):

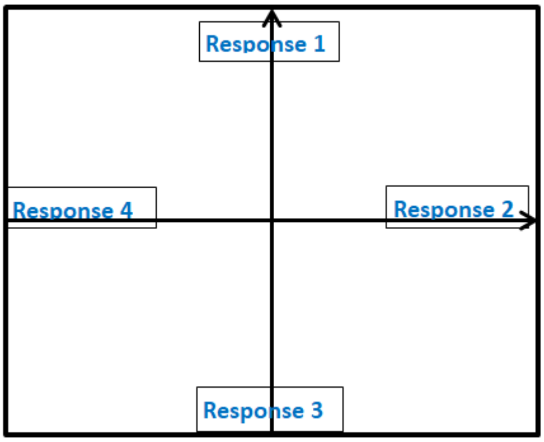


Figure 5.8: Proposed distribution design of four response alternatives for the mouse tracking experiment

For the current experiment, this response design would not be suitable, as discussed below. In this case, participants could integrate the response order into the local relation. Therefore, they could ignore the relation between objects totally (because it is on a smaller scale) and concentrate on the larger scale, which, in this case, is the coordinate system of the whole spatial relation, namely, the room (see 3.3). This means that participants could adopt this order as the spatial order of this relation. This aspect also suits nonrandomized response alternatives.

A further reason for not using this response order is that the screens are usually rectangles rather than squares. Hence, the vertical and horizontal trajectories would not be same length.

In addition, the response order, rather than the alternatives order, does not appear to be not correct, because mathematically, these trajectories are not same (starting from the middle of the screen). The trajectories from the start button, from the middle, to all of the response alternatives would be more or less straight ahead. These would not be comparable with the usual trajectories of mouse tracking experiments. Finally, the greatest difficulties may involve the influence of the alternative order on the responses because of the spatial order.

For these reasons, I decided to randomize both response alternatives and trials.[2] Moreover, I decided on the more advanced design for mouse tracking, which means four alternative responses due to the fact that two responses would not be sufficient to review all possible answer alternatives. For instance, in the above spatial relation (5.7), four

[2]Thank you very much to all, who discussed these factors with me – especially Torgrim Solstad and Manfred Krifka.

responses are possible:

- *behind* the cupboard (corresponding to the interpretation in terms of the translation / align strategy of the relative frame of reference from the participants' point of view)
- *in front of* the cupboard (corresponding to the outside perspective of the intrinsic frame of reference)
- *to the left of* the cupboard (corresponding to the interpretation in terms of the reflection / facing strategy of the relative frame of reference – from Hans' point of view)
- *to the right of* the cupboard (corresponding to the interpretation in terms of the rotation strategy of the relative frame of reference – from Hans' point of view).

(Please refer to the following link for more details on the more advanced experimental method: [*MouseTracker* n.d., retrieved on December 7th 2017].)

5.6 German

5.6.1 Location of the experiment in Germany

The experiment was conducted in the psycholinguistics laboratory at the Leibniz Centre General Linguistics (ZAS) in Berlin, Germany, which is led by John Tomlinson. The laboratory has four work stations with one computer in each so that four participants can be investigated simultaneously. Each work station looks like a cabin and is separated from the other cabins by a folding screen (see 5.9). This made it possible for each participant to concentrate on his or her own task. Nonetheless, within the scope of this experiment, a maximum of two participants were investigated simultaneously because they were usually interviewed after the experiment.

Figure 5.9: Mouse tracking Laboratory at ZAS (source Leibniz-Zentrum Allgemeine Sprachwissenschaft (n.d.))

In each case, the distance between the screen and the participants was approximately 50 cm.

5.6.2 Participants: German native speakers

46 German native speakers, 33 female and 13 male, participated in the experiment. The participants were found via LingEX, a participants' portal developed by ZAS (see *LingEX* n.d.), as well as via the HU Student List, an email list for all students of Humboldt University. All were between 19 and 60 years old, with a mean of 28.9 years (see 5.10).

As a result of the location of the experiment, most of the participants were students of one of the universities in Berlin. Students studying a variety of subjects were investigated,

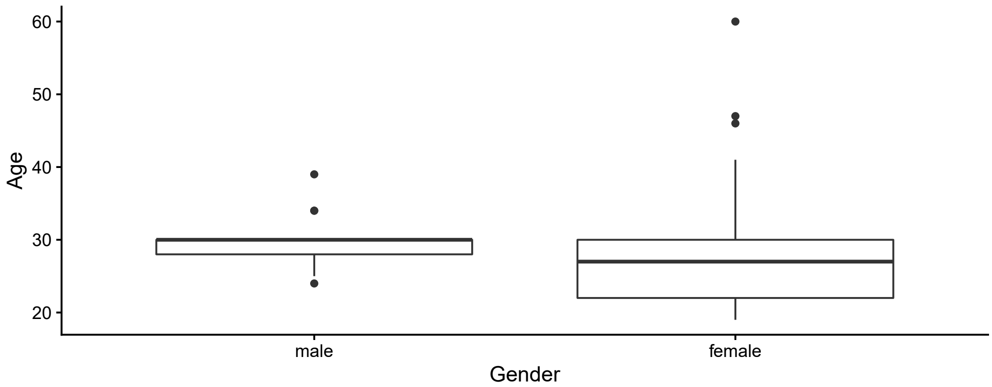


Figure 5.10: The gender and age distribution of German native speakers in the experiment

as illustrated in 5.11. The diversity was important for us, because the specialization can influence the perspective choice for the interpretation of spatial relations (as shown by Hüther et al., 2016). However, all of the participants belong to the WEIRD group (Western, Educated, Industrialized, Rich, and Democratic), defined by Henrich et al. (2010).

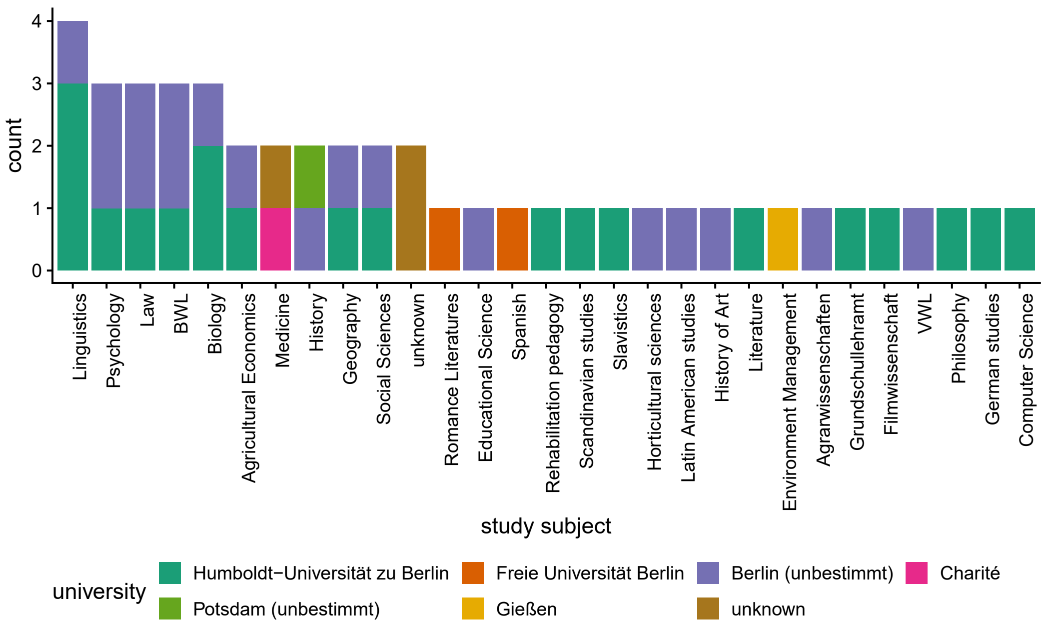


Figure 5.11: Universities attended and subjects studied by participants in the experiment

For participating in the experiment, participants received 10€ compensation. In addition to the mouse tracking experiment, they were also asked to complete a questionnaire based on the Edinburgh Handedness Inventory (see Oldfield, 1971). The aim was to find out whether handedness can influence spatial perception and thus the interpretation of spatial expressions. Based on the results of the questionnaire, ≈ 56.52% of participants were right-handed (dominant hand), 4.35% left-handed, and 39.13% were mixed (meaning that they prefer performing some tasks with the right hand and others with the left, or they conduct some tasks using both hands – depending on the situation or their mood). However, all the participants used the mouse with the right hand. Left-handed participants stated that they write with the left hand but use the mouse with the right due to the lack of mouses for left-handed users – especially in public places such as pc pools/computer labs at universities or schools.

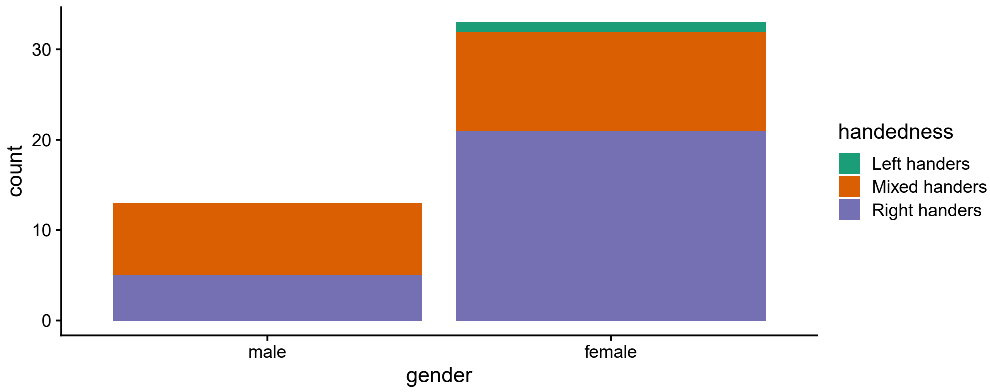


Figure 5.12: The distribution of gender and handedness of the participants

With regard to their origin, all the participants were born in Germany. Two were bilingual: German and Serbian, and German and Greek. I included them in the analysis, for many reasons: their dominant language is German, they were born and grew up in Germany, they use navigation systems in German, and describe spatial relations most frequently in German.

5.6.3 Results for questionnaire study: identifying sides by German native speakers[3]

Within the questionnaire study, I investigated how German native speakers assign sides to canonically and non-canonically positioned cupboard. As explained above, the following

[3]This part of the dissertation was already published by Stoltmann, Fuchs, and Krifka (2018).

answers were expected (due to the theoretical assumptions):

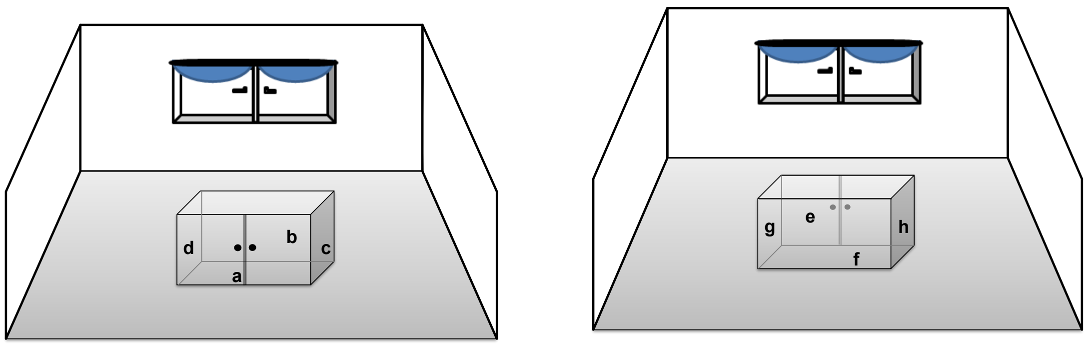
Canonically positioned cupboard

a. Front side
b. Back side
c. Right side
d. Left side

Non-canonically positioned cupboard

e. Front side
f. Back side
g. Right side
h. Left side.

Approximately 62% of the participants named all four sides according to the intrinsic frame of reference to both the canonically and the non-canonically positioned cupboard, fully corresponding to the outside perspective of the intrinsic frame of references (as explained in points (a) to (h) above). However 97% of the participants identified the *front* and *back side* along the expected perspective. Only 3.3% considered the cupboard as an extrinsic object, assigning the sides according to the reflection / facing strategy of the relative frame of reference – for both the canonically and the non-canonically positioned cupboard. No participant employed the translation / align strategy consistently.



(a) canonical (b) non-canonical

Figure 5.13: The images show pictures of the cupboards viewed canonically (with the front facing – on the left) and non-canonically (with the back facing – on the right) from the survey

Considering the results in detail, I found that all participants chose (a) for the *front* and (b) for the *back* (see 5.13, left), which is to be expected, as here the naming following the intrinsic and relative frame of reference coincide. Furthermore, for the spatial relation with canonically positioned cupboard, 10% of the participants assigned *left* to (c) and *right* to (d), conducting a mental rotation of 180°. This means that these 10% of the participants (3 persons) assigned the sides according to the rotation strategy of the relative frame for the canonically positioned cupboard, which corresponds to the inside perspective (following Grabowski, 1999). Two of these three persons assigned the sides to the non-canonically positioned object according to the outside perspective (Grabowski, 1999) – as would be expected for the cupboard as a vis-à-vis object. The other person assigned the sides to the non-canonically positioned cupboard using the rotation strategy of the relative reference frame (see 5.13).

Regarding the assignment of sides to the non-canonically positioned cupboard, 97% of the participants selected (e) for the *front* and (f) for the *back*. 69% assigned the *right side* to (g) and the *left side* to (h) – that is, according to the outside perspective. This means that approximately 30% of participants deviated from the expected strategy (the outside perspective) for the non-canonically positioned cupboard. Around 89% of this 30% assigned the sides using the translation / align strategy of the relative reference frame. For the spatial relations of the non-canonically positioned cupboard, the intrinsic assignment of *front* and *back* merged with the assignment of the translation / align strategy, but not for the right and left sides. These speakers allocated the dimensional spatial expressions of the second horizontal axis egocentrically – as would be expected according to the translation / align strategy for this relation. The remaining 11% considered the non-canonically positioned object as extrinsic, assigning the sides according to the reflection / facing strategy.

The 5.14 shows details of the participants' responses to the canonical and non-canonical positioning of the cupboard in the questionnaire (here, the following applies: Vorderseite – 'front', Rückseite – 'back', Rechte Seite – 'right side', Linke Seite – 'left side'):

ID	q11_a	q11_b	q11_c	q11_d	q12_e	q12_f	q12_g	q12_h
17	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
18	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
19	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
20	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
21	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
22	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
23	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
24	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
25	Vorderseite					Rückseite		
26	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
27	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
28	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
29	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
30	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
31	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
32	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
33	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
34	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
35	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
36	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
37	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
38	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
39	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
40	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
41	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
42	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
43	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
44	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
45	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
46	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite

Figure 5.14: Responses to the questionnaire on the assignment of sides to the canonically (a–d) and non-canonically (e–h) positioned cupboard

An important question that arises at this point is: Do these answers match those for the simple spatial relations of mouse tracking? The task so far has clarified how participants recognize and spatially perceive a cupboard. The simple spatial constellations of the mouse tracking study examine how participants perceive relations between objects that are in spatial relations with the cupboard. The results show the interpretation of the investigated spatial relations by the participants. The following subsections include a step by step analysis regarding the cupboard as a reference object:

- Clarification questionnaire – assignment of only the sides to the cupboard as representative of vis-à-vis objects (above, see 5.6.3)
- Mouse tracking – simple static situations with the cupboard as a reference object (below, see 5.6.4.2.1.2)
- Mouse tracking – complex static situations with the cupboard as a reference object (below, see 5.6.4.2.1.2)
- Questionnaire – spatial relations with the cupboard as a reference object described by dynamic verbs (below – in the discussion, 5.6.4.3).

5.6.4 Results for mouse tracking study: interpretation of spatial relations by German native speakers

First, I report the results for the categorical answers with respect to the experimental design and then describe the continuous measures of the mouse trajectories. Thereafter, I conduct a detailed data analysis for each particular spatial relation (see 5.6.4.2.1.1 5.6.4.2.1.2, 5.6.4.2.2.1).

Several Fisher's exact tests were conducted for the categorical responses and linear mixed models, as well as ANOVAs for the differences and similarities of the continuous measures of the trajectories. All statistical tests and visualizations – bar and trajectory plots – were computed by the software R (version 3.4.2., R Development Core Team, 2017).

For the computation, I used various additional packages: ggplot2 (Wickham et al., 2013), lme4 (Bates et al., 2014), shiny (Chang et al., 2015), shinyjs, data.table, tidyr (Wickham, 2017), gridExtra (Auguie, 2017), and purr (Henry and Wickham, 2017). *GGplot2* is a data visualization package and *lme4* is R package computing mixed models. *Shiny* is an R package that may be applied to build interactive web apps. *Data.table* package provides an enhanced version of data.frame in R.

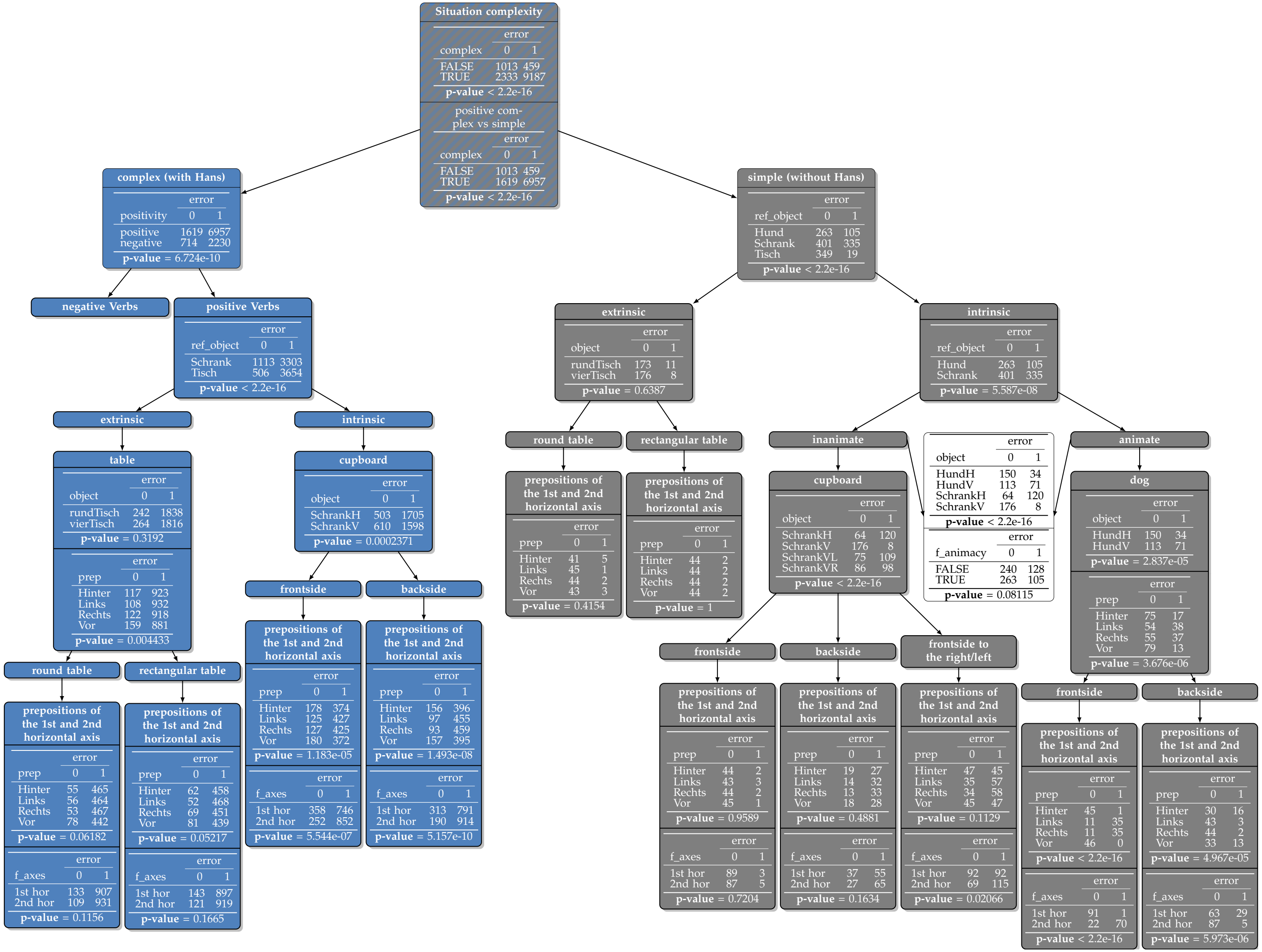


Figure 5.15: Computation of statistical analyses for categorical answers in German with respect to the experimental design

5.6.4.1 Computation of statistical analyses for categorical answers in German with respect to the experimental design

5.15 depicts the setup of the experiment – the structure as a whole supplemented by the statistical analysis for the particular situations. In this part of the work, those factors that caused significance and those that did not are emphasized. The analysis is conducted top down following the structure of the graphs. For the computation, first I compare the "correctness" with respect to a particular reference frame using for the interpretation of the particular spatial relations. This means, for the extrinsic spatial relations, independent of the relations' complexity with the round and rectangular tables, I defined the reflection / facing strategy from participants' point of view as *correct*. That means that the assumption applies for all spatial constellations with tables, both with and without Hans.

However, for the complex intrinsic spatial relations, I assumed the outside perspective of the intrinsic reference frame, independent on the position of the reference object and Hans. The same assumptions apply for the simple relations with a cupboard.

For the spatial relations with the dog, I assumed the inside perspective of the intrinsic frame of references, which also applies for humans. All in all, *correctness* is only used in terms of definition for computation not in terms of application of reference frames in particular relations.

Furthermore, the chart supports the analysis of null hypotheses *one*, *two*, and *three* (see 5.3). These are all null hypotheses that can be computed individually.

Interpretation of the complex spatial relations:

Situation complexity

	error	
complex	0	1
FALSE	1013	459
TRUE	2333	9187
p-value < 2.2e-16		

positive complex vs simple

	error	
complex	0	1
FALSE	1013	459
TRUE	1619	6957
p-value < 2.2e-16		

Figure 5.16: Computation of statistical analyses for categorical answers in German with respect to the complexity of spatial relation

First, I have discovered that the complexity of relations influences interpretation by the German native speakers. The *p-value* between the complex and simple spatial relations is < 0.001. With this result, I can reject the first null hypothesis: The presence of the third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift; and confirm the alternative hypothesis: The presence of the third person as artificial agent in a spatial relation expressed by indirect speech affects an origo shift. This result indicates that the presence of an additional person – in this case, the artificial agent – influences a perspective shift while spatial relations interpretation by the investigated German native speakers. In particular, the attribution to the artificial agent is by the indirect speech.

Results for the second null hypothesis:

complex (with Hans)		
	error	
positivity	0	1
positive	1619	6957
negative	714	2230
p-value = 6.724e-10		

Figure 5.17: Computation of statistical analyses for categorical answers in German with respect to verb semantic

With complex spatial relations, the high significance applies to the complex spatial relations embedded by both positive and negative predicates. It is caused by the perspective shift from the participants' to Hans' point of view (compare the detailed analysis of particular situations below – 5.6.4.2). Especially, the results reveal very high significant differences between the positive and negative descriptions of spatial relations ($p < 0.0001$). It is worth mentioning that significantly more German native speakers selected the *correct* answers when interpreting the negative spatial relations than did with the positive.

Furthermore, I found very strong significant differences not only between the negative and positive verbs but also within the groups. First, I computed the significance for all complex positive situations – independent on the reference object: the cupboard or table, and the position of Hans with respect to the reference object – to the right or left of the particular object. The results reveal a *p-value* of < 0.0001. Considering the results in greater detail, the investigated German native speakers interpreted the intrinsic spatial relations with the cupboard *correctly* more frequently – that is, according to the outside perspective rather than the relations with the tables, according to the expected reflection / facing strategy from participants' point of view. That is, the German native speakers shifted the origo from themselves to Hans' point of view and interpreted the complex spatial relations from his point of view significantly more frequently in situations with an extrinsic than with an intrinsic reference object. This implies that the objects' properties (intrinsicality and functionality) play important role for the German native speakers because they shift the perspective to Hans' point of view more frequently with extrinsic objects than with intrinsic ones. However, intrinsicality is not a strong enough property for the participants to concentrate only on it while interpreting of spatial relations.

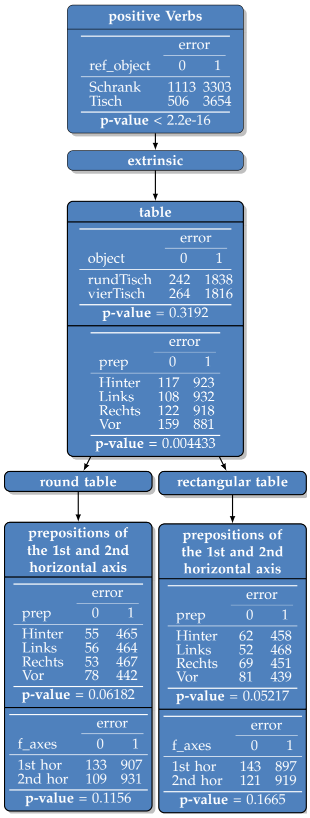


Figure 5.18: Computation of statistical analyses for categorical answers in German with round and rectangular table in complex spatial relations

Analyzing the answers for positive spatial relations in greater depth, we see that there is no significant difference ($p = 0.31$) between complex spatial relations with the round or with the rectangualr table. This implies that the shape of the tables did not significantly influence the interpretive strategy of the participants. With the extrinsic objects, I conducted further analysis to understand the semantic differences and similarities between the particular spatial expressions. First, the results reveal that participants selected different interpretive strategies depending on the prepositions ($p = 0.004$) for both tables taken together. The German native speakers interpreted the complex extrinsic spatial relations most frequently with respect to the reflection / facing strategy from their point of view in relations with the bottle *in front of* the table (from their point of view). In contrast, they selected the reflection / facing strategy less frequently with the bottle to the *left of* the table (from their point of view). In the last step, I examined whether the shape of the table influences the interpretation of particular extrinsic complex constellations. The separate analysis of the particular situations, either with the round or the rectangular table, revealed no significant differences. In the constellations with both tables (considering the situations individually), the participants interpreted most frequently the spatial relations with the bottle *in front of* the round or rectangular table with respect to the reflection / facing strategy from the participants' point of view.

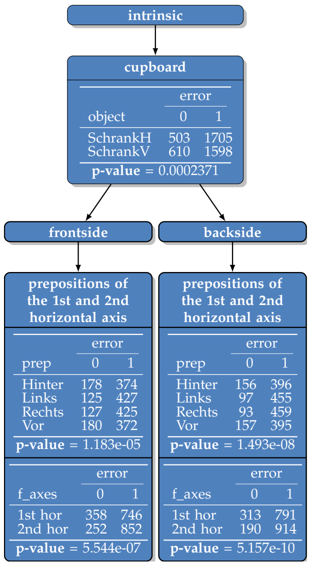


Figure 5.19: Computation of statistical analyses for categorical answers in German with cupboard in complex spatial relations

I also found several significant differences for the complex intrinsic spatial relations. [4] The first very general result between the canonically and the non-canonically positioned cupboard revealed very high significant differences ($p < 0.0001$). These indicate that German native speakers interpret canonical spatial relations with the cupboard more frequently according to the outside perspective of the intrinsic frame of reference than with the non-canonically positioned cupboard. However, it is also important to stress that, for the canonical relations, considerably more German native speakers shifted the origo to Hans and interpreted even the canonical spatial relations from Hans' point of view according to the reflection / facing strategy of the relative frame of reference.

[4]Part of this data (for th verb *sagen* 'say') was published in Stoltmann, Fuchs, and Krifka, 2018.

Considering the complex intrinsic spatial relations individually, the results indicate that the semantics of the prepositions influences the perspective choice very strongly, with $p < 0.0001$ for both the canonically and the non-canonically positioned cupboard. The results indicate that German native speakers interpreted the spatial constellations both with the bottle *behind* and *in front of* the canonically and non-canonically positioned cupboard according to the outside perspective of the intrinsic frame of reference most frequently. In contrast, they interpreted the spatial relations with the bottle *to the right* and *left of* the cupboard significantly fewer times according to the outside perspective of the intrinsic frame of reference. In the latter situations, more participants shifted the origo to Hans' point of view and interpreted the relations from his point of view – most frequently according to the reflection / facing strategy. This implies that these German native speakers ignored the intrinsic properties of the cupboard in their interpretations and considered the cupboard as an extrinsic object.

To sum up, these results reject the assumption of the second null hypothesis: The interpretation of dimensional spatial expression does not depend on the semantics of embedding predicates and confirm the alternative one *The interpretation of dimensional spatial expression depends on the semantics of embedding predicates.*

Interpretation of the simple spatial relations:

The results of the simple spatial relations (without Hans) indicate very high significant differences in respect of the above-defined *correctness* ($p < 0.0001$) in general. Considering the general result in further detail, we may recognize that the German native speakers interpreted the spatial relations less frequently according the expected strategy, the outside perspective of the intrinsic frame of reference with the cupboard. This result is followed by that of the dog and this by the table. These results indicate that the objects' properties influence the interpretation of spatial relations by the German native speakers. They are more constant when interpreting the spatial relations with extrinsic reference objects, which cannot be positioned canonically or non-canonically, than with an animate or merely intrinsic.

In analyzing the simple extrinsic spatial relations, the results show no significant differences between the interpretation of the extrinsic spatial relations with a round or rectangular table ($p > 0.6$). This means that with regard to the simple spatial relations with a table too, – the shape of the reference object does not influence their interpretation of particular spatial relations by the German native speakers. For simple extrinsic spatial relations, I also did not find any significant differences between the individual constellations ($p = 0.42$ for round table and $p = 1$ for the rectangular table).

In contrast to the extrinsic spatial relations, the simple intrinsic relations revealed very high significant differences ($p < 0.0001$). This is caused by significantly more frequent interpretations according to the intrinsic frame of reference in spatial relations with the dog than with the cupboard in general (see also Stoltmann, Fuchs, and Krifka, 2018). However, considering the data further, we can find explanations for the more general result.

For spatial relations with inanimate intrinsic reference object, the cupboard (positioned in different ways), the results indicate a high significant difference ($p < 0.0001$) too. This is caused by the fact that the participants interpreted the spatial relations with the canonically positioned cupboard almost in all situations according to the outside perspective of the intrinsic frame of reference, as expected for relations with cupboard as reference object. However, in all situations with the non-canonically positioned cupboard, I found deviations from this interpretation. It is interesting that most deviations were evidenced for the cupboard with the back to the participants, where only 64 out of 184 answers were selected according to the outside perspective. This is even less than with the cupboard with the front to the right (75) or left (86).

To conduct the analysis in more detail, I examined the answers for the individual positions with respect to the canonically and non-canonically positioned cupboard too. The results showed:

a) No significant differences for the canonically positioned cupboard ($p > 0.95$) – almost all German native speakers interpreted all these spatial relations according to the outside perspective of the intrinsic reference frame.
b) No significant differences ($p > 0.48$) for the non-canonically positioned cupboard (with the back to the participants)
c) No significant differences ($p > 0.11$) for the non-canonically positioned cupboard (with the front to the right / left from participants' point of view).

Results for the third null hypothesis:

Animacy did not create significant differences overall ($p < 0.08$). However, for the individual positions, the results revealed very large significant differences. The largest differences between the dog and the cupboard as reference objects are visible for the interpretation with the bottle to the right and left of the canonically positioned entities. A Fisher's exact test revealed large significant differences between both objects and positions ($p < 0.001$). No significant differences were found in categorical judgments for the first horizontal axis (*front-back*). For the non-canonically positioned reference objects, a Fisher's exact test revealed significant differences for animacy and both positions (*to the right* vs. *left of*) with $p < 0.001$. This also applies to the first horizontal dimension (*in front of* vs. *behind*) and both the reference objects (see also Stoltmann, Fuchs, and Krifka, 2018).

Considering animate spatial relations, the results indicate significant differences for the interpretation of spatial relations with a canonically and non-canonically positioned dog ($p < 0.0001$). German native speakers interpreted the spatial relation with the non-canonically positioned dog more frequently according to the intrinsic reference frame than with the canonically one (in contrast to the cupboard). Analyzing the data in further detail, the results indicate significant differences within the individual spatial positions with respect to the canonically ($p < 0.0001$) and non-canonically ($p < 0.0001$) positioned dog. The differences are due to the intrinsic interpretation of "in front of" and "behind" in the spatial relations with the canonically positioned dog. In contrast, participants selected the answers according to the intrinsic perspective in non-canonical spatial relations with the bottle "to the right / left of" the dog significantly more frequently than "in front of / behind" the dog. It is worth mentioning that the interpretation of these spatial relations, which were interpreted along the *intrinsic* reference frame coincides with the reflection / facing strategy. Therefore, I can only say that the prepositions *vor* and *hinter* were interpreted more frequently with respect to the reflection / facing strategy with the dog according the intrinsic reference frame than with the prepositions *rechts von* "to the right of" and *links von* "to the left of."

The results support the hypothesis that the animacy of a reference object influences the interpretation of the spatial expressions.

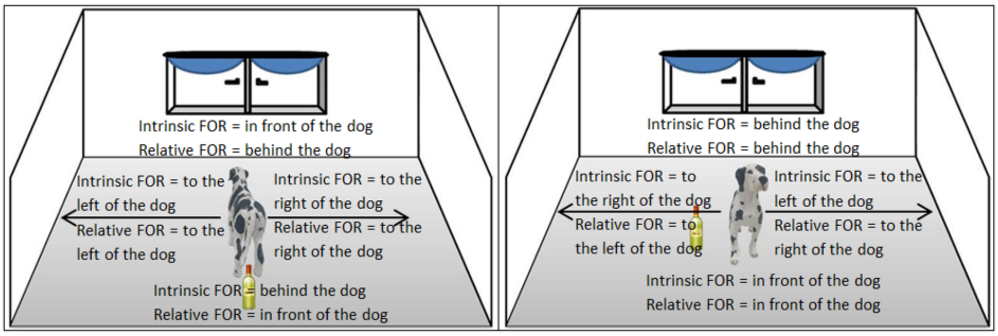


Figure 5.20: Assignment of regions to the dog according to the frames of reference

5.6.4.2 Detailed data analysis

5.6.4.2.1 First null hypothesis

> *The presence of the third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift.*

To provide a detailed answer to the null hypothesis, it is important to analyze the simple and complex spatial relations (supplemented by Hans) separately and compare them in the last step; in my opinion, this is also more reader-friendly. All complex situations with the positive embedded predicates are contrasted with the simple spatial relations, that is, without Hans. The analysis is conducted step by step in the following order:

Extrinsic spatial relations:

- Round table
- Rectangular table

Inanimate intrinsic spatial relations:

- Cupboard with the front to the participant
- Cupboard with the back to the participant
- Cupboard with the left side to the participant
- Cupboard with the right side to the participant.

In the next step, the following spatial relations are contrasted:

- All extrinsic simple spatial relations without Hans and complex extrinsic spatial relations with Hans embedded by positive predicates.
- Intrinsic simple spatial relations without Hans and complex intrinsic spatial relations with Hans embedded by positive predicates (indirect speech):
  - Cupboard with the front, and
  - Cupboard with the back (see also Stoltmann, Fuchs, and Krifka, 2018).

5.6.4.2.1.1 Analysis of simple and complex extrinsic spatial relations

Round table

As we can recognize on both the bar plots and the trajectories, German native speakers had fewer problems interpreting spatial relations when the bottle stood to the right of or to the left of than in front of or behind the table (5.21).

In the spatial relation with the bottle in front of the table, 6.5% of participants deviated from the answer in accordance with the reflection / facing strategy (of relative frame of reference). In the spatial relation with the bottle behind the table, even more – 10.9% of participants – did not select a response in accordance with the reflection / facing strategy: 6.5% of them decided for the translation / align strategy of the relative frame of reference.

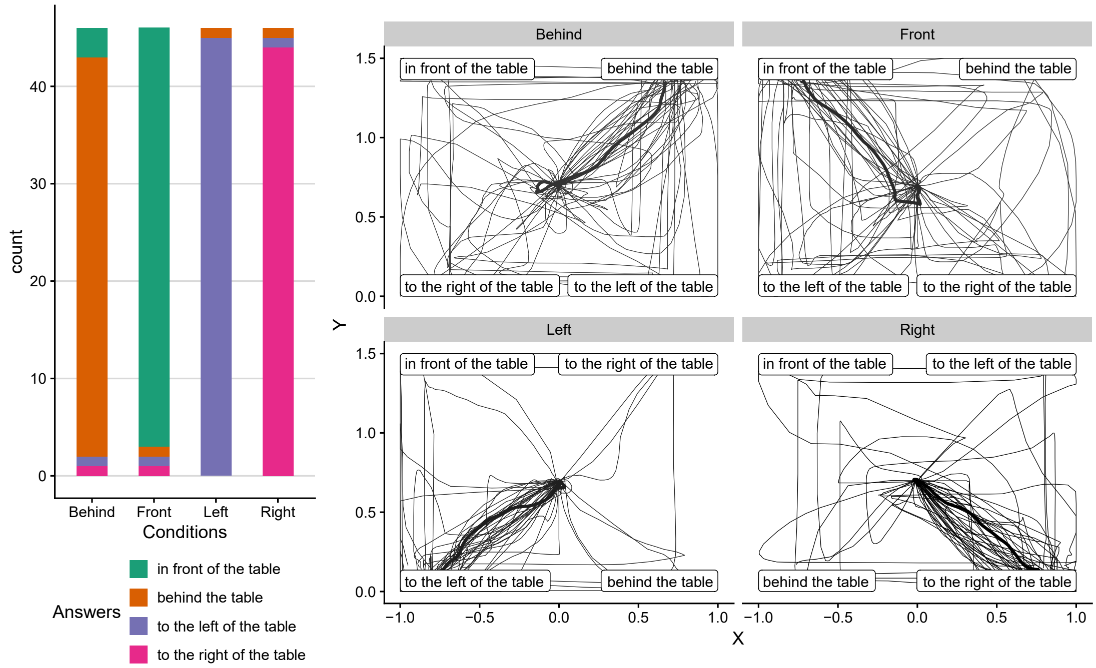
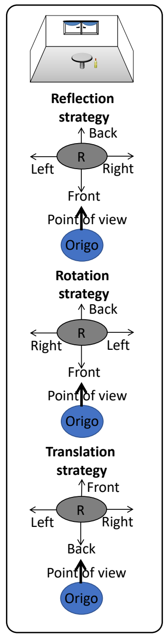


Figure 5.21: Answers for the simple extrinsic relation with round table: bar plots with answers (to the left) and trajectories through the response with the mean trajectories (to the right)

It is interesting that the interpretation of the spatial relations with the bottle to the right and left of the table was conducted with fewer doubts. As shown in the 5.21, the trajectories were direct (almost ideal), in contrast to the interpretation of the dimensional spatial expressions of the first horizontal axis (*front-back*). Furthermore, not only the course of the trajectories was consistent between the participants; their answers were too. Approximately 96% of the participants decided on the interpretation of the reflection / facing strategy of the relative frame of reference for the dimensional spatial expression *rechts von* "to the right of," and around 98% for *links von* "to the left of."



The differences are also recognizable with the MAD.abs, AUC.abs values and with the X- and Y-flips. The highest MAD.abs value amounted to ≈ 0.49 and relates to the positive spatial dimensional expression of the first horizontal axis *vor*, "in front of". *Vor* is immediately followed by *hinter* with MAD.abs of ≈ 0.47. The lowest MAD.abs was computed for *rechts von*, "to the right of," with ≈ 0.29. The spatial expression *links von*, "to the left of," reached MAD.abs of only 0.02 more, with ≈ 0.31. This means that the aggregated maximal absolute deviation was significantly lower for the dimensional spatial expressions of the second horizontal axis than for the first ($p > 0.0004$).

For the AUC.abs, the order differs within the axis but not between the axes. The significantly ($p > 0.002$) lower AUC.abs is related to the second horizontal axis and the higher to the first, with ≈ 0.19 for *links von*, "to the left of;" ≈ 0.2 for *rechts von*, "to the right of"; ≈ 0.34 for *vor*, "in front of;" and ≈ 0.37 for *hinter*, "behind".

The xpos-flips reflect the same axis order as the result of MAD.abs with exactly 1 for *links von*, ≈ 1.59 for *rechts von*, ≈ 1.74 for *vor*, and 1.87 for *hinter*.

While the ypos-flips have the same axis order as the results of AUC.abs, with ≈ 1.28 for *rechts von*; ≈ 1.48 for *links von*; ≈ 1.76 for *hinter*; and ≈ 1.98 for *vor*. This means that in this case too, the spatial expressions of the second horizontal axis are lower.

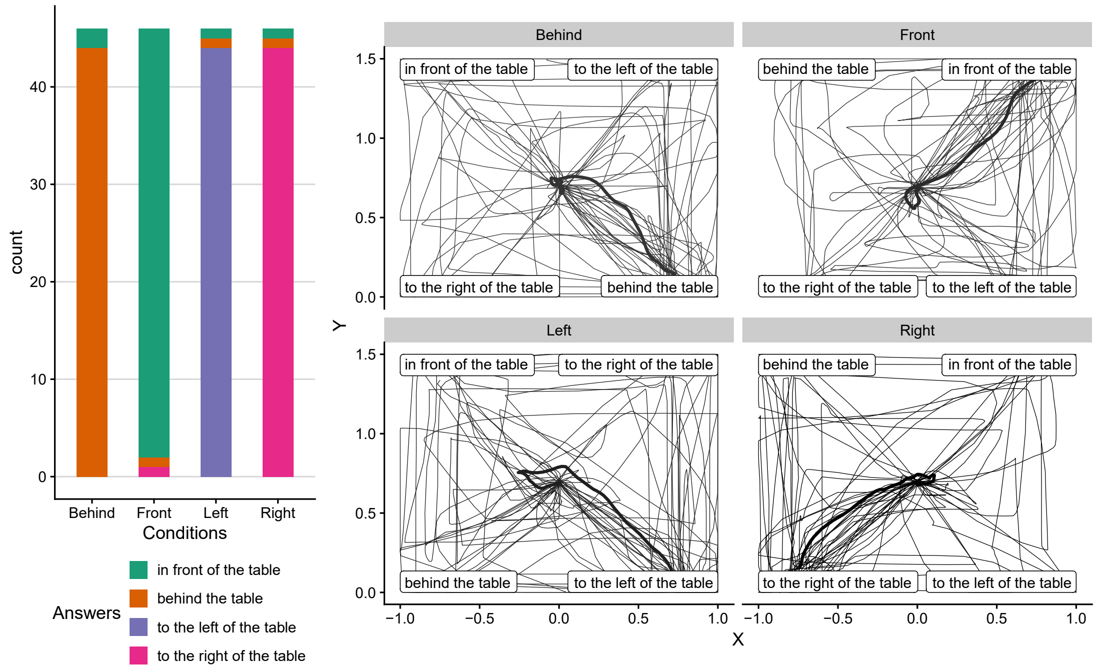
Considering the results of the complex situations, supplemented by Hans, we recognize more important differences. In general, it can be summarized that in all complex constellations with the round table, participants decided most frequently for the reflection / facing strategy from Hans' perspective and thus covered Hans and especially his point of view as origo in the particular spatial relations. The percentage of the interpretations in accordance with the reflection / facing strategy of relative frame of reference (from Hans' point of view) increased from $\approx 82\%$ for the dimensional spatial expression *rechts von*, "to the right of" to $\approx 87\%$ for *hinter*, "behind" (considering the interpretation from Hans' point of view). The spatial expressions of the first horizontal axis were perceptually interpreted in almost the same manner, with $\approx 87\%$ for *hinter*, "behind" and $\approx 86\%$ for *vor*, "in front of," from Hans' reflection / facing strategy for the relative frame of reference than those of the second horizontal axis (with $\approx 82\%$ for *rechts von*, "to the right of" and *links von*, "to the left of").

This means that the choice of the reflection / facing strategy has significantly decreased by $p \approx 0.0025$ in comparison to the simple spatial relations without Hans. However, still, it is worth emphasizing that all the participants who shifted the origo to Hans' point of view interpreted the particular spatial relations consistently according to the reflection / facing strategy.

Furthermore, I found a tendency, but no significant differences, in that more participants decided on the reflection / facing strategy from the view of point of Hans when Hans stood to the right of the round table and not to the left of it (see also Baltaretu et al., 2016, p. 3 for left and right objects mentioned as targets).

The MAD.abs values cannot be defined so clearly for the particular spatial expressions as for the simple spatial relations. In contrast, some conclusions can be generated. The lowest MAD.abs were most frequently found for the spatial expression *rechts von*, "to the right of" – three times. *Rechts von* also achieved twice the highest MAD.abs. As regards the lowest MAD.abs, second place was attained for *hinter*, "behind," which came last once too. *Vor*, "in front of," appeared once with the lowest MAD.abs. The question that arises here is: is this result influenced by the semantics of the embedded predicates? Considering the statistical analysis for the positive embedded predicates, the verb semantics did not influence the cognitive processes in these spatial relations ($p > 0.38$). It is interesting that the MAD.abs also does not depend on the position of Hans with respect to the reference object ($p > 0.25$).

Rectangular table



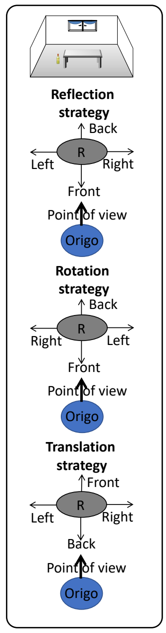


Figure 5.22: Answers for the simple extrinsic relation with rectangular table: bar plots with answers (to the left) and trajectories through the response with the mean trajectories (to the right)

In terms of interpretation of spatial relations with rectangular table, participants were more consistent than in the situations with round table, which is illustrated in the 5.22. Approximately 96% of the participants interpreted the four dimensional spatial expressions in accordance with the reflection / facing strategy of the relative frame of reference. There were no differences between the individual expressions.

Regarding the AUC.abs and MAD.abs, I found some differences relative to the spatial relations with the rectangular table.

In contrast to the round table, in these spatial relations, the spatial expression *vor* "in front of," attained the second lowest MAD.abs result with ≈ 0.48. But still the difference was not meaningful and reached only ≈ 0.01 (≈ 0.49 in relation with round table). Similarly to the constellation with the round table, here too, the lowest MAD.abs was computed for the spatial expression *rechts von*, “to the right of,” with ≈ 0.45 – this is ≈ 0.16 more than for the spatial relation with the round table. *Hinter*, “behind,” comes directly after *vor* “in front of,” with ≈ 0.52, and is followed by *links von*, “to the left of,” with ≈ 0.58. The differences between the expressions of the first (*front-back*) and second (*right-left*) horizontal axis are not significant ($p > 0.79$).

The AUC.abs values are also higher in the spatial constellations with the rectangular table. Unlike with the relations with the round table, ordering of the results is found not only within the axes but also between them in comparison to the MAD.abs values. The lowest AUC.abs was computed for *rechts von*, “to the right of,” with ≈ 0.30 (the lowest AUC.abs for round table amounted to ≈ 0.19 for *links von*, “to the left of”). This is followed by *vor*, “‘in front of,’ with ≈ 0.35, *hinter*, “behind,” with ≈ 0.39, and *links von*, “to the left of” with ≈ 0.48. In terms of the AUC.abs values, the differences were not significant ($p > 0.7$) between the axes.

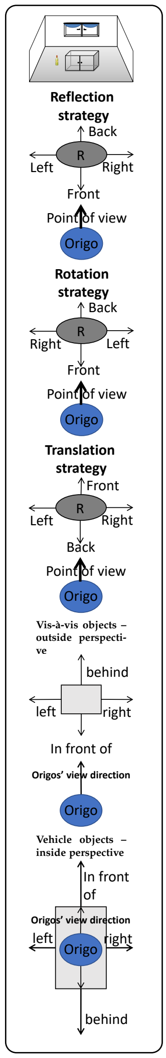
Considering the spatial relations with rectangular table supplemented by Hans, it can be determined that the spatial expressions of the first horizontal axis were more frequently interpreted from Hans’ point of view according to the reflection / facing strategy of the relative frame of reference, with 86% for *vor*, “in front of,” and 85% for *hinter*, “behind,” than for the second horizontal axis, with 80% for *links von*, “to the left of,” and 79% for *rechts von*, “to the right of.” This means that the choice of the reflection / facing strategy from participants’ point of view has significantly decreased with $p < 0.0001$ in comparison with the simple spatial relations without Hans. However, it is worth emphasizing that all participants who shifted the origo to Hans’ point of view interpreted the particular spatial relations according the reflection / facing strategy – as in the spatial relations with round table as reference object.

In terms of the MAD.abs, the spatial expression *hinter*, “behind,” was computed most frequently – four times – with the lowest MAD.abs value. In contrast, the spatial expression *links von*, “to the left,” most frequently attained the highest value (also four times). In terms of AUC.abs, *vor*, “in front of,” most commonly attained the highest value (three times) and *hinter*, “behind”: the lowest (also three times). The statistical analysis does not show any significant differences between the spatial expressions for the interpretation of spatial relations (embedded by positive predicates) with $p > 0.46$.

For the extrinsic spatial constellation, it can be summarized to the effect almost all German native speakers used the interpretation according to the reflection / facing strategy. In terms of accuracy, there was a significant difference neither between the particular spatial expressions nor between the objects (the round and rectangular tables). In contrast, the AUC.abs and MAD.abs values distinguished significantly between the objects ($p > 0.002$) for simple spatial relations. The largest difference was found for *links von*, “to the left of”. In spatial relations with round table, the value amounted to ≈ 0.31, and with the rectangular table to ≈ 0.58. The second largest difference was found for *rechts von*, “to the right of.” In spatial relations with round table, the value amounted to ≈ 0.29, and with the rectangular table to ≈ 0.45.

For the complex spatial constellations, it can be determined that the German native speakers chose the reflection / facing strategy from Hans’ point of view significantly more frequently for the expressions of the first horizontal axis than for the second. In situations with the rectangular table, participants more frequently deviated from the strategy than in relations with round table and considered themselves as origo rather than Hans.

With these results, the first null hypothesis for spatial relations with the extrinsic reference object, *The presence of the third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift* can be rejected and the alternative hypothesis confirmed: The presence of the third person as artificial agent in a spatial relation expressed by indirect speech affects an origo shift.



5.6.4.2.1.2 Analysis of simple and complex intrinsic spatial relations

Cupboard with the front side to the participants[5]

In terms of the canonically positioned cupboard, very few differences between the correctness of responses to the interpretation of the situation concerning the outside perspective can be seen: *vor* “in front of” ≈ 98%, *hinter* “behind” ≈ 96%, *rechts von* “to the right of” ≈ 96%, and *links von* “to the left of” ≈ 93%.

It is important to stress that in this case, the interpretation according to the outside perspective (of the intrinsic reference frame) and reflection / facing strategy (of the relative reference frame) coincide. Therefore, it is impossible to determine whether the participants used the intrinsic reference frame (in particular the outside perspective) or the reflection / facing strategy of the relative frame of reference for the interpretation of the constellation.

Comparing these results with the questionnaire results, I find some deviations. The *front* and *back* of the cupboard were all assigned according to the outside perspective and the reflection / facing strategy (of the relative reference frame). In addition, in the case of questionnaire, the assignment of the *right* and *left* sides caused more variation. Around 10% of the participants deviated from the outside perspective and chose the inside perspective, which coincides with the rotation strategy (of the relative frame) in this case. It follows that more participants deviated from the outside perspective in assigning the sides to the cupboard than interpreting spatial relations with the cupboard, related to the second horizontal axis (*right-left*).

From the AUC.abs and MAD.abs values it can be derived that participants had the

[5] See also Stoltmann, Fuchs, and Krifka, 2018.

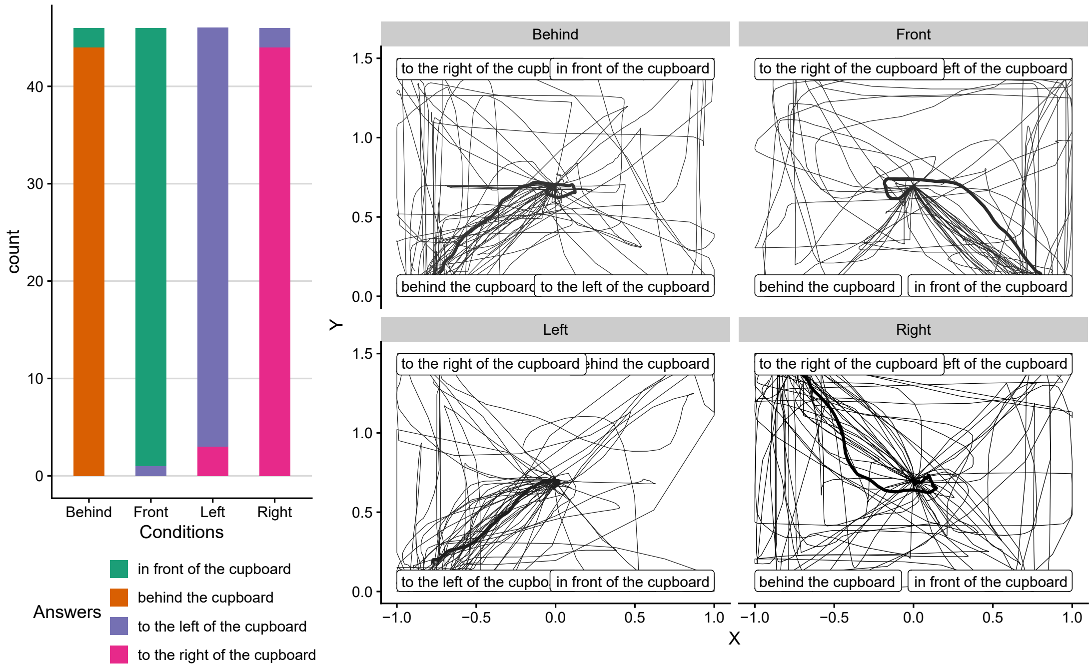
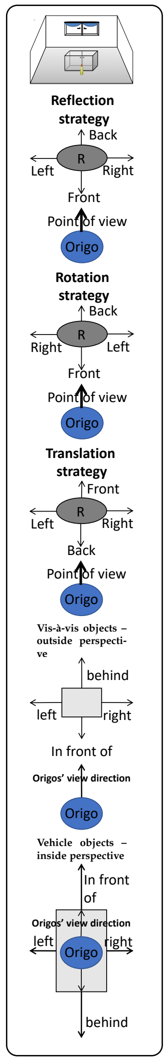


Figure 5.23: Answers to the simple intrinsic relation with cupboard: bar plots with answers (left) and trajectories through the response with the mean trajectories (right)

least difficulties with the interpretation of the negative dimensional spatial expression of the second horizontal axis (*links von*). In contrast, most problems occurred with the interpretation of the spatial relation with the bottle to the right of the cupboard, with respect to the outside perspective. More specifically, the spatial expressions attained the following MAD.abs and AUC.abs values: *rechts von* "to the right of," with MAD.abs $\approx$ 0.55 and AUC.abs $\approx$ 0.39. This was followed by *hinter*, "behind," with MAD.abs $\approx$ 0.47 and AUC.abs $\approx$ 0.29, *vor*, "in front of,' with MAD.abs $\approx$ 0.44 and AUC.abs $\approx$ 0.43, and *links*, "to the left of," with MAD.abs $\approx$ 0.38 and AUC.abs $\approx$ 0.16. The MAD.abs results did not reveal any significance ($p > 0.19$).

Comparing the canonical situations from the survey and the mouse tracking, I can clearly perceive that in terms of accuracy, the interpretations of *vor* and *hinter* do not cause any problems. Nonetheless I cannot determine that participants reached these interpretations with less doubts.

The results for the complex spatial relations with canonical positioned cupboard are reported together with the results for the complex spatial relations with non-canonical positioned cupboard below.



Cupboard with the back side to the participants[6]

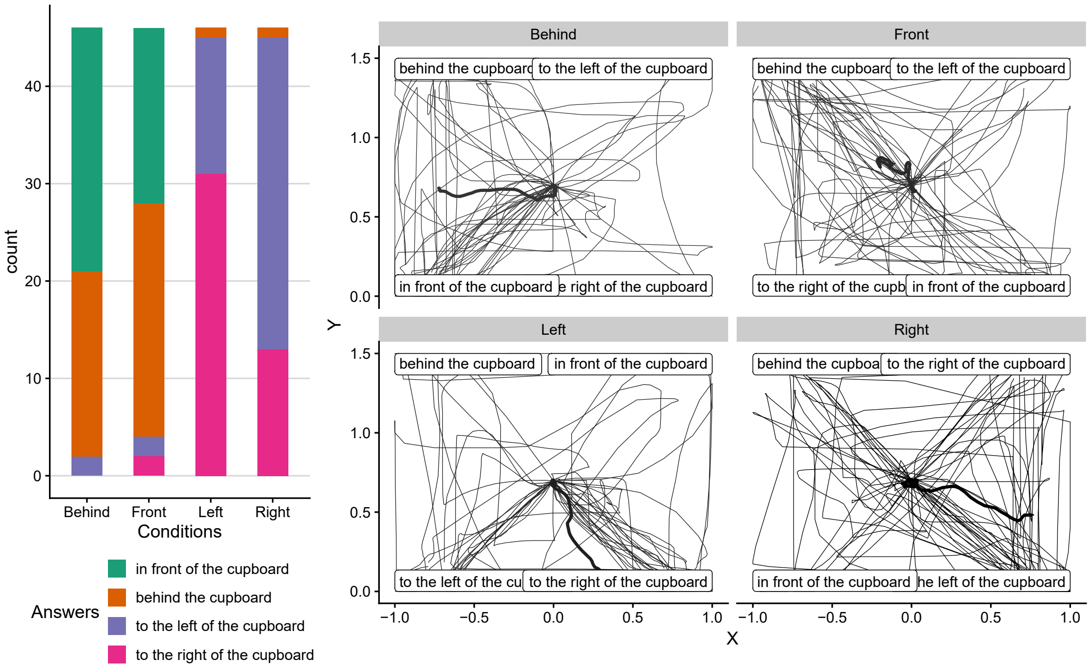


Figure 5.24: Answers for the simple intrinsic relation with non-canonically positioned cupboard: bar plots with answers (left) and trajectories through the response with the mean trajectories (right)

At first, it is noticeable that each of the spatial relations investigated caused problems for the participants. This is indicated by the variety of selected answers as well as by the trajectories leading to the responses. The mean trajectories appear between the responses – they do not lead exactly to only one response – and are most striking for the spatial relation with the bottle behind the cupboard with reference to the outside perspective (regarding Grabowski, 1999).

Considering the absolute values of the correct responses, *vor* ("in front of") and *hinter* ("behind") come clearly on top with only around 39% for "in front of" and 41.3% for "behind" of selected answers with respect to the outside perspective. Those are followed by the assignment of *links von* ("to the left of") with around 30.4% of chosen answers with respect to the outside perspective. *Rechts von* ("to the right of") appears in last position with only approximately 28.3% answers according to the outside perspective. It follows that, maximally, around 28.3% of all participants considered the cupboard

[6]See also Stoltmann, Fuchs, and Krifka, 2018.

as a vis-à-vis object in these spatial relations. This means that only these participants decided on the interpretation according to outside perspective (of the intrinsic reference frame) in these spatial constellations.

The aggregated MAD.abs and AUC.abs values show that the MAD.abs values for *hinter* and *links von* were almost same with ≈ 0.37; this is also the case for *vor*, with ≈ 0.42, and *rechts von*, with ≈ 0.43. The order of the AUC.abs values deviates from this with AUC.abs ≈ 0.70 for *hinter*, ≈ 0.22 for *vor*, ≈ 0.25 for *links von*, and ≈ 0.32 for *rechts von*. The MAD.abs did not indicate any significant differences between the spatial expressions ($p > 0.65$) nor between the axes ($p > 0.9$).

To test the first null hypothesis, *The presence of the third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift*, different situations with more (an additional agent Hans, a reference, and a localized object) or less complex (a reference and a localized object only) scenarios were compared. The aim of this experimental part was to determine whether the participants changed their spatial interpretation from intrinsic to relative reference frame. As above, I first report the categorical responses and then the outcomes for the continuous measures of the mouse trajectories.

For the simple situation, it was found that German native speakers consistently interpreted the canonically positioned cupboard with respect to the outside perspective. In contrast, if the cupboard was placed non-canonically, participants had problems in all spatial relations and frequently used the reflection strategy.

The statistical results of the Fisher's exact test show significant effects for complexity ($p < 0.001$). This result indicates that the participants selected the outside perspective more frequently in the simple spatial relations than in the complex one. In the latter situations, participants shifted perspective to the agent and interpreted the constellations from his point of view with respect to the reflection / facing strategy. Furthermore, a detailed analysis has shown that significant differences were found in all spatial relations with canonical but not with non-canonical positions. The Fisher's exact test revealed $p < 0.001$ for all canonical relations (*in front of, behind, to the right of, to the left of*) with respect to complexity. However, for the non-canonical spatial relations, Fisher's exact tests indicated no significant differences for complexity, that is, a similar number of participants chose the same answers in simple and complex conditions.

For the continuous measures of the mouse trajectories *MAD.abs* and *AUC.abs*, I ran several mixed models to compare the results of the simple and complex spatial relations. For these computations, either *MAD.abs* or *AUC.abs* was used as the dependent variable and *situation* (simple vs. complex and Hans on the left, complex and Hans on the right), *side* (reference object with canonical vs. non-canonical side to the participants), and *position of the localized object* (bottle in front of, behind, to the right of, to the left of the reference object) as independent factors, as well as two-way interactions and *subject* as a random effect. For the MAD.abs values, an interaction between situational complexity and side was found ($t = 2.322$, $p = 0.020$). In the simple situation, mouse trajectories deviated more when the cupboard was presented canonically than non-canonically. In the complex situation, the effect of the side changed, that is, more deviations were observable when the cupboard was presented non-canonically. The AUC.abs values showed no significant differences. [7]

In summary, up to 83% of participants chose the reflection / facing strategy from Hans' point of view. This means that in these situations participants shifted the origo from the cupboard to Hans' viewing direction. Moreover, it also means that these participants changed the reference frame, and therefore the first alternative hypothesis should be accepted: The presence of an agent in a spatial relation causes an origo shift and a shift from the intrinsic to the relative reference frame.

Comparing the results of the spatial relation with the questionnaire results, it is very clear that significantly more participants assigned the sides to the non-canonically positioned cupboard 62% in the questionnaire than in the mouse tracking experiment (max. approximately 28.3%). In contrast to the mouse tracking experiment, in the questionnaire tasks no bottle was present. In the questionnaire, participants were asked to assign the sides to the cupboard directly and in the mouse tracking to describe a spatial relation between a cupboard as a reference object and bottle as a localized object using dimensional spatial expressions. Furthermore, comparing these results to previous questionnaire studies (Perużyńska, 2012a; Stoltmann, 2014), these results indicate that in canonically positioned situations described with dynamic verbs ≈ 97% and 98%, respectively, of 75 participants interpreted the relations according to the outside perspective (which coincided with the reflection / facing strategy) for *vor* and *hinter*, and ≈ 95% for *rechts von* and *links von*. In relations with the cupboard with its back to participants, ≈ 48% selected responses according to the outside perspective for the preposition *rechts von* and ≈ 41% for *links von*.

Therefore, an interpretation hierarchy can be determined: most participants decided on the side allocation according to the outside perspective of the intrinsic reference frame in the questionnaire of the current study (≈ 62%), where the participants were asked to assign the sides to the cupboard and not to interpret a spatial relation with the object. This point arises as a very important factor or influencer. The results of a questionnaire with dynamic verbs (Perużyńska, 2012a) appear in the second position (≈ 41%) with regard to intrinsic spatial interpretations. In these local constellations, participants were asked to complete a questionnaire, putting the bottle on one of these positions (*front / back / right / left*) in relation to the cupboard (see 5.25). The answers to mouse tracking experiment clearly come last with only ≈ 28% of the answers with

[7] The data was already published in Stoltmann, Fuchs, and Krifka (2018).

respect to the intrinsic interpretation according to the outside perspective. In contrast to the questionnaire study, the participants were asked here to interpret a situation with the bottle and cupboard directly. This means they saw the localized as well as reference object and were asked to interpret a static relation and not dynamic one.

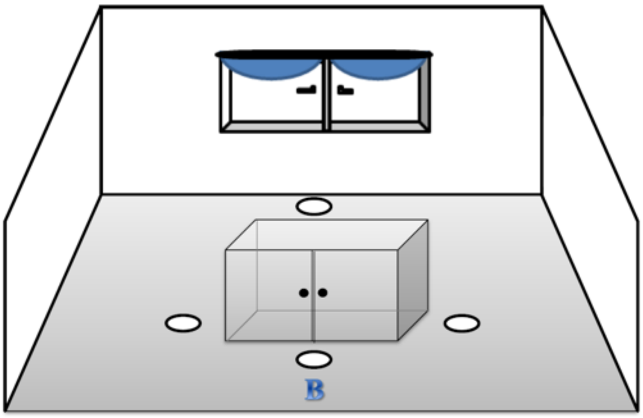


Figure 5.25: One of the situations with the cupboard, from the experiments by Perużyńska (2012a) and Stoltmann (2014)

The hierarchy can be visualized as follows:

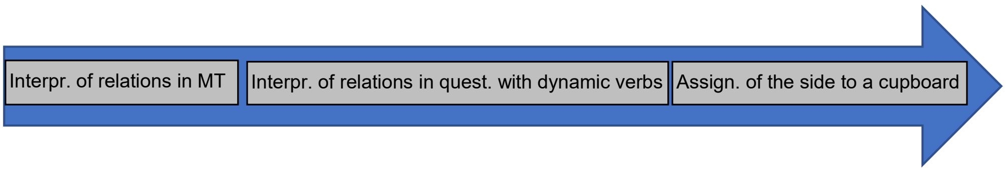


Figure 5.26: Hierarchy of the interpretation results of spatial relations with the cupboard (three experiments)

Cupboard with the left side to the participants

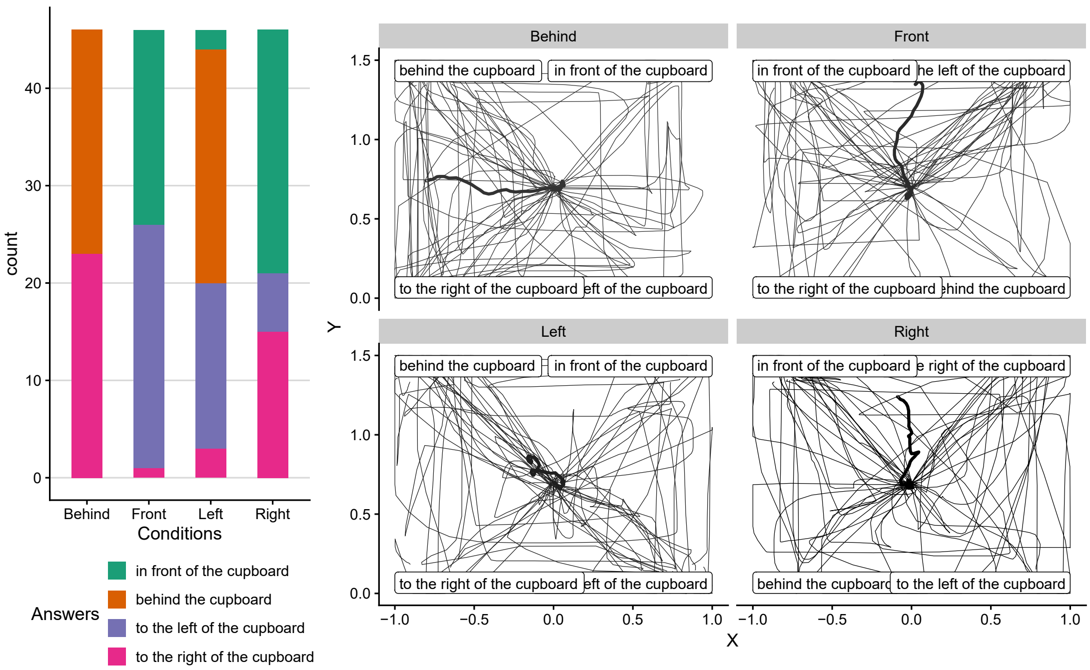
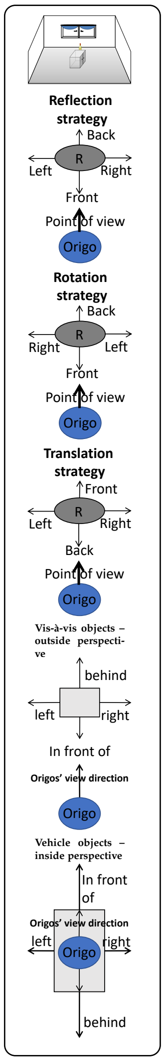


Figure 5.27: Answers for the simple intrinsic relation with the non-canonically positioned cupboard: bar plots with answers (left) and trajectories through the response with the mean trajectories (right)



Regarding the absolute results, it appears clear that the interpretation of the spatial relation with the bottle on the right side of the cupboard according to the outside perspective caused the most variations: approximately 67% of participants decided against this spatial interpretation. More than 54% of these German native speakers chose the reflection / facing strategy in this case. Only two participants more ($\approx$ 37% in total) interpreted the spatial relation with the bottle on the left side of the cupboard according to the outside perspective. In contrast, $\approx$ 52.2% of participants decided on the interpretation in accordance with the reflection / facing strategy. The interpretation of the bottle on the front side of the cupboard was described by $\approx$ 43.4% participants according to the outside perspective and $\approx$ 54.3% in accordance with the reflection / facing strategy. The interpretation of the spatial relation with the bottle to the back of the cupboard was performed most frequently, with 50% of all participants according to the outside perspective of the intrinsic reference frame; they thus considered the cupboard as a vis-à-vis object. The other half of participants described this relation as with an extrinsic reference object using the reflection / facing strategy as a basis.

The MAD.abs values underline that the participants deviated less from the direct line in case of *vor* “in front of”, with ≈ 0.43, and most in case of *links von* “to the left of”, with ≈ 0.48. In terms of the AUC.abs values, the spatial expressions *rechts von* “to the right of” and *hinter* “behind” lead with ≈ 0.33, and *vor* comes last with ≈ 0.24. All in all, the MAD.abs showed no significant differences between the interpretations of the four spatial expressions ($p > 0.87$).

Regarding the xpos and ypos flip, I can determine that the numbers are very high. The highest xpos-flip value were with the spatial relation with the bottle on the left side (with respect to the intrinsic frame of reference), with ≈ 2.02, and the lowest with the bottle behind the relatum, with ≈ 1.52. The highest ypos-flip value was computed for the constellation with the bottle on the right side of the cupboard, with ≈ 2.59, and the lowest with the bottle to the back, with ≈ 1.37.

Cupboard with the right side to the participants

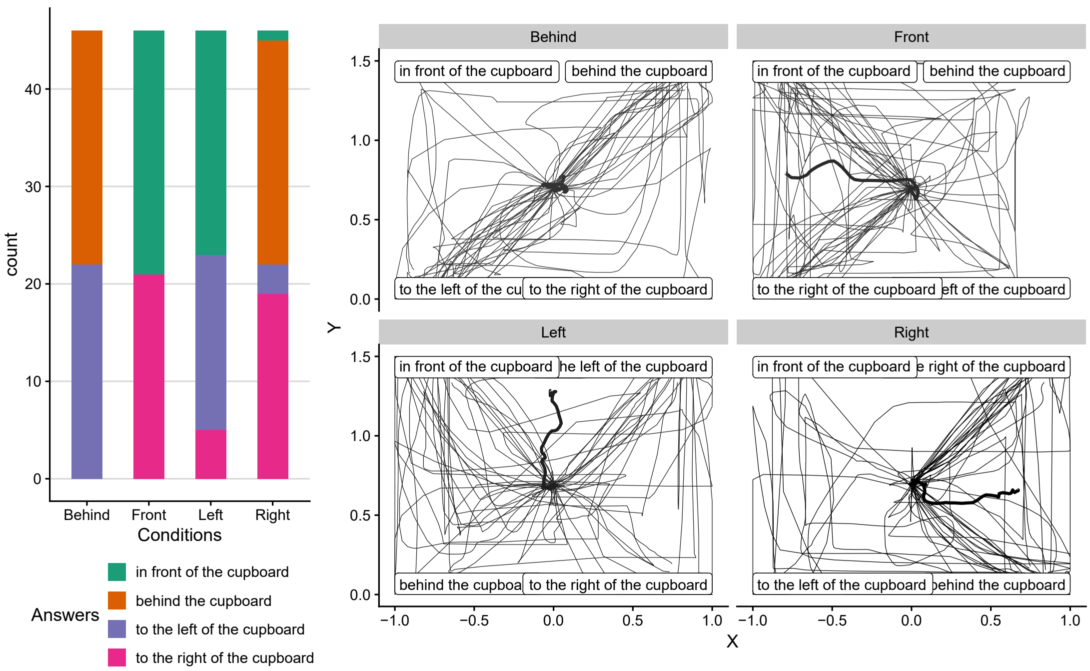
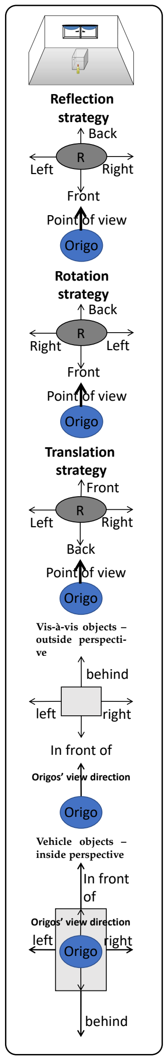


Figure 5.28: Answers for the simple intrinsic relation with the non-canonically positioned cupboard: bar plots with answers (left) and trajectories through the response with the mean trajectories (right)

It is noticeable that in these spatial constellations, participants did not interpret the spatial relation of the first horizontal axis (*front-back*) more frequently than of the second horizontal axis (*right-left*) according to the outside perspective. More specifically, in the spatial relation with the bottle in front of the cupboard, ≈ 45.7% of participants decided on the outside perspective, ≈ 47.8% when it was behind, ≈ 58.7% when it was to the right, and 60.9% when it was to the left. Almost all of the rest of participants chose the reflection / facing strategy and thus did not interpret the constellation object in a centered manner but egocentrically. It is remarkable that more participants used the intrinsic interpretation for the cupboard with the front to the right than to the left (in each of these individual spatial relations).



It is interesting, that the MAD.abs indicated for these four spatial relations significant differences between the interpretations of the spatial expressions ($p < 0.005$). The results revealed significant differences between the axes too ($p < 0.018$). The lowest MAD.abs value was computed for *vor*, with ≈ 0.43, and the highest for *links*, with ≈ 0.48. *Vor* also had the lowest AUC.abs value, with ≈ 0.24 and *rechts von* the highest, with ≈ 0.33.

Considering the eight simple spatial relations with the cupboard to the right or to the left together, it can be determined that the position of the cupboard plays an important role. In the constellation with the front side of the cupboard to the left, German native speakers performed the best interpretation of the first horizontal axis, in terms of the object centric. In spatial relations with the cupboard to the right, the order was opposite. This evidence emphasizes that the local constellation influences the interpretation of dimensional spatial expressions. Furthermore, despite the accuracy of responses between the relations, the lowest and highest MAD.abs values are the same for both relations: *vor* and *links*.

5.6.4.2.2 Third null hypothesis

5.6.4.2.2.1 Analysis of spatial relations with animate vs. inanimate entities

In this part of the thesis, the third null hypothesis is analyzed:

The animacy of relata does not affect the interpretation of spatial relations.

To provide a detailed answer to the null hypothesis, it is important to analyze the simple spatial relations with the dog and compare those to the results with those with the cupboard (see also Stoltmann, Fuchs, and Krifka, 2018). The analysis is conducted as follows:

Animate intrinsic spatial relations:

- Dog with the front to the participants

- Dog with the back to the participants

Inanimate intrinsic spatial relations:

- Cupboard with the front to the participants
- Cupboard with the back to the participants.

As the cupboard has already been analyzed in detail, it is not analyzed in further detail here.

Dog with the front to the participants

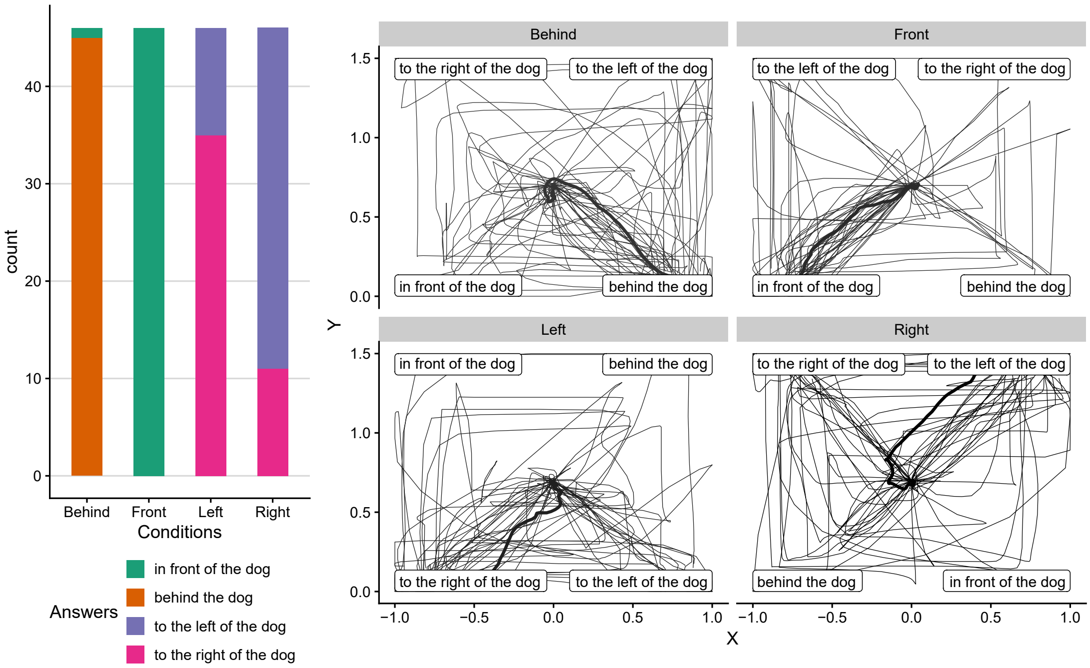
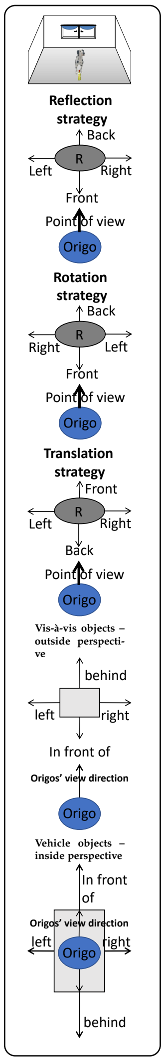


Figure 5.29: Answers for the simple intrinsic animate relation with the dog: bar plots with answers (left) and trajectories through the response with the mean trajectories (right)

The bar plots visualize that the German native speakers show almost no variation with the interpretation of the canonical spatial constellation with the bottle *behind* as well as *in front of* the dog, where the intrinsic and relative (reflection / facing strategy) interpretation coincide. In case when the bottle was in front of the dog, 100% of participants decided on the intrinsic interpretation. 98% selected the response according to the intrinsic reference frame in canonical relations with the bottle behind the dog. Based on the MAD.abs and AUC.abs, it can also be determined that the participants did not have many doubts in interpreting these situations. The MAD.abs for *in front of* amounted to ≈ 0.35, and for *behind* to ≈ 0.45. The AUC.abs ranged between ≈ 0.18 for *in front of* and ≈ 0.28 for *behind*.

In contrast to the interpretation of the spatial relations of the first horizontal axis, in the constellations with the bottle to the right and left of the dog, participants showed more doubts – their mean line deviated from the ideal line (see 5.29). This is evidenced by the MAD.abs value of ≈ 0.44 for *to the right of* and ≈ 0.42 for *to the left of*; and AUC.abs of ≈ 0.34 for *in front of* and ≈ 0.26 for *behind*. However, the statistical analysis does not show any significant differences between the interpretations of the four spatial relations ($p > 0.37$ for MAD.abs for all relations, $p > 0.5$ for axes, and $p > 0.1$ for AUC.abs for all relations and $p > 0.12$ for axes). Regarding accuracy, only 24% chose the answer (*rechts von*, *links von*) according to the intrinsic interpretation and 76% according to the relative (reflection / facing strategy).



Dog with the back to the participants

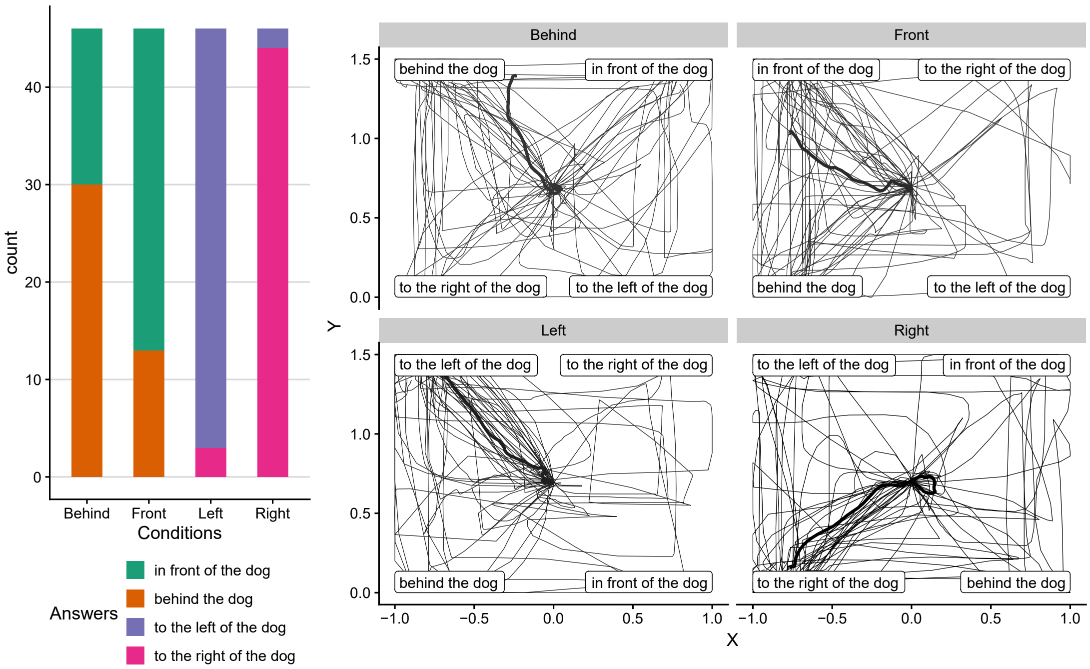
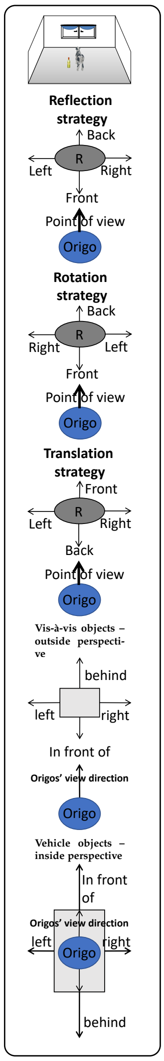


Figure 5.30: Answers for the simple intrinsic animate relation with dog: barplots with answers (to the left) and trajectories through the response with the mean trajectories (to the right)

The answer bar plots indicate very clearly that German native speakers selected more frequently responses according to the intrinsic reference frame in spatial relations with the bottle to the right or left of the dog than with the bottle in front of or behind the dog. Thereby, the interpretation of the spatial relations with the bottle to the right of and to the left of according to the intrinsic reference frame coincides with the relative reference frame (reflection / facing strategy). The important answers in these situations are *vor* "in front of" and *hinter* "behind" the dog, and those were interpreted according to the intrinsic frame of reference more frequently than to the reflection / facing strategy of the relative frame. More specifically, 71.7% of participants chose the response with the intrinsic frame in constellation with the bottle *in front of* the dog, 65.2% with *behind*, 95.7% with *to the right of*, and 93.5% with *to the left of*. The rest of participants decided on the reflection / facing strategy. None deviated from either of these possibilities.

On the mean trajectory of trajectory plots, it can be recognized that participants had the least doubts interpreting the spatial relation with the bottle to the left of the dog. In relations with the bottle positioned on the first horizontal axis to the dog (*front-back*), participants tended very often to the opposite answer (see 5.30). The MAD.abs value amounted to ≈ 0.39, in case of "to the right of", to ≈ 0.47, for "in front of" to ≈ 0.50, and for "behind" to ≈ 0.50. In addition, the lowest AUC.abs ≈ 0.27 was for the bottle positioned on the intrinsic left side of the dog. This was followed by *behind* with ≈ 0.32, *in front of* with ≈ 0.32 and *to the right of* with ≈ 0.34. Neither the MAD.abs nor the AUC.abs values show significant difference.



Considering the plots for the spatial relations including dog, in summary it can be said that the dimensional spatial expressions of the first horizontal axis were significantly more frequently interpreted according to the intrinsic reference frame than those of the second horizontal axis. In the case of *hinter*, "behind", only 34% of participants decided on the interpretation of the spatial relation with the dog and the bottle according to the reflection / facing strategy rather than the side assignment according to the inside perspective (of the intrinsic reference frame, as per Grabowski, 1999). In contrast, in the spatial relations of the second horizontal axis, ≈ 76% of participants chose the reflection / facing strategy for the interpretation rather than the inside perspective – in these situations, the intrinsic and relative interpretation did not coincide.

Comparing the results of the simple spatial relations with the dog and the cupboard positioned with the front and back to the participants demonstrates that the interpretation of spatial relations with the bottle as localized object and one of these reference objects is performed more frequently according to the intrinsic frame of references in the case of the first horizontal dimension than in the second.

Overall, for the categorical response selection, some differences in canonical visible animacy regarding the intrinsic frame of reference were evidenced. The largest differences were shown for the interpretation of the bottle to the right and left of the canonically positioned reference objects. For this, a Fisher's exact test revealed highly significant differences between both reference objects and positions ($p < 0.001$). No significant differences were found in categorical judgements for the first horizontal axis (*front-back*).

For the continuous measures of the mouse trajectories, numerous linear mixed-effects models were run using one of the continuous factors, *MAD.abs* or *AUC.abs.* The final model (with the lowest AIC value, which was significantly better than the others) comprised *animacy* (animate versus inanimate), *side* (canonical versus non-canonical), and *position of the localized object* (bottle in front of, behind, to the right of, to the left of the reference object) as independent factors, the interactions (animacy*side, animacy*bottle, side*bottle) and the *participant* as random effects. Two significant effects were found for the MAD.abs: a main effect for the position of the bottle ("behind" versus "in front of" $t = 2.614$, $p = 0.009$), and an interaction between the side and the position of the bottle ($t = -2.91$, $p = 0.004$). Participants were more uncertain (showed greater MAD.abs values) when they saw the reference objects in the canonical position than in the non-canonical one and when the bottle was placed behind vs. in front of the reference object. But also here, no effect of animacy was found (see Stoltmann, Fuchs, and Krifka, 2018).

For the non-canonical position, it is evident that, overall, participants show more variable responses when interpreting spatial relations with the inanimate object, as shown above. This result differs from that of the animate reference object, where participants decided more consistently that the bottle was *to the right of* and *to the left of* the dog. A Fisher's exact test revealed significant differences for animacy and both positions, with $p < 0.001$. This also applies to the first horizontal dimension (*front-back*) and both the reference objects.

Each of the spatial relations investigated elicited a variety of responses. This is supported by the selected answers as well as by the trajectories leading to the responses. The mean trajectories appear between different responses. This is most striking for the spatial relation with the bottle behind the cupboard. Larger MAD.abs values, that is, more uncertainty, were found when the bottle was placed in front of the reference object than when it was behind the reference object. Animacy did not affect the MAD.abs values and no significant differences were found for AUC.abs.

Results for simple spatial relations with the dog and the cupboard positioned canonically and non-canonically, as well as for complex spatial relations indicate that, in all these situations, the interpretation of spatial relations of the first horizontal axis leads in terms of the intrinsic frame of reference.

We observe a tendency towards more frequent intrinsic interpretation of the first horizontal axis preposition than of the second in all positive complex situations with the non-canonically positioned cupboard. Therefore, an interpretive hierarchy for the particular dimensional spatial expressions can be defined:

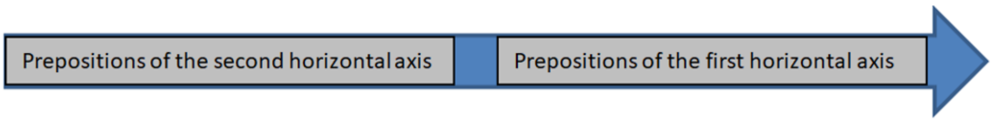


Figure 5.31: Hierarchy for the intrinsic interpretation of the respective dimensional spatial expressions in German

Finally, the results of the current study support the assumption of Bowerman (1996) (for the preposition *aan*), Feist and Gentner (1997) (for *in*), and Feist (2000) that animacy influences the choice of spatial expressions, but only with respect to the choice of spatial expressions of the first horizontal axis *vor* and *hinter* in German and not of the second (in terms of significancy).

The comparative analysis can be summarized by means of the following answer hierarchy with respect to the intrinsic reference frame:

First horizontal axis (front – back):

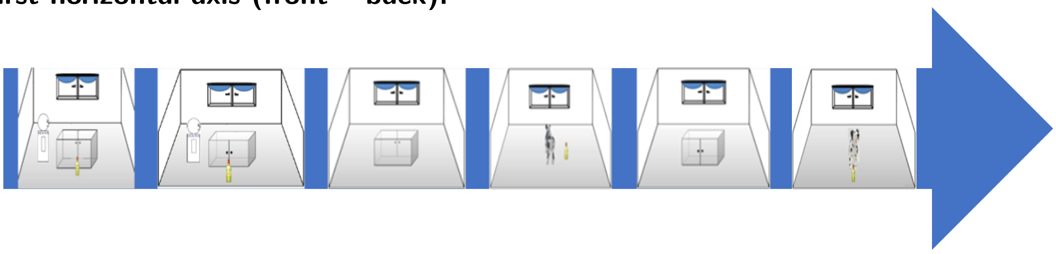


Figure 5.32: Hierarchy for the front-back responses with respect to the intrinsic reference frame

Second horizontal axix (right – left):

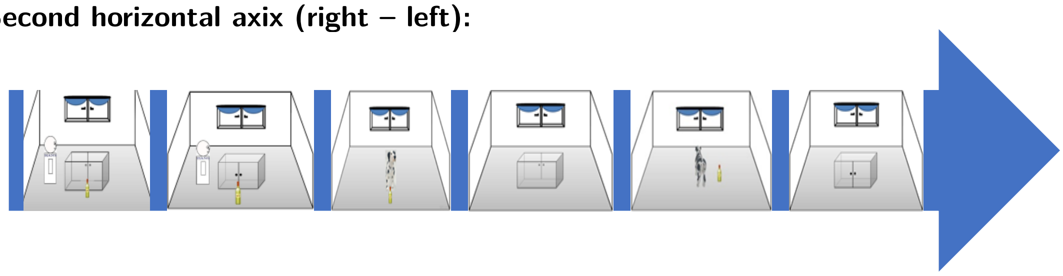


Figure 5.33: Hierarchy for the right-left responses with respect to the intrinsic reference frame

5.6.4.3 Summary and discussion

The mouse tracking study achieved the investigation of the interpretation of dimensional spatial expressions by German native speakers. This was explored in simple spatial relations containing a reference and a localized object in a room with window, as well as more complex spatial relations, which were supplemented by an artificial agent (Hans). The spatial relations were distinguishable in terms of inanimate and animate reference objects. Inanimate objects were represented by cupboard (canonically vs. non-canonically positioned) and tables (round and rectangular) and animate objects by dog (visible from the front and back).

With the spatial relations with an extrinsic reference object, I investigated which strategy of the relative reference frame (facing / reflection, align / translation, rotation) German native speakers apply when interpreting it (see 3.3). The results reveal that the German native speakers investigated prefer the application of the reflection strategy to interpret static spatial relations. This result expands on the results of the study of

Perużyńska (2012a), which indicated that German native speakers apply the reflection strategy for the interpretation of spatial relations described by dynamic verbs (and not static verbs as in the current study). Moreover, these results also reveal that German native speakers apply the reflection strategy in dynamic situations – as in the experiments by Grabowski (1999) and Grabowski and Miller (2000) – as well as in static situations.

The results of the experiment with spatial relations, supplemented by Hans, reveal that in all complex constellations with the round table, participants decided most frequently on the reflection strategy from Hans' point of view (82% to 87% of the participants) and thus covered Hans and especially his point of view as the origo in the particular spatial relations. In the complex spatial relations with the rectangular table, less German native speakers (79–86%) shifted the origo to Hans' point of view and interpreted the particular spatial relations using the reflection strategy. The differences between the spatial relations with a round and a rectangular table may be a result of the edges of the table (see 2.1.1; Miller and Johnson-Laird, 1976). These results indicate that *the presence of an artificial agent as a third person in a spatial relation expressed by means of indirect speech affects origo shift* (rejection of the first null hypothesis).

With the intrinsic spatial relation, I asked the participants to complete a questionnaire. It included the same spatial relation as in the mouse tracking task: a cupboard in a room (visible from the front vs. from the back). In the questionnaire, the spatial relation did not include a localized object. The results of the questionnaire reveal that up to 97% of the German native speakers investigated recognized the front and back in terms of the outside perspective. However, up to 62% of the participants identified all sides of the cupboard using the outside perspective (front, back, right, left), which applies to vis-à-vis objects. In the simple spatial relation with the cupboard visible from the front, almost all participants used the outside strategy when producing an interpretation. In contrast, between 30 and 40% of the participants selected the outside strategy for the interpretation of the spatial relation with the cupboard visible from the back. This result indicates a contrast between the side identification of a cupboard by German native speakers and the interpretation of spatial relations with the cupboard. The analysis of the canonical complex spatial relations reveals that the participants selected the outside perspective significantly more frequently with the simple spatial relations than with the complex ones. In the latter situations, participants shifted the origo to the artificial agent and interpreted the constellations from his point of view in terms of the reflection strategy. This result represents a rejection of the assumption of the first null hypothesis and thus supports the alternative one: The presence of an artificial agent as a third person in a spatial relation expressed by means of indirect speech affects origo shift as well as a shift of reference frame.

As regards animacy, the results reveal that significantly more participants interpreted the spatial relation with the animate object according to the intrinsic frame of reference than they did with an inanimate reference object (confirming the assumptions of the third null hypothesis).

5.7 Polish

5.7.1 Location of the experiment in Poland

The experiment was conducted at the Institute of English Studies at Wrocław University in Poland thanks to DAAD 43114 project led by PD Dr. Marzena Żygis. Each participant was investigated individually.

The experimental situation was very similar to the one in Berlin, at the Leibniz-Centre General Linguistics. Even the screen size was same, because it was transported from the research center to the university.

5.7.2 Participants: Polish native speakers

Fifty Polish native speakers were recorded, 13 of them male. All participants were between 19 and 31 years old with mean of 21.7 years (see 5.34). The Polish native speakers investigated were sourced via the Facebook fan page of the Institute of English Studies at Wrocław University and via several mailing lists, thanks to Marzena Żygis and Joanna Błaszczak.

Before the experiment began, all participants read and signed the participants' information sheet and consent form. They were instructed that they could withdraw from the experiment at any time, up to the point of completion, without having to provide a reason and without any consequences. After the experiment, the participants were asked to complete a questionnaire. This included some questions regarding the metadata, which are depicted in the charts below. Additionally, in the preliminary study, I sought to

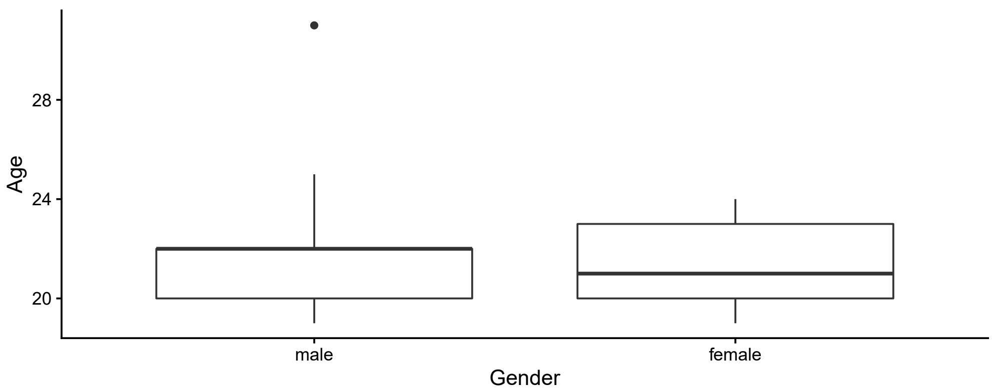


Figure 5.34: The charts depict the gender and the age distribution of the Polish native speakers

obtain a general baseline for the assignment of spatial locations to an intrinsic reference object – as occurred for German (see Stoltmann, Fuchs, and Krifka, 2018).

The experiment was conducted at Wrocław University and most of the participants were students at the University. That the study subject of the most participants was English (37 participants) was influenced by the location of the experiment (the Institute of English Studies). All the study subjects of the students are depicted in 5.35.

As with the German native speakers, the Polish native speakers received 10€ compensation for their participation. In addition to the mouse tracking experiment, they were also asked to fill in a questionnaire based on the Edinburgh Handedness Inventory (see Oldfield, 1971). According to the questionnaire, 50% of attendees were right-handed (dominant hand), 2% left-handed, and 48% (≈ 9% more than the German native speakers) were mixed (this means that they prefer performing some tasks with the right hand and others with the left or they can perform some tasks using both hands – depending on the situation or their mood). All participants used the mouse with the right hand. As with the German native speakers, the Polish left-handed speakers stated that they write with the left hand but are used to using the computer mouse with the right hand due to lack of mice for left-handed users – especially in public places like PC pools at universities and schools.

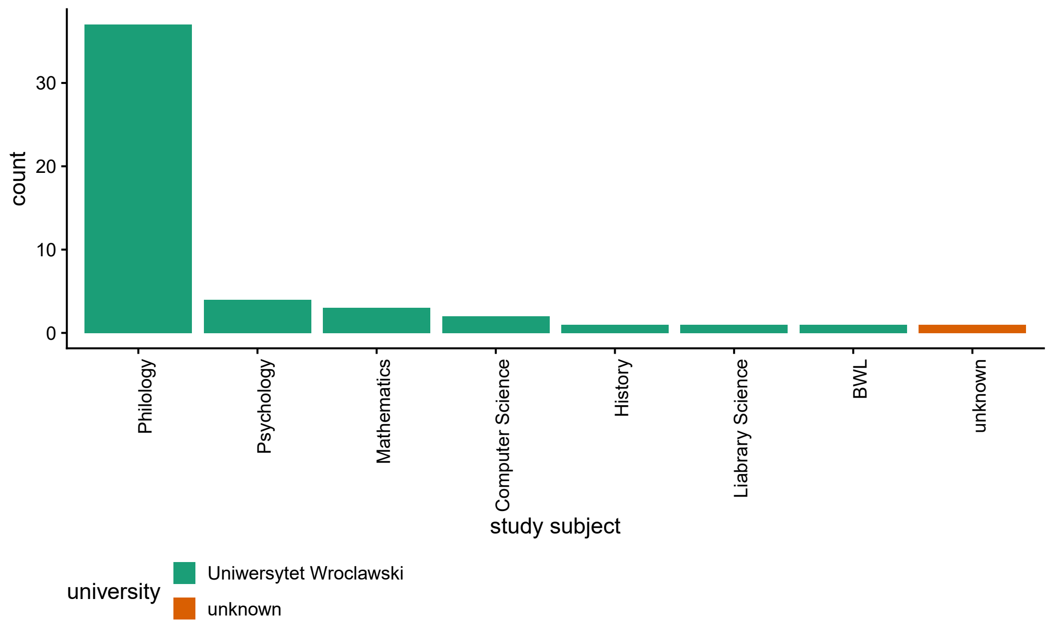


Figure 5.35: The study subjects of the participants

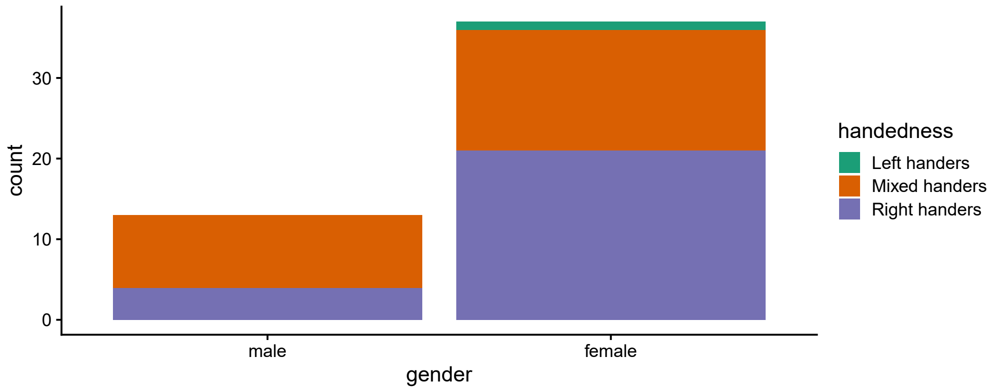


Figure 5.36: The distribution of gender and handedness of the participants

All the participants were born and grew up in Poland. None was bilingual or multilingual.

5.7.3 Results for questionnaire study: identifying sides by Polish native speakers

In the last part of the participant's questionnaire, all Polish native speakers were asked to assign sides to a cupboard (see 5.37). The pictures are the same as the situations from the mouse tracking. For the first question, the cupboard was placed canonically (with the front to participants) and in the second, non-canonically (with the back to the participants) – as in the 5.37.

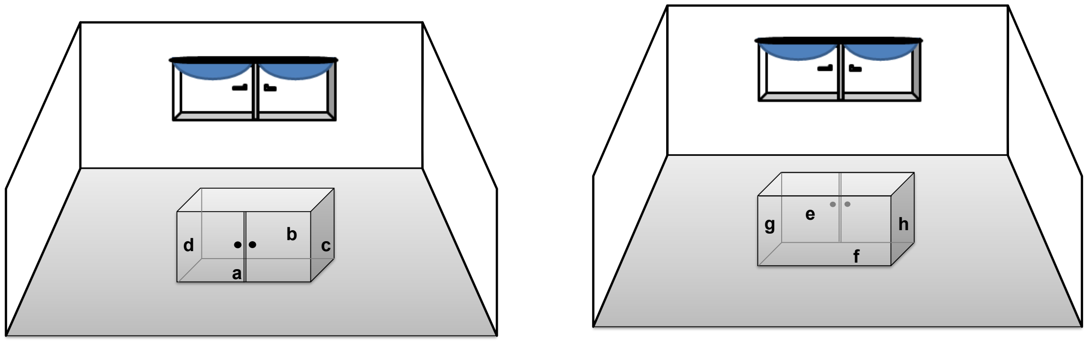
Canonically positioned cupboard

a. Front side
b. Back side
c. Right side
d. Left side

Non-canonically positioned cupboard

e. Front side
f. Back side
g. Right side
h. Left side.

Results of the survey show that 44% (22 participants) of the 50 Polish native speakers assigned the inherent sides to the canonically and non-canonically positioned cupboard



(a) canonical (b) non-canonical

Figure 5.37: The images show pictures of the cupboards viewed canonically (with the front facing – on the left) and non-canonically (with the back facing – on the right) from the survey

fully corresponding to the outside perspective; this is by approx. 18% less than the German native speakers. Nevertheless, the result is not significant. It merely shows that more German native speakers use the outside perspective for the side assignment of the cupboard.

As with the German data, the results of the survey of Polish native speakers reveal that participants almost exclusively assigned *front* and *back* in the expected directions. When the cupboard was placed in the canonical position, 100% of the participants chose a) (see 5.37) for the front, and b) for the back. If the cupboard was placed in the non-canonical position, 88% of the participants selected e) for the front side and f) for the back side. Here again, the Polish native speakers selected the intrinsic perspective approx. 10% less frequently than the German native speakers did. This result is not significant either; however, it shows stronger deviations from the outside perspective by the Polish native speakers than was the case with the German ones. It also involves more variations in the answers.

Similar to the German native speakers, the results for the Polish participants were less consistent with respect to the second horizontal dimension, *left* and *right*. When the cupboard was positioned canonically, 82% of all participants assigned left to d) and right to c) in 5.37, while 18% chose the opposite assignment, conducting a mental rotation of 180° while making the assignment. This represents a difference of 8% between the native speakers of the two languages. If the cupboard was positioned non-canonically, even fewer participants, 48%, assigned left and right to the expected position. The rest of the participants deviated from the expected strategy. This means that 21% more German than Polish native speakers assigned the right and left sides to the non-canonically

ID	q11_a	q11_b	q11_c	q11_d	q12_e	q12_f	q12_g	q12_h
47	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
49	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
50	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
51	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
52	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
53	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
54	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
55	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
56	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
57	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
58	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
59	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
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62	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
63	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
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67	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
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69	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
70	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
71	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
72	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
73	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Rechte Seite	Linke Seite
74	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
75	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
76	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
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85	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
86	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
87	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
88	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
89	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
90	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
91	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
92	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
93	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
94	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
95	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
96	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
97	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite

Figure 5.38: Questionnaire: Assignment of sides to the canonically (a-d) and non-canonically (e-h) positioned cupboard

positioned cupboard with respect to the outside perspective.

These results serve as a baseline. In the next section, the extent to which these answers also match the simple and complex situations in the mouse tracking experiment is demonstrated. In all situations, a bottle is positioned in relation to the reference object. In the complex situations, an additional agent is introduced.

The survey was designed to provide evidence as to whether participants recognize a cupboard as a vis-à-vis or vehicle-intrinsic object or rather as an extrinsic object by assigning the sides according the translation / align, reflection / facing, or rotation strategy. Furthermore, it provides a baseline for the question of whether participants conduct a mental rotation for the assignment of the front and back, as well as whether they assign the positive (right) and negative (left) sides of the second horizontal axis egocentrically (see also Stoltmann, Fuchs, and Krifka, 2018).

The table 5.38 shows in detail participants' responses to the canonically and non-canonically positioned cupboard in the questionnaire (Vorderseite: "front side," Rückseite: "back side," Rechte Seite: "right side," Linke Seite" "left side").

A very important question which arises at this point is: do the answers here match the answers of the simple spatial relations of the mouse tracking? This task clarifies how Polish native speakers recognize and perceive a cupboard (spatially) in the simple spatial situation, as well as how participants perceive the relations between the objects in spatial relations with a cupboard. As with the German language, the following sub-sections include a step-by-step analysis of the cupboard as a reference object:

- Clarification questionnaire – assignment of only the sides to the cupboard as representative of vis-à-vis objects (above)
- Questionnaire – dynamic spatial relations with the cupboard as a reference object (below – in the 5.7.4.3)
- Mouse tracking – simple static situations with the cupboard as a reference object (below, 5.7.4.2.1.2)
- Mouse tracking – complex static situations with the cupboard as a reference object (below, 5.7.4.2.1.2).

5.7.4 Results for mouse tracking study: interpretation of spatial relations by Polish native speakers

As with the German language, first I report the results for the categorical answers with respect to the experimental design. In the section detailed data analysis, I run a detailed data analysis for each particular spatial relation (see 5.7.4.2.1.1, and 5.7.4.2.1.2). In the detailed analysis, I assess whether the hypotheses have been confirmed.

Similar to the analysis of the German data, Fisher's exact tests were conducted for the categorical responses and linear mixed models, as well as ANOVAs for the differences and similarities of the continuous measures of the trajectories. All statistical tests and visualizations – bar- and trajectory plots – were computed using the software R (version 3.2.3., R Development Core Team, 2017).

For the computation, I used different additional packages: *ggplot2* (Wickham et al., 2013), *lme4* (Bates et al., 2014), *shiny* (Chang et al., 2015), *shinyjs*, *data.table*, *tidyr* (Wickham, 2017), *gridExtra* (Auguie, 2017), and *purrr* (Henry and Wickham, 2017).

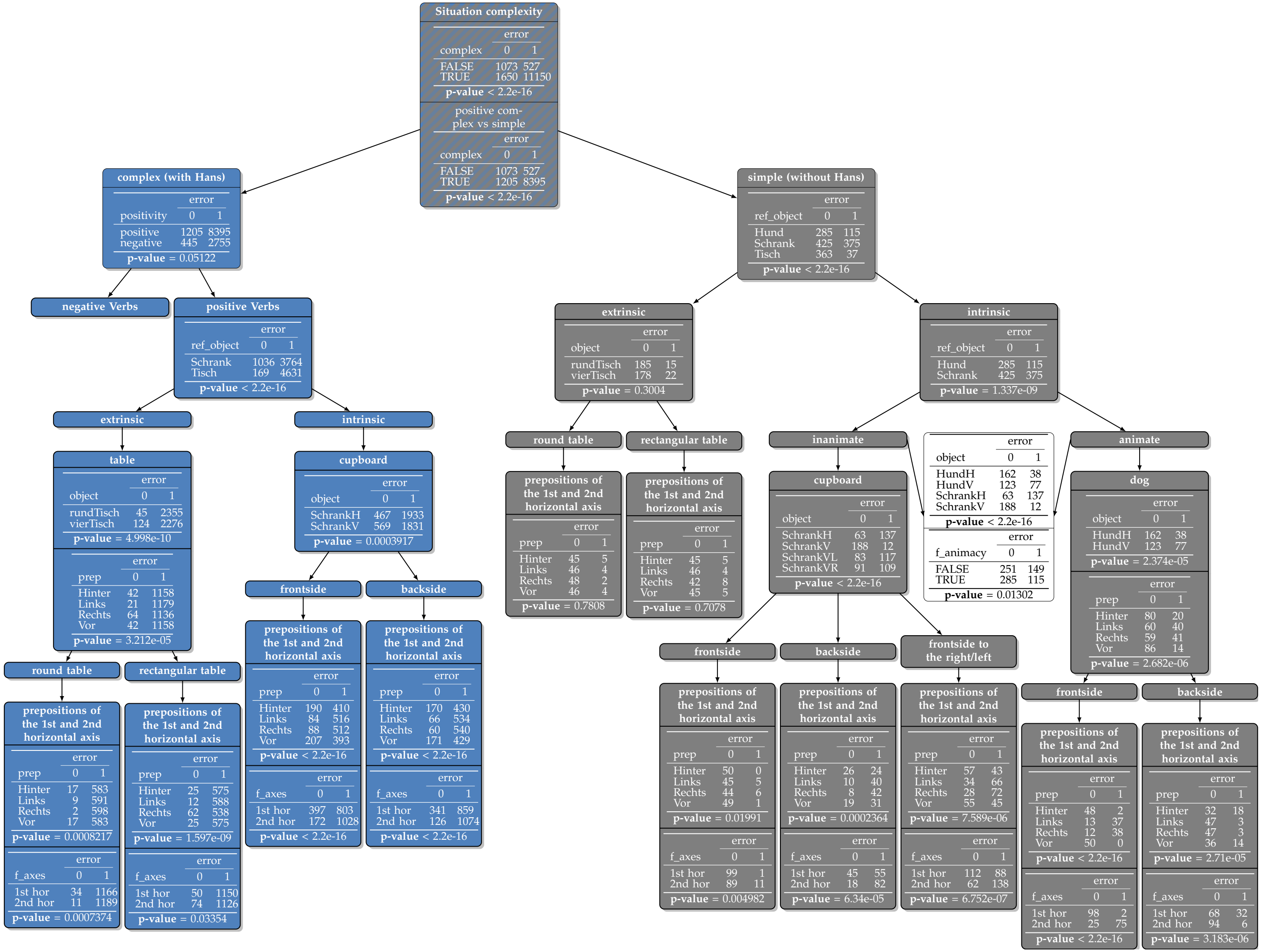


Figure 5.39: Computation of statistical analyses for categorical answers in Polish with respect to the experimental design

5.7.4.1 Computation of statistical analyses for categorical answers in Polish with respect to the experimental design

The chart 5.39 visualizes the setup of the experiment – the entire structure supplemented by the computed statistical analysis for the categorical answer choices by Polish native speakers for the particular situations. In this part of the work, it is emphasized which factors caused categorical significance and which did not. As with the German language, the analysis for Polish is conducted top down following the graphs' structure. Furthermore, the method of computation is the same: First, I compare the *correctness* with respect to a particular reference frame, applying for the interpretation of the particular spatial relations. For the extrinsic spatial relations, this means independent of the complexity of the relations (with the round and rectangular tables, I defined the reflection / facing strategy from participants' point of view as *correct*). That means that the assumption applies to all spatial constellations with tables, both with and without Hans.

However, for the complex intrinsic spatial relations, I assumed the outside perspective of the intrinsic frame of reference independent of the position of the reference object and Hans. The same assumptions apply for the simple relations with a cupboard.

For the spatial relations with the dog, I assumed the inside perspective of the intrinsic reference frame, which also applies for humans.

Furthermore, the chart supports the analysis of null hypotheses *one, two*, and *three* (see 5.3).

Situation complexity

	error	
complex	0	1
FALSE	1073	527
TRUE	1650	11150

p-value < 2.2e-16

positive complex vs simple

	error	
complex	0	1
FALSE	1073	527
TRUE	1205	8395

p-value < 2.2e-16

Figure 5.40: Computation of statistical analyses for categorical answers in Polish with respect to the complexity of spatial relation

First, I compared the categorical answers for all simple and complex spatial relations to investigate the influence of complexity in general. For the situations' complexity as a factor, I have found that it influences the interpretation by the Polish native speakers very strongly ($p < 0.001$). With this result, I can reject the first null hypothesis, *The presence of a third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift* and confirm the alternative hypothesis, *The presence of a third person as artificial agent in a spatial relation expressed by indirect speech affects* *an origo shift.* This result indicates that the presence of an additional person – in this case, an artificial agent – affects a perspective shift in spatial relations interpretation by the Polish native speakers investigated.

As with the German native speakers, within the complex spatial relations, I found highly significant results between the complex spatial relations embedded by positive and negative predicates. This is caused by the perspective shift from the participants' to Hans' point of view (compare this with the detailed analysis of particular situations below – 5.7.4.2). Therefore, the second null hypothesis can be rejected ($p < 0.0001$): The interpretation of dimensional spatial expression does not depend on the semantics of embedding predicates, and the alternative hypothesis can be confirmed: The interpretation of dimensional spatial expression depends on the semantics of embedding predicates.

To provide further detail for the complex and simple spatial relations, I undertook a more detailed analysis which found that the Polish native speakers interpreted the intrinsic spatial relations with the cupboard *correctly* more frequently – that is, along the outside perspective than with the relations with the tables – along the expected facing / reflection strategy from participants' point of view ($p < 0.0001$). This means that the Polish native speakers shifted the origo from themselves to Hans' point of view more frequently in situations with an extrinsic than with intrinsic reference object. This implies that the objects' properties play an important role for Polish native speakers because they shift the perspective to Hans' point of view more frequently with extrinsic objects than with intrinsic ones. However, intrinsicality is not a strong enough property for the participants to concentrate only on intrinsicality while interpreting the spatial relations.

Analyzing the answers for spatial relations described by positive verbs in greater depth, we can see that there is a significant difference ($p < 0.0001$) between the complex spatial relations with the round and with the rectangular table. This implies that the shape of the tables significantly influences the interpretative strategy of the Polish participants. Within the extrinsic tables, I conducted further analysis to understand the semantical differences and similarities between the particular spatial expressions. First, the results reveal that participants selected different interpretative strategies depending on the spatial expression ($p < 0.001$) for both tables taken together. The Polish participants interpreted the complex extrinsic spatial relations most frequently with respect to the reflection / facing strategy from their point of view in relation with the bottle to the right of the table (from their point of view). In contrast, they selected the reflection / facing strategy less frequently with the bottle to the left of the table (from their point of view). Finally, I examined whether the shape of the table influences the interpretation of the particular complex spatial relations. The separate analysis of the particular situations with either the round or rectangular table showed very highly significant differences ($p < 0.0009$ for the round table and $p < 0.0001$ for rectangular table). In the relations with both tables

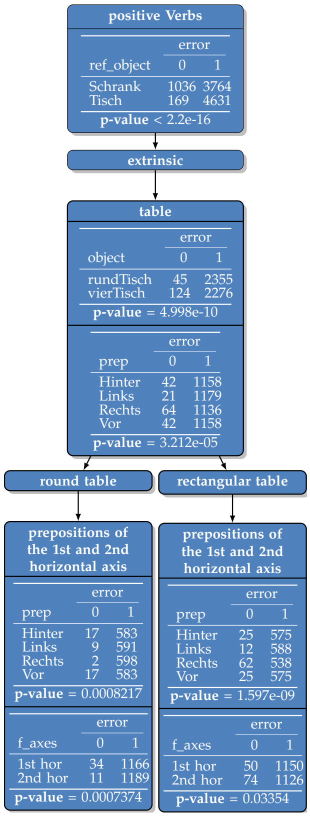


Figure 5.41: Computation of statistical analyses for categorical answers in Polish with tables in complex spatial relations

(considering the situations individually), the fewest participants interpreted the spatial relations with the bottle to the right of the round table and to the left of the rectangular table with respect to the reflection / facing strategy from the participants' point of views. However, Polish participants most frequently chose the reflection / facing strategy from participants' point of view with the bottle behind and in front of the round table and to the right of the rectangualr table.

I also found several significant differences for the complex intrinsic spatial relations. The first result revealed a highly significant difference ($p < 0.0004$) between reactions to the canonically vs. the non-canonically positioned cupboard. Polish native speakers interpret spatial relations with canonically positioned cupboard more frequently than non-canonically positioned cupboard in relation to the outside perspective. However, it is important to stress that in the canonical relations too, considerably more Polish native speakers shifted the origo to Hans and interpreted even the canonical spatial relations

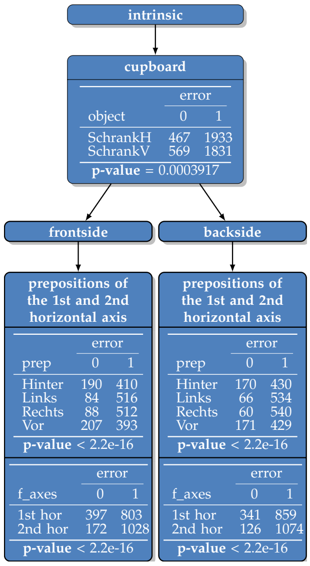


Figure 5.42: Computation of statistical analyses for categorical answers in Polish with cupboard in complex spatial relations

from Hans' point of view with respect to the reflection / facing strategy of the relative frame of references.

Analyzing the complex intrinsic spatial relations individually, the results indicate that the semantics of the prepositions influences the choice of reference frame, with $p < 0.0001$ for both the canonically and non-canonically positioned cupboard. It means that the participants interpreted most frequently the spatial relations with the bottle *behind* and *in front of* the canonically as well as non-canonically positioned cupboard in relation to the outside perspective – similar to the German native speakers. In contrast, they interpreted the spatial relations with the bottle *to the right* and *left of* the cupboard significantly fewer times in relation to the outside perspective. In these situations, more participants shifted the origo to Hans' point of view and interpreted the relations from his point of view most frequently in relation to the reflection / facing strategy. This implies that these Polish native speakers ignored the intrinsic properties of the cupboard in their interpretations and considered the cupboard as an extrinsic object.

The results of the simple spatial relations (without Hans) indicate very high significant differences with respect of the above-defined *correctness* ($p < 0.0001$) in general. Considering the general result in more detail, it can be observed that the Polish native speakers interpreted the spatial relations less frequently within the expected strategy – the outside perspective with the cupboard (similar to the German native speakers). This result is followed by the dog and this by the table. These results indicate that the

simple (without Hans)

	error	
ref_object	0	1
Hund	285	115
Schrank	425	375
Tisch	363	37

p-value < 2.2e-16

Figure 5.43: Computation of statistical analyses for categorical answers in Polish (simple spatial relations)

properties of the object influence the interpretation of spatial relations by native speakers of both languages. They are more constant when interpreting the spatial relations with the extrinsic reference objects, which cannot be positioned canonically or non-canonically. Only a few Polish native speakers deviated from the expected interpretation of the spatial relations with the table as reference object.

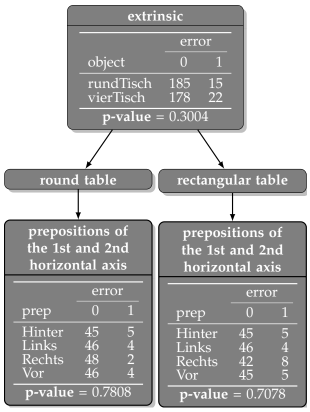


Figure 5.44: Computation of statistical analyses for categorical answers in Polish (simple extrinsic spatial relations)

In analyzing the simple extrinsic spatial relations, the results show no significant differences between the interpretation of the extrinsic spatial relations with a round or rectangular table ($p = 0.3$). This means that the shape of the table as reference object does not influence significantly the interpretation of particular spatial relations by the Polish (as it did by the German) native speakers. This is in contrast to the complex spatial relations as shown above. For simple extrinsic spatial relations, neither did I find any significant differences between the individual constellations ($p \approx 0.78$ for round table and $p \approx 0.70$ for the rectangular table).

In contrast to the extrinsic spatial relations, the simple intrinsic relations revealed significant differences ($p < 0.0001$) for Polish native speakers – as for the Germans. This is caused by significantly more frequent interpretations following the intrinsic frame of reference in spatial relations with the dog than with the cupboard. However, considering the data further, I found explanations for more general result.

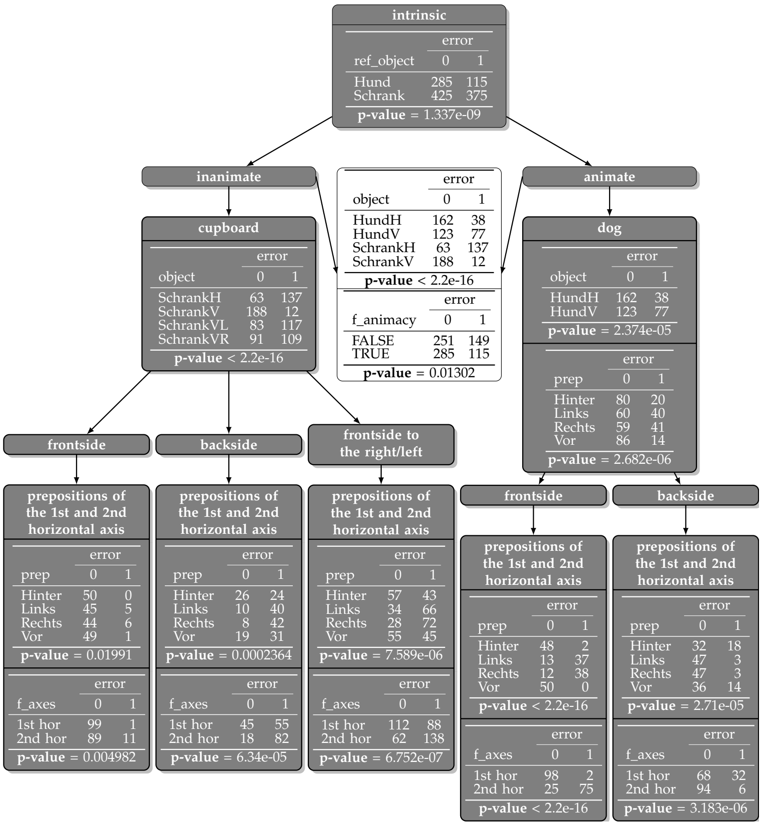


Figure 5.45: Computation of statistical analyses for categorical answers in Polish (animacy in simple spatial relations)

For spatial relations with an inanimate intrinsic reference object, the cupboard (positioned in different ways), the results also indicate a high significant difference ($p < 0.0001$). This is caused by the fact that, in almost all situations, the participants interpreted the spatial relations with the canonically positioned cupboard according to the outside perspective, as expected for relations with the cupboard as reference object. However, in all situations with the non-canonically positioned cupboard, I found deviations from this interpretation. It is interesting that most deviations were evidenced for the cupboard with its back to the participants, where only 63 of 200 answers conforming to the outside perspective were selected. This is even less than with the cupboard with the front to the right (91) or left (83). For the canonically (front) vs. non-canonically (back) positioned cupboard, I obtained a very high significant difference too ($p < 0.0001$).

To conduct the analysis in greater detail, I also examined the answers for the individual positions with respect to the canonically and non-canonically positioned cupboard. The results showed:

a) Significant differences for the canonically positioned cupboard ($p < 0.02$) – all Polish native speakers interpreted the spatial relation with the bottle behind the cupboard according to the outside perspective and almost all with the bottle in the front. Polish native speakers deviated from this strategy with the bottle to the right most frequently (six and five for the left). This result caused the significant difference. German native speakers did not demonstrate significant differences for these four spatial relations.

b) A highly significant difference ($p = 0.0002$) for the non-canonically positioned cupboard (with the back to the participants). Here, the Polish native speakers most frequently selected the answer according to the outside perspective with the bottle behind the cupboard (similar to the canonically positioned cupboard). In addition, in this spatial relation, the Polish native speakers deviated from the outside perspective with the bottle to the right of the cupboard most frequently (42 and 40 for left). In contrast to Polish native speakers, German native speakers did not demonstrate any significant differences for these spatial relations.

c) Significant differences ($p < 0.0001$) for the non-canonically positioned cupboard (with the front to the right / left from participants' point of view).

Animacy (cupboard with front / back vs. dog with front / back) generated overall statistical significance ($p = 0.013$). For the individual positions, the results revealed very large significant differences. The largest differences between the dog and the cupboard as reference objects are visible for the interpretation with the bottle in front of the reference object (86 *correct* answers for the dog vs. 68 for the cupboard). The largest differences between the dog positioned canonically / non-canonically and the cupboard positioned canonically / non-canonically individually as reference objects are visible for the interpretation with the bottle to the right and left of the canonically positioned objects. A Fisher's exact test revealed significant differences between both objects and positions ($p < 0.001$). No significant differences were found in categorical judgments for the first horizontal axis (*front-back*). For the non-canonically positioned reference objects, a Fisher's exact test revealed significant differences for animacy and both positions (to the right vs. left of), with $p < 0.001$. This also applies to the first horizontal dimension (in front of vs. behind) and both reference objects. With the statistical analysis, the third

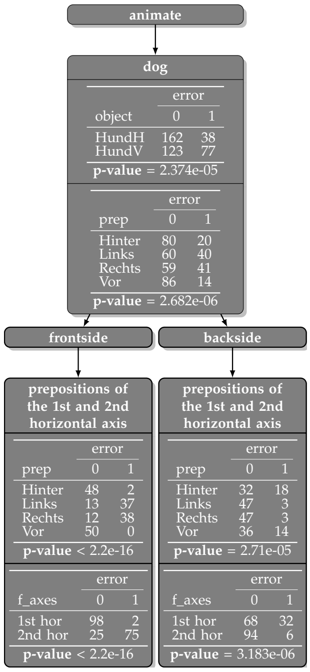


Figure 5.46: Computation of statistical analyses for categorical answers in Polish (animate spatial relations)

null hypothesis can be rejected: The animacy of relata does not affect the interpretation of spatial relations.

Considering animate spatial relations, the results indicate significant differences for the interpretation of spatial relations with a canonically and non-canonically positioned dog ($p < 0.0001$). Similar to German native speakers, Polish participants also interpreted the spatial relation with the non-canonically positioned dog more frequently according to the intrinsic frame of reference than with the canonically positioned one (in contrast to the cupboard). Analyzing the data in further detail, the results indicate significant differences within the individual spatial positions with respect to the canonically ($p < 0.0001$) and non-canonically ($p < 0.0001$) positioned dog – as for the German participants. The differences are due to the intrinsic interpretation of “in front of” and “behind” in the spatial relations with the canonically positioned dog. In contrast, participants selected the answers according to the intrinsic perspective in non-canonical spatial relations with the bottle *to the right* / *left of* the dog significantly more frequently than *in front of*/*behind* the dog. It is worth mentioning that the interpretation of these spatial relations, which was undertaken along the intrinsic reference frame, coincides with the reflection / facing strategy. Therefore, I can only say that in relations with the dog the prepositions *przed* “in front of” and *za* “behind” were interpreted more frequently according to the intrinsic frame of reference than the prepositions *na prawo* “to the right of” and *na lewo* “to the left of”.

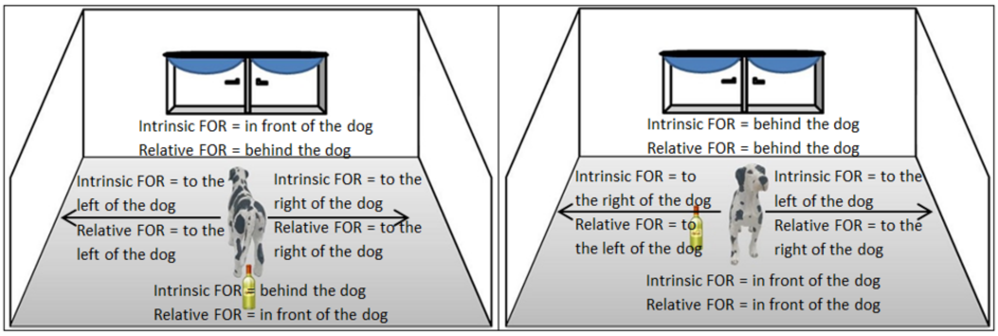


Figure 5.47: Assignment of regions to the dog according to the frames of reference

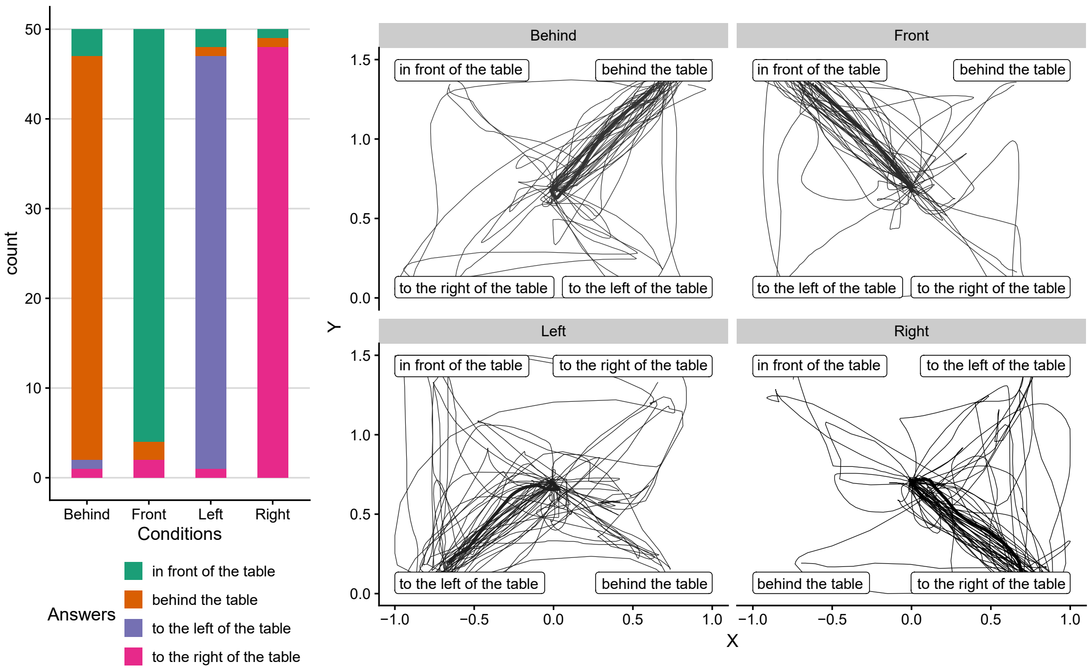
5.7.4.2 Detailed data analysis

5.7.4.2.1 First null hypothesis

The presence of the third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift.

5.7.4.2.1.1 Analysis of simple and complex extrinsic spatial relations

Round table



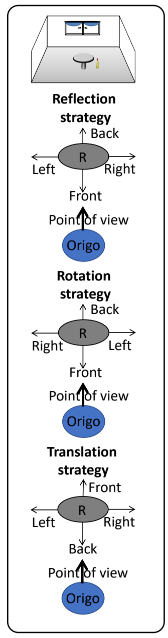


Figure 5.48: Answers for the simple extrinsic relation with round table: barplots with answers (left) and trajectories through the response with the mean trajectories (right)

The results of the barplots and trajectories show small deviations for the Polish native speakers. More specifically, the participants had fewer problems with the interpretation of spatial relations when the bottle stood *behind* or *in front of* rather than *to the right* or *left of* the round table (see mouse trajectories). The normalized trajectories on the plots are very accurate – they are almost ideal. This applies especially to the dimensional spatial expressions *przed* "in front of" and *za* "behind". However, the Polish native speakers were less consistent when the bottle was localized relative to the first horizontal axis with reference to the table (see bar plots). When the bottle was placed *behind* the table, five participants decided against the reflection / facing strategy and four deviated from the strategy in relations with the bottle *in front of* the round table. Furthermore, in spatial relations with the bottle *to the left of* the table, four participants deviated from the expected reflection / facing strategy. However, in constellations with the bottle *to the right of* the reference object, only two participants selected a strategy other than the reflection / facing one.

The differences can be also recognized on the MAD.abs and AUC.abs values as well as on the X- and Y- flips. The highest MAD.abs value amounts to ≈ 0.29 and relates to the negative spatial dimension expression of the second horizontal axis *na lewo* "to the left of." *Na prawo* "to the right of" is immediately followed by na lewo with MAD.abs of ≈ 0.24. The lowest MAD.abs was computed for both *przed* "in front of" and *za* "behind" with MAD.abs ≈ 0.19. In general, the results demonstrate that maximal absolute deviation was significantly ($p < 0.0001$) lower for the dimensional spatial expressions of the first horizontal axis than for the second one.

In contrast to the MAD.abs, the AUC.abs results cannot be considered in terms of the axes. The highest result, 0.16, was achieved for the spatial relation with the bottle to the left of the table and the lowest for the bottle to the right of the reference object, with 0.09.

For all complex spatial relations, the outcomes for the Polish native speakers showed very clearly that verb semantics influenced the interpretation, as occurred with the German language.

The results for the complex spatial relations showed very clearly for *za* "behind" (from the participants' point of view) that verb semantics influences the choice of answer. In the positive situations (with verbs of positive semantics), most participants (between 43 and 48) selected the reflection / facing strategy. This means that the choice of the reflection / facing strategy of the relative frame in positive complex relations has not changed much (from $\approx 90\%$ to between $\approx 96\%$ and 86%) in comparison to the simple spatial relations without Hans. However, it also demonstrates that the participants investigated shifted the origo to Hans and considered the spatial relations from the artificial agent's point of view.

Furthermore, for the preposition *przed* "in front of," I found that verb semantics influenced the interpretation of the spatial relation. In the situations described by the verbs with negative semantics, a maximum of 38% of the participants selected the answer aligned with the reflection / facing strategy from Hans' point of view. However, almost all Polish native speakers chose the reflection / facing strategy interpretation in complex relations supplemented by Hans and described by positive verbs (between 43 and 49). This means that the choice of the reflection / facing strategy of the relative frame in positive complex relations has not varied considerably (from $\approx 92\%$ to between $\approx 98\%$

and 86%) in comparison to the simple spatial relations without Hans. Furthermore, it also points out that of all these participants, 86-98% shifted the origo to Hans and interpreted the spatial relations from his point of view using the reflection / facing strategy of the relative frame of references.

For the preposition *na prawo* “to the right of”, I have also found that verb semantics influence the interpretation of the spatial relation. In the situations described by the verbs with negative semantics, a maximum of 32% of participants selected the answer aligned with the reflection / facing strategy from Hans’ point of view. However, almost all Polish native speakers shifted the origo to Hans and chose the reflection / facing strategy interpretation in complex relations supplemented by Hans and described by positive verbs (between 43 and 49). This means that the choice of the reflection / facing strategy of relative frame in positive complex relations has not changed (from $\approx 96\%$ to between $\approx 100\%$ and 98%) in comparison to the simple spatial relations without Hans.

Finally, verb semantics also influenced the interpretation of the spatial relations with the bottle to the left of the table (from the participants’ point of view, with respect to the reflection / facing strategy). In situations with a positive verb, between 96% and 100% of the Polish native speakers shifted the origo to Hans and selected an answer aligned with the reflection / facing strategy from his point of view. This means that these participants selected the reflection / facing strategy more frequently in the complex situations (supplemented by an artificial agent) than in the simple ones (92%). In the situations described by verbs of negative semantics, approx. 25% and 33% decided on the reflection / facing strategy from Hans’ point of view.

Considering the AUC.abs and MAD.abs, the results indicate some differences. The lowest MAD.abs was found for the verb “to know” and Hans to the right of the table, with ≈ 0.15. In contrast, the highest value for MAD.abs was found for “reckon” with Hans and bottle to the left, with 0.39. It is interesting that the MAD.abs depends on the position of Hans with respect to the reference object: in spatial relations with Hans to the right of the table, the MAD.abs is mostly smaller than with Hans to the left of the table, and shows a $p = 0.055$.

Rectangular table

The results of the barplots and trajectories show some deviations for Polish native speakers in situations with rectangular table. They mostly differ in the interpretation of the situation with the bottle *to the right of* the table. In this situation, eight participants (16%) selected a response against the reflection / facing strategy from the participant’s point of view – and showed the opposite result for the round table, where the Polish native speakers were more constant. In contrast, most participants (46) chose the reflection / facing strategy in the constellation with the bottle *to the left of* the table. *In front of* and

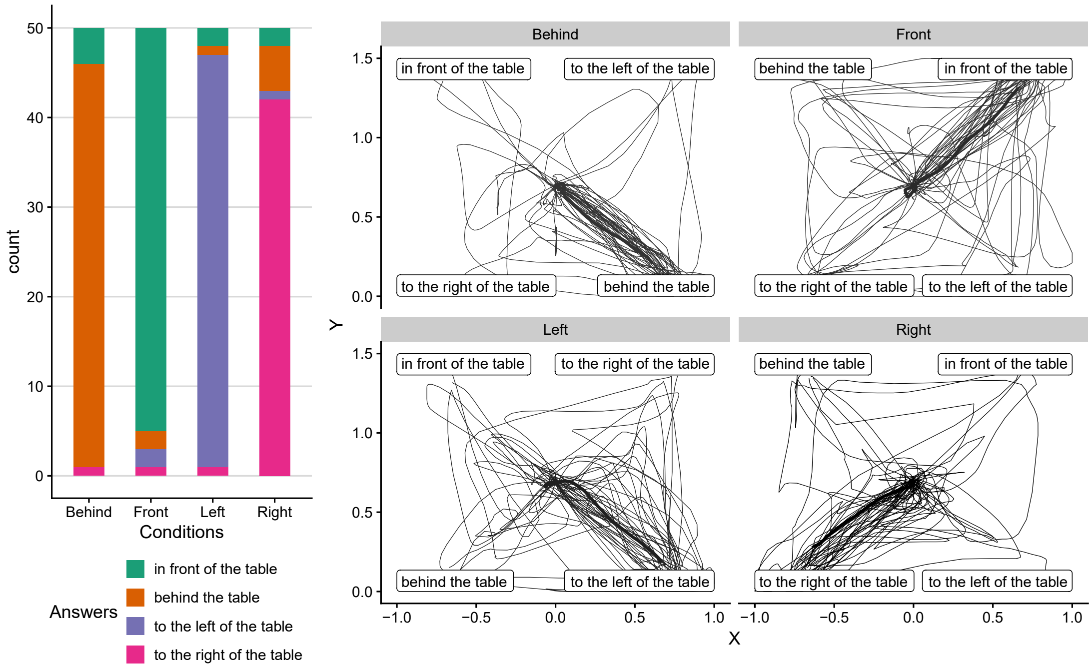


Figure 5.49: Answers for the simple extrinsic relation with rectangular table: barplots with answers (left) and trajectories through the response with the mean trajectories (right)

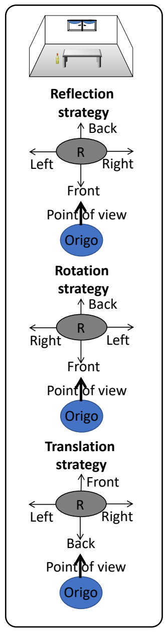
behind attained the same score, with 45 participants interpreting the situations in relation to the reflection / facing strategy from the participants' point of view. In contrast to the Polish native speakers, German native speakers have not shown any differences between the individual expressions.

With respect to the trajectories and to the MAD.abs and AUC.abs values, some differences between the particular situations were found. The lowest MAD.abs ≈ 0.2 was found for the bottle *behind* the rectangular table and the highest of 0.31 for *in front of*. This order applies for the AUC.abs values too. The lowest value amounts to 0.1 for *behind* and the highest to 0.17 for *in front of*, with $p \approx 0.003$ for all spatial relations.

Therefore, neither the AUC.abs nor the MAD.abs results can be considered in terms of the axes or of the one of the models for the perception of axes by Franklin and Tversky (1990) *spatial framework*, *equiavailability* or *mental transformation* (see 3.1.2).

For all complex spatial relations with both the rectangular and the round table, the outcomes for the Polish native speakers showed very clearly that verb semantics influenced the interpretation.

In the spatial relation with the bottle *in front of* the rectangular table (from the participants' point of view with respect to the reflection / facing strategy), the verb semantics of the embedding predicates also influenced the interpretation of the particular relations very clearly. In spatial constellations embedded with a positive verb, most participants, between 44 and 49 – depending on the relation – selected the reflection / facing strategy. In the simple spatial relation without Hans, 45 Polish native speakers selected the reflection / facing strategy. This demonstrates that for some complex situations, the interpretation in relation with the reflection / facing strategy increased in comparison to the simple one.



Considering the AUC.abs and MAD.abs, the results indicate some differences. The lowest MAD.abs was found for the verb "claim" and Hans to the right of the table with ≈ 0.17, and "to know" with ≈ 0.17 and Hans to the left of the table. In contrast, the highest value of ≈ 0.39 for MAD.abs was found for "to believe" and Hans to the right. It is interesting that the MAD.abs was not strongly influenced by the position of Hans in relation to the reference object: the spatial relations with Hans to the right were three times the lower MAD.abs value (therefore one time with negative verb semantics) and five times with Hans to the left (therefore one time with negative verb). Still, there is significance ($p < 0.0001$) between the verbs but no significance ($p = 0.3$) between the positions of Hans.

In the spatial relation with the bottle *behind* the rectangular table from the participants' point of view with respect to the reflection / facing strategy, the positive vs. negative verb semantics of the embedding predicates influenced the interpretation of the particular relations too. In spatial constellations embedded with a positive verb, most participants, between 44 and 49 – depending on the relation – selected the reflection / facing strategy. Only up to 30% selected the answer aligned with the reflection / facing strategy from Hans' point of view in situations described with a verb of negative semantics. This shows that the choice of the reflection / facing strategy of the relative frame in positive complex relations is almost same (from ≈ 90% in the simple spatial relations to between ≈ 88% and 98%) as in the simple spatial relations without Hans.

Considering the AUC.abs and MAD.abs, the results indicate some differences. The lowest MAD.abs was found for the verb "reckon" and Hans to the right of the table, with ≈ 0.17. In contrast, the highest value, ≈ 0.39, for MAD.abs was found for "to know" and Hans to the left. It is interesting that the MAD.abs was very strong influenced by the position of Hans with respect to the reference object: the spatial relations with Hans to the left reached six times higher value (therefore one time with negative verb semantics) and only two times with Hans to the right (therefore one time with a negative verb). The results revealed no significance between the verbs ($p = 0.6$) but did between the positions of Hans $p < 0.0001$ – in contrast to *in front of*.

Furthermore, for the preposition *to the right of*, I found that the verb semantics but only *positive* vs. *negative* influenced the interpretation of the spatial relation. In the situations described by the verbs with negative semantics, a maximum of 34% of participants selected the answer in relation to the reflection / facing strategy from Hans' point of view. However, almost all Polish native speakers chose the reflection / facing strategy from Hans' point of view in complex relations described by positive verbs (between 46 and 50). This means that the choice of the reflection / facing strategy of the relative frame in positive complex relations has significantly increased (from ≈ 84% to between ≈ 92% and 100%, $p < 0.006$) in comparison to the simple spatial relations without Hans.

Considering the AUC.abs and MAD.abs, the results for the spatial relations with the bottle to the right of the rectangular table from the participants' point of view also show numerous differences. The lowest MAD.abs indicates the spatial relation embedded by the verb "claim" and Hans to the left of the table, with ≈ 0.16. However, the highest MAD.abs value amounts to ≈ 0.35 and applies to spatial relation with the bottle and Hans to the right of the table. This situation was embedded with the verb "to know." The results revealed no significance between the verbs ($p = 0.47$) but did between the positions of Hans ($p < 0.005$).

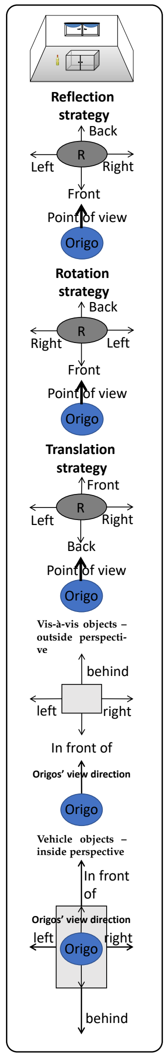
In addition, for the preposition *to the left of*, I can recognize that the verb semantics influenced the interpretation of the spatial relation. In the spatial relations described by the verbs with negative semantics, a maximum of 36% (min. 16%) of participants selected the answer aligned with the reflection / facing strategy from Hans' point of view. However, almost all Polish native speakers shifted the origo to Hans and decided on the reflection / facing strategy interpretation in complex relations embedded by positive verbs (between 90% and 100%). This means that the choice of the reflection / facing strategy of the relative reference frame for spatial relations described by positive verbs is almost the same (from ≈ 92% to between ≈ 90% and 100%) as in the simple spatial relations without Hans.

Considering the AUC.abs and MAD.abs, the results for the spatial relations with the bottle to the left of the rectangular table from the participants' point of view also show some differences. The lowest MAD.abs applies to the spatial relation embedded with the verb "say" and Hans to the right of the table, with ≈ 0.16, as well as "reckon" and Hans to the right too. However, the highest MAD.abs value amounts to ≈ 0.33 and applies to the spatial relation with the bottle and Hans to the left of the table and embedded with the verb "say" as was the previous one. These differ with regard to the position of Hans in relation to the table only. The results revealed no significance between the verbs ($p > 0.19$) but did between positions of Hans ($p < 0.0001$).

With these detailed analysis, the first null hypothesis for spatial relations with the extrinsic reference object can be rejected, *The presence of the third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift* and confirm the alternative hypothesis: The presence of the third person as artificial agent in a spatial relation expressed by indirect speech affects an origo shift.

5.7.4.2.1.2 Analysis of simple and complex intrinsic spatial relations

Cupboard with the front side to the participants



In terms of the canonically positioned cupboard, only a few differences can be recognized between the responses of the particular situation interpretation regarding the outside perspective: both spatial expressions of the first horizontal axis (*front-back*) were interpreted by most Polish native speakers with respect to the outside perspective ("in front of" by 98%; "behind" by 100%); whereas 90% of the participants interpreted the spatial relations with the bottle *to the left* and 88% with the bottle *to the right* in the meaning of the outside perspective.

It is important to stress that in this case, the interpretation with respect to the outside perspective and reflection / facing strategy of the relative reference frame coincide. Therefore, it is impossible to determine whether the participants used the intrinsic reference frame (in particular the outside perspective) for the interpretation of the constellation or rather the reflection / facing strategy of the relative frame of references.

Comparing these results with the questionnaire results, some deviations can be found.

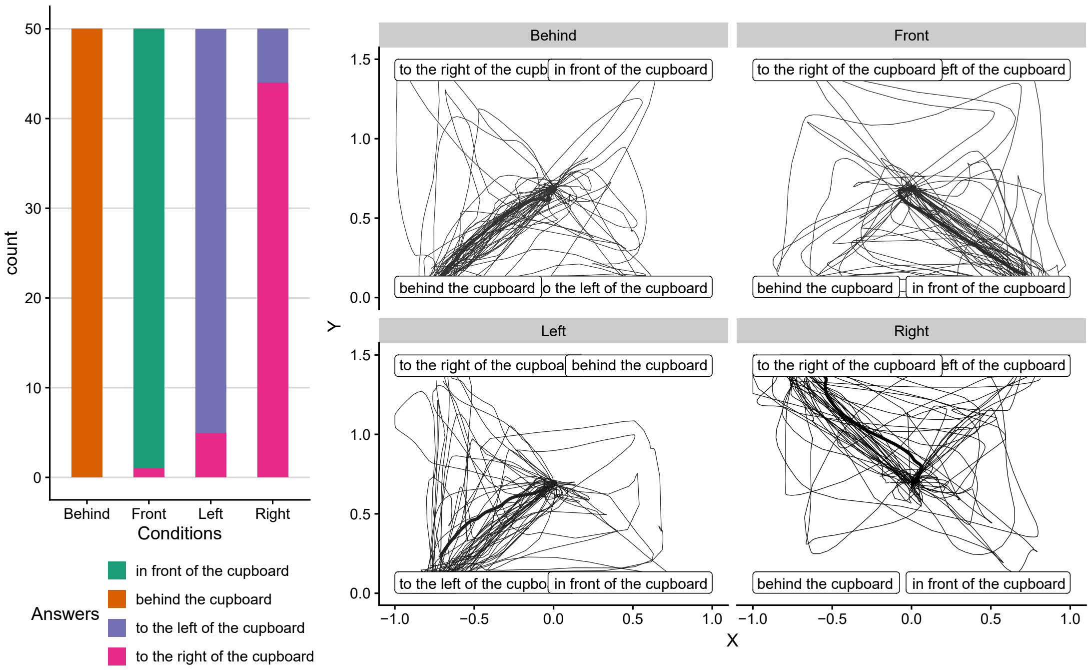


Figure 5.50: Answers for the simple intrinsic relation with cupboard: barplots with answers (left) and trajectories through the response with the mean trajectories (right)

As in the survey, the front and back of the cupboard were assigned by 100% of the time according to the outside perspective as well as the reflection / facing strategy. In the mouse tracking study, the spatial relations with the bottle *in front of* or *behind* the cupboard were also interpreted by allmost all Polish native speakers in relation to the outside perspective. In addition, in the case of the questionnaire, the assignment of the right and left side caused more inconsistency between the participants. Eighteen percent of Polish native speakers deviated from the outside perspective and chose the inside perspective, which coincides with the rotation strategy of the relative frame in this case. It is notable that Polish native speakers selected the outside perspective of the intrinsic frame of references in the mouse tracking study more frequently than in the survey.

From the AUC.abs and MAD.abs values, we can derive that participants had the fewest difficulties with the interpretation of the negative dimensional spatial expression of the first horizontal axis (za "behind"). In contrast, most variations arose during the interpretation of the spatial relation with the bottle to the left of the cupboard – in relation to the outside perspective. More specifically, the spatial expressions reached the following MAD.abs and AUC.abs values: *za* "behind" MAD.abs ≈ 0.26 and AUC.abs ≈ 0.11. This was followed by *na prawo* "to the right of" with MAD.abs ≈ 0.31 and AUC.abs ≈ 0.17, *przed* "in front of" with MAD.abs ≈ 0.32 and AUC.abs ≈ 0.18, and *na lewo* "to the left of" with MAD.abs ≈ 0.34 and AUC.abs ≈ 0.17. The results have revealed no significance, neither between the bottles' positions ($p > 0.66$) nor between the axes ($p > 0.6$).

Comparing the canonical situations from the survey and the mouse tracking, it can be clearly recognized that in terms of the interpretation with respect to the outside perspective *przed* "in front of" and *za* "behind" does not cause any difficulties to the participants. Nonetheless I cannot determine whether participants reach the interpretation with fewer variations – especially in case of *przed* "in front of."

The results for the Polish native speakers for interpretation of complex spatial relations with the bottle *in front of* the cupboard, visible from the front, show for the constellation that verb semantics influences the choice of answer.

In the positive situations (with verbs of positive semantics), most participants (between 30 and 36) selected the reflection / facing strategy from Hans' point of view. This is more than 20% (between 42 and 49 participants) fewer than for the rectangular table. This indicates that the intrinsicality of the reference object plays an important role in the interpretation of the spatial relations. In general, the outcomes indicate that the choice of the reflection / facing strategy of the relative reference frame in positive complex relations increased significantly (from 0% to between $\approx 60\%$ and 72%, $p < 0.0001$) in comparison to the simple spatial relations without Hans.

The differences are also visible in the MAD.abs and AUC.abs values as well as in the X- and Y- flips. The highest average MAD.abs value amounts to ≈ 0.39 and applies to

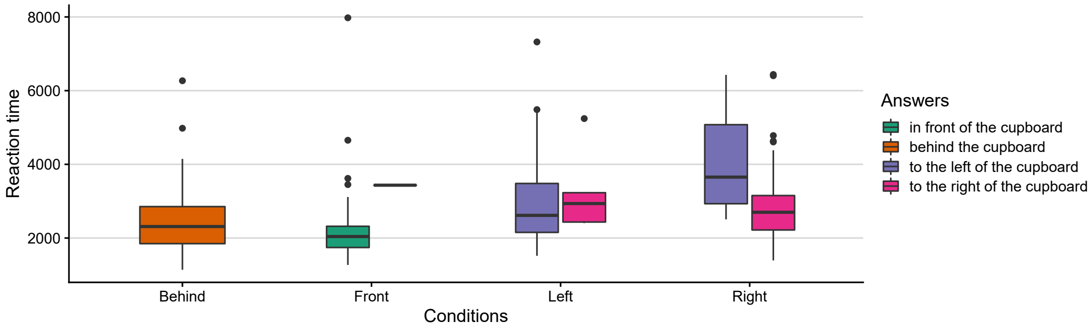


Figure 5.51: Reaction time for the spatial relations with the cupboard facing the participants

the verb "know" with Hans to the right of the cupboard. In general, the outcome means that maximal absolute deviation was more frequently higher with Hans to the right of the cupboard. The results do not indicate any significance between the verbs ($p > 0.32$) nor between the positions of Hans ($p > 0.67$).

The results for the Polish native speakers for interpretation of spatial relations with the bottle *behind* the cupboard, visible from the front side, show for the constellation (without contribution of Hans to the picture) that verb semantics influences the choice of answer.

In the situations with verbs of positive semantics, most participants (between 31 and 37 out of 50) selected the reflection / facing strategy from Hans' point of view and between 14 and 19, the outside perspective. In contrast, in the simple spatial relation all participants selected the intrinsic frame of reference. Still, it is striking that the intrinsicality plays an important role for 40% of participants. In general, the outcomes indicate that the choice of the reflection / facing strategy of the relative frame in positive complex relations significantly increased (from 0% in the simple relation to between $\approx 62\%$ and 74% in the complex constellation, $p < 0.0001$) in comparison to the simple spatial relations without the artificial agent *Hans*.

The differences are also visible in the MAD.abs, AUC.abs values as well as in the X- and Y- flips. The highest average MAD.abs value amounts to ≈ 0.30 and applies to the verbs *myśleć* "think" with Hans to the right of the cupboard. The lowest MAD.abs was computed for the verb *sądzić* "reckon" and Hans to the right of the cupboard, with MAD.abs ≈ 0.17. The results do not indicate any significance between the verbs ($p > 0.94$) nor between the positions of Hans ($p > 0.46$).

In situations with the bottle on the right side of the cupboard described by verbs of positive semantics, most participants (between 34 and 42) selected the reflection / facing strategy from Hans' point of view. This is approx. 10% (between 30 and 36 /

7 participants) more than for the front or back side. This suggests that localization in relation to the reference object plays an important role. Furthermore, the outcomes demonstrate that intrinsicality plays an important role here too. For the rectangular and round tables with the bottle to the right, between 43 and 50 Polish native speakers selected the reflection / facing strategy – this means that Polish native speakers selected the reflection / facing strategy approx. 16% more frequently in the extrinsic constellations with the bottle to the right of the reference object embedded by indirect speech and supplemented by an artificial agent. The outcomes indicate that the choice of the reflection / facing strategy of the relative frame in positive complex relations has significantly increased (from ≈ 12% to between ≈ 68% and 84%, $p < 0.0001$) in comparison to the simple spatial relations without Hans.

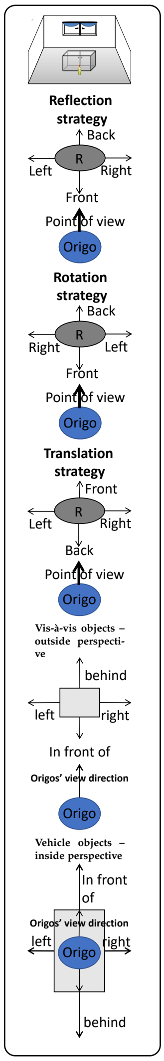
I also found some differences between the MAD.abs and AUC.abs values as well as between the X- and Y- flips. The highest MAD.abs value amounts to ≈ 0.33 and relates to the verb *twierdzić* "claim" and Hans to the right of the cupboard. In contrast, the lowest MAD.abs was computed for the verb *wierzyć* "think" with Hans to the right of the cupboard as well, with MAD.abs ≈ 0.15. All in all, the outcomes indicate that the maximal absolute deviation was lower for the constellations with Hans to the left than to the right. This applies to four verbs. The MAD.abs results indicate a significant difference between verbs, $p < 0.007$, and an almost significant difference for the results between the positions of Hans, with $p < 0.06$.

In the spatial relation with canonically positioned cupboard and the bottle to the left of the cupboard (with respect to the outside perspective), the Polish native speakers showed different interpretations influenced by verb semantics.

Again here, in the spatial relations described by verbs of positive semantics, most participants (between 37 and 42) chose the reflection / facing strategy from Hans' point of view. This is even more than with the bottle to the right of the cupboard and approx. 12% (between 30 and 36 / 7 participants) more than for the front or back side. This suggests that the localization with respect to the reference object plays an important role. The result points out also that the intrinsicality plays an important role. All in all, the results for the spatial relation with the bottle located to the left of the canonically positioned cupboard point out that the choice of the reflection / facing strategy in positive complex relations has significantly increased (from ≈ 10% to between ≈ 74% and 84%, $p < 0.0001$) in comparison to the simple spatial relations without Hans.

As for all spatial relations, some differences between the MAD.abs and AUC.abs values as well as the X- and Y- flips also apply for the complex relation with the bottle to the left of the cupboard. The highest MAD.abs value amounts to ≈ 0.33 and relates to the positive verb *twierdzić* "claim" and Hans to the left of the cupboard. The lowest MAD.abs was computed for the verb *myśleć* "think" with Hans to the right of the cupboard, with MAD.abs ≈ 0.18. All in all, the outcomes mean that the maximal absolute deviation was lower for the constellations with Hans to the right than to the left (and almost significant with $p = 0.06$). It is the opposite compared to the bottle to the right of the canonically positioned cupboard.

Cupboard with the back side to the participants



As for the German native speakers, it is noticeable that each of the spatial relations investigated caused difficulties for the Polish native speakers. This is indicated very clearly by the selected answers as well as by the trajectories leading to the responses. The mean trajectories appear between the responses – these do not lead exactly to only one response. It can be recognized that the Polish native speakers usually considered two opposite answers – one as interpretation with respect to the outside perspective of the intrinsic frame of reference and one with respect to the reflection / facing strategy of the relative frame of reference.

Considering the absolute values of the responses, *za* "behind" comes clearly on top with 26 ($\approx$ 52%) of selected answers with respect to the outside perspective. This is followed

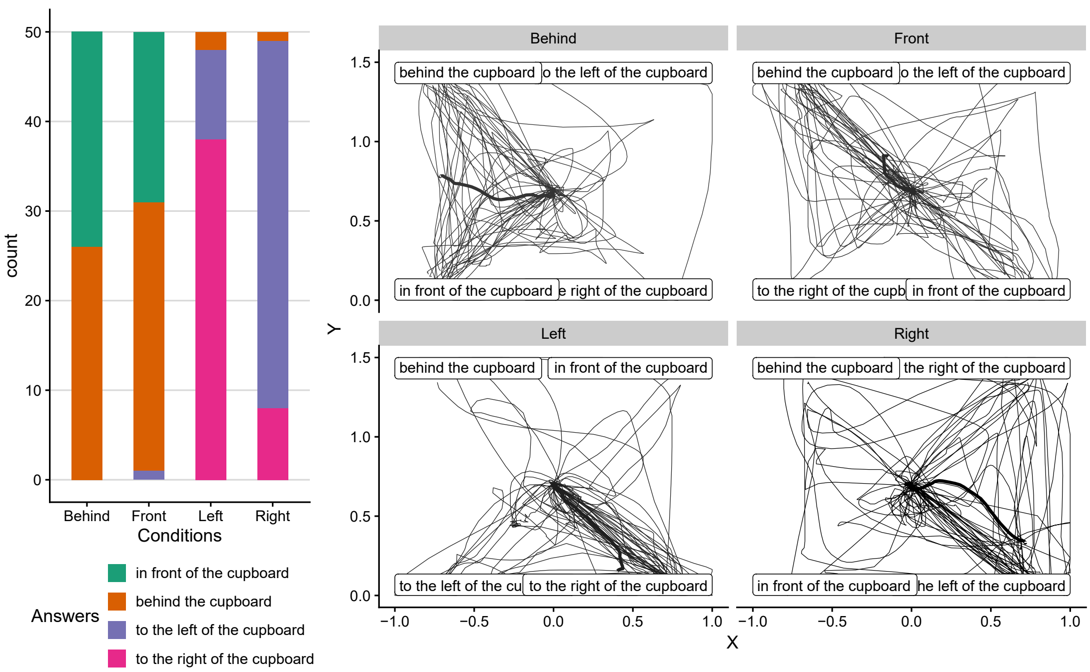


Figure 5.52: Answers for the simple intrinsic relation with cupboard: barplots with answers (left) and trajectories through the response with the mean trajectories (right)

by the assignment of *przed* "in front of" with 19 ($\approx$ 38%) of chosen answers for the outside perspective. *Na prawo* "to the right of" was interpreted by 8 (16%) participants regarding the outside perspective and *na lewo* "to the left of" by 10 (20%) persons. It follows that, maximally, around 16% of all participants considered the cupboard as a vis-à-vis object in these spatial relations. This means that only these participants decided for the interpretation along the intrinsic frame of reference in these spatial constellations. These results are significant with $p = 0.035$. This means that Polish native speakers interpreted the spatial relations between the localized and reference objects of the first horizontal axis significantly more frequently with respect to the outside perspective than the constellations of the second horizontal axis.

Pursuant to the answers, the statement also applies for Polish native speakers (as for German): clearly more participants considered the spatial relations regarding the reflection / facing strategy of the relative frame of reference than the intrinsic.

The differences can be also recognized in the MAD.abs and AUC.abs values as well as in the X- and Y- flips. The highest MAD.abs value amounts to ≈ 0.33 and relates to the negative spatial dimension expression of the first horizontal axis, *za* "behind." This is immediately followed by *na prawo* "to the right of," with MAD.abs of ≈ 0.32. The lowest MAD.abs was computed for both *przed* "in front of" with MAD.abs ≈ 0.27 and *na lewo* "to the left of" with MAD.abs ≈ 0.24. In contrast to the outcomes for the rectangular table, the results cannot be considered in terms of the axes. This means that it is impossible to determine which axis reached a lower or higher MAD.abs and thus a faster decision judgment ($p > 0.39$ between axes, and $p > 0.3$ for all spatial relations). The same applies for the AUC.abs.

In the situations described with verbs of positive semantics and the bottle in front of the cupboard, most participants (between 32 and 37) selected the reflection / facing strategy. This is 20% (between 42 and 49 participants) fewer than with respect to the rectangular table. It indicates that the intrinsicality of the reference object plays an important role in the interpretation of spatial relations. In general, the outcomes indicate that the choice of outside perspective in complex relations described by positive verbs has not significantly increased (from $\approx$ 38% to between $\approx$ 22% and 36%) in comparison to the simple spatial relations without Hans. However, the results reveal origo shift to Hans.

The differences are also visible in the average MAD.abs and AUC.abs values as well as in the X- and Y- flips. The highest mean MAD.abs value amounts to ≈ 0.35 and applies to the verb *sądzić* "reckon" with Hans to the left of the cupboard. The lowest MAD.abs was computed for the verb *mówić* "say" also with Hans to the left of the cupboard, with MAD.abs ≈ 0.17. In general, the outcome means that the maximal absolute deviation was divided the same with respect to the position of Hans in relation to the cupboard: the MAD.abs was four times higher for Hans to the left and four times for Hans to the right. Neither the MAD.abs between verbs indicated significant differences, with $p > 0.26$, nor the MAD.abs between the Hans positions, with $p > 0.45$.

The results for the Polish native speakers interpretation of spatial relations with the bottle *behind* the cupboard with the back indicated (for behind without the contribution of Hans to the picture) that verb semantics influences the choice of answer.

In the situations with verbs of positive semantics, most participants (between 32 and 36) selected the reflection / facing strategy from Hans' point of view. This is approx. 20% (between 42 and 49 participants) fewer than with respect to the rectangular table. This indicates that the intrinsicality of the reference object plays an important role when interpreting the spatial relations. In general, the outcomes point out that the choice of the reflection / facing strategy of the relative frame in positive complex relations has increased (from $\approx 48\%$ to between $\approx 62\%$ and 72%) in comparison to the simple spatial relations without Hans. These participants shifted the origo to Hans point of view and interpreted the spatial constellations from his point of view applying the reflection / facing strategy.

The differences can be also seen in the MAD.abs and AUC.abs values as well as in the X- and Y- flips. The highest MAD.abs value amounts to ≈ 0.38 and relates to the verbs *wierzyć* "believe" and *twierdzić* "claim" and Hans to the left of the cupboard. It is interesting that the lowest MAD.abs was also computed for the verb *wierzyć* "believe" but with Hans to the right of the cupboard, with MAD.abs ≈ 0.15 and *wiedzieć* "know" with Hans to the right of the cupboard, with MAD.abs ≈ 0.18. In general, the outcome means that maximal absolute deviation was significantly ($p < 0.0041$) lower for the constellations with Hans to the right than to the left. However, the results between the verbs did not reveal any significance ($p > 0.1$).

Furthermore, the results for the Polish native speakers for interpretation of spatial relations with the bottle *to the right of* the non-canonically positioned cupboard indicated that verb semantics influence the choice of answer.

In the situations with verbs of positive semantics, most participants (between 36 and 42) selected the reflection / facing strategy from Hans' point of view. This is approx. 10% (between 32 and 36/7 participants) more than with respect to the *front* or *back* side. It suggests that localization with respect to the reference object plays an important role. Furthermore, the outcomes demonstrate that intrinsicality is important too. For the rectangular and round tables with the bottle to the right of them, between 43 and 50 Polish native speakers selected the reflection / facing strategy from Hans' point of view – this means that Polish native speakers selected the reflection / facing strategy approx. 12% more frequently in the extrinsic constellations with the bottle to the right of the reference object than with the non-canonically positioned intrinsic cupboard.

All in all, the outcomes indicate that the choice of the reflection / facing strategy of the relative frame in positive complex relations has not increased (from $\approx 84\%$ to between

$\approx$ 72% and 84%) in comparison to the simple spatial relations without Hans. However, the strategy was chosen from Hans' point of view.

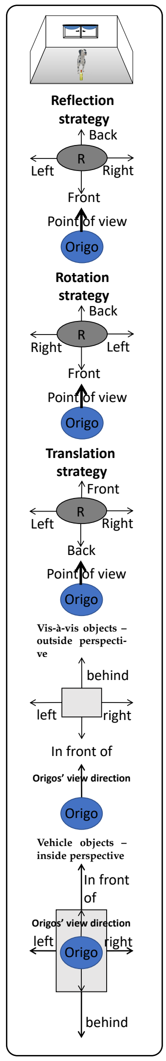
Some differences between the MAD.abs and AUC.abs values as well as the X- and Y-flips were revealed too. The highest MAD.abs value amounts to ≈ 0.32 and relates to the verb *wierzyć* "believe" and Hans to the right of the cupboard. The lowest MAD.abs was computed for the verb *twierdzić* "claim" but with Hans to the right of the cupboard, with MAD.abs ≈ 0.15. All in all, the outcome means that the maximal absolute deviation was significantly lower ($p < 0.017$) for the constellations with Hans to the left than to the right. This applies to six verbs. However, any significant differences were found between the verbs ($p > 0.23$).

As with all constellations up to now, the results for the Polish native speakers for interpretation of spatial relations with the bottle *to the left of* the cupboard with the back side indicated (to the left of the cupboard without the contribution of Hans to the picture) that verb semantics influences the choice of answer.

In the situations with verbs of positive semantics, most participants (between 36 and 42) selected the reflection / facing strategy – as with the constellation with the bottle to the right of the cupboard. The outcomes indicate that the choice of the reflection / facing strategy of the relative frame in positive complex relations has not changed much (from $\approx$ 80% to between $\approx$ 72% and 84%) in comparison to the simple spatial relations without Hans. However, the participants shifted the origo to Hans and applied this strategy from his point of view.

The highest MAD.abs value amounts to ≈ 0.34 and relates to the verbs *myśleć* "think" and *mówić* "say" and Hans to the left of the cupboard. The lowest MAD.abs was computed for the verb *mówić* "say" but with Hans to the right of the cupboard, with MAD.abs ≈ 0.13. In general, the outcome means that maximal absolute deviation was significantly ($p < 0.0001$) lower for the constellations with Hans to the right than to the left. However, the results between the verbs of positive semantics did not reveal any significance ($p > 0.9$). In contrast, the negative and positive verbs showed significant differnces with $p < 0.00001$. Polish native speakers followed more frequently the intrinsic frame of reference in the spatial relations described by verbs of positive semantics than of the negative one.

In summary, up to 96% of Polish native speakers investigated chose the reflection / facing strategy from Hans' point of view. This means that in these situations participants shifted the origo from the cupboard to Hans' viewing direction. The outcome also indicates that these participants applied the relative reference frame and not the intrinsic one as expected. Therefore the first alternative hypothesis should be accepted: The presence of an agent in a spatial relation causes an origo shift and a shift from the intrinsic to the relative reference frame.



5.7.4.2.2 Third null hypothesis

5.7.4.2.2.1 Analysis of spatial relations with animate vs. inanimate entities

In this subsection, the third null hypothesis is analyzed:

> *The animacy of reference objects does not affect the interpretation of spatial relations.*

To provide a detailed answer to the null hypothesis, it is important to analyze the simple spatial relations with the dog and compare those to the results with the cupboard. The analysis is conducted as follows:

Animate intrinsic spatial relations:

- Dog with the front to the participants
- Dog with the back to the participants

Inanimate intrinsic spatial relations:

- Cupboard with the front to the participants
- Cupboard with the back to the participants.

Dog with the front to the participants

From the answer barplots, it can be ascertained that the Polish native speakers did not have any problems with the interpretations of the canonical spatial constellation with the bottle *za* "behind" or *przed* "in front of" the dog, where the intrinsic and relative (reflection / facing strategy) interpretations coincide. In the case of the bottle *in front of* the dog, 100% of participants (same as German) decided for the intrinsic interpretation. Ninety-six percent selected the response along the intrinsic reference frame in canonical relations with the bottle *behind* the dog.

Pursuant to the MAD.abs and AUC.abs, it can be determined that the Polish native speakers did not have many problems in interpreting these situations. The MAD.abs for *przed* "in front of" amounted to ≈ 0.23, and for *za* "behind" to ≈ 0.30. The AUC.abs spread between ≈ 0.10 for *przed* "in front of" and ≈ 0.15 for *za* "behind".

In contrast to the interpretation of the spatial relations of the first horizontal axis (*front-back*), in the constellations with the bottle *na prawo od* "to the right of" and *na lewo od* "to the left of" the dog, attendees showed more variations with decisions – their mean line deviated from the ideal line much more (see 5.53). Participants clearly considered the opposites, right or left. This is evidenced by the MAD.abs value of ≈ 0.33

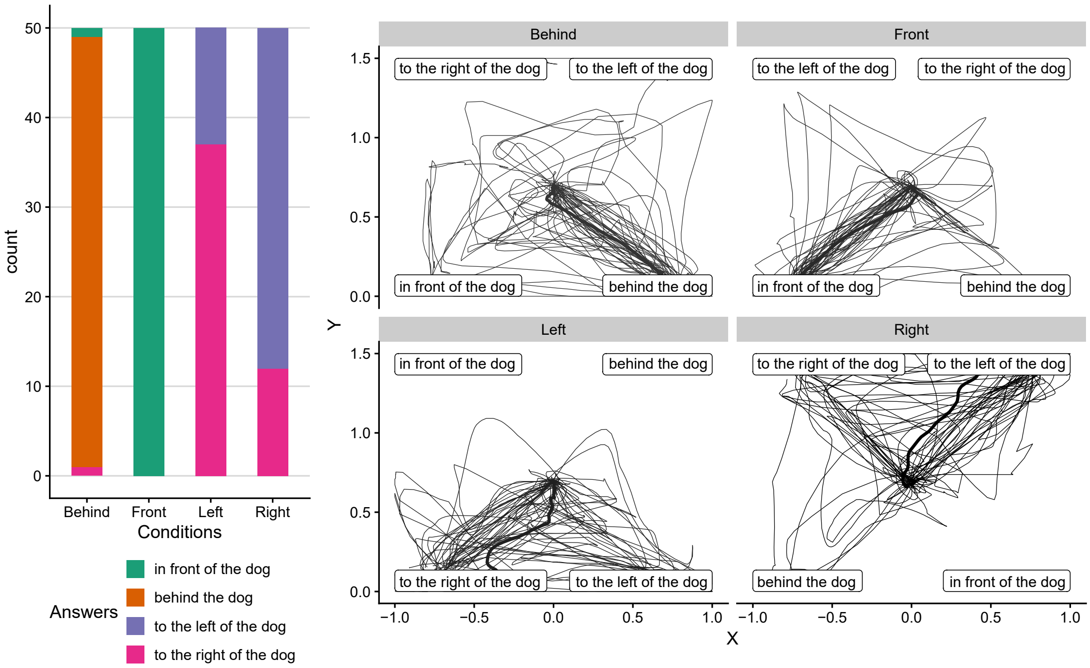


Figure 5.53: Answers for the simple intrinsic animate relation with the dog: bar plots with answers (left) and trajectories through the response with the mean trajectories (right)

for "to the right of" and ≈ 0.39 for "to the left of" and AUC.abs of ≈ 0.18 for "to the right of" and ≈ 0.16 for "to the left of". Regarding the MAD.abs value, the lmer and ANOVA computations show significant differences between all positions, with $p < 0.044$, and even stronger differences between the axes, with $p = 0.01$.

With regard to the responses, only 26% (to the left of) and 24% (to the right of) chose the answer along the intrinsic interpretation and 74/6% along the relative (facing / reflection strategy). Analyzing the data statistically, the results indicate significant differences within the individual spatial positions with respect to the canonically positioned dog ($p < 0.0001$) as well as between the axes ($p < 0.0001$).

The RT was highest for *na lewo* "to the left of" and lowest for *przed* "in front of" (see 5.54). As with the German data, this result confirms the assumptions of the spatial framework model (see Franklin and Tversky, 1990), which states that space is conceptualized in terms of three axes: the axis *above / below* is perceived fastest, *in front of / behind* is second and to the *right / left of* is the slowest. This means that the model is confirmed for the interpretation of localization with respect to the body, which is a very important indication.

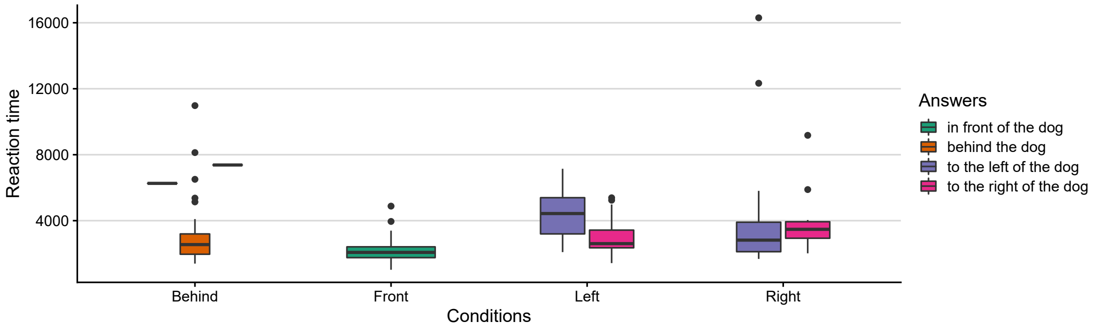
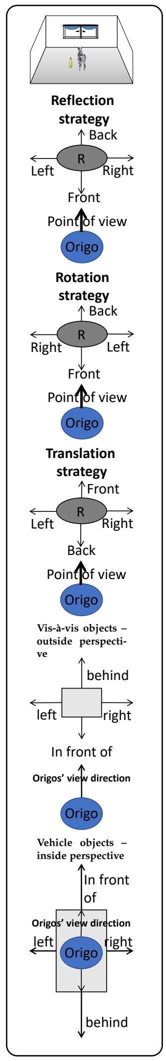


Figure 5.54: Reaction time for the spatial relations with dog looking at the participants



Dog with the back to the participants

The answer barplots visualize very clearly that Polish native speakers selected the more correct responses for constellations with the bottle *na prawo od* "to the right of" and *na lewo od* "to the left of" the dog, where the interpretations along the intrinsic and relative reference frames (in particular the reflection / facing strategy) coincide. The important answers in these situations are *przed* "in front of" and *za* "behind" the dog and those were interpreted along the intrinsic reference frame more frequently than along the reflection / facing strategy (of the relative reference frame). More specifically, 72% of the Polish native speakers selected the response regarding the intrinsic frame in constellation with the bottle *in front of* the dog, 64% with *behind*, 94% with *to the right of*, and 94% with *to the left of*.

On the mean trajectory of the trajectories plots, it can be clearly recognized that the participants had the fewest doubts interpreting the spatial relation with the bottle on the left side of the dog – it applies also to the German native speakers. In relations with the bottle positioned along the first horizontal axis to the dog, Polish native speakers tended to the opposite answer very often (see 5.55).

It can be seen that the participants changed their decision when the mouse was already above the opposite answer. The MAD.abs value for the spatial relations with the dog positioned with the back and the bottle *to the right of*, amounted to ≈ 0.44, in case of *to the left of* to ≈ 0.26, *in front of* to ≈ 0.33, and *behind* to ≈ 0.34. The lmer and ANOVA computations show significant differences for MAD.abs between all positions, with $p < 0.02$, but no differences between the axes ($p > 0.97$).

In addition, the lowest AUC.abs ≈ 0.16 fits for the bottle positioned on the intrinsic left side of the dog. It is followed by *in front of* ≈ 0.17, *right* ≈ 0.25, and *behind* with ≈ 0.34.

Considering the barplots for the spatial relations including the dog, in summary, it can be said that the dimensional spatial expressions of the first horizontal axis were significantly more frequently recognized as intrinsic than those of the second horizontal axis. In the relation with dog with its back to participants and the bottle *za* "behind," only 36% of Polish native speakers decided on the interpretation of the spatial relation with the dog and the bottle with respect to the reflection / facing strategy of the relative frame and not the side assignment of the inside perspective (as per Grabowski, 1999) of the intrinsic reference frame. In contrast, in the spatial relations of the second horizontal axis with the canonically positioned dog, 76% of the Polish native speakers selected the response along the reflection / facing strategy and not the inside perspective – in these situations, the intrinsic and relative interpretation did not coincide.

As stated above (5.7.4.1), animacy (cupboard with front / back vs. dog with front / back) showed overall statistical significance, with $p = 0.013$. For the individual positions, the results revealed very large significant differences. The largest differences between the dog and the cupboard as reference entities are visible for the interpretation with the bottle in front of the reference object (86 *correct* answers in total for the dog vs. 68 for the cupboard). However, the largest differences between the dog canonically /

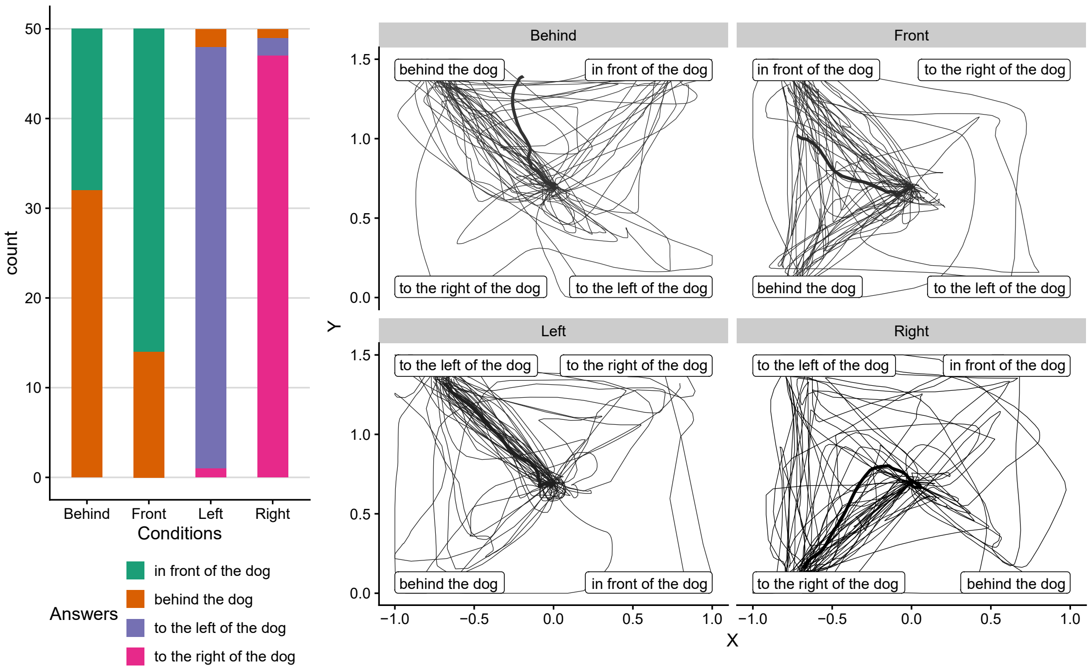


Figure 5.55: Answers for the simple intrinsic animate relation with the dog: bar plots with answers (left) and trajectories through the response with the mean trajectories (right)

non-canonically and the cupboard canonically / non-canonically individually as reference objects are visible for the interpretation with the bottle to the right and left of the canonically positioned entity. A Fisher's exact test revealed large significant differences between both objects and positions ($p < 0.001$). No significant differences were found in categorical judgments for the first horizontal axis for the individual categorical reference objects' positions (canonical and non-canonical). With these results, the third null hypothesis can be rejected: The animacy of relata does not affect the interpretation of spatial relations, and an alternative hypothesis confirmed: The animacy of relata affects the interpretation of spatial relations.

The MAD.abs between the reference objects did not show any significant difference for any spatial localizations ($p > 0.7$) nor for the axes ($p > 0.39$).

5.7.4.3 Summary and discussion

The aim of the mouse tracking study was to find out how Polish native speakers interpret dimensional spatial expressions: *przed* "in front of", *za* "behind", *na prawo od* "to the right of", *na lewo od* "to the left of" in different spatial relations. These spatial relations split into *simple* and *complex*. The *simple* spatial relations contained a localized and reference object, whereas the *complex* ones were supplemented by an artificial agent (Hans). All the spatial relations were either requested by static verbs ("Where is the bottle standing?" – in case of simple spatial relations) or described by static verbs ("Hans says that the bottle is standing. . . " – in case of complex spatial relations). Additionally, the complex spatial relations were introduced by indirect speech to assign the act to Hans. All the spatial relations – simple and complex – were illustrated in a room with window to make the spatial relation more natural. The spatial constellations differed between each other pursuant to the reference object: animate vs. inanimate and their position: canonical vs. non-canonical. In total, the reference object was represented by: cupboard (as representative of the vis-à-vis objects), table (as representative of extrinsic objects regarding front-back, right-left), and dog (as representative of animate entities). A bottle served as a localized object for all spatial constellations.

Using tables as reference objects, I investigated which strategy of the relative reference frame, Polish native speakers apply (reflection / facing, align / translation, rotation) in spatial relations with extrinsic objects. Results of the current study indicate that Polish native speakers prefer the reflection strategy to interpret spatial relations described and requested by static verbs. This outcome extends the results of Perużyńska (2012a), which pointed out that Polish native speakers use the reflection strategy to interpret spatial relations described by dynamical verbs. Moreover, the results also showed that Polish native speakers shifted the origo from themselves to the artificial agent in complex spatial relations with tables (introduced by indirect speech). Considering Hans' point of view as origo, Polish native speakers applied the reflection / facing strategy to interpret the particular spatial relations (between 84% and 100% of participants). These results revealed that the presence of the third person as artificial agent in a spatial relation expressed by indirect speech affects an origo shift (rejection of the first null hypothesis).

In addition to the spatial relations including extrinsic object as reference, I investigated spatial relations with intrinsic object as reference. First of all, I asked the Polish native speakers to fill in a questionnaire assigning sides to a cupboard – visible from front and back. The cupboard was located in the same room as the one in mouse tracking experiment. However, the spatial relations illustrated in the questionnaire haven't included any localized object. The aim of the questionnaire study was to find out how do Polish native speakers identify sides of a cupboard – along the inside or outside perspective (see 2). Results of the questionnaire revealed variation between side assignment to the cupboard visible from front and back. Almost all Polish native speakers identified the sides of the cupboard visible from front regarding the outside perspective (front: 98%, back: 100%, right and left: 82%). Polish native speakers deviated from the outside perspective, which applies for vis-à-vis objects, in spatial relations with cupboard visible from back (front and back: 88%, right and left: 48% along the outside perspective). Also the spatial relation in the mouse tracking study including cupboard as reference object showed variation. In the simple spatial relations including cupboard as reference object visible from front and bottle as localized object, almost all Polish native speakers applied the outside strategy while interpreting these (front and back: 100%, right: 88% and left: 90%). However, up to 84% of Polish native speakers deviated from this strategy interpreting spatial relations with cupboard visible from back (answers along outside strategy: front = 38%, back = 52%, right = 16%, left = 20%). These outcomes indicate the differences between the side identification of a cupboard by Polish native speakers and interpretation of spatial relations with cupboard as reference. In the last step, I supplemented the simple spatial relations with the cupboard by an artificial agent (Hans). Outcomes of these spatial relations interpretations reveal that Polish native speakers shifted the origo to Hans' point of view and applied the facing / reflection strategy most frequently (relations introduced by verbs of positive semantics). This result rejects the assumption of the first null hypothesis and thus supports the alternative one: The presence of the third person as artificial agent in a spatial relation expressed by indirect speech affects an origo shift as well as a shift of reference frame.

The categorical answers showed also that significantly more Polish native speakers interpreted the spatial relation with the animate than the inanimate reference object according to the intrinsic reference frame (confirming the assumptions of the third alternative hypothesis). In contrast, the continuous measures (AUC.abs and MAD.abs) haven't revealed any significant differences.

Finally, the categorical answers revealed significant differences between the spatial relations introduced by positive and negative verbs. More Polish native speakers shifted the origo to Hans in positive spatial relations than in negative and interpreted these from his point of view (second null hypothesis).

5.8 Italian

5.8.1 Location of the experiment in Italy

The experiment for Italian was conducted at the Center for Mind / Brain Science (CIMeC) of the University of Trento thanks to Prof. Dr. Roberto Bottini in October 2018. Prof. Dr. Roberto Bottini, the PI of the Bottini lab, supported and advised me during my stay at the center with respect to the following topics:

- Ethical application
- Advertisement for participants
- Participants recruiting.

His colleagues also provided support and participated in the experiment – especially Federica Sigismondi. The experimental situation was very similar to all previous ones.

5.8.2 Participants: Italian native speakers

All in all, I tested 49 Italian native speakers (43 female, 6 male). One female participant was excluded from the mouse tracking experiment.

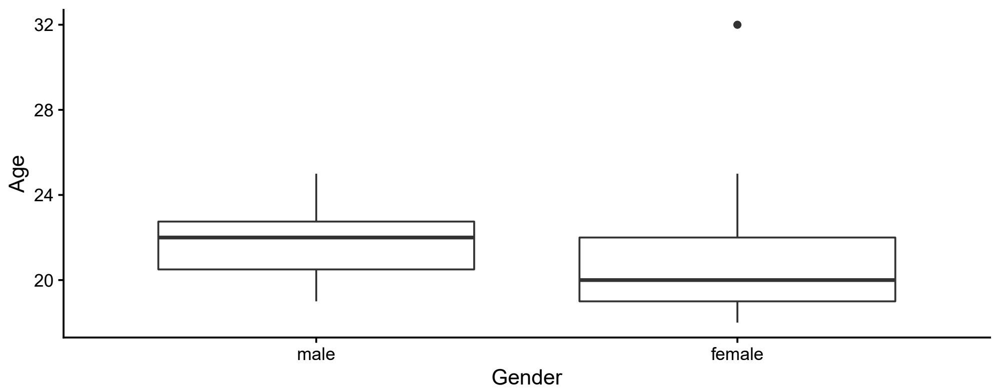


Figure 5.56: The charts depict the gender and the age distribution of the Italian native speakers

As with the participants in Germany and Poland, the Italian native speakers received €10 as compensation for their participation. In addition to the mouse tracking experiment, they were also asked to complete a questionnaire based on the Edinburgh Handedness Inventory (see Oldfield, 1971). According to the questionnaire, 53% of participants were right-handed (dominant hand), 2% left-handed, and 45% were mixed (this means that they prefer performing some tasks with the right hand and others with the left or they can perform some tasks using both hands – depending on the situation or their mood). All participants used the mouse with the right hand – also the left-handed participants – giving the same reasons as the native speakers of the previously analyzed languages.

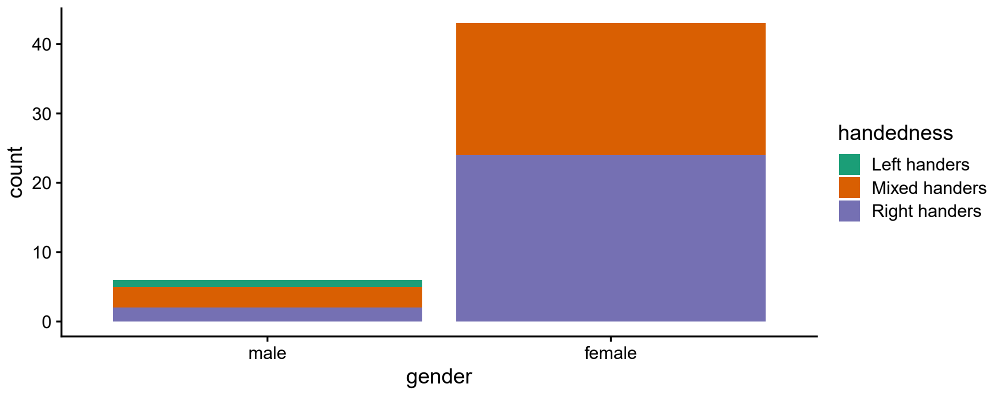


Figure 5.57: The distribution of gender and handedness of the participants

A small percentage of the native speakers tested for Italian were born (6%) and/or raised (2%) outside of Italy. However, all participants stated that Italian is their dominant language.

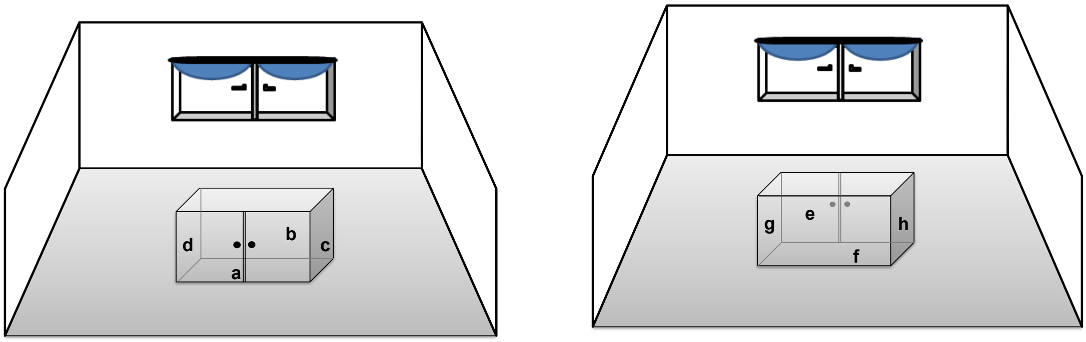
5.8.3 Results for questionnaire study: identifying sides by Italian native speakers[8]

In the last part of the participant's questionnaire, all Italian native speakers (n = 49) were asked to assign sides to a cupboard (see 5.58). The pictures matched the situations used in the mouse tracking experiment. Again here, for the first question, the cupboard was placed canonically (with the front facing participants) and for the second, non-canonically (with the back facing participants) – as 5.58.

Canonically positioned cupboard

a. Front side
b. Back side
c. Right side
d. Left side

[8]This part of the dissertation was already submitted by Stoltmann, Fuchs, and Krifka (2020).



(a) canonical (b) non-canonical

Figure 5.58: The images from the survey show pictures of the cupboards viewed canonically (with the front facing participants, on the left) and non-canonically (with the back facing participants, on the right)

Non-canonically positioned cupboard

e. Front side
f. Back side
g. Right side
h. Left side.

Results of the survey show that all Italian native speakers assigned the *front* and *back* of the cupboard as expected when an outside perspective of the intrinsic reference frame is assumed – in the case of the canonically positioned cupboard, (a) was described as the *front* and (b) the *back*. However, about 33% of the participants identified the *right* and *left* side of the object according to the inside perspective of the intrinsic reference frame, describing (c) as the *left* side and (d) as the *right*. This means that these participants conducted a mental rotation of 180° while assigning the sides. The other participants identified the sides using the outside perspective of the intrinsic reference frame – as expected. In this, Italian speakers differed from English, German and Polish speakers: 24% more Italian participants deviated from the outside perspective assigning the right and left sides than the English, 23% than the German and 15% more than the Polish.

For the non-canonically positioned cupboard, around 88% of participants identified the front and back as assumed for the intrinsic frame of references, that is, (e) as *front* and (f) as *back* (in comparison: 82% English, 97% German and 88% Polish speakers). The rest assigned the sides referring to the facing / reflection strategy of the relative reference frame. In this spatial constellation, around 69% of Italian participants determined the right and left sides of the cupboard according to the inside perspective of the intrinsic frame of references, that is, (g) as *left* and (h) as *right*, which coincides with the facing /

reflection strategy. However, 31% assigned the *right* and *left* sides using the outside perspective of the intrinsic frame of references – (g) as the *right* side and (h) as the *left*. There was only one participant who, for the non-canonically positioned cupboard, identified the front as the back, and then used the outside perspective of the intrinsic frame of references to identify the right and left sides.

Looking at both spatial constellations together (canonical and non-canonical), only 26.5% of the Italian participants assigned all sides to the cupboard taking the outside perspective of the intrinsic reference frame. This is around 15% less than English participants, 18% less than Polish participants, and 36% less than German participants. Additionally, the results reveal that more Italian native speakers, $\approx$ 31%, assigned the sides to the cupboard (in canonical and non-canonical positions) by consistently referring to the inside perspective of the intrinsic frame of references.

The table 5.59 shows in detail the responses of the participants to the canonically and non-canonically positioned cupboard in the questionnaire (*Vorderseite*: 'front side', *Rückseite*: 'back side', *Rechte Seite*: 'right side', *Linke Seite* 'left side').

Similar to the previous analyzed data (on German, and Polish), a very important question which arises at this point is: Do the answers here match the answers of the simple spatial relations established in the mouse tracking task? This task clarifies how Italian native speakers recognize and perceive the cupboard (spatially) in the simple spatial situation, as well as how participants perceive the relations between the objects in spatial relations with the cupboard. As with the analyses of the three other languages, the following subsections include a step-by-step analysis of the cupboard as a reference object:

- Clarification questionnaire – assignment of only the sides to the cupboard as representative of vis-à-vis objects (above)
- Questionnaire – dynamic spatial relations with the cupboard as a reference object (below – in the 5.8.4.3)
- Mouse tracking – simple static situations with the cupboard as a reference object (below, 5.8.4.2.1.2)
- Mouse tracking – complex static situations with the cupboard as a reference object (below, 5.8.4.2.1.2).

5.8.4 Results for mouse tracking study: interpretation of spatial relations by Italian native speakers

As with the previously analyzed languages, I first report the results for the categorical answers with respect to the experimental design. In 5.8.4.2, I analyze each particular

q11_a	q11_b	q11_c	q11_d	q12_e	q12_f	q12_g	q12_h
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
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Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
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Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite

Figure 5.59: Questionnaire: Assignment of sides to the canonically (a-d) and non-canonically (e-h) positioned cupboard

spatial relation separately (see 5.8.4.2.1.1, 5.8.4.2.1.2, 5.8.4.2.1.2). In the detailed analysis, I assess whether our results confirm the hypotheses.

In the analysis of the Italian data, several Fisher's exact tests were conducted for the categorical responses and linear mixed models, as well as ANOVAs for the differences and similarities between the continuous measures of the trajectories. All statistical tests and visualizations – bar and trajectory plots – were computed using the statistical software R (R Development Core Team, 2017).

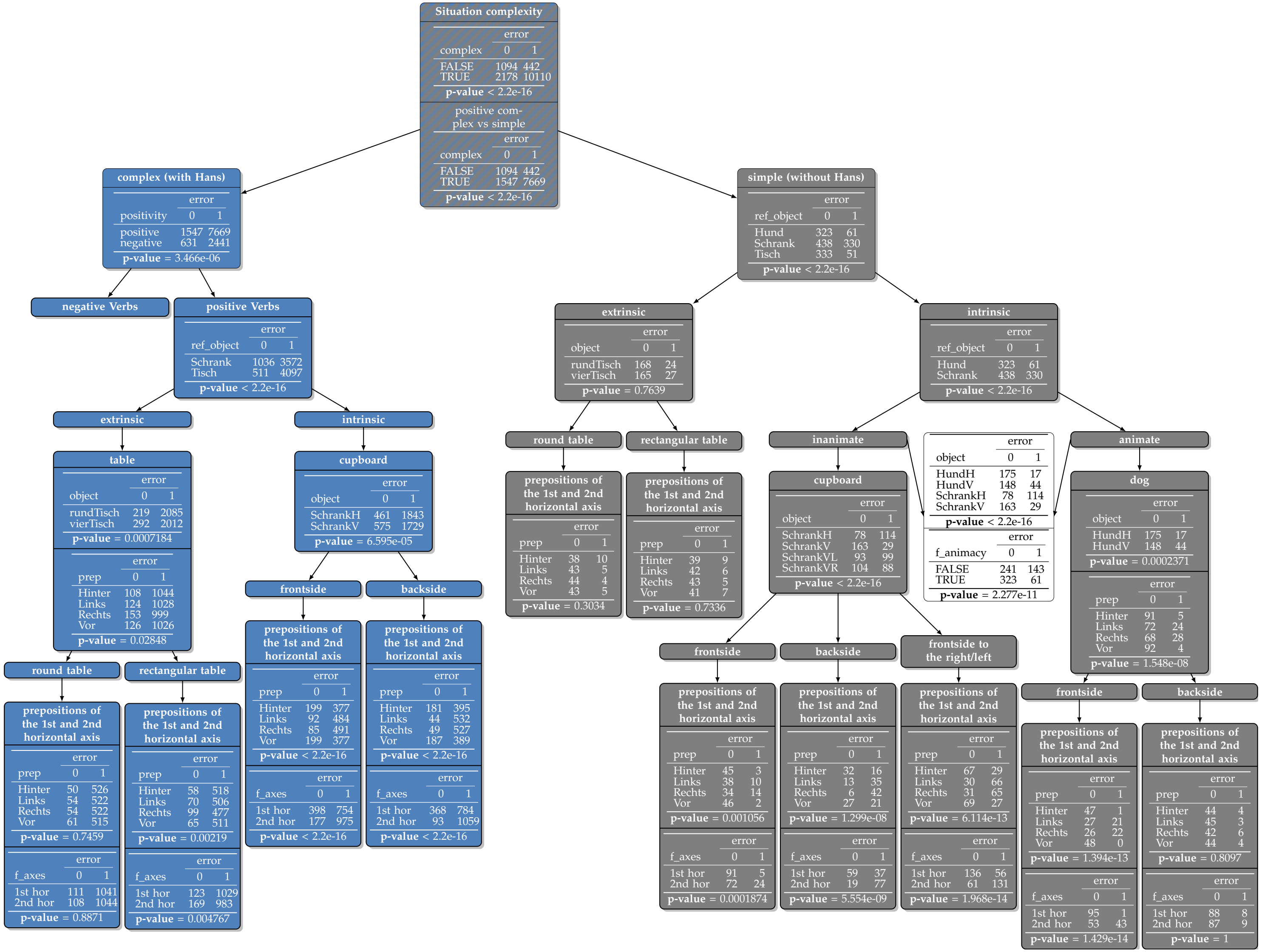


Figure 5.60: Computation of statistical analyses for categorical answers in Italian with respect to the experimental design

5.8.4.1 Computation of statistical analyses for categorical answers in Italian with respect to the experimental design

As with the other languages, I created a chart with the statistical analysis between the particular categories. 5.60 shows both the setup of the entire experiment and the calculation of statistical analysis for the categorical answer choices made by Italian native speakers each situation. This part of the work highlights which factors resulted in categorical significance and which did not. As with the other languages, the analysis for Italian is conducted top-down following the graph's structure. Furthermore, the method of computation is the same: first, I compare the *correctness* with respect to a particular reference frame, using for the interpretation of the particular spatial relations. For the extrinsic spatial relations, this means independent of the relations' complexity (with the round and rectangular tables, I defined the reflection / facing strategy from participants' point of view as *correct*). That means that the assumption applies to all spatial constellations with tables, both with and without Hans. However, for the complex intrinsic spatial relations, I assumed the outside perspective of the intrinsic frame of reference independent of the position of the reference object and Hans. The same assumptions apply for the simple relations with a cupboard. For the spatial relations involving the dog, I assumed the intrinsic perspective of the intrinsic frame of reference, which also applies for humans.

Furthermore, the chart supports the analysis of null hypotheses *one*, *two*, and *three* (see above 5.3). The statistical tests were run to confirm / reject the hypotheses individually. Null hypothesis 4 was defined for analysis between all languages. Therefore, it cannot be analyzed on the basis of the results in the chart only.

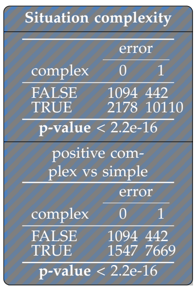


Figure 5.61: Computation of statistical analyses for categorical answers in Italian with respect to the complexity of spatial relation

First, I explored the categorical answers for all simple and complex spatial relations for investigating the influence of complexity in general. For Italian native speakers, I have found that the complexity of a situation strongly influences how they interpret it ($p < 0.001$). Furthermore, this result is similar for both positive complex situations and simple situations ($p < 0.001$). As with the similar results for German, English and Polish, the Italian results also allow to reject the first null hypothesis, *The presence of the third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift.*

complex (with Hans)

	error	
positivity	0	1
positive	1547	7669
negative	631	2441
p-value = 3.466e-06		

Figure 5.62: Computation of statistical analyses for categorical answers in Italian with respect to verb semantic

As with the German and Polish participants, there is a significant difference between the complex spatial relations embedded by positive and negative predicates for Italian participants. This result is caused by the perspective shift from the point of view of the participants to the point of view of Hans (compare this with the detailed analysis of particular situations below – 5.8.4.2). Italian native speakers shifted the origo to Hans less frequently interpreting the spatial relations described by verbs of negative semantics. Therefore, the second null hypothesis can be rejected ($p < 0.0001$): The interpretation of dimensional spatial expression does not depend on the semantics of embedding predicates.

positive Verbs

	error	
ref_object	0	1
Schrank	1036	3572
Tisch	511	4097
p-value < 2.2e-16		

Figure 5.63: Computation of statistical analyses for categorical answers in Italian with cupboard in complex spatial relations

Moreover, I also found very strong significant differences within the groups (situations introduced by verbs of positive vs. negative semantics). First, I computed the statistical analysis for all complex positive situations – independently of the reference object: cupboard or table and the position of Hans with respect to the reference object – relative to the right or left of the particular object. The results reveal a *p-value* of *< 0.0001.*

In a second step, I undertook a more detailed analysis. I found that the Italian native speakers interpreted the intrinsic spatial relations with the cupboard *correctly*[9] more frequently – that is, along the outside perspective rather than with the relations with the tables – in line with the expected reflection / facing strategy from participants' point of

[9]See above the definition for *correctly*. It refers to the expected strategy for particular situations but it does not judge the decisions of participants.

view ($p < 0.0001$). This shows that the Italian native speakers shifted the origo from themselves to Hans' point of view and interpreted the complex spatial relations from his point of view significantly more frequently in situations with an extrinsic reference object than in situations with an intrinsic reference object. Furthermore, this implies that the properties of the object play an important role for the Italian participants because they shift the perspective to Hans' point of view more frequently with extrinsic objects than with intrinsic ones. However, intrinsicality is not a strong enough property for the participants to concentrate only on intrinsicality while interpreting the spatial relations.

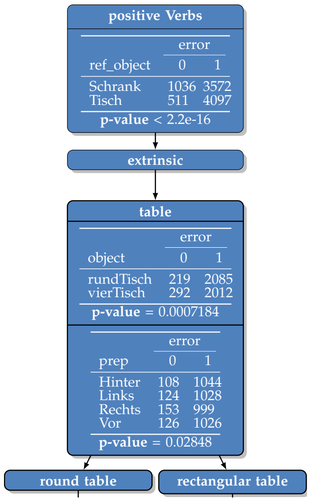


Figure 5.64: Computation of statistical analyses for categorical answers in Italian with tables in complex spatial relations

Analyzing the answers for the positive spatial relations in greater depth, we can see that there is significant difference ($p < 0.0008$) between the complex spatial relations with the round table and with the rectangular table. This means that the shape of the tables significantly influenced the interpretative strategy of the Italian native speakers investigated. Italian native speakers shifted the origo to Hans less frequently in spatial relations with the rectangular table than with the round table. As for the previous languages, I conducted a further analysis to understand the semantic differences and similarities between the particular spatial expressions. The results reveal that participants selected different interpretative strategies depending on the prepositions ($p < 0.03$). When the bottle was located to the right of the table, speakers examined interpreted the complex extrinsic spatial relations most frequently using the reflection / facing strategy from their point of view. In contrast, when the bottle was located behind the table (from the participant's point of view), participants selected the reflection / facing strategy less frequently.

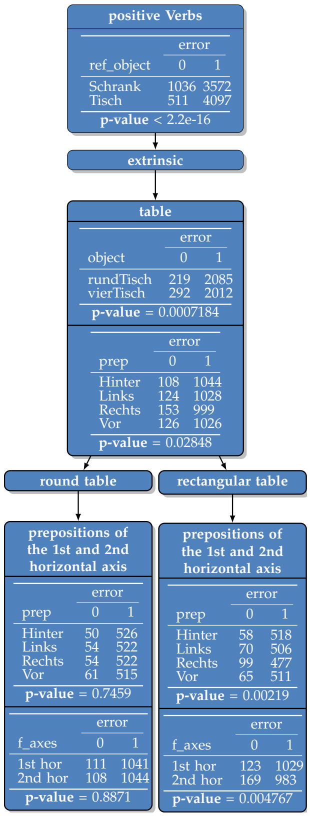


Figure 5.65: Computation of statistical analyses for categorical answers in Italian with round and rectangular table in complex spatial relations

In the last step, I examined whether the shape of the table influences the interpretation of the particular extrinsic complex constellations. The separate analysis of the situations with either the round or rectangular table revealed highly significant difference ($p < 0.003$ for the rectangular table). In the constellations with both tables (considering the situations individually), very few participants interpreted the spatial relations with the bottle behind the round table using the reflection / facing strategy from their point of view. The Italian participants most frequently selected the reflection / facing strategy from the participants' point of view with the bottle in front of the round table and to the right of the rectangular table.

As with the German and Polish participants, I also found several significant differences for the complex intrinsic spatial relations for the Italian native speakers. The first very general results revealed a highly significant difference ($p < 0.0001$) between interpretations of the canonically versus the non-canonically positioned cupboard. These indicate that

Italian speakers use the outside perspective of the intrinsic frame of reference more frequently with the canonically positioned cupboard than with the non-canonically positioned cupboard. However, it is important to stress that in the canonical relations too, considerably more Italian native speakers shifted the origo to Hans and interpreted even the canonical spatial relations from Hans' point of view by employing a reflection / facing strategy.

Considering the complex intrinsic spatial relations individually, the results indicate that choice of preposition influences the choice of the reference object very strongly, with $p < 0.0001$ for both the canonically and non-canonically positioned cupboard. Italian native speakers most frequently interpreted the spatial constellations with the bottle behind and in front of the canonically as well as non-canonically positioned cupboard in relation to the outside perspective – similarly to the German and Polish native speakers. In contrast, they interpreted the spatial relations with the bottle to the right and left of the cupboard significantly fewer times using the outside perspective. In these situations, more participants shifted the origo to Hans' point of view and interpreted the relations from his point of view using the reflection / facing strategy. This suggests that these Italian native speakers ignored the intrinsic properties of the cupboard in their interpretations and considered the cupboard as an extrinsic object.

simple (without Hans)

	error	
ref_object	0	1
Hund	323	61
Schrank	438	330
Tisch	333	51
p-value < 2.2e-16		

Figure 5.66: Computation of statistical analyses for categorical answers in Italian (simple spatial relations)

The results of the simple spatial relations (without Hans) indicate very highly significant differences with respect to the above-defined *correctness* ($p < 0.0001$) in general. Considering the general result in more detail, we observe that the Italian native speakers interpreted the spatial relations using the expected strategy less frequently – the outside perspective with the cupboard (similarly to the German and Polish native speakers). This result is followed by the dog and this by the table. These results indicate that the specific properties of the objects influence how native speakers of these languages interpret spatial relations. In other words, interpretations are more consistent when spatial relations are interpreted using extrinsic reference objects, which cannot be positioned canonically or non-canonically.

For the simple extrinsic spatial relations, the results show no significant differences between the interpretation for a round versus a rectangular table ($p > 0.7$). This means that the shape of the reference object does not influence the interpretation of simple

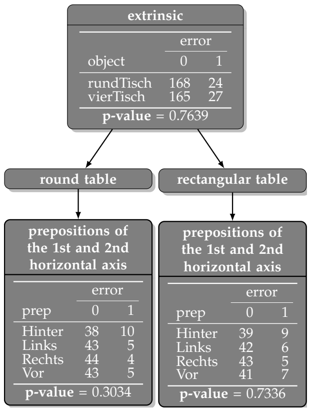


Figure 5.67: Computation of statistical analyses for categorical answers in Italian (simple extrinsic spatial relations)

spatial relations concerning the table for the Italian native speakers (similar to the German and Polish participants). For simple extrinsic spatial relations, I also did not find any significant difference between the individual constellations ($p \approx 0.30$ for the round table and $p \approx 0.73$ for the rectangular table).

In contrast to the extrinsic spatial relations, the simple intrinsic relations revealed very highly significant differences ($p < 0.0001$) for Italian native speakers – as was also found for the Polish and German data. This is caused, in general, by a significantly higher frequency of interpretations using the intrinsic frame of reference in spatial relations with the dog than with the cupboard. However, considering the data further, we can find explanations for the more general result.

For spatial relations with an inanimate intrinsic reference object, the cupboard (positioned in different ways), the results also indicate a highly significant difference ($p < 0.0001$). For the canonically positioned cupboard, participants followed the outside perspective of the intrinsic reference frame most frequently, as expected for relations with the cupboard as reference object. This result points out that the Italian native speakers identify sides of the cupboard in a different way than when they interpret the spatial relations with the cupboard as reference object (see 5.8.3). Furthermore, in all situations with the non-canonically positioned cupboard, the majority deviated from this interpretation. It is interesting that most deviations occurred when the back of the cupboard was facing participants; here only 78 of 202 answers reflected the outside perspective. This is even less than when the cupboard was positioned with the front to the right ($n = 104$) or to the left ($n = 93$). For the canonically (front-facing) vs. non-canonically (back-facing) positioned cupboard, I obtained a highly significant difference for the results of Italian participants, too ($p < 0.0001$).

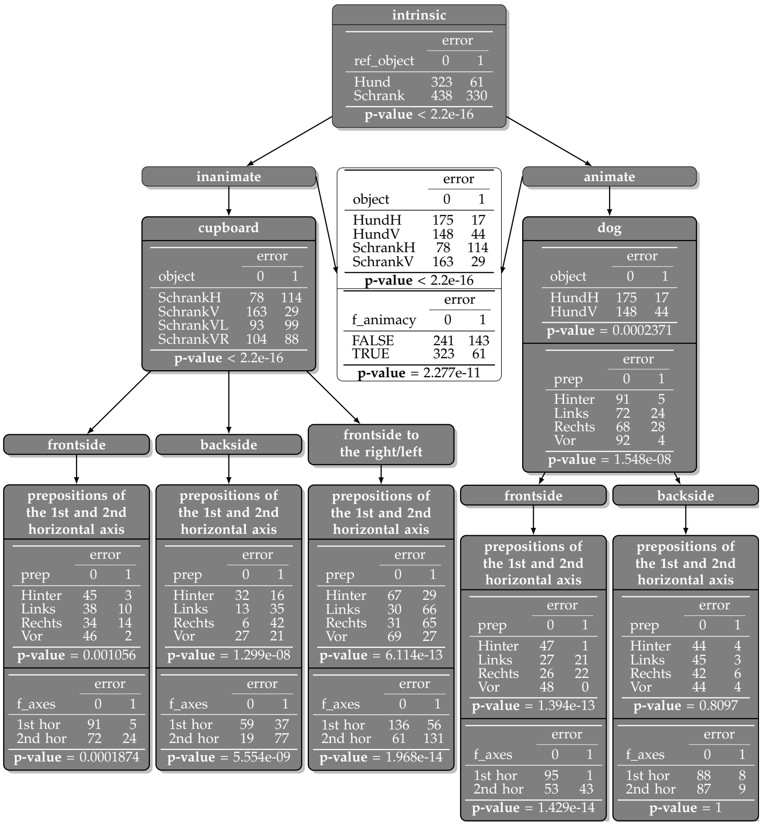


Figure 5.68: Computation of statistical analyses for categorical answers in Italian (animacy in simple spatial relations)

To conduct the analysis in greater detail, I also examined the answers for the individual positions for the canonically and non-canonically positioned cupboard. The results showed (see also Stoltmann, Fuchs, and Krifka, 2020):

a) Significant differences for the canonically positioned cupboard ($p > 0.001$) – there was no spatial relation which was interpreted by all Italian participants in the same way. However, almost all Italian participants interpreted the spatial relation with the bottle in front of and behind the cupboard according to the outside perspective. Similarly to the Polish native speakers, the Italian participants deviated from this strategy most frequently when the bottle was located to the right (right: 14; left: 10). This result caused the significant difference.

b) There was a highly significant difference ($p < 0.0001$) for the non-canonically positioned cupboard (with the back to the participants). Here, the Italian native speakers most frequently selected the answer according to the outside perspective with the bottle behind the cupboard. In addition, in this spatial relation, the Italian native speakers deviated from the outside perspective with the bottle to the right of the cupboard most frequently (42; left: 35).

c) The Italian participants revealed a significant difference ($p < 0.001$) for the non-canonically positioned cupboard (with the front to the right / left from participants' point of view). Around 70% of the Italian participants selected the outside perspective with the bottle behind and in front of the cupboard. In contrast, only around 32% chose the strategy with the bottle to the right or to the left of the cupboard. That means that approx. 68% selected the inside perspective of the intrinsic frame of reference.

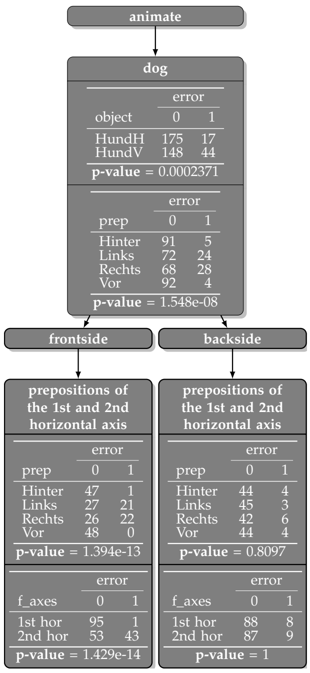


Figure 5.69: Computation of statistical analyses for categorical answers in Italian (animate spatial relations)

Animacy (cupboard with front / back vs. dog with front / back) proved to be statistically significant ($p < 0.0001$) for Italian native speakers. For the individual positions, the results revealed very large significant differences, too. The largest differences between the dog and the cupboard as reference objects can be seen for the interpretation with the bottle to the right of the reference object (68 *correct* answers for the dog vs. 40

for the cupboard). The largest differences between the dog positioned canonically/non-canonically and the cupboard positioned canonically/non-canonically individually as reference objects are found for the interpretation with the bottle to the right and left of the canonically positioned objects. A Fisher's exact test revealed large significant differences between both objects and positions ($p < 0.001$). No significant differences were found in categorical judgments for the first horizontal axis (in front of vs. behind). For the non-canonically positioned reference objects, a Fisher's exact test revealed significant differences for animacy and both positions (to the right vs. to the left), with $p < 0.0001$. This also applies to the first horizontal dimension (in front of vs. behind) and both reference objects. This result is similar to the one found for the German and Polish data. With the statistical analysis, the third null hypothesis can be rejected for the Italian participants too: The animacy of relata does not affect the interpretation of spatial relations.

Considering animate spatial relations, the results indicate significant differences for the interpretation of spatial relations with a canonically and non-canonically positioned dog ($p < 0.001$). Similar to German and Polish native speakers, Italian participants also interpreted the spatial relation more frequently according to the intrinsic reference frame with the non-canonically than the canonically positioned dog (in contrast to the cupboard). Analyzing the data in further detail, the results indicate significant differences within the individual spatial positions in situations with the canonically positioned dog ($p < 0.0001$). The differences are due to the more frequent intrinsic interpretation of "in front of" and "behind". In contrast to the German and Polish data, the results for Italian participants do not reveal any significant differences between the individual positions of the bottle for the situations with the non-canonically positioned dog ($p > 0.8$). In contrast to the Polish or German participants investigated, almost all Italian participants selected the answers according to the intrinsic reference frame in all spatial relations with the bottle and the non-canonically positioned dog.

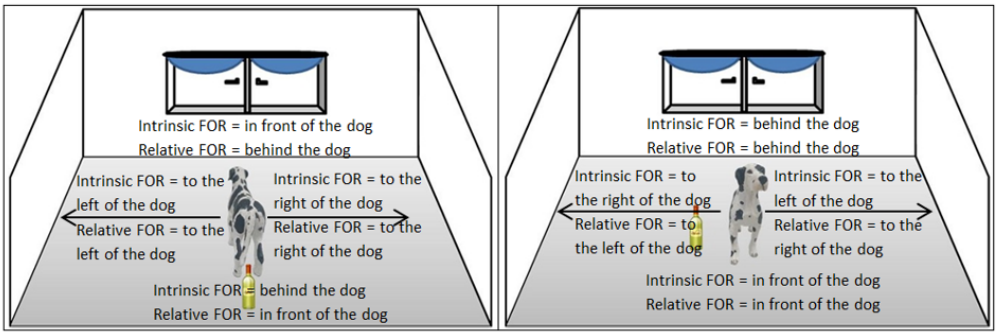


Figure 5.70: Side assignment with the dog according to the frames of reference

5.8.4.2 Detailed data analysis

5.8.4.2.1 First null hypothesis

5.8.4.2.1.1 Analysis of simple and complex extrinsic spatial relations

Round table

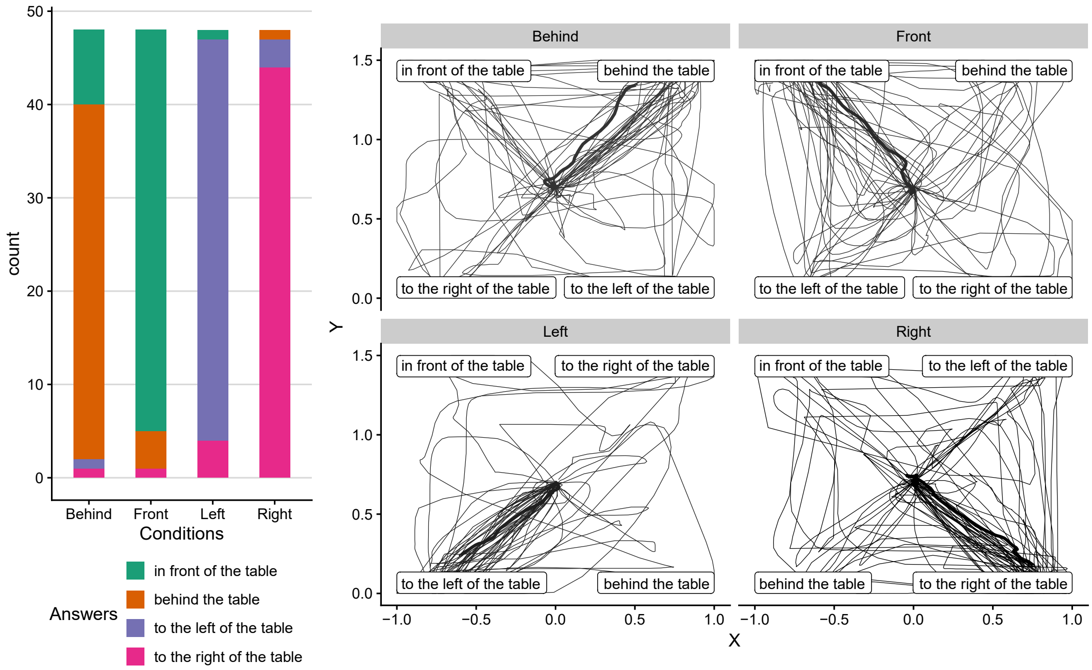
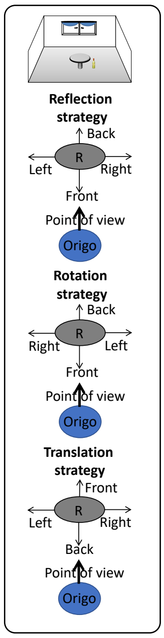


Figure 5.71: Answers for the simple extrinsic relation with round table: bar graphs with answers (left) and trajectories through the response with the mean trajectories (right)

The results of the bar plots and trajectories show variations between the answers. Specifically, the participants had fewer problems with the interpretation of spatial relations when the bottle stood *to the left of* or *to the right of* rather than *in front of* or *behind* the round table (see mouse trajectories). The normalized trajectories seen in the plots are very accurate in the case of *to the left of*. The categorical responses also show that the Italian participants were less consistent when the bottle was located relative to the first horizontal axis with reference to the table (see bar plots). When the bottle was placed *behind* the table, 10 participants (≈ 20%) decided against the reflection / facing strategy (compare with Polish and German: 10% each) and five deviated from the strategy in relation with the bottle *in front of* the round table. Furthermore, in spatial relation with the bottle *to the left of* the table, five participants deviated from the expected reflection / facing strategy. However, in situation with the bottle *to the right of* the reference object, only four participants did not choose the reflection / facing strategy; rather they chose the rotation strategy.



For Italian native speakers, the differences can also be seen in the MAD.abs and AUC.abs values and the X- and Y- flips. The highest MAD.abs value amounts to ≈ 0.42 and relates to "to the right of" and "in front of". "In front of" is immediately followed by "behind" with MAD.abs of ≈ 0.39. The lowest MAD.abs was computed for the spatial expression "to the left of" with MAD.abs ≈ 0.24. In contrast to the Polish data, the results for the Italian participants demonstrate no significant result ($p > 0.12$) for the maximal absolute deviation between the dimensional spatial expressions of the first and second horizontal axis. The MAD.abs result between all positions individually did not show any significance either ($p > 0.27$).

The AUC.abs results cannot be considered in terms of the axes. The highest result, 0.27, was achieved for the spatial relation with the bottle *to the right of* the table and the lowest for the bottle *to the left of* the reference object, with 0.14. Neither the results between the axes nor between the individual positions were significant ($p > 0.93$ between axes and $p > 0.91$ between the particular positions).

However, for all complex spatial relations, the outcomes for the Italian native speakers showed very clearly that verb semantics influenced the interpretation, as was found for the German and Polish languages.

The results for the complex spatial relations showed very clearly for *behind* (from the participants' point of view) that verb semantics influence the choice of answer. In the positive situations (with semantically positive verbs), most participants (between 34 and 44) selected the reflection / facing strategy. This means that the choice of the reflection / facing strategy of the relative frame in positive complex relations does not change much (from ≈ 80% to between ≈ 71% and 92%) in comparison to the simple spatial relations without Hans. Furthermore, it also demonstrates that the participants shifted the origo to Hans and considered the spatial relations from the artificial agent's point of view.

Furthermore, for the spatial relation with the bottle *in front of* the table, I found that verb semantics influenced the interpretation as well. In the situations described by semantically negative verbs, a maximum of 29% of the participants selected the answer aligned with the reflection / facing strategy from Hans' point of view (min. 15%). The Italian native speakers also showed several deviations in the spatial relations described by semantically positive verbs. Between 34 and 41 Italian native speakers chose the reflection / facing strategy interpretation in complex relations supplemented by Hans. This means that the choice of the reflection / facing strategy of the relative frame in positive complex relations varied considerably (from ≈ 90% to between ≈ 86% and 71%) in comparison to the simple spatial relations without Hans. Furthermore, it also indicates that of all these participants, 71%–86% shifted the origo to Hans and interpreted the spatial relations from his point of view using the reflection / facing strategy.

For the spatial relation with the bottle *to the right of* the table, I have also found that verb semantics influence the interpretation but proportionally less than for the spatial relations of the first horizontal axis (*in front of* and *behind*). In the situations described by semantically negative verbs, a maximum of 33% of participants selected the answer aligned with the reflection / facing strategy from Hans' point of view (minimum of 23%). The variation can also be seen in the spatial relations described by semantically positive verbs. Between 38 and 43 Italian native speakers shifted the origo to Hans. This means that the choice of the reflection / facing strategy of relative frame in positive complex relations did not change (from ≈ 92% to between ≈ 79% and 90%) in comparison to the simple spatial relations without Hans.

Finally, verb semantics also influenced the interpretation of the spatial relations with the bottle *to the left of* the table (from the participants' point of view using the reflection / facing strategy). In situations with a semantically positive verb, between 75% and ≈ 94% of the Italian native speakers shifted the origo to Hans and selected an answer aligned with the reflection / facing strategy from his point of view. This means that these participants selected the reflection / facing strategy with the embedding predicate at the almost same frequency in the complex situations as in the simple ones.

Considering the AUC.abs and MAD.abs, the results indicate some differences. The lowest MAD.abs was found for the verb "to believe" with Hans to the left of and the bottle behind the table, with ≈ 0.23. In contrast, the highest value for MAD.abs was found for "to believe" with Hans to the left and the bottle in front of the table, as well as for the verb "to think" with Hans to the right and the bottle behind the table, with 0.48. In contrast to the Polish results, the results of the Italian participants did not reveal any significant difference between the particular positions of Hans with respect to the reference object ($p > 0.9$) nor for the particular positions of the bottle ($p > 0.29$). Also, the AUC.abs results did not show any significance between the positions of Hans.

Rectangular table

The results for situations with the rectangular table were similar to those for the round table, with the bar plots and trajectories showing that Italian native speakers interpreted the spatial relations in different ways with respect to the position of the bottle. The participants mostly differed in their interpretation of the situation with the bottle *behind* the table. In this situation, nine participants (≈ 18%) selected a response that did not reflect a reflection / facing strategy from the participants' point of view. In contrast, in the constellation with the bottle *to the right of* the table, most participants (43 ≈ 90%) chose the reflection / facing strategy from the participants' point of view to

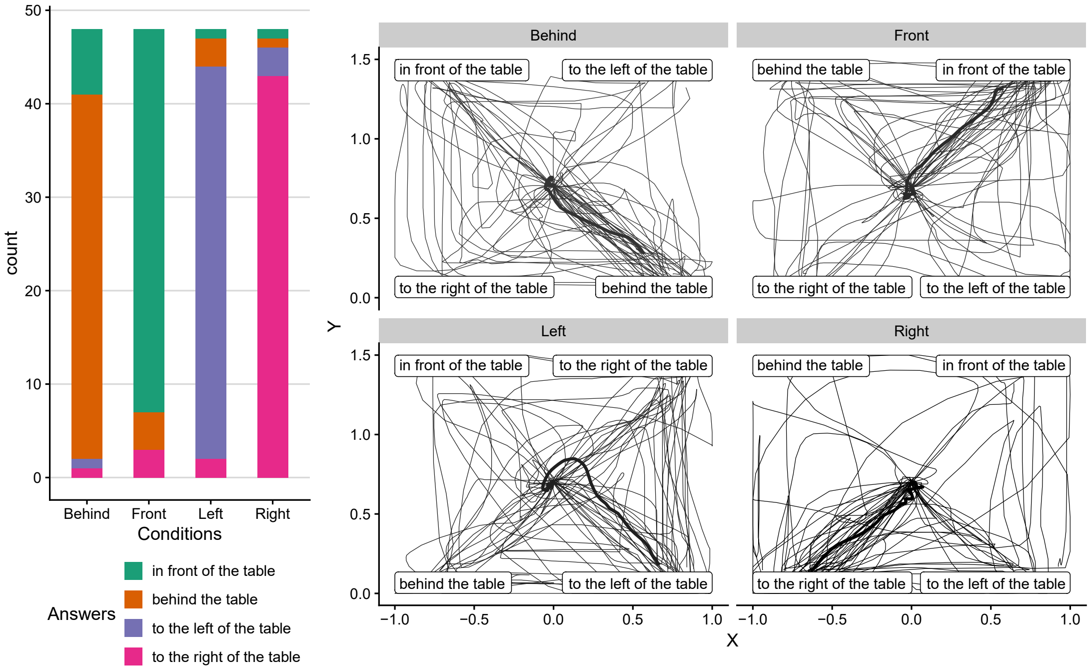
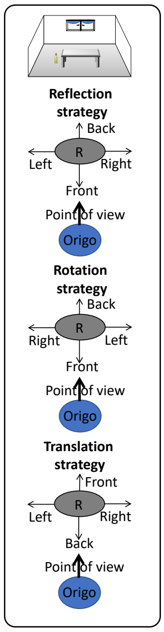


Figure 5.72: Answers for the simple extrinsic relation with rectangular table: barplots with answers (to the left) and trajectories through the response with the mean trajectories (to the right)

interpret the situation. This was also the case for situations with the bottle *in front of* (41 participants) and *to the left of* the table (42 participants).

With respect to the trajectories and to the MAD.abs and AUC.abs values, some differences between the particular situations were found. The lowest MAD.abs (≈ 0.32) was found for the bottle *behind* the rectangular table and the highest (0.55) for *to the left of*. This order was also shown for the AUC.abs values: the lowest value was for *behind* (0.23) and the highest for *to the left of* (0.31). No significance was found for the MAD.abs results between all the spatial relations with p $\approx$ 0.09 and no significant differences between the axes ($p > 0.18$). For the AUC.abs, no significant difference was found between the four spatial relations ($p > 0.28$) or between the axes ($p > 0.73$) either.



For all complex spatial relations with both the rectangular and the round table, the outcomes for the Italian native speakers showed very clearly that verb semantics influenced the interpretation.

In the spatial relation with the bottle *in front of* the rectangular table (from the participants' point of view according to the facing strategy), the verb semantics of the embedding predicates also influenced the interpretation of the specific relations very clearly. In spatial constellations embedded with a semantically positive verb, most participants, between 33 and 41, – depending on the relation – selected the reflection / facing strategy from Hans' point of view. For this spatial relation, I did not find any differences between the semantically positive verbs. The highest and simultaneously the lowest score was reached by the situations described with the communication verbs *ritenere* "reckon", with 33 for the situation with Hans to the right of the table and 41 with Hans to the left of the table. In the simple spatial relation without Hans, 41 Italian native speakers selected the reflection / facing strategy. This demonstrates that for some complex situations, the interpretation in relation to the reflection / facing strategy decreased in comparison to the simple one.

Considering the AUC.abs and MAD.abs, the results indicate some differences too. The lowest MAD.abs value was found for the verb *affermare* "claim" and Hans to the right of the table (≈ 0.26), and the highest value was found for the spatial relation described by, *credere* "believe" and Hans to the right of the table. The MAD.abs value amounted to ≈ 0.48 for the Italian participants. Nonetheless, the results do not reveal any significant differences between verbs ($p > 0.19$) or positions of Hans ($p > 0.25$).

In the spatial relation with the bottle *behind* the rectangular table from the participants' point of view with respect to the facing / reflection strategy, the positive vs. negative verb semantics of the embedding predicates also influenced the interpretation of the specific relations. In spatial constellations embedded with a semantically positive verb, most participants, between 34 (71%) and 41 (85%), depending on the relation – selected the reflection / facing strategy. In contrast, in situations described with a semantically negative verb, only between 23% and 29% selected the answer that reflected a reflection / facing strategy from Hans' point of view. This indicates that participants choose the reflection / facing strategy in positive complex relations almost as often as in the simple spatial relations without Hans ($\approx 71\%$ and 85% for complex situations vs. $\approx 81\%$ for simple spatial relations).

The AUC.abs and MAD.abs values also indicate some differences. Like the results for the Polish native speakers, the outcomes for Italian participants revealed the lowest MAD.abs for the combination of the verb *ritenere* "reckon" and the position of Hans being to the right of the table (≈ 0.20). The highest MAD.abs value, ≈ 0.54, was found for the same verb and Hans positioned to the left. However, the results did not reveal any significant differences between verbs ($p > 0.72$) or axes ($p > 0.72$). In contrast, the results demonstrate a very strong significant difference between the positions of Hans ($p < 0.005$).

Furthermore, for the bottle *to the right of* the table, I found that the verb semantics influenced the interpretation of the spatial relations in that there was a clear difference between semantically positive vs. negative verbs. In the situations described by the semantically negative verbs, a maximum of 30% of participants selected the answer that employed the facing / reflection strategy (minimum 21%) from Hans' point of view. However, most Italian native speakers chose the facing / reflection strategy interpretation in complex relations that contained Hans and were described by semantically positive verbs (between 36 and 44 speakers). This means that the presence of Hans caused speakers to choose the reflection / facing strategy in positive complex relations at the same frequency as in situations without Hans (from ≈ 89.6% to between ≈ 75% and 92%).

Considering the AUC.abs and MAD.abs, the results for the spatial relations with the bottle *to the right of* the rectangular table from the participants' point of view also show numerous differences. The lowest MAD.abs value was for the spatial relation embedded by the verb *affermare* "to claim" with Hans positioned *to the left of* the table (≈ 0.31). The highest MAD.abs value amounts to ≈ 0.43 and applies to spatial relation with the bottle and Hans *to the right of* the table. This situation was embedded with the verb *dire* "to say". The results revealed neither significance between the verbs (p ≈ 0.98) nor between the positions of Hans $p > 0.54$.

In addition, the verb semantics influenced the interpretation of the spatial relation with the bottle *to the left of* the table. In the spatial relations described by semantically negative verbs, a maximum of 25% (min. 19%) of participants selected the answer aligned with the reflection / facing strategy from Hans' point of view. However, for situations embedded with semantically positive verbs, almost all Italian native speakers decided on the reflection / facing strategy interpretation in complex relations including Hans (between 70.8% and 87.5%). This means that the reflection / facing strategy is chosen almost as often in situations with positive complex relations (from ≈ 87.5% to between ≈ 70.8% and 87.5%) as in situations with simple spatial relations without Hans.

The AUC.abs and MAD.abs results for the spatial relations with the bottle *to the left of* the rectangular table from the participants' point of view also show some differences. The lowest MAD.abs applies to the spatial relation embedded with the verb *credere* "to believe" and Hans positioned *to the right of* the table (≈ 0.24). However, the highest MAD.abs value, amounts to ≈ 0.47 and applies to the spatial relation embedded with the verb *dire* "to say" and with the bottle and Hans *to the left of* the table. This situation also showed the highest MAD.abs value in the Polish data. The Italian results approached no significance between the verbs ($p < 0.093$) but a significant difference between the positions of Hans ($p > 0.024$).

5.8.4.2.1.2 Analysis of simple and complex intrinsic spatial relations

Cupboard with the front side to the participants[10]

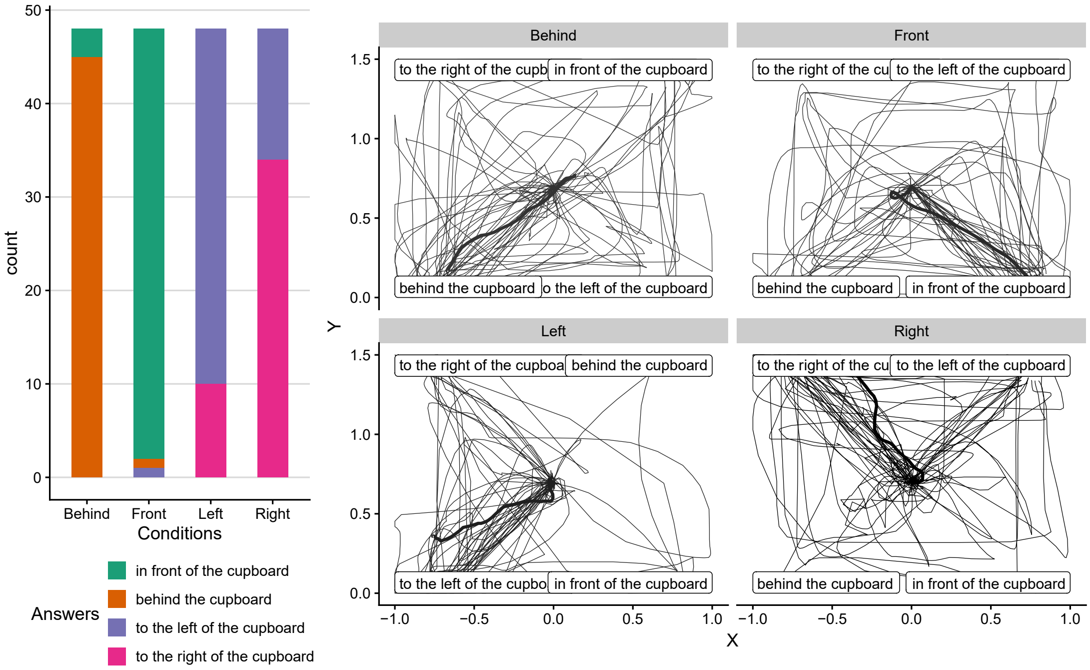


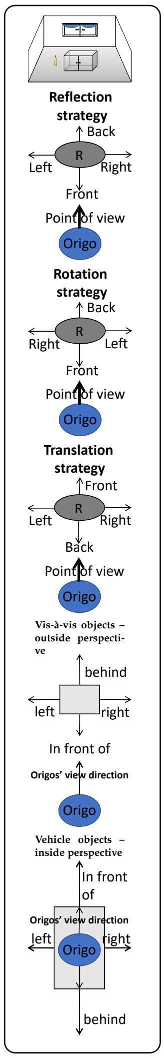
Figure 5.73: Answers for the simple intrinsic relation with cupboard: barplots with answers (left) and trajectories through the response with the mean trajectories (right)

In contrast to the results for the German and Polish participants, the results for the Italian participants demonstrate several differences in how situations with the canonically positioned cupboard are interpreted using the outside perspective: both spatial expressions of the first horizontal axis were interpreted by almost all Italian native speakers with respect to the intrinsic frame of reference (*in front of*: 96%; *behind*: 94%), whereas 71% of the participants interpreted the spatial relations with the bottle *to the right* and 79% with the bottle *to the left* in the meaning of the outside perspective. The outcomes show a very strong significant difference between the axes ($p < 0.0001$). Moreover, the results for the Italian participants point out that they behaved different than the Polish and German speakers.

It is important to stress that in this case, the interpretation would be the same

[10]See also Stoltmann, Fuchs, and Krifka, 2020.

for the intrinsic strategy and the reflection / facing strategy of the relative reference frame. Therefore, it is impossible to determine whether the participants used the outside perspective or the reflection / facing strategy. Still, it is possible to say that approx. 30% of the Italian participants decided for the inside perspective of the intrinsic reference frame interpreting the simple spatial relation. This means that they conducted a mental rotation of 180° while interpreting all of four constellations not just the one of the first horizontal axis.



Comparing these results with the questionnaire results, we find some divergence in the responses. In the survey, all Italian participants assigned the *front* and *back* sides to the cupboard according to the outside perspective and the reflection / facing strategy. In the mouse tracking study, up to 6% deviated from this interpretation. In the questionnaire, approx. 33% of the Italian native speakers investigated assigned the *right* and *left* sides to the cupboard aligned the inside perspective. The outcome resembles the spatial relation interpretation with the bottle *to the left of* the cupboard, where approx. 20% conducted a mental rotation while interpreting the spatial constellation. However, the result for the spatial relation with the bottle *to the right of* the reference object demonstrates a deviation – with 29%. All in all, these data show that Italian native speakers selected the outside perspective in the mouse tracking study more frequently than in the questionnaire study – as did the Polish participants. This outcome indicates a contrast to that of the German native speakers.

The AUC.abs and MAD.abs values show very interesting outcomes. The lowest MAD.abs is demonstrated by the interpretation of the negative dimensional spatial expression of the second horizontal axis (*a sinistra* "to the left of") with ≈ 0.28. In contrast, the highest MAD.abs value arose during the interpretation of the spatial relation with the bottle *to the right of* the cupboard (with MAD.abs ≈ 0.44 and AUC.abs ≈ 0.23) – in relation to the outside perspective. The Italian participants reached for the spatial expressions the following aggregated MAD.abs and AUC.abs values: *dietro* "behind" MAD.abs ≈ 0.42 and AUC.abs ≈ 0.30 and *davanti a* "in front of" MAD.abs ≈ 0.32 and AUC.abs ≈ 0.30. The results have revealed significant difference between the four positions of the bottle individually but no significance between the axes ($p > 0.2$).

The results for the Italian native speakers show that verb semantics influences the choice of answer when participants interpret complex spatial relations with the bottle in front of the cupboard, visible from the front.

In the situations described with semantically positive verbs, more than 50% of participants (between $24 = 50\%$ and $34 \approx 71\%$) selected the reflection / facing strategy from Hans' point of view. This is more than 16% (between 33 and 41 participants) fewer than for the rectangular table. This indicates that the intrinsicality of the reference object plays an important role in the interpretation of the spatial relations – similar to the results for the previously described languages. However, some differences between

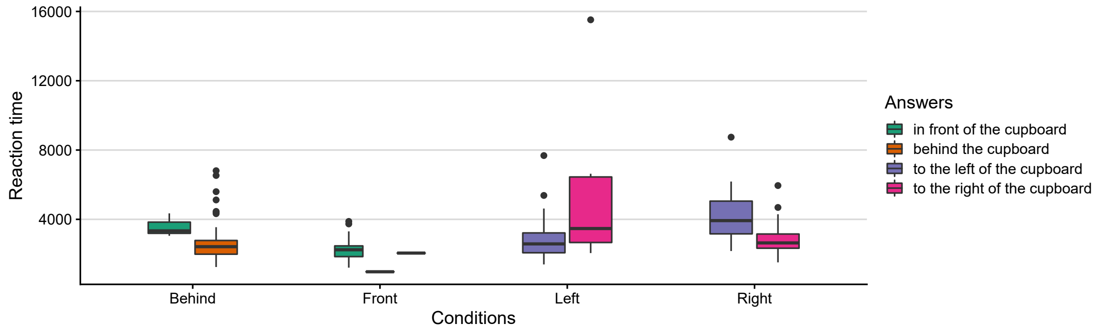


Figure 5.74: Reaction time for the spatial relations with the cupboard facing the participants

the semantically positive verbs can be also observed, with the most consistent result for *affermare* "claim" and the less for *sapere* "know" (independent on the position of Hans). In general, the results indicate that participants are significantly more likely to choose the reflection / facing strategy in positive complex relations (from 4% to between ≈ 50% and 71%, $p < 0.0001$) than in simple spatial relations without Hans.

The differences are also visible in the MAD.abs and AUC.abs values as well as in the X- and Y- flips. The highest MAD.abs value amounts to ≈ 0.53 for the verb *affermare* "claim" with Hans to the left of the cupboard. This is followed by the verbs *credere* "believe" (MAD.abs ≈ 0.43) and *ritenere* "reckon" (MAD.abs ≈ 0.41). The lowest MAD.abs value was computed for the verb *pensare* "think" and Hans to the left of the cupboard (MAD.abs ≈ 0.28). In general, the results indicate that maximal absolute deviation was more frequently higher with Hans to the right of the cupboard. The results show strong significant difference between the verbs ($p < 0.005$) and between the positions of Hans ($p < 0.02$).

Verb semantics also influenced Italian native speakers' interpretation of spatial relations with the bottle behind the cupboard, visible from the front side (without contribution of Hans in the picture).

In the positive situations (with semantically positive verbs), more than half of the participants (between 24 and 31) selected the reflection / facing strategy and between 14 and 22 (up to approx. 46%) selected the outside perspective. In contrast, in the simple spatial relation almost all participants selected the outside perspective (≈ 94%). It is striking that intrinsicality plays an important role for 46% of participants (6% more than Polish participants). However, with the semantically positive verbs, some differences with respect to the intrinsic interpretation can be observed again: the strongest result for *sapere* "know" (independent of the position of Hans) and weakest for *dire* "say" and Hans to the right, as well as *ritenere* "reckon" and Hans to the left. In general, the results indicate that there was a significant increase in the percentage of responses selecting the reflection / facing strategy in complex relations described by verbs of positive semantics (from 6% in the simple relation to between ≈ 50% and 65% in the complex constellation, $p < 0.0001$) vs. simple spatial relations without the artificial agent *Hans*.

The differences are also reflected in the MAD.abs, AUC.abs values as well as in the X- and Y-flips. The highest MAD.abs value, amounts to ≈ 0.52 for the verb *ritenere* "reckon". This is followed by the verb *pensare* "think" with Hans to the right (MAD.abs ≈ 0.41). The lowest MAD.abs value was computed for the verb *ritenere* "reckon" and Hans to the right of the cupboard (≈ 0.28). The results do not indicate any significant difference between the verbs ($p > 0.81$) nor between the positions of Hans ($p > 0.18$).

Furthermore, in the constellation with the bottle *to the right of* the cupboard, the results for the Italian native speakers indicate (for *to the right of* align the outside) that verb semantics influences the choice of answer.

In positive situations (with semantically positive verbs), most participants (between 29 and 37) selected the reflection / facing strategy. This is approx. 10% (between 24 and 34 participants) more than for the *front* or *back*. This suggests that localization in relation to the reference object plays a role. Furthermore, the results demonstrate that intrinsicality plays an important role here, too. For the rectangular and round tables with the bottle *to the right*, between 43 and 44 Italian native speakers selected the reflection / facing strategy – this means that Italian native speakers selected the reflection / facing strategy from Hans' point of view approx. 22% more frequently in the extrinsic constellations with the bottle located *to the right of* the reference object which were embedded by indirect speech and which contained an artificial agent. Some differences between the semantically positive verbs for this spatial relation can be observed, too. *Affermare* "claim" and *ritenere* "reckon" attained the highest number of responses (37) in favour of the reflection / facing strategy when Hans was located *to the left of* the cupboard. In contrast, the verb *sapere* "know" with Hans to the right of (29) and left of (30) the cupboard garnered the lowest number of responses employing the reflection / facing strategy and the most using the outside perspective (11 ≈ 23%). To sum up, the results indicate that the amount of responses reflecting the outside perspective in complex relations described by verbs of positive semantics has significantly decreased (from ≈ 71% up to ≈ 23%, $p < 0.0001$) compared to the simple spatial relations without Hans.

Some differences were found between the MAD.abs and AUC.abs values as well as between the X- and Y-flips. The highest MAD.abs value, ≈ 0.49, relates to the verb *pensare* "think" and Hans to the right of the cupboard. The lowest MAD.abs value was computed for the semantically negative verb *negare* "deny" – independent of Hans' position (MAD.abs ≈ 0.28). The MAD.abs results indicate no significant difference between (semantically positive) verbs ($p > 0.73$), and no significant difference between the positions of Hans ($p > 0.13$).

Finally, the results for the Italian native speakers' interpretations of spatial relations with the bottle *to the left of* the canonically positioned cupboard also indicate that verb semantics influences the choice of answer (for to the left align the outside perspective).

In situations described by semantically positive verbs, most participants (between 29 and 34) selected the reflection / facing strategy. This suggests that localization in relation to the reference object plays an important role and can be specified by the horizontal axes. The reflection / facing strategy is applied to interpret spatial relations of the second horizontal axis more frequently than of the first one. Furthermore, the results confirm that intrinsicality plays a role here too. For the rectangular and round tables with the bottle *to the left*, between 75% and 94% Italian native speakers selected the reflection / facing strategy from Hans' point of view – this means that Italian native speakers selected the reflection / facing strategy approx. 15% more frequently in the extrinsic constellations with the bottle *to the left of* the reference object in situations which were embedded by indirect speech and contained an artificial agent.

We can observe some differences between the semantically positive verbs for this spatial relation, too. *Affermare* "claim" and *credere* "believe" received the highest number of responses (34) choosing the reflection / facing strategy when Hans was located to the left of the cupboard. In contrast, the verb *sapere* "know" with Hans to the right and left of the cupboard achieved the lowest number of responses (29). The highest number of responses reflecting the outside perspective was found for *credere* "believe" with Hans to the right and left of the cupboard (10 participants $\approx$ 21%). To sum up, the outcomes indicate that the choice of the outside perspective in positive complex relations has significantly decreased (from $\approx$ 79% up to $\approx$ 21%, $p < 0.0001$) in comparison to the simple spatial relations without Hans.

Some variations were found between the MAD.abs and AUC.abs values as well as between the X- and Y-flips. The highest MAD.abs value amounts to ≈ 0.46 and relates to the verb *credere* "believe" and Hans to the right of the cupboard. The lowest MAD.abs was computed for the semantically negative verb *negare* "deny" and Hans to the left (MAD.abs ≈ 0.29). The MAD.abs results indicate no significant difference between (semantically positive) verbs ($p = 0.1$), and very weak significant difference between the positions of Hans, with $p < 0.052$.

Cupboard with the back side to the participants[11]

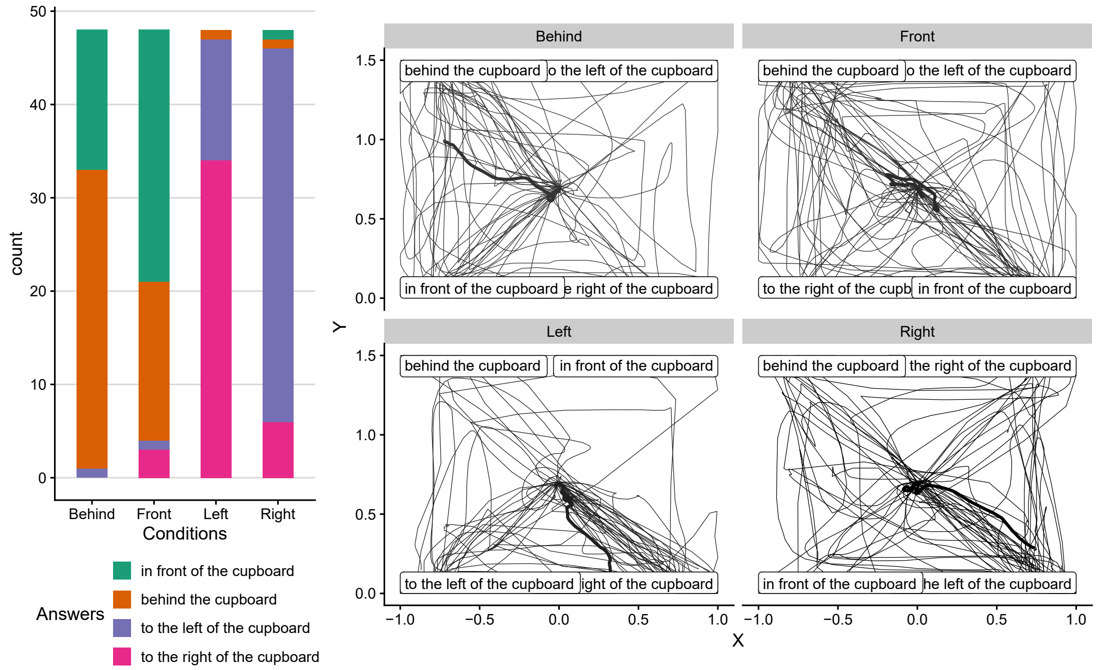
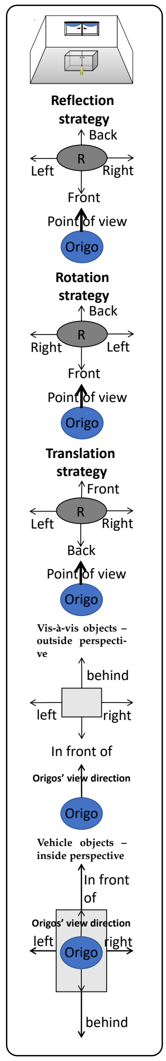


Figure 5.75: Answers for the simple intrinsic relation with the non-canonically positioned cupboard: barplots with answers (left) and trajectories through the response with the mean trajectories (to the right)



As was the case for the German and Polish native speakers, it is very noticeable that almost all of the spatial relations investigated caused difficulties for the Italian participants. This is indicated very clearly by the selected answers as well as by the trajectories leading to the responses. Nonetheless, in contrast to the Polish and German data the mean trajectories appear between the responses – these do not lead exactly to only one response in only two cases "in front of" and "behind" the cupboard. For the responses "to the right" and "left of" the cupboard this statement does not apply. For *behind* and *in front of*, we can recognize that the Italian native speakers usually considered two opposite answers – one interpretation using the outside perspective and one with respect to the reflection / facing strategy.

Looking at the absolute values of the responses, *a destra* "to the right of" comes clearly on top with 40 ($\approx$ 83%) of selected answers with respect to the inside perspective (which coincides with the reflection / facing strategy) and 6 (12.5%) aligned the outside

[11]See also Stoltmann, Fuchs, and Krifka, 2020.

perspective. This is followed by the interpretation of *a sinistra* “to the left of” with 34 ($\approx$ 69.4%) of chosen answers reflecting the inside perspective and 13 (26.5%) the outside perspective. *Davanti a* “in front of” was interpreted by 27 participants (56.3%) regarding the outside perspective and by 17 aligned the inside perspective (35.4%). *Dietro* “behind” was interpreted by 32 participants (67%) according to the outside perspective and by 15 (31.3%) pursuant to the inside perspective. The question which arises here is: When interpreting the situation with the bottle to the right / left, did the Italian native speakers apply the inside perspective or did they use the reflection / facing strategy? The results between the first and second horizontal axis are significant with $p < 0.0001$. This means that Italian native speakers interpreted the spatial relations between a locatum and the reference object of the second horizontal axis significantly more frequently with respect to the inside perspective than the constellations of the first horizontal axis. The results of all localizations taken together reveal a strongly significant difference as well.

Comparing the results of the spatial relation with the questionnaire results (for *right* and *left*), it is very clear that more participants assigned the sides to the cupboard with respect to the inside perspective in the mouse tracking task than in the questionnaire experiment (83% and 67%, respectively vs. 69%). Also, the interpretation of *in front of* and *behind* align the outside perspective, which was selected in the questionnaire study significantly more frequently than in the mouse tracking experiment (67% vs. 56% and 88%).

The differences can be also recognized in the MAD.abs and AUC.abs values as well as in the X- and Y-flips. The highest MAD.abs value, at ≈ 0.44, was found for the positive spatial dimension expression of the second horizontal axis, *a destra* “to the right of”. This is immediately followed by *dietro* “behind” and *davanti* a “in front of” with a MAD.abs value of ≈ 0.43. The lowest MAD.abs value was computed for a sinistra “to the left of” (MAD.abs ≈ 0.36). The outcomes are neither significantly different between the axes ($p > 0.52$) nor between the particular localizations ($p > 0.64$).

In positive situations (with semantically positive verbs) with the bottle *in front of* the non-canonically positioned cupboard, many participants (between 23 $\approx$ 48% and 31 $\approx$ 67%) selected the reflection / facing strategy from Hans’ point of view. This is approx. 20% fewer than for the rectangular table (between $\approx$ 86% and 71%). Between the semantically positive verbs some differences can be also observed. In the spatial relations embedded with the verb *sapere* “know”, the participants selected the outside perspective most frequently (19 participants $\approx$ 41.3%). In contrast, the spatial relations described by the verbs *pensare* “think” and *dire* “say” were interpreted less frequently in terms of the outside perspective (13 participants $\approx$ 27%). In general, the outcomes indicate that the choice of the number of responses choosing the reflection / facing strategy in positive complex relations has increased (from $\approx$ 35% to between $\approx$ 48% and 67%) in comparison to the simple spatial relations without Hans.

Few differences can also be seen in the MAD.abs and AUC.abs values as well as in the X- and Y-flips. The highest MAD.abs value is ≈ 0.44 for the verbs *negare* "deny" and *ritenere* "reckon" with Hans to the left of the cupboard. The lowest MAD.abs value was computed for the verb *dubitare* "doubt" with Hans to the right of the cupboard (MAD.abs ≈ 0.32). This was followed by the outcome for the verbs *sapere* "know", *credere* 'believe', *pensare* "think" and *affermare* "claim" (all MAD.abs ≈ 0.33). There was no significant difference between the MAD.abs value for different verbs ($p > 0.83$), nor was there a significant difference between Hans' positions ($p > 0.9$).

The results for the Italian native speakers' interpretation of spatial relations with the bottle *behind* the cupboard with the back indicated that verb semantics influences the choice of answer (for *dietro di* "behind" aligned the outside perspective).

In the positive situations (with semantically positive verbs), several participants (between 21 $\approx$ 44% and 32 $\approx$ 67%) selected the reflection / facing strategy from Hans' point of view. This is approx. 23% ($\approx$ 71% and 85%) less than with respect to the rectangular table. Also this result indicates that the intrinsicality of the reference object plays an important role when interpreting the spatial relations. The outcomes indicate that the choice of the reflection / facing strategy in positive complex relations has increased (from $\approx$ 33% to between $\approx$ 44% and 67%) in comparison to the simple spatial relations without Hans. It means that these participants shifted the origo to Hans and interpreted these spatial relations from his point of view using the reflection / facing strategy.

Some differences can also be seen in the MAD.abs and AUC.abs values as well as in the X- and Y- flips. The highest MAD.abs value is ≈ 0.44 and was found for the verbs *affermare* "claim" with Hans to the left of the cupboard and *ritenere* "reckon" with Hans to the right. The lowest MAD.abs value was computed for the verb *sapere* "know" with Hans to the right of the cupboard, with MAD.abs ≈ 0.20. In general, the outcome means that the maximal absolute deviation significantly differs between the verbs ($p > 0.0027$). However, the results did not reveal any significant difference between the positions of Hans ($p > 0.27$).

Furthermore, the results for the Italian native speakers' interpretation of spatial relations with the bottle to the right of the non-canonically positioned cupboard demonstrated that verb semantics influenced the choice of answer.

In the positive situations (with semantically positive verbs), most participants (between 27 $\approx$ 56.3% and 38 $\approx$ 79.2%) selected the reflection / facing strategy from Hans' point of view. This is approx. 12.5% (between 21 and 32 participants) more than in situations with bottle at the *front* or *back*. It suggests that localization with respect to the reference object plays an important role for the Italian participants, too (as with the Polish participants). Furthermore, the outcomes demonstrate that intrinsicality is important. For the rectangular and round tables with the bottle *to the right of* them, between 79%

and 90% of Italian participants selected the reflection / facing strategy from Hans' point of view – this means that Italian native speakers choose the reflection / facing strategy approx. 17% more frequently in the extrinsic constellations with the bottle *to the right of* the reference object than with the non-canonically positioned intrinsic cupboard.

We can observe some differences within the positive verbs too. *Pensare* "think" had the highest number of responses with respect to the reflection / facing strategy when Hans was located to the right of the cupboard (38 $\approx$ 78% of participants). In contrast, the verb *sapere* "know" with Hans to the right of the cupboard achieved the lowest number of responses (27) according to the reflection / facing strategy.

Some differences between the MAD.abs and AUC.abs values as well as the X- and Y-flips were revealed too. The highest MAD.abs value, ≈ 0.45, was found for the verbs *ritenere* "reckon" and *pensare* "think" – both with Hans to the right of the cupboard. The lowest MAD.abs value for a semantically positive verb was computed for *sapere* "know" with Hans to the left of the cupboard, with MAD.abs ≈ 0.37. All in all, the outcome means that the maximal absolute deviation was higher for the constellations with Hans to the right than to the left ($p > 0.067$). This applies for seven verbs. However, I have not found any significant differences between the verbs ($p > 0.95$).

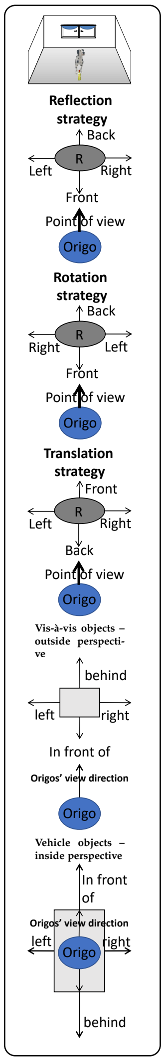
As with all constellations up to now, the results for the Italian native speakers' interpretation of spatial relations with the bottle *to the left of* the cupboard with the back side facing the participants indicated that verb semantics influenced the choice of answer (to the left of the cupboard using the outside perspective).

In the spatial relations described with semantically positive verbs, most participants (between 29 $\approx$ 60.4% and 36 $\approx$ 75%) selected the reflection / facing strategy from Hans' point of view. Again, this is approx. 12.2% (between 21 and 32 participants) more than with respect *to the front* or *back* (as with the outcomes for the Polish native speakers). It stresses that localization with respect to the reference object plays a role. Furthermore, the outcomes indicate that intrinsicality is considered. For the rectangular and round tables with the bottle *to the left of* them, between 75% and 94% of Italian native speakers selected the reflection / facing strategy – this means that Italian native speakers selected the reflection / facing strategy from Hans' point of view approx. 15% more frequently in the extrinsic constellations with the bottle *to the left of* the reference object.

We can also observe some differences between the positive verbs. *Pensare* "think" garnered the highest number of responses with respect to the reflection / facing strategy when Hans was located to the right of the cupboard. In contrast the verb *affermare* "claim" with Hans to the left of the cupboard achieved the lowest outcome, with just 29 responses employing the reflection / facing strategy.

The highest MAD.abs value amounts to ≈ 0.49 and relates to the verb *pensare* "think" with Hans to the left of the cupboard. The lowest MAD.abs value was computed for the verb *dire* "say" but with Hans to the right of the cupboard, with MAD.abs ≈ 0.28. In general, the outcome means that the maximal absolute deviation did not significantly differ between the constellations with Hans ($p > 0.26$). No significant difference was found between the verbs ($p < 0.19$).

5.8.4.2.2 Third null hypothesis



5.8.4.2.2.1 Analysis of simple spatial relations with animate vs. inanimate entities

Like the data for the languages previously discussed, the Italian data for the third null hypothesis is analyzed in the following way:

First, animate intrinsic spatial relations will be presented:

- Dog with the front to the participant
- Dog with the back to the participant.

Second, the results for the inanimate intrinsic spatial relations will be summed up and contrasted with the results for animate data:

- Cupboard with the front to the participant
- Cupboard with the back to the participant (for this, please see the analysis 5.8.4.2.1.2)

Dog with the front to the participants

As with the Polish native speakers, bar graphs for the responses show that the Italian native speakers did not have any problems interpreting the canonical spatial constellation with the bottle *behind* or *in front of* the dog, where the intrinsic and relative (reflection / facing strategy) interpretations coincide (5.76). In the case of the bottle *in front of* the dog, 100% of participants (as in German and Polish) picked the intrinsic interpretation. Ninety-eight percent decided for the response along the intrinsic reference frame in canonical relations with the bottle *behind* the dog. Pursuant to the MAD.abs and AUC.abs values, I can also determine that the Italian native speakers did not have many problems interpreting these situations. The MAD.abs value for *davanti a* "in front of" was ≈ 0.19 (that's even lower than for Polish participants), and for *dietro di / a* "behind" it was ≈ 0.34. The AUC.abs values spread between ≈ 0.09 for *davanti a* "in front of" and ≈ 0.17 for *dietro di / a* "behind".

Like the Polish participants, the Italian native speakers seemed to have more difficulties deciding on *the right* and *left side of* the dog – their mean line deviated from the ideal line much more (see 5.76). Participants clearly considered two opposite responses, *right* and *left*. This is shown by the MAD.abs value of ≈ 0.44 for *a destra* "to the right of"

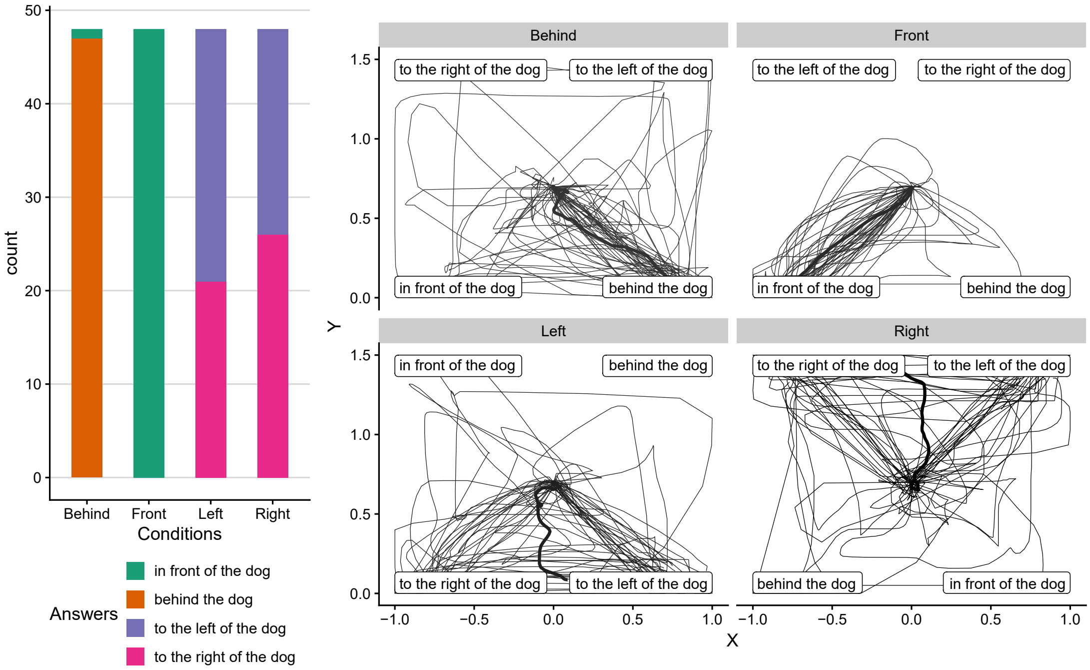


Figure 5.76: Answers for the simple intrinsic animate relation with dog: barplots with answers (left) and trajectories through the response with the mean trajectories (right)

and ≈ 0.45 for *a sinistra* “to the left of” and the AUC.abs value of ≈ 0.28 for *destra* “to the right of” and ≈ 0.20 for *a sinistra* “to the left of”. Regarding the MAD.abs value, the lmer and ANOVA computations show significant differences between all positions, with $p < 0.001$, as well as between the axes, with $p < 0.0001$.

Approximately 56.3% of participants chose the response showing the intrinsic interpretation for *a sinistra* “to the left of” and 54% *a destra* “to the right of”. The remaining participants selected the interpretation along the reflection / facing strategy. Analyzing the categorical data statistically, the results indicate significant differences between the individual spatial positions for the canonically positioned dog ($p < 0.0001$) as well as between the axes ($p < 0.0001$).

The RT was highest for *davanti a* “in front of” and lowest for *dietro di / a* “behind” (5.77). In contrast to the German and Polish data, this result does not confirm the assumptions of the spatial framework model (see Franklin and Tversky, 1990), which states that space is conceptualized in terms of three axes: the axis *above / below* is perceived fastest, followed by *in front of / behind*, with *to the right / left of* being perceived slowest.

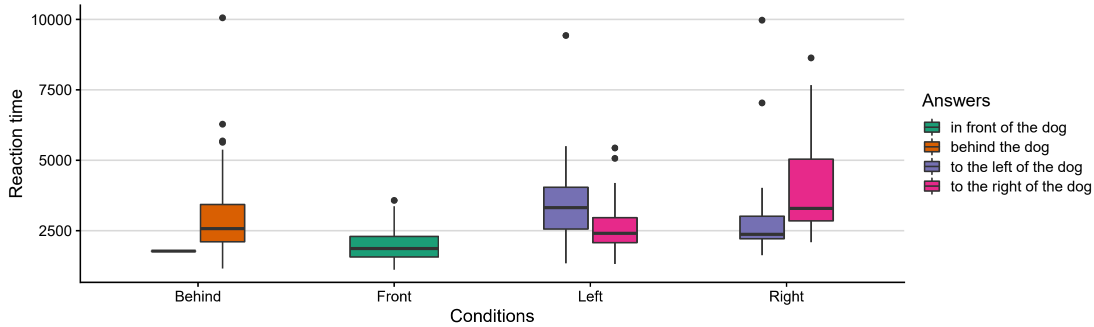
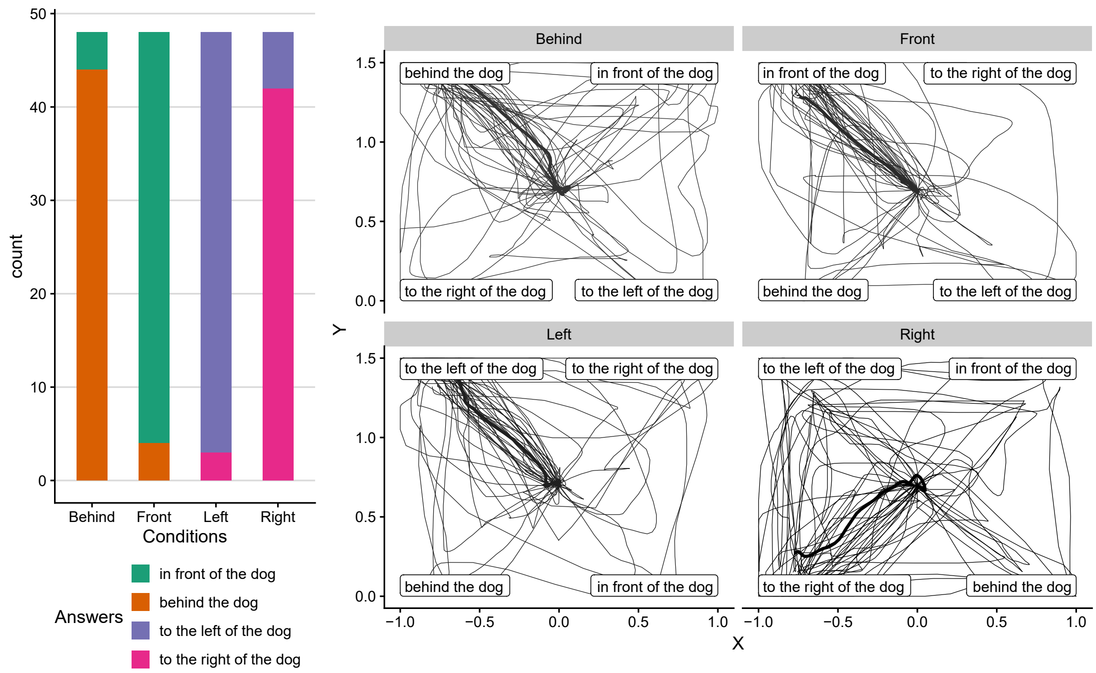


Figure 5.77: Reaction time for the spatial relations with dog facing the participants

Dog with the back to the participants



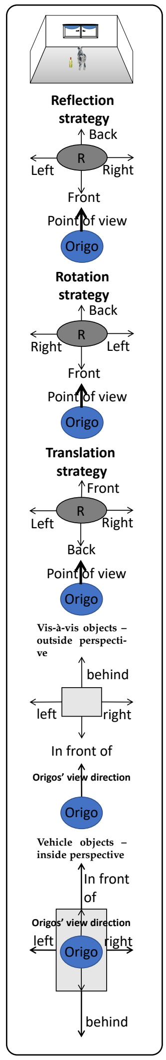


Figure 5.78: Answers for the simple intrinsic animate relation with dog: barplots with answers (to the left) and trajectories through the response with the mean trajectories (to the right)

In contrast to the Polish data, the bar plots for the responses visualize very clearly that Italian native speakers most frequently selected answers along the intrinsic interpretation for the four localizations (*davanti a* "in front of" = 44, *dietro di / a* "behind" = 44, *a destra* "to the right of" = 42, *a sinistra* "to the left of" = 45). The statistical tests do not reveal any significant differences between the particular localizations ($p \approx 0.81$). Also, the results between the axes do not show any differences, $p = 1$.

On the mean trajectory of the trajectory plots, we can clearly see that the participants had the fewest doubts when interpreting the spatial relation with the bottle *in front of* the dog – this stands in contrast to the German and Polish native speakers. In contrast to the Polish native speakers, in relations with the bottle positioned along the first horizontal axis to the dog, Italian native speakers did not tend to consider the opposite answer very often (see 5.78). For the relation with the bottle *behind* the dog, we can see that some participants changed their decision when the mouse was already above the opposite answer (*davanti a* "in front of").

The MAD.abs values for the spatial relations with the dog positioned with the back facing the participant and the bottle in different positions were as follows: *in front of* ≈ 0.26; *behind* ≈ 0.40; *to the right of* ≈ 0.50; and *to the left of* ≈ 0.34. The lmer and ANOVA computations show significant differences in the MAD.abs values between all positions, with $p \approx 0.004$, but no differences between the axes ($p \approx 0.057$). In addition, the lowest AUC.abs ≈ 0.17 fits for the bottle positioned *in front of* the intrinsic front of the dog. It is followed by *to the left of* ≈ 0.17, *behind* ≈ 0.23, and *right* with ≈ 0.28.

Considering the bar plots for the spatial relations including the dog, in summary, it can be said that the dimensional spatial expressions of the first horizontal axis were significantly more frequently recognized as intrinsic than those of the second horizontal axis ($p < 0.0001$). The data also reveal significant differences between the four localizations with $p < 0.0001$.

As stated above (5.8.4.1), animacy (cupboard with front / back vs. dog with front /

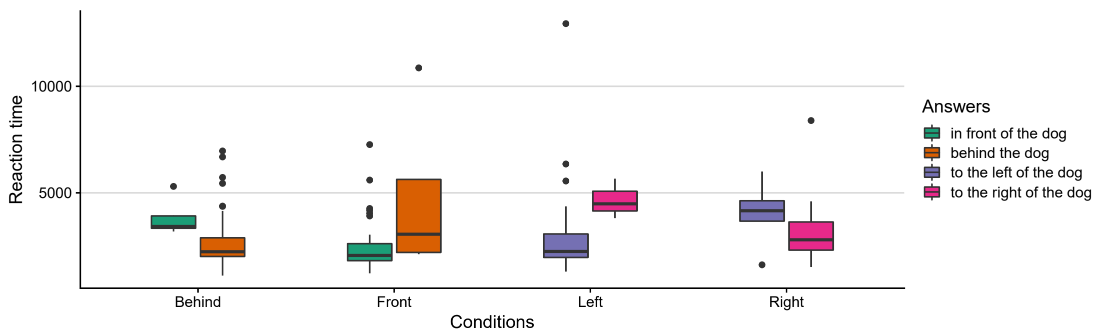


Figure 5.79: Reaction time for the spatial relations with dog facing with the back to the participants

back) showed a statistical significance overall, with $p < 0.0001$. The results also indicated very large significant differences between the individual positions. The largest differences between the dog and the cupboard as reference objects were found for the interpretation with the bottle *to the right of* the reference object (68 *correct* answers for the dog vs. 40 for the cupboard). The largest differences between the dog positioned canonically / non-canonically and the cupboard positioned canonically / non-canonically individually as reference objects are visible for the interpretation with the bottle *to the right* and *left of* the canonically positioned objects. A Fisher's exact test revealed large significant differences between both objects and positions ($p < 0.001$). No significant differences were found in categorical judgments for the first horizontal axis (*in front of* vs. *behind*). For the non-canonically positioned reference objects, a Fisher's exact test revealed significant differences for animacy and both positions (*to the right* vs. *left of*), with $p < 0.0001$. This also applies to the first horizontal dimension (*in front of* vs. *behind*) and both reference objects. This result is similar to the one found in the German and Polish data. With the statistical analysis, the third null hypothesis can be rejected for the Italian participants too: The animacy of reference objects does not affect the interpretation of spatial relations.

The MAD.abs values for the reference objects did not reveal any significant difference between the animate and inanimate reference objects ($p > 0.94$). However, the data for the axes and animacy indicate a weak significant difference ($p < 0.04$) and strong difference for the individual positions ($p < 0.0001$).

5.8.4.3 Summary and conclusion

This subchapter centers the interpretation of spatial relations by the Italian native speakers. Mouse tracking and survey served as experimental methods. Using the survey, Italian native speakers were asked to identify sides of a cupboard (visible from front and back to the participants) – as representative of vis-à-vis objects. The same cupboard was used in the mouse tracking study. In addition, the latter method used a dog and a table as reference objects. An artificial agent (Hans) was also supplemented to investigate, how Italian native speakers interpret spatial relations with an artificial agent and introduced by indirect speech "Hans says that the bottle is standing . . . " Results of the interpretation of spatial relations with Hans were compared to results of the interpretation of spatial relations without Hans (which were introduced by an interrogative sentence "Where is the bottle standing?").

The reference objects used in the mouse tracking study represent a hierarchy in accordance to intrinsic properties: table (only *up-down* axis), cupboard (pronounced *up-down*, *front-back* sides) and a dog (pronounced *up-down*, *front-back* and *right-left*). Considering the spatial relations with the table as reference object, I explored which strategy of the relative reference frame Italian native speakers apply interpreting those (see 3.3). The results indicate that the Italian participants prefer the application of the reflection strategy to interpret static spatial relations. This result expands on the results of the study of Perużyńska (2012a), which revealed that Italian participants apply the reflection strategy for the interpretation of spatial relations described by dynamic verbs (and not static verbs as in the current mouse tracking study).

The results of the experiment with spatial relations, supplemented by Hans, reveal that in all complex constellations with tables, participants decided most frequently on the reflection strategy from Hans' point of view and thus covered Hans and especially his point of view as the origo in the particular spatial relations. These results point out that the presence of an artificial agent as a third person in a spatial relation expressed by means of indirect speech affects origo shift (rejection of the first null hypothesis).

The intrinsic spatial relations included either a cupboard or a dog (animacy). To find out, how do Italian native speakers identify the sides of the cupboard, they were asked to assign sides to the cupboard. This cupboard (visible either from *front* or *back*) was localized in a room with window to make the situation as natural as possible. Results of the survey indicate that most of the Italian participants identified the *front* and *back* of a cupboard along the assumption of the outside perspective – independent of the visibility of it (from *front* vs. *back*). In contrast to the *right* and *left* sides of the cupboard: Only minority of the Italian participants identified the right and left side of the cupboard along the outside perspective seeing it from back. Around 67% of the Italian participants assigned the right and left side to the cupboard along the outside perspective to the cupboard visible from front. In the simple spatial relation with the cupboard visible from the front, almost all participants used the outside perspective when producing an interpretation. Analyzing the mouse tracking data with the cupboard, few differences are visible in comparison to the survey results. In these spatial relations, the participants were asked to interpret the spatial relations with the cupboard as a reference object and a bottle as a localized one. Up to around 70% of the Italian participants interpreted the spatial relations with the cupboard visible from front along the outside perspective. In the spatial relations with the cupboard visible from back and the bottle to the *right* or *left*, only minority of the Italian participants (approx. 12 and 30%) used the outside perspective while interpreting. However, just over half of the participants applied the outside perspective interpreting the spatial relations with the bottle located *in front of* or *behind* the non-canonically positioned cupboard.

The analysis of the spatial relations with Hans and cupboard visible from front confirms that the Italian selected the outside perspective significantly more frequently for interpretation of the spatial relations without Hans than with Hans. In the latter situations, participants shifted perspective to Hans and interpreted the constellations from his point of view in terms of the facing / reflection strategy. This result represents a rejection of the assumption of the first null hypothesis and thus supports the alternative one: The presence of an artificial agent as a third person in a spatial relation expressed by means of indirect speech affects origo shift as well as a shift of reference frame.

Finally also for Italian native speakers, animacy of reference object turned out to be an important factor: Significantly more participants interpreted the spatial relation according to the intrinsic frame of reference with the animate object than an inanimate. This outcome rejects the assumptions of the third null hypothesis.

5.9 English

5.9.1 Location of the experiment in United Kingdom

The experiment for the English language was conducted at two Universities in Scotland, thanks to Dr. Susanne Fuchs. First part, I conducted with Prof. Jim Scobbie as chief of the experiment at the Queen Margaret University (Edinburgh) in May 2018. The second part of the English native speakers, I had the pleasure to investigate at the University of Strathclyde (Glasgow) in October 2018 – together with Joanne Cleland as supervisor. These both researchers supported me and consulted during my stay at the department with regard to the following topics:

- Ethical application
- Advertisement for participants
- Participants collection.

The experimental situation was very similar to the one in Germany and in Poland.

5.9.2 Participants: English native speakers

All in all, I managed to test 34 English native speakers, 28 female and 6 male.

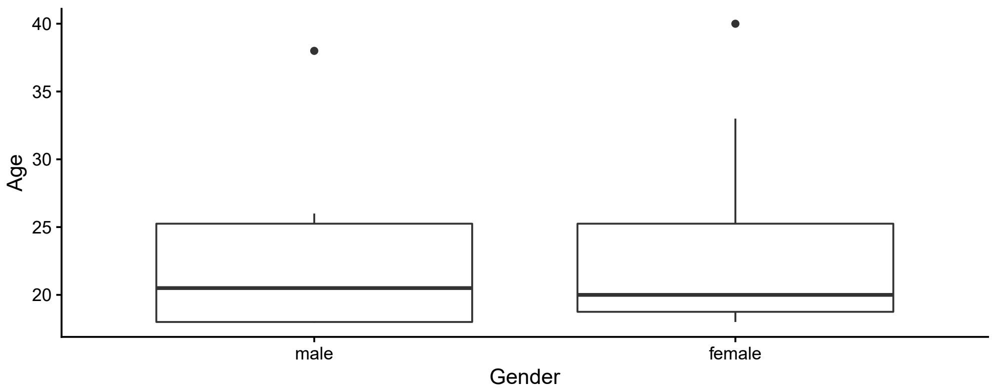


Figure 5.80: The charts depict the gender and the age distribution of the English native speakers

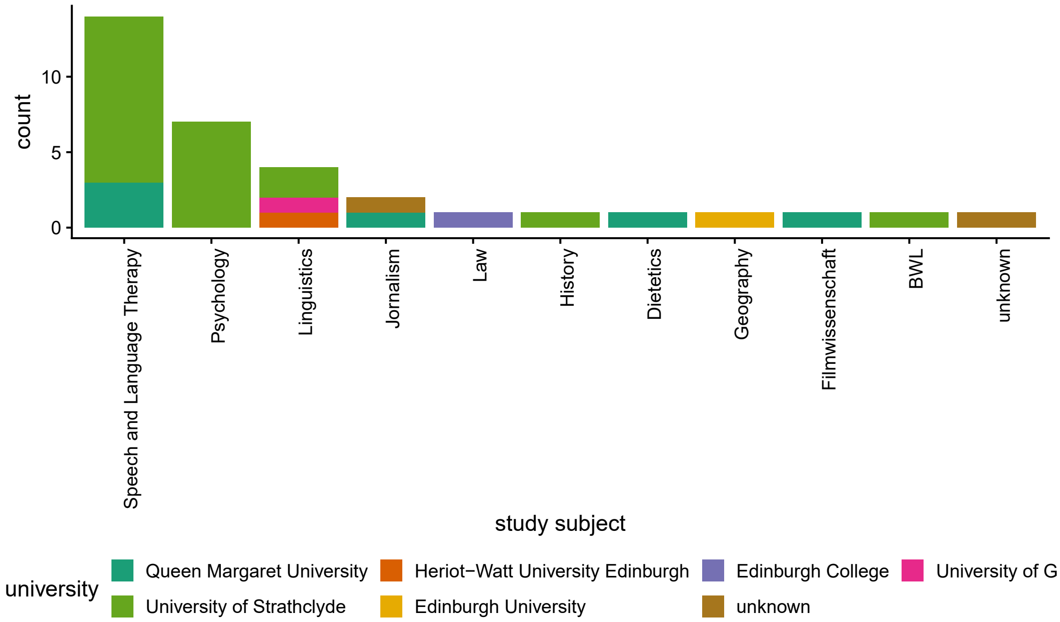


Figure 5.81: Universities attended and subjects studied by participants in the experiment

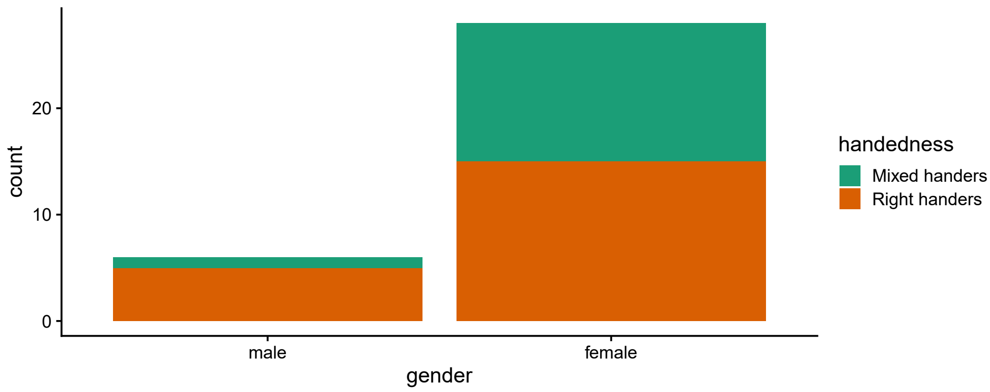


Figure 5.82: The distribution of gender and handedness of the participants

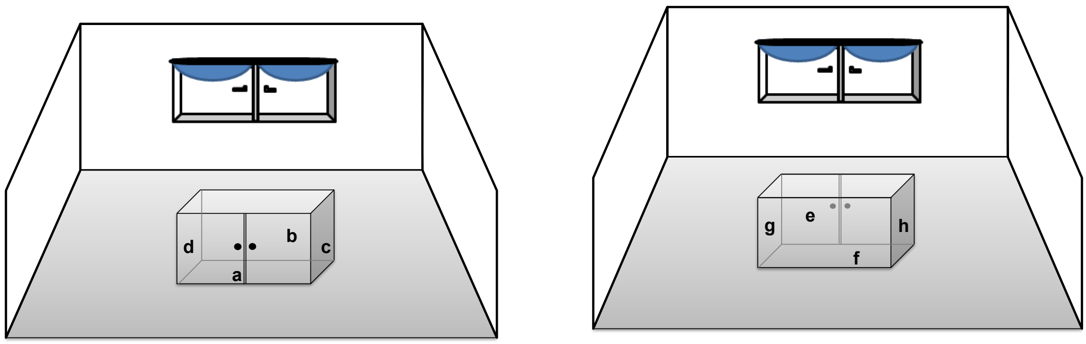
The English native speakers received 10€ compensation for their participation in Edinburgh and 10£ in Glasgow – as recommended by Joanne Cleland. In addition to the mouse tracking experiment, they were also asked to complete a questionnaire based on the Edinburgh Handedness Inventory (see Oldfield, 1971). According to the questionnaire, 59% of attendees were right-handed (dominant hand), 0% left-handed, and

41% were mixed (this means that they prefer performing some tasks with the right hand and others with the left or they can perform some tasks using both hands – depending on the situation or their mood). All participants used the mouse with the right hand – also the left-handed – for the same reasons as the German and Polish native speakers did. Some participants who filled in that they are right handed stated that they had to change their handedness for writing.

All the participants were born and grew up in the English speaking country (33 in the United Kingdom and one in Canada). One participant was bilingual German-English. However, the participant stated that English is her dominant language.

5.9.3 Results for questionnaire study: identifying sides by English native speakers

In the last part of the participant's questionnaire, also all English native speakers were asked to assign sides to a cupboard (see 5.83). The pictures matched the situations from the mouse tracking. Again here, for the first question, the cupboard was placed canonically (with the front to participants) and in the second, non-canonically (with the back to the participants) – as in the 5.83.



(a) (b)

Figure 5.83: The images show pictures of the cupboards viewed canonically (with the front – on the left) and non-canonically (with the back – on the right) from the survey

Canonically positioned cupboard

a. Front side
b. Back side
c. Right side

d. Left side

Non-canonically positioned cupboard

e. Front side
f. Back side
g. Right side
h. Left side.

Results of the survey show that all English native speakers identified the *front* and *back* referring to the outside perspective in the spatial relation with canonical positioned cupboard. Around 91% of the English participants assigned the *right* and *left* side also referring to the outside perspective in the constellation. It is important to emphasize that in this situation the outside perspective of the intrinsic reference frame coincide with the reflection / facing strategy of the relative reference frame. This result is by 9% more frequently than the Polish native speakers, 1% than the German and 24% than the Italian native speakers.

In the spatial relation with the non-canonical positioned cupboard, around 82% assigned the *front* and *back* regarding the outside perspective. This is around 6% less than the Polish as well as the Italian participants and 15% than the German. Approximately 47% chose the outside perspective for the identification of the *right* (g) and *left* (h) side of the non-canonical positioned cupboard. This is by about 1% less frequently than the Polish, 16% more than Italian and 22% less than the German native speakers.

All in all, 41% of the English native speakers (this is 3% less than the Polish and 21% less than German) assigned the sides to the cupboard with regard to the outside perspective consistently and only two participants identified the sides of the cupboard according to the inside perspective of the intrinsic frame of reference consistently. This result points out that the *front* and *back* is significantly stronger recognized as intrinsic than the *right* or *left* side of the vis-à-vis object (as in this case – cupboard).

The table below shows in detail participants' responses to the canonically and non-canonically positioned cupboard in the questionnaire (Vorderseite: "front side," Rückseite: "back side," Rechte Seite: "right side," Linke Seite" "left side").

A very important question which arises at this point is: do the answers here match the answers of the simple spatial relations of the mouse tracking? This task clarifies how English native speakers recognize and perceive a cupboard (spatially) in the simple spatial situation, as well as how participants perceive the relations between the objects in spatial relations with a cupboard. Similar to the analysis on the German, Polish, and Italian, the following sub-sections include a step-by-step analysis of the cupboard as a reference object:

ID	q11_a	q11_b	q11_c	q11_d	q12_e	q12_f	q12_g	q12_h
98	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
99	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
100	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
101	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
102	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
104	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
105	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Rechte Seite	Linke Seite
106	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
107	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
108	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
109	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
111	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
112	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
114	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
115	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
116	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
117	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
118	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
119	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
120	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
121	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
122	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
123	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
124	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
125	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
126	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite
127	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
128	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
129	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
130	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
131	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
132	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Vorderseite	Rückseite	Linke Seite	Rechte Seite
133	Vorderseite	Rückseite	Rechte Seite	Linke Seite	Rückseite	Vorderseite	Linke Seite	Rechte Seite
134	Vorderseite	Rückseite	Linke Seite	Rechte Seite	Vorderseite	Rückseite	Rechte Seite	Linke Seite

Figure 5.84: Questionnaire: Assignment of sides to the canonically (a-d) and non-canonically (e-h) positioned cupboard

- Clarification questionnaire – assignment of only the sides to the cupboard as representative of vis-à-vis objects (above)
- Questionnaire – dynamic spatial relations with the cupboard as a reference object (below – in the 5.9.4.3)
- Mouse tracking – simple static situations with the cupboard as a reference object (below, 5.9.4.2.1.2)
- Mouse tracking – complex static situations with the cupboard as a reference object (below, 5.9.4.2.1.2).

5.9.4 Results for mouse tracking study: interpretation of spatial relations by English native speakers

Similar to the previous analyzed languages, also for English first I report the results for the categorical answers with respect to the experimental design. In the section detailed data analysis, I run a detailed data analysis for each particular spatial relation (see 5.9.4.2.1.1, 5.9.4.2.1.2, 5.9.4.2.2.1). In the detailed analysis, I assess whether the results confirm the hypotheses.

Similar to the analysis of the German, Polish, and Italian data, several Fisher's exact tests were conducted for the categorical responses and linear mixed models, as well as ANOVAs for the differences and similarities of the continuous measures of the trajectories. All statistical tests and visualizations – bar- and trajectory plots – were computed using the software R (R Development Core Team, 2017).

For the computation, I used additional packages: ggplot2 (Wickham et al., 2013), lme4 (Bates et al., 2014), shiny (Chang et al., 2015), shinyjs, data.table, tidyr (Wickham, 2017), gridExtra (Auguie, 2017), and purrr (Henry and Wickham, 2017).

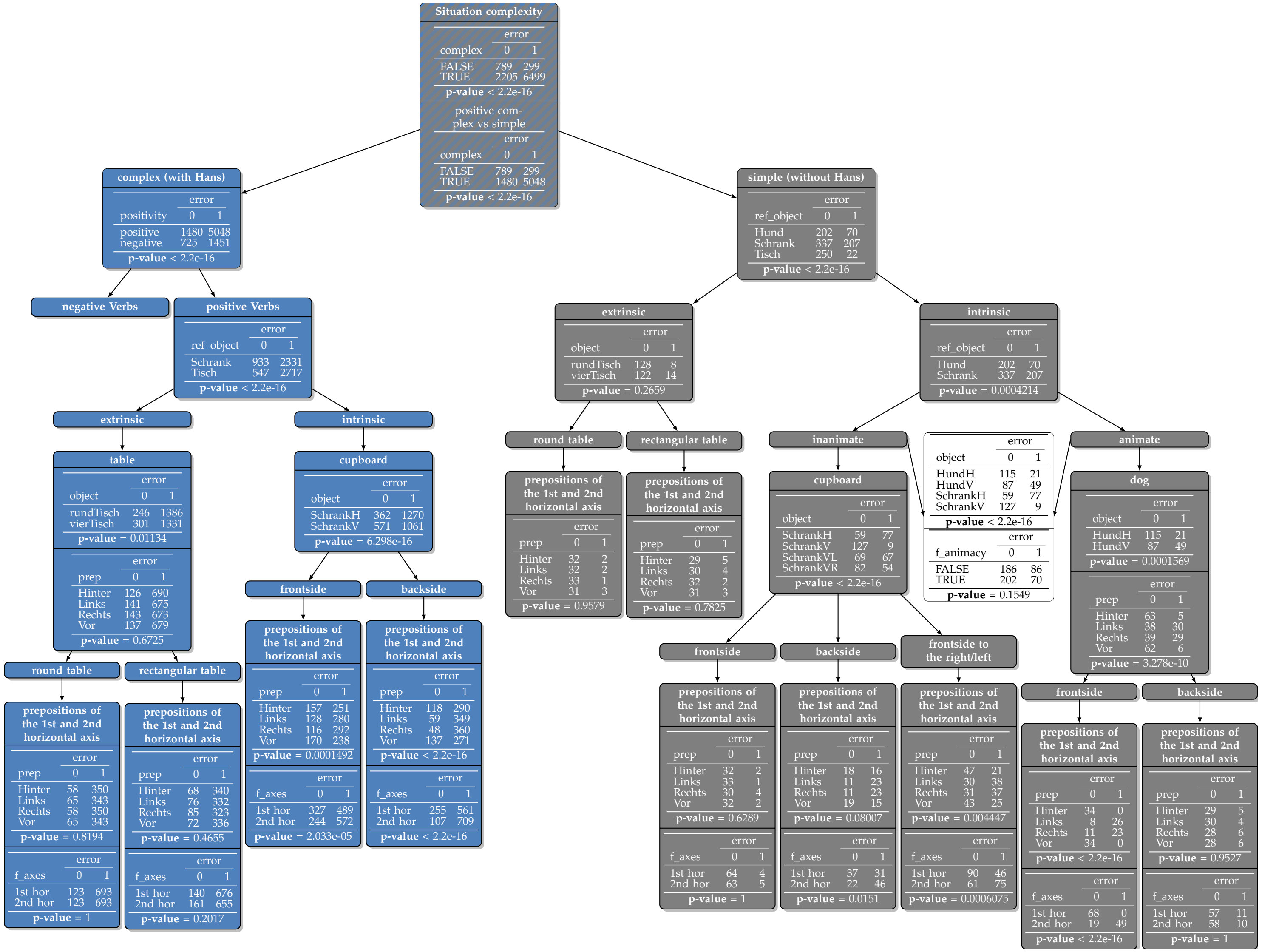


Figure 5.85: Computation of statistical analyses for categorical answers in English with respect to the experimental design

5.9.4.1 Computation of statistical analysis for categorical answers in English with respect to the experimental design

As for all another native speakers for the English native speakers, I created a chart with the statistical analyses between the particular categories too. 5.85 shows both the setup of the entire experiment and the calculation of statistical analysis for the categorical answer choices made by English native speakers each situation. This part of the work highlights which factors resulted in categorical significance and which did not. As with the other languages, the analysis for English is conducted top-down following the graph's structure. Furthermore, the method of computation is the same: first, I compare the *correctness* with respect to a particular perspective, taking for the interpretation the particular spatial relations. For the extrinsic spatial relations, this means independently of the relations' complexity (with the round and rectangular tables, I defined the reflection / facing strategy from participants' point of view as *correct*). That means that the assumption applies to all spatial constellations with tables, both with and without Hans.

However, for the complex intrinsic spatial relations, I assumed the outside perspective of the intrinsic frame of reference independent of the position of the reference object and Hans. The same assumptions apply for the simple relations with a cupboard.

For the spatial relations with the dog, I assumed the inside perspective of the intrinsic reference frame, which also applies for humans.

Furthermore, the chart supports the analysis of null hypotheses *one*, *two*, and *three* (see 5.3). Null hypothesis *4* was defined for analysis between all languages and cannot be analyzed on the basis of the results in the chart only.

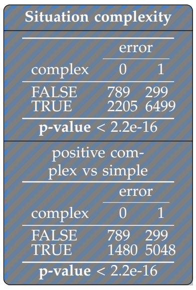


Figure 5.86: Computation of statistical analyses for categorical answers in English with respect to the complexity of spatial relation

First, I explored the categorical answers for all simple and complex spatial relations to investigate the influence of complexity in general. For the situation's complexity as a factor, I have found that it influences the interpretation by the English native speakers very strongly ($p < 0.0001$). Furthermore, this result is similar for both positive complex situations and simple situations ($p < 0.0001$). As with the same results for German, Italian and Polish, the English results also allow to reject the first null hypothesis, *The presence of a third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift*, and confirm the alternative hypothesis, *The presence of the third person as artificial agent in a spatial relation expressed by indirect speech affects an origo shift*.

complex (with Hans)

	error	
positivity	0	1
positive	1480	5048
negative	725	1451
p-value < 2.2e-16		

Figure 5.87: Computation of statistical analyses for categorical answers in English with respect to the verb semantic

As with the German, Polish and Italian participants, also with the English participants within the complex spatial relations, the high significance applies between the complex spatial relations embedded by positive and negative predicates. This result is caused by the perspective shift from the participants' to Hans' point of view (compare this with the detailed analysis of particular situations below – 5.9.4.2). Therefore, the second null hypothesis can be rejected ($p < 0.0001$): The interpretation of dimensional spatial expression does not depend on the semantics of embedding predicates, and the alternative hypothesis can be confirmed: The interpretation of dimensional spatial expression depends on the semantics of embedding predicates.

positive Verbs

	error	
ref_object	0	1
Schrank	1036	3572
Tisch	511	4097
p-value < 2.2e-16		

Figure 5.88: Computation of statistical analyses for categorical answers in English (complex spatial relations embedded by verbs of positive semantics)

Moreover, I found very strong significant differences within the groups. First, I conducted the statistical analysis for all complex positive situations (and I focus only on this here) – independent on the reference object: cupboard or table and the position of Hans with respect to the reference object – relative to the right or left of the particular object. The results reveal a *p-value of* < 0.0001, which is similar to the data on the German, Polish and Italian language.

To provide further detail for this result, I undertook a more detailed analysis which found that the English native speakers interpreted the intrinsic spatial relations with the cupboard *correctly* more frequently – that is, along the outside perspective than with the relations with the tables – along the expected reflection / facing strategy from participants' point of view ($p < 0.0001$, this also applied for the Polish, German and Italian native speakers as shown above). This points out that the English native speakers shifted the origo from themselves to Hans' point of view and interpreted the complex spatial relations from his point of view significantly more frequently in situations with an extrinsic than with intrinsic reference object. Furthermore, this implies that the objects' properties play an important role for the English participants because they shift the perspective to Hans' point of view more frequently with extrinsic objects than with intrinsic ones. However, intrinsicality is not a strong enough property for the participants to concentrate only on intrinsicality while interpreting of the spatial relations.

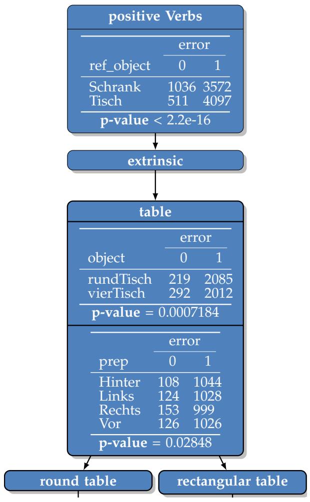


Figure 5.89: Computation of statistical analyses for categorical answers in English (extrinsic complex spatial relations embedded by verbs of positive semantics)

Analyzing the answers for the positive spatial relations in greater depth, we can see that there is significant difference ($p \approx 0.0008$) between the complex spatial relations with the round and rectangular table. This result indicates that the shape of the tables significantly influences the interpretative strategy of the participants. As for the three previous languages (German, Polish and Italian), within the extrinsic tables, I conducted further analysis to understand the semantical differences and similarities between the particular spatial expressions. The results for English native speakers reveal that participants selected significantly different interpretative strategies depending on the prepositions ($p < 0.03$) for both tables taken together. Furthermore, the results show that the English native speakers interpreted the complex extrinsic spatial relations most frequently with respect to the reflection / facing strategy from their point of view in relations with the bottle *to the right of the table* (from their point of view). In contrast, they selected the reflection / facing strategy less frequently with the bottle *behind the table* (from their point of view).

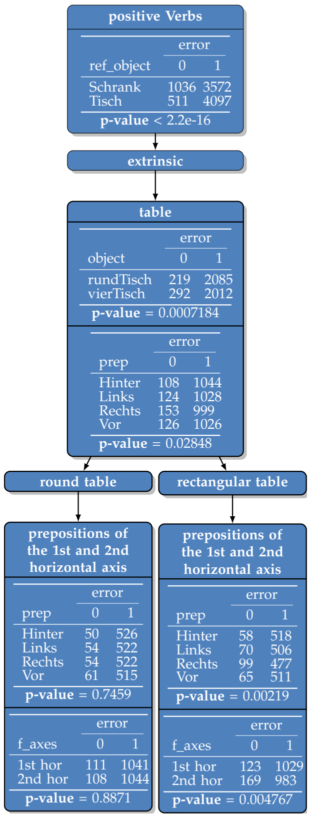


Figure 5.90: Computation of statistical analyses for categorical answers in English (extrinsic complex spatial relations: round vs. rectangular table)

In the last step, I examined whether the shape of the table influences the interpretation of the particular extrinsic complex constellations. The separate analysis of the particular situations with either the round or rectangular table showed significant differences for rectangular table ($p > 0.0022$) and no significant differences for the round table ($p > 0.23$) separately. In the constellations with both tables (considering the situations individually), the fewest participants interpreted the spatial relations with the bottle *behind* the table with respect to the reflection / facing strategy from the participants' point of view. However, there is a difference according to the most frequently chosen answer.

I also found several significant differences for the complex intrinsic spatial relations for the English native speakers. The first very general result of the canonically and non-canonically positioned cupboard revealed very high significant differences ($p < 0.0001$). These indicate that English native speakers interpret more frequently the spatial relations with canonically than non-canonically positioned cupboard in relation to the outside perspective. However, it is important to stress that in the canonical relations too, considerably more English native speakers shifted the origo to Hans and interpreted even the canonical spatial relations from Hans' point of view with respect to the reflection / facing strategy of the relative frame of references.

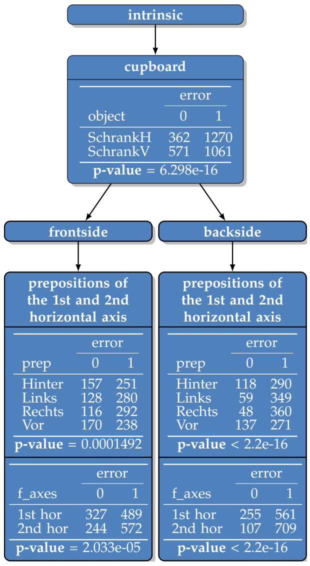


Figure 5.91: Computation of statistical analyses for categorical answers in English (intrinsic complex spatial relations)

As with Italian native speakers, the results of the simple spatial relations (without Hans) indicate very high significant differences with respect of the above-defined *correctness* ($p < 0.0001$) in general. Considering the general result in more detail, it can be recognized that the English native speakers interpreted the spatial relations within the expected strategy less frequently – the outside perspective with the cupboard. This result is followed by the dog and this by the table. These results indicate that the objects' properties influence the interpretation of spatial relations by native speakers of all four examined languages. They are more constant when interpreting the spatial relations with the extrinsic reference objects, which cannot be positioned canonically or non-canonically. The exactly differences between languages are discussed in 5.9.4.2 below.

simple (without Hans)

ref_object	error 0	error 1
Hund	202	70
Schrank	337	207
Tisch	250	22
p-value < 2.2e-16		

Figure 5.92: Computation of statistical analyses for categorical answers in English (simple spatial relations)

As with the Italian data, analyzing the simple extrinsic spatial relations on the basis of the English data, the results show no significant differences between the interpretation of the extrinsic spatial relations with a round or rectangular table ($p > 0.26$). This means that, with regard to the simple spatial relations with a table, the shape of the reference object does not influence the interpretation of particular spatial relations by the English native speakers. For simple extrinsic spatial relations, neither did I find any significant differences between the individual constellations ($p \approx 0.96$ for round table and $p \approx 0.78$ for the rectangular table). This result also resembles the outcome for the complex spatial relations – supplemented by Hans (s. a.).

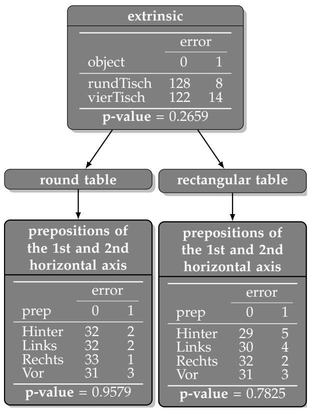


Figure 5.93: Computation of statistical analyses for categorical answers in English (simple extrinsic spatial relations)

In contrast to the extrinsic spatial relations, the simple intrinsic relations revealed very high significant differences ($p \approx 0.0004$) for English native speakers – as with the Polish, Italian and German data. In contrast to the extrinsic reference objects, the intrinsic reference objects were localized in different ways on the pictures (canonical vs. non-canonical) and they also differ in the shape, animacy status and functionality. The outcome points out in general, significantly more frequent interpretations according to the intrinsic reference frame in spatial relations with the dog than with the cupboard.

However, considering the data in more detail, we can find explanations for the more general result.

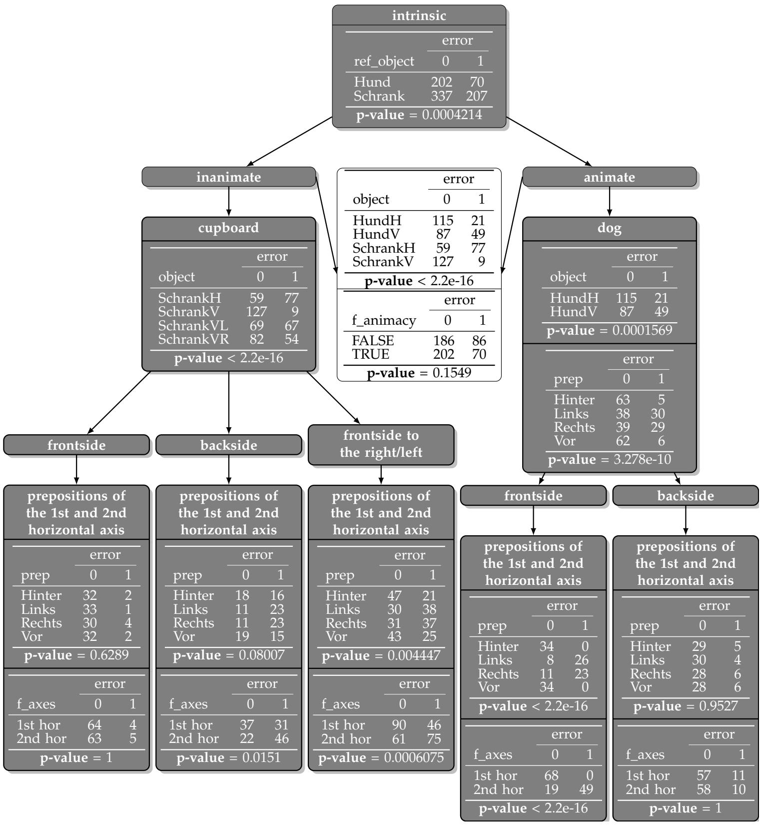


Figure 5.94: Computation of statistical analyses for categorical answers in English (simple intrinsic spatial relations)

For spatial relations with an inanimate intrinsic reference object, the cupboard (positioned in different ways), the results also indicate a high significant difference ($p < 0.0001$).

This is caused by the fact that, in almost all situations, the participants interpreted the spatial relations with the canonically positioned cupboard according to the outside perspective, as expected for relations with the cupboard as reference object. However, this result points out that the English native speakers identify sides of the cupboard in different way that they interpret the spatial relations with the cupboard as reference object (see 5.9.3). For instance, more English native speakers used the outside perspective for the interpretation of *to the left of* in the mouse tracking study than during the side assignment to the cupboard in the questionnaire study.

Furthermore, in all situations with the non-canonically positioned cupboard, I found deviations from this interpretation. It is interesting that most deviations were evidenced for the cupboard with its back to the participants, where only 59 out of 136 answers conforming to the outside perspective were selected. This is even less than with the cupboard with the front to the left (69) or right (82). For the canonically (front) vs. non-canonically (back) positioned cupboard, I obtained for the results of English participants a very high significant difference too ($p < 0.0001$).

To conduct the analysis in greater detail, I also examined the answers for the individual positions with respect to the canonically and non-canonically positioned cupboard. The results showed:

a) No significant differences for the canonically positioned cupboard ($p > 0.62$). However, there was no spatial relation which was interpreted by all English participants in the same way. Nonetheless, almost all English participants investigated interpreted the four spatial relations with the bottle *in front of*, *behind*, *to the right of*, *to the left of* the cupboard with regard to the outside perspective. Similar to the Polish and Italian native speakers, the English participants deviated from this strategy with the bottle *to the right* most frequently.

b) No significant difference ($p > 0.08$) for the non-canonically positioned cupboard (with the back to the participants). Here, the English native speakers most frequently selected the answer according to the outside perspective with the bottle *behind* and *in front of* the cupboard. In contrast, the English native speakers deviated from the outside perspective with the bottle *to the right* and *left of* the cupboard most frequently ($23 \approx 68\%$).

c) The results for the English participants revealed significant differences ($p > 0.0004$) for the non-canonically positioned cupboard (with the front to the right / left from participants' point of view). Considering the both relations in greater detail, I found significant differences between the individual situations ($p \approx 0.004$). Around 70% of the English participants selected the outside perspective with the bottle *behind* and approx. 63% *in front of* the cupboard. In contrast, only around 45% chose the strategy with the bottle *to the right* or *to the left of* the cupboard.

Animacy (cupboard with front / back vs. dog with front / back) generated overall statistical significance (s. a. $p < 0.0001$). For the individual positions, the results revealed differences too. The largest differences between the dog and the cupboard as reference objects are visible for the interpretation with the bottle *behind* the reference object (62 *correct* answers for the dog vs. 51 for the cupboard). However, the largest differences between the dog positioned canonically / non-canonically and the cupboard positioned canonically / non-canonically individually as reference objects are visible for the interpretation with the bottle *to the right* and *left of* the canonically positioned objects. A Fisher's exact test revealed large significant differences between both objects and positions ($p < 0.001$). In contrast to the Italian data, significant differences were found in categorical judgments for the second horizontal axis (*to the right of* vs. *to the left of*, $p < 0.0016$) and no for the first horizontal axis. It also applies for the canonical positioned reference objects (p < 0.0001). For the non-canonically positioned reference objects, a Fisher's exact test revealed significant differences for animacy and both positions (*to the right* vs. *left of*), with $p < 0.0001$. This also applies to the first horizontal dimension (*in front of* vs. *behind*) and both reference objects. With the statistical analysis, the third null hypothesis can be rejected for the English participants too: The animacy of relata does not affect the interpretation of spatial relations.

Considering animate spatial relations, the results indicate significant differences for the interpretation of spatial relations with a canonically and non-canonically positioned dog ($p < 0.0001$). It also applies for the all three previous analyzed languages. Similar to German, Italian and Polish native speakers, English participants also interpreted the spatial relation with the non-canonically positioned dog more frequently according to the intrinsic frame of reference than with the canonically positioned one (in contrast to the cupboard). Analyzing the data in further detail, the results indicate significant differences within the individual spatial positions with respect to the canonically positioned dog ($p < 0.0001$). The differences are due to the more frequently intrinsic interpretation of *in front of* and *behind*. English participants do not reveal any significant differences between the individual positions of the bottle with respect to the non-canonical positioned dog ($p > 0.9$). In the four spatial relations with non-canonical positioned dog, most English participants selected the answers according to the intrinsic perspective, which coincides with the reflection / facing strategy of the relative frame of references here.

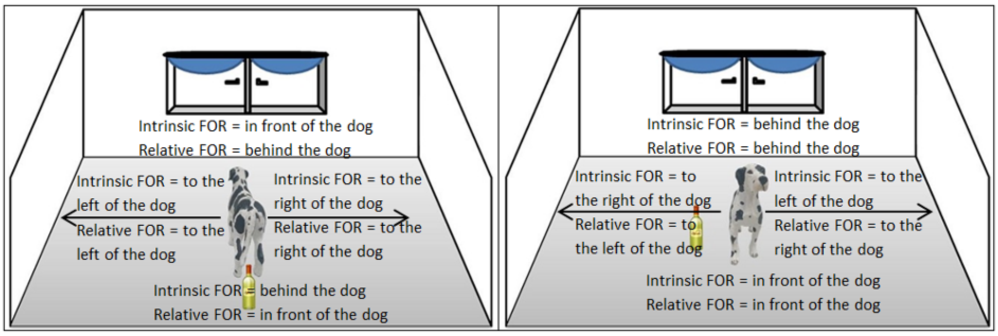


Figure 5.95: Assignment of the regions to the dog according to the frames of reference

5.9.4.2 Detailed data analysis

5.9.4.2.1 First null hypothesis

5.9.4.2.1.1 Analysis of simple and complex extrinsic spatial relations

Round table

The results of the barplots and trajectories show few deviations for the English native speakers. In contrast to the outcomes of Italian native speakers, the normalized trajectories on the mouse tracking plots are almost ideal. Considering the results in greater details, the participants investigated had fewer problems with the interpretation of the spatial relations when the bottle was located behind or to the left of rather than in front of the round table (see mouse trajectories). The small difference is also reflected by categorical responses (see bar plots). The English native speakers were less frequently consistent in case of the bottle in front of the round table (31 ≈ 91%) and most with the bottle to the right of (33 ≈ 97%) the round table. When the bottle was located to the left of or behind the table, 32 (≈ 94%) participants selected the reflection / facing

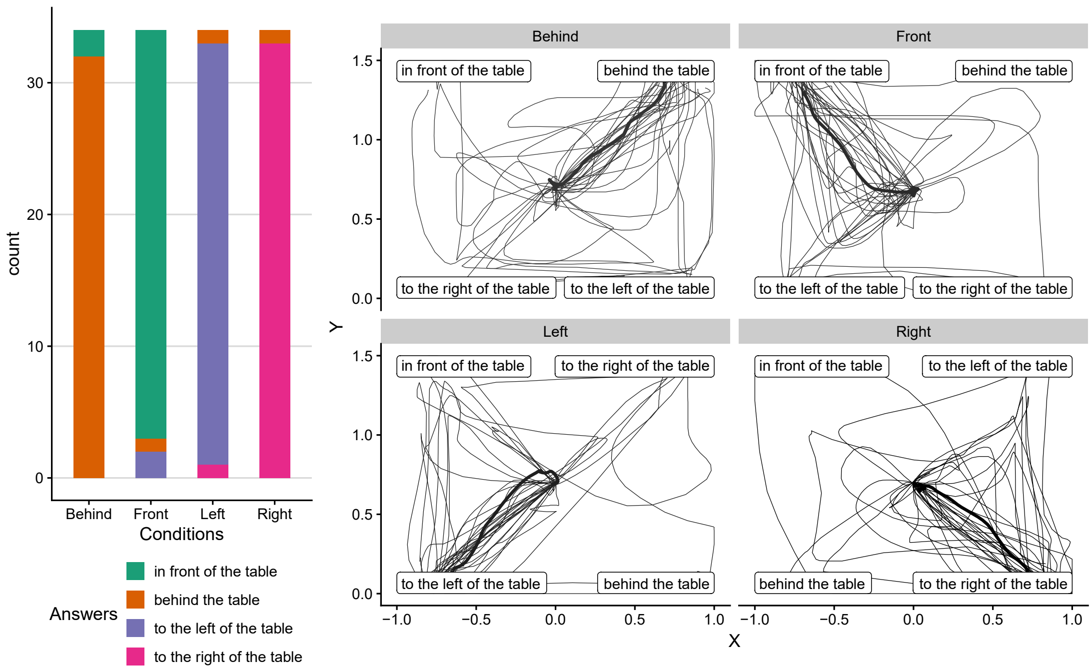
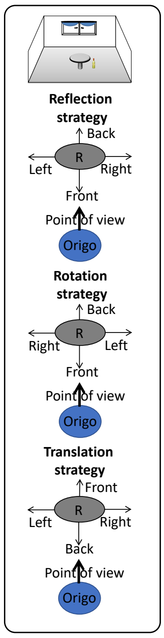


Figure 5.96: Answers for the simple extrinsic relation with round table: barplots with answers (left) and trajectories through the response with the mean trajectories (right)

strategy. All in all, only few participants deviated from this interpretations' way in the simple spatial relations with the round table.



These results differ from the Italian one, where up to 20% decided against the reflection / facing strategy. However, the outcome of the English native speakers investigated resemble the data of German and Polish native speakers, where between 90 and 98% selected the reflection / facing strategy.

For English native speakers, the differences can be also hardly visibly on the MAD.abs and AUC.abs values as well as on the X- and Y- flips. The highest MAD.abs value amounts to ≈ 0.36 and relates to *in front of* and *behind*. Those are immediately followed by *to the right of* with MAD.abs of ≈ 0.34. The lowest MAD.abs was computed for the spatial expression *to the left of* with MAD.abs ≈ 0.32 (as for Italian native speakers). In contrast to the Polish data, the results for the English participants demonstrate no significant result ($p > 0.57$) for the maximal absolute deviation between the dimensional spatial expressions of the first and second horizontal axis. Also the MAD.abs results between all positions individually have not showed any significance ($p > 0.72$). The computation also applied for the Italian participants.

As with the Italian data, also the AUC.abs results cannot be considered in terms of the axes. The highest result, ≈ 0.24, was achieved for the spatial relation with the bottle *behind* the table and the lowest for the bottle *to the left of* the reference object, with ≈ 0.14. Neither the results between the axes nor between the individual positions revealed significance ($p > 0.35$ between axes and $p > 0.12$ between the particular positions).

For all complex spatial relations, the outcomes for the English native speakers showed very clearly that verb semantics influenced the interpretation, as occurred with the German, Polish, and Italian languages.

The results for the complex spatial relations showed very clearly for *behind* (from the participants' point of view) that verb semantics influences the choice of answer. In the positive situations (with verbs of positive semantics), most participants (between 25 and 29) selected the reflection / facing strategy. However, within the positive verbs too, some differences can be observed with the most constant result for *know* and the less for *believe* (in terms of *correctness*). It indicates that the choice of the reflection / facing strategy in positive complex relations has not changed much (from $\approx 94\%$ to between $\approx 74\%$ and 91%) in comparison to the simple spatial relations without Hans. Furthermore, it also demonstrates that the participants investigated shifted the origo to Hans and considered the spatial relations from the artificial agent's point of view.

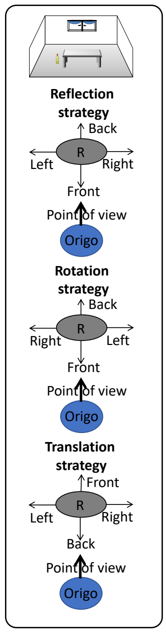
Furthermore, for the preposition *in front of*, I found that verb semantics influenced the interpretation of the spatial relation. In the situations described by the verbs with negative semantics, a maximum of 38% of the participants selected the answer aligned with the reflection / facing strategy from Hans' point of view (min. 29%). The English native speakers showed also several deviations in the spatial relations described by the verb of positive semantics. Between 25 and 29 English participants investigated chose the reflection / facing strategy interpretation in complex relations supplemented by Hans. This means that the choice of the reflection / facing strategy in positive complex relations has not varied considerably (from ≈ 91% to between ≈ 74% and 85%) in comparison to the simple spatial relations without Hans. Furthermore, it also points out that of all these participants, 74-85% shifted the origo to Hans and interpreted the spatial relations from his point of view using the reflection / facing strategy.

For the preposition *to the right of*, I have also found that verb semantics influences the interpretation of the spatial relation. In contrast to the Italian data, the results for the second horizontal axis are not proportional less than for the spatial expressions of the first horizontal axis (*in front of* and *behind*). In the situations described by the verbs with negative semantics, a maximum of 38% of participants selected the answer aligned with the reflection / facing strategy from Hans' point of view (minimum of 18%). Few variations can be also seen in the spatial relations described by positive verbs. Between 24 and 29 English native speakers shifted the origo to Hans and chose the reflection / facing strategy interpretation in complex relations supplemented by Hans and described by positive verbs. This means that the choice of the reflection / facing strategy in positive complex relations has considerable changed (from ≈ 97% to between ≈ 71% and 85%) in comparison to the simple spatial relations without Hans.

Finally, verb semantics also influenced the interpretation of the spatial relations with the bottle *to the left of* the table (from the participants' point of view, with respect to the reflection / facing strategy). In situations with a positive verb, between ≈ 71% and ≈ 82% of the English native speakers shifted the origo to Hans and selected an answer aligned with the reflection / facing strategy from his point of view. This outcome indicates that also in these spatial relations, English native speakers were considerable more constant in the simple spatial relations (≈ 94%) than in the complex supplemented by artificial agent and embedded by indirect speech.

Considering the AUC.abs and MAD.abs, the results indicate some differences. The lowest MAD.abs was found for the verb *reckon* with Hans to the left of and the bottle *in front of* the table, with ≈ 0.28. In contrast, the highest value for MAD.abs was found for *say* with Hans to the right and the bottle *in front of* with ≈ 0.59. In contrast to the Italian results, results of the English participants (similar to the Polish one) reveal significance aligned to the position of Hans with respect to the reference object ($p \approx 0.001$) but no for the particular positions of the bottle ($p > 0.59$). Also the AUC.abs results did not show any significance between the positions of the bottle but it revealed a strong significance between the positions of Hans ($p \approx 0.001$).

Rectangular table



In contrast to the spatial relations with the round table, the results of the barplots and trajectories show some deviations for English participants investigated interpreting the spatial relations with rectangular table. Similar to the Italian data, the outcomes of the English native speakers show the most inconsistency for the spatial constellation with the bottle *behind* the reference object – from participant's point of view. About 85% chose the interpretation aligned the reflection / facing strategy. In contrast, the most consistent spatial relation turned out to be with the bottle *to the right of* the table with more than 94%. These participants selected the answer regarding the reflection / facing strategy. As for the Italian data, *in front of* and *to the left of* attained almost the same score, with 31 ($\approx$ 91% *in front of*) and 30 ($\approx$ 88% *to the left of*) for the English participants.

With respect to the trajectories and to the MAD.abs and AUC.abs values, few differences between the particular situations were found. The lowest MAD.abs $\approx$ 0.42 was found for the bottle *to the right of* the rectangular table and the highest of $\approx$ 0.60 for *to*

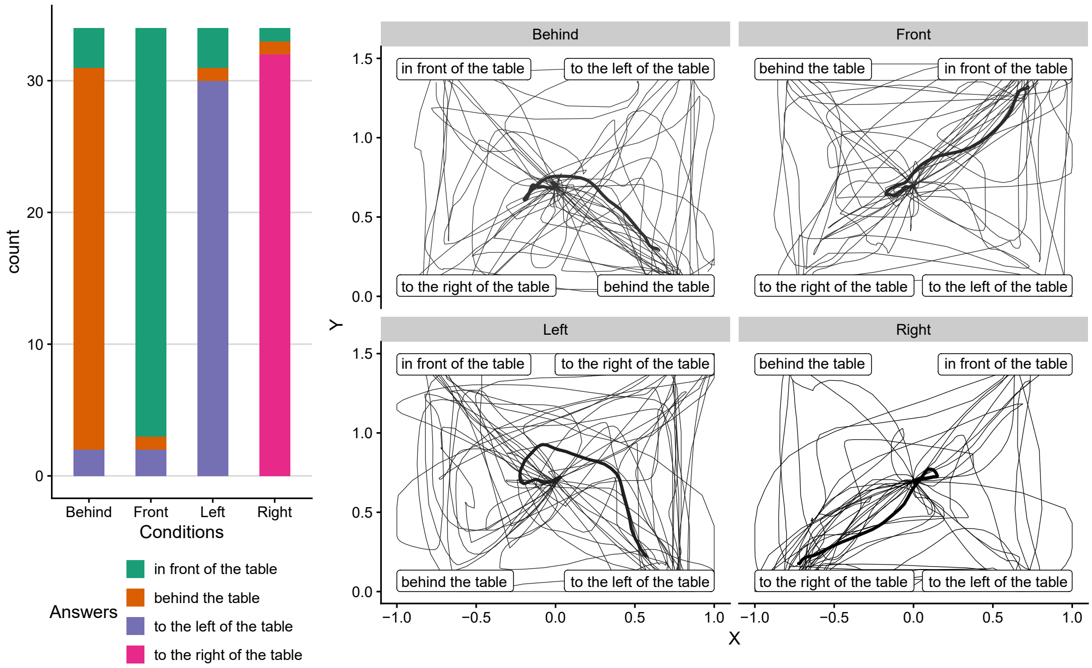


Figure 5.97: Answers for the simple extrinsic relation with rectangular table: barplots with answers (to the left) and trajectories through the response with the mean trajectories (to the right)

the left of (as for the Italian participants). This order applies for the AUC.abs values too. The lowest value amounts to ≈ 0.23 for *to the right of* and the highest to ≈ 0.43 for *to the left of.* The MAD.abs results haven not revealed neither significant differences between the all spatial relations (with p ≈ 0.23) nor between the axes (p ≈ 0.72). For the AUC.abs I have found any significant difference neither between the four particular spatial relations ($p > 0.11$) nor between the axes ($p > 0.34$).

As with the results for the Polish and Italian data, neither the aggregated AUC.abs nor the MAD.abs for the English results can be considered in terms of the axes or one of the models for the perception of axes by Franklin and Tversky (1990), i.e., spatial framework, equiavailability, mental transformation.

For all complex spatial relations with both the rectangular and the round table, the outcomes for the English native speakers showed very clearly that verb semantics influenced the interpretation.

In the spatial relation with the bottle *in front of* the rectangular table (from the participants' point of view according to the reflection / facing strategy), the verb semantics of the embedding predicates influenced the interpretation of the specific relations very clearly. In spatial constellations embedded with a semantically positive verb, most participants, between 24 and 28 – depending on the relation – selected the reflection / facing strategy from Hans' point of view. The highest score reached the situations described with the verb *believe*, with 28 – independent of the position of Hans (to the right or left of the reference object). In the simple spatial relation without Hans, 31 English native speakers selected the reflection / facing strategy. This demonstrates that for some complex situations, the interpretation in relation to the reflection / facing strategy decreased in comparison to the simple one (from ≈ 91% to ≈ 71% and ≈ 82%).

Considering the AUC.abs and MAD.abs, the results indicate some differences like for the other languages investigated. The lowest MAD.abs value was found for the verb *reckon* and Hans to the right of the table (≈ 0.22), and the highest value was found for the spatial relation described by *say* and Hans to the right of the table. Nonetheless, the results do not reveal any significant differences between verbs ($p > 0.57$), axes ($p > 0.19$) or positions of Hans ($p > 0.06$).

In the spatial relation with the bottle *behind* the rectangular table from the participants' point of view with respect to the reflection / facing strategy, the positive vs. negative verb semantics of the embedding predicates also influenced the interpretation of the specific relations. In spatial constellations embedded with a semantically positive verb, most participants, between 23 (≈ 68%) and 28 (≈ 82%), depending on the relation – selected the reflection / facing strategy from Hans' point of view. This indicates that participants choose the reflection / facing strategy in positive complex relations almost as often as in the simple spatial relations without Hans (≈ 68% and 82% for complex situations vs. ≈ 85% for simple spatial relations).

As for the most spatial relations until now, also the AUC.abs and MAD.abs values indicate some differences for the interpretation of the complex spatial relation with the rectangular table and Hans to the right or left of it. The lowest score was found for the verb *believe* with Hans to the left (≈ 31). In contrast, the highest MAD.abs value revealed the MAD.abs for the combination of the verbs *believe* (again) and the position of Hans to the left of the table (≈ 0.58) and *say* with Hans to the left (≈ 0.57). However, the results did not reveal any significant differences between verbs ($p > 0.57$) or positions of Hans ($p > 0.06$).

For the preposition *to the right of*, I found that the verb semantics influenced the interpretation of the spatial relations. There was a clear difference between semantically positive vs. negative verbs. In the situations described by the semantically negative verbs, a maximum of 35% of participants selected the answer that employed the reflection / facing strategy from Hans' point of view (minimum 26.5%). However, most English native speakers chose the reflection / facing strategy interpretation in complex relations that contained Hans and were described by semantically positive verbs (between 24 and 29 speakers). This means that the presence of Hans caused speakers to choose the reflection / facing strategy from his viewpoint in positive complex relations significantly less (from ≈ 94.1% to between ≈ 71% and 85%) than in situations without Hans.

Considering the AUC.abs and MAD.abs, the results for the spatial relations with the bottle *to the right of* the rectangular table from the participants' point of view also show numerous differences. The lowest MAD.abs value was for the spatial relation embedded by the verb *say* with Hans positioned to the left of the table (≈ 0.31). The highest MAD.abs value amounts to ≈ 0.42 and applies to spatial relation with the bottle and Hans *to the right of* the table. This situation was embedded with the verb *reckon*. The results revealed neither significance between the verbs ($p \approx 0.61$) nor between the positions of Hans ($p > 0.23$).

In addition, I saw that the verb semantics influenced the interpretation of the spatial relation for the preposition *to the left of*. In the spatial relations described by semantically negative verbs, a maximum of 44% (min. 35%) of participants selected the answer aligned with the reflection / facing strategy from Hans' point of view. This is by about 20% more than Italian native speakers. However, for situations embedded with semantically positive verbs, almost all English native speakers decided on the reflection / facing strategy interpretation from Hans' point of view (between 68% and 85%). This means that the reflection / facing strategy is chosen less frequently in situations with positive complex relations (from ≈ 88.2% to between ≈ 68% and 85%) than in simple spatial relations without Hans.

The AUC.abs and MAD.abs results for the spatial relations with the bottle *to the left of* the rectangular table from the participants' point of view also show some differences. The lowest MAD.abs applies to the spatial relation embedded with the verb *believe* and

Hans positioned to the right of the table (≈ 0.27). In contrast, the highest MAD.abs value, amounts to ≈ 0.48 and applies to the spatial relation embedded with the verb *believe* but with Hans and bottle to the left of the table. The English results approached significance neither between the verbs ($p > 0.076$) nor between the positions of Hans ($p > 0.29$).

5.9.4.2.1.2 Analysis of simple and complex intrinsic spatial relations

Cupboard with the front side to the participants

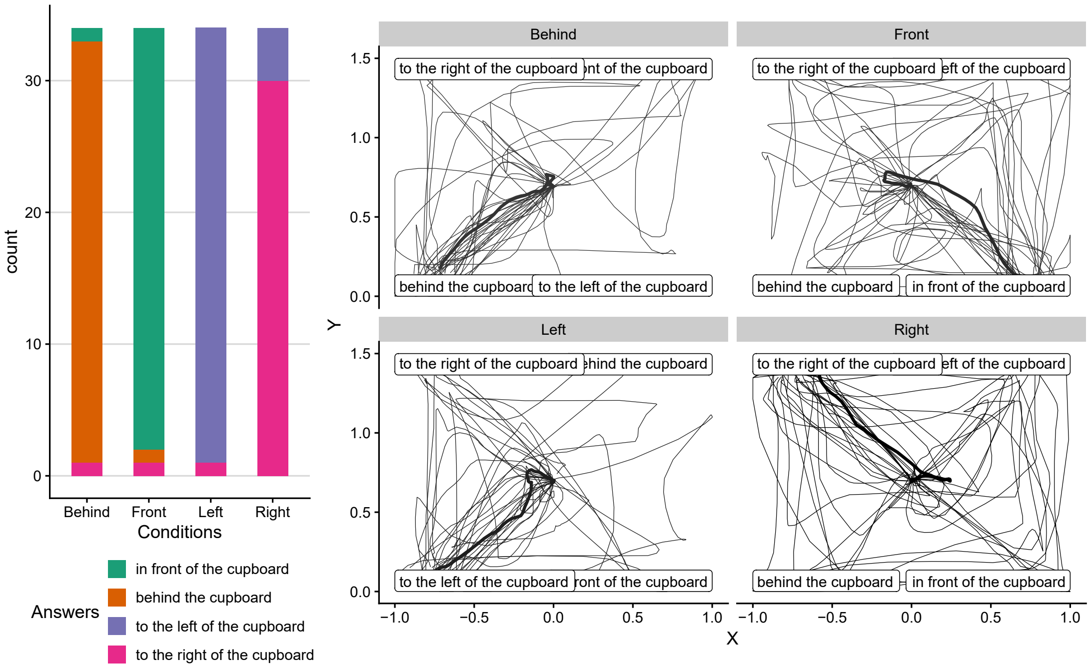
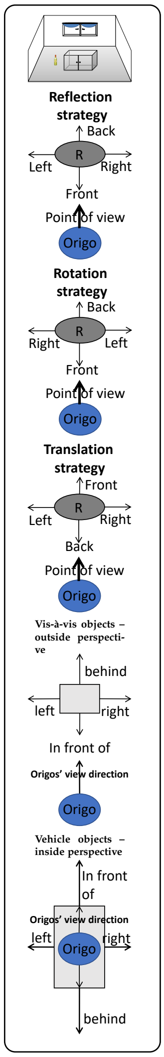


Figure 5.98: Answers for the simple intrinsic relation with cupboard: barplots with answers (left) and trajectories through the response with the mean trajectories (right)

As with the data on the German and Polish participants and in contrast to the Italian participants, the results for the English participants do not demonstrate several differences in how situations with the canonically positioned cupboard are interpreted using the outside perspective: both spatial expressions of the first horizontal axis (*front-back*) were interpreted by approx. 94% English native speakers with respect to the outside perspective. Almost all English native speakers interpreted the spatial relations with the bottle *to the right* and *left of* the cupboard in the meaning of the outside perspective



($\approx$ 97% for *to the left of* and $\approx$ 88% for *to the right of*). The outcomes neither show significant difference between the axes (p $\approx$ 1) nor the individual positions of the bottle ($p > 0.6$).

It is important to stress that in this case, the interpretation would be the same for the intrinsic strategy and the reflection / facing strategy. Therefore, it is unclear whether the participants used the intrinsic reference frame (specifically the outside perspective) to interpret the situation or the reflection / facing strategy of the relative reference frame.

Comparing these results with the questionnaire results, we find only few differences between the responses. In the survey, all English participants assigned the *front* and *back* to the cupboard according to the outside perspective and the reflection / facing strategy. In the mouse tracking study, approx. 6% deviated from this interpretation.

Moreover, in the questionnaire, up to 9% of the English native speakers identified the *right* and *left* sides of the cupboard according to the inside perspective of the intrinsic reference frame. The result is between the outcome for *right* ($\approx$ 12%) and *left* ($\approx$ 3%) in the mouse tracking study. However, it points out that more English native speakers conducted a mental rotation while assigning the sides of the second horizontal axis (*right-left*) than interpreting the spatial relations with the cupboard as reference object in the mouse tracking study. This variation shows a similarity to the Italian and Polish data but a contrast to the German data.

For the continuous measure, *behind* showed the lowest MAD.abs value with ≈ 0.32. It was followed by *to the left of* with MAD.abs ≈ 0.42, *in front of* ≈ 0.48 and *to the right of* ≈ 0.50. The English participants reached the following aggregated AUC.abs values for the spatial expressions: *behind* AUC.abs ≈ 0.16, *to the left of* AUC.abs ≈ 0.19, *in front of* AUC.abs ≈ 0.32 and *to the right of* AUC.abs ≈ 0.41. The results have revealed no significant difference between the four positions of the bottle individually ($p > 0.13$) and no significance between the axes ($p > 0.3$).

Comparing the canonical situations from the survey and the mouse tracking experiment, it can be clearly recognized that the participants did not have any difficulties interpreting situations of *in front of* and *behind* using the outside perspective.

The results for the English native speakers show that that verb semantics influences the choice of answer when participants interpret complex spatial relations with the bottle *in front of* the cupboard, visible from the front.

In the positive situations (with semantically positive verbs), more than 45% of participants (between 16 $\approx$ 47% and 21 $\approx$ 62%) selected the reflection / facing strategy from Hans' point of view. This is more than 20% (between 68% and 82% participants) fewer than for the rectangular table. This difference resembles the one for the Italian participants (16%). Furthermore, this result confirms that the intrinsicality of the reference object plays an important role in the interpretation of the spatial relations – similar to the results for the previously described languages.

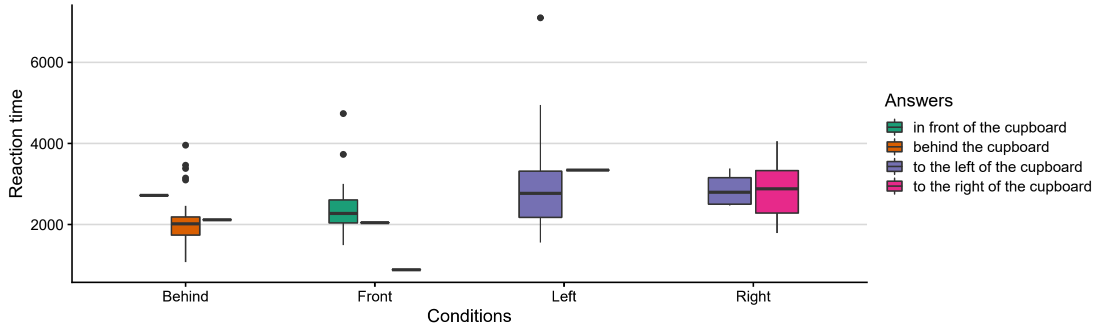


Figure 5.99: Reaction time for the spatial relations with the cupboard facing the participants

However, any differences between the semantically positive verbs cannot be observed, with the most consistent result for *claim* and *know* and Hans to the left of the cupboard. The less consistent data was also found for *claim* and *know* but with Hans to the right of the cupboard. All in all, the results show that participants choose significantly more the reflection / facing strategy in positive complex relations (from ≈ 6% to between ≈ 47% and 62%, $p < 0.0001$) than in simple spatial relations without Hans. These participants shifted the origo to Hans and used the strategy from his point of view.

The differences are also visible in the MAD.abs and AUC.abs values as well as in the X- and Y- flips. The highest MAD.abs value amounts to ≈ 0.46 for the verb *know* with Hans to the left of the cupboard. This is followed by the verbs *believe* and *reckon* (MAD.abs ≈ 0.44) with Hans on the left side of the cupboard. In contrast, the lowest MAD.abs value was computed for the verb *claim* and Hans to the right of the cupboard (MAD.abs ≈ 0.26). The results don't show any significant differences between the verbs ($p > 0.5$) nor between the positions of Hans ($p > 0.1$).

Verb semantics also influenced English native speakers' interpretation of spatial relations with the bottle behind the cupboard, visible from the front (without contribution of Hans in the picture).

In the positive situations (with semantically positive verbs), more than 35% of the participants (between 12 ≈ 35% and 22 ≈ 65%) selected the reflection / facing strategy and between 11 ≈ 32% and 16 ≈ 47% selected the outside perspective. In contrast, in the simple spatial relation almost all participants selected the outside perspective (≈ 94%). It is striking that intrinsicality plays an important role for the 47% of participants. However, within the semantically positive verbs some differences with respect to the intrinsic interpretation can again be observed: the strongest result for *know* and *claim* with Hans on the left side of the cupboard. The weakest result was found for *claim* and Hans to the right as well as *reckon* and *say* with Hans on the left.

In general, the results indicate that there was a significant increase in the percentage of responses selecting the reflection / facing strategy in positive complex relations (from $\approx 6\%$ in the simple relation to between $\approx 35\%$ and 65% in the complex constellation, $p < 0.0001$) vs. simple spatial relations without the artificial agent Hans. As in the situation above, also here shifted the participants the origo from themselves to Hans and interpreted the situation from his point of view along the reflection / facing strategy.

The variations are also reflected in the MAD.abs, AUC.abs values as well as in the X- and Y-flips. The highest MAD.abs value, amounts to ≈ 0.58 for the verbs *reckon* and Hans to the left (as with the Italian data). This is followed by the verbs *doubt* with Hans to the leftt (MAD.abs ≈ 0.46) and *think* with Hans to the right (MAD.abs ≈ 0.44). The lowest MAD.abs value was computed for the verbs *think* and Hans to the left of the cupboard (≈ 0.25), *know* and *doubt* with Hans to the right (≈ 0.25). The results do not indicate any significant difference between the verbs ($p > 0.92$) nor between the positions of Hans ($p > 0.33$).

Furthermore, in the constellation with the bottle *to the right of* the cupboard, the results for the English native speakers indicate (for to the right of align the outside perspective of the intrinsic frame of reference) that verb semantics influences the choice of answer. In positive situations (with semantically positive verbs), most participants (between 18 $\approx 53\%$ and 24 $\approx 71\%$) selected the reflection / facing strategy from Hans' point of view.

Similar to the Italian native speakers, also the English participants interpreted the spatial relation of the second horizontal axis (*right-left*) more frequently than of the first horizontal axis (*front-back*) along the reflection / facing strategy from Hans' point of view. This suggests that localization in relation to the reference object plays an important role for speakers of all investigated languages.

Some differences between the semantically positive verbs can be observed for this spatial relation, too. *Believe* attained the highest number of responses (24) in favor of the reflection / facing strategy when Hans was located to the right of the cupboard. In contrast, the verb *know* with Hans on the left of (18) the cupboard garnered the lowest number of responses employing the reflection / facing strategy and the most using the outside perspective (11 $\approx 32\%$). To sum up, the results indicate that the amount of responses reflecting the outside perspective in positive complex relations has significantly decreased (from $\approx 88\%$ up to $\approx 32\%$, $p < 0.0001$) compared to the simple spatial relations without Hans.

Some differences between the MAD.abs and AUC.abs values as well as between the X- and Y-flips within the spatial relations described by the positive verbs were also found. The highest MAD.abs value, ≈ 0.49, relates to the verb *think* and Hans to the right of the cupboard (similar to the Italian data). The lowest MAD.abs value was computed for the same verb but with Hans on the left side of the cupboard (MAD.abs ≈ 0.34). The

MAD.abs results indicate no significant difference between (semantically positive) verbs ($p > 0.92$), and no significant difference between the positions of Hans ($p > 0.33$).

Finally, the results for the English native speakers' interpretations of spatial relations with the bottle *to the left of* the canonically positioned cupboard also indicate that verb semantics influences the choice of answer (for to the *left* align the outside perspective).

As with the bottle *to the right of* the cupboard, in positive situations with the bottle on the *left* side (semantically positive verbs), most English speaking participants (between 18 ≈ 53% and 24 ≈ 71%) selected the reflection / facing strategy from Hans' point of view. This suggests that localization in relation to the reference object plays an important role and can be specified by the horizontal axes. The reflection / facing strategy from Hans' point of view is applied to interpret spatial relations of the second horizontal axis more frequently than of the first one (in all investigated languages). Furthermore, the results demonstrate that intrinsicality plays an important role in spatial relations embedded by indirect speech and contained an artificial agent.

Some differences between the semantically positive verbs for this spatial relation can be observed, too. As with the data for Italian native speakers *claim* and *believe* received the highest number of responses (24) choosing the reflection / facing strategy when Hans was located on the left side of the cupboard. In contrast, the verb *know* with Hans to the right (18) of the cupboard achieved the lowest number of responses along the reflection / facing strategy from Hans' point of view. To sum up, the outcomes indicate that the choice of the outside perspective in positive complex relations has significantly decreased (from ≈ 97% up to ≈ 41%, $p < 0.0001$) in comparison to the simple spatial relations without Hans.

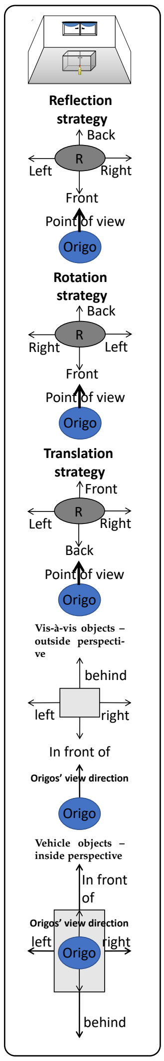
Some differences between the MAD.abs and AUC.abs values as well as between the X- and Y-flips were also found. The highest MAD.abs value amounts to ≈ 0.51 and relates to the verb *say* and Hans to the left of the cupboard. Within the verbs of the positive semantics, the lowest MAD.abs value was computed for the verbs *reckon* and Hans on the left side of the cupboard, *believe* and *claim* with Hans on the right (MAD.abs ≈ 0.34). The MAD.abs results indicate no significant difference between (semantically positive) verbs ($p > 0.3$), and no significant difference between the positions of Hans, with $p > 0.08$.

Cupboard with the back side to the participants

As was the case for the German, Polish and Italian native speakers, it is very noticeable that almost all of the spatial relations investigated caused difficulties for the English participants. This is indicated very clearly by the selected answers as well as by the trajectories leading to the responses. The mean trajectories appear between the responses for the four spatial relations. For *behind* and *to the right of*, it can be recognized that the English native speakers usually considered two opposite answers – one interpretation using the outside perspective and one with respect to the reflection / facing strategy.

Looking at the absolute values of the responses, *in front of* and *behind* come clearly on top with 19 (in front of ≈ 56%) and 18 (behind ≈ 53%) of selected answers with respect to the outside perspective. *To the left of* and *to the right of* were interpreted less frequently align the outside perspective (to the right / left of 11 ≈ 32%). The results between the first and second horizontal axis are significant with $p > 0.015$. This means that English native speakers interpreted the spatial relations between a locatum and the reference object of the first horizontal axis significantly more frequently with respect to the outside perspective than the constellations of the second horizontal axis. The results of all localizations taken together did not reveal any significant difference ($p > 0.08$).

Comparing the results of the spatial relation with the questionnaire results, it is very clear that significantly more participants assigned the sides to the cupboard with respect to the outside perspective in the survey task than in the mouse tracking experiment. The difference amounts to around 15% for *the right* and *left side* and 25% for *front* and *back*. It points out that the English native speakers consider the objects intrinsicality more



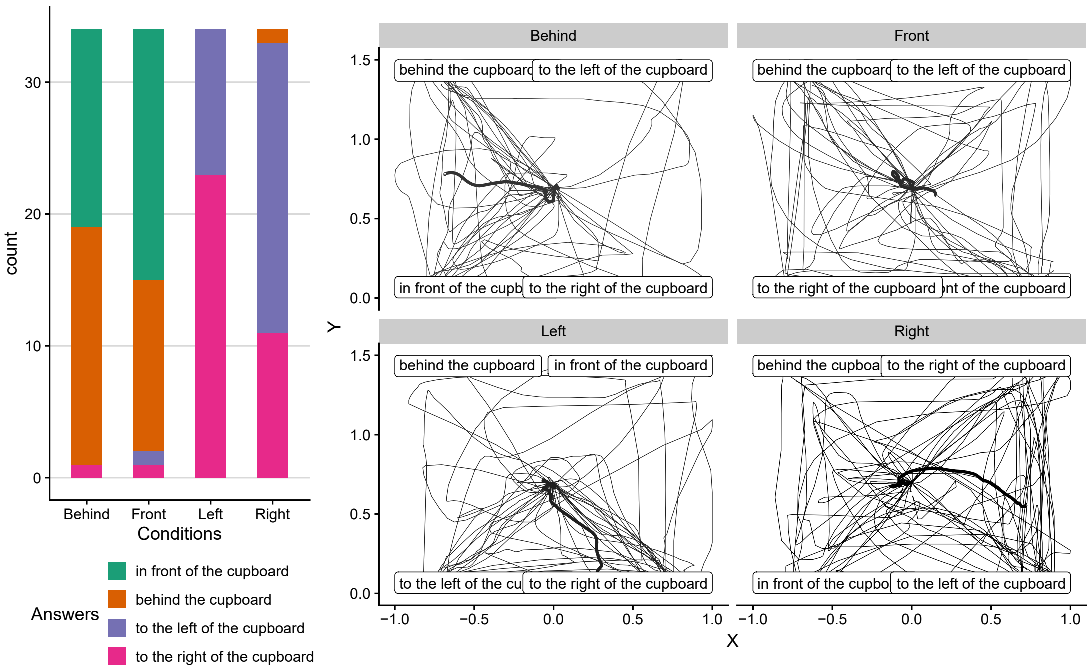


Figure 5.100: Answers for the simple intrinsic relation with the non-canonically positioned cupboard: barplots with answers (left) and trajectories through the response with the mean trajectories (to the right)

frequently while side identification than spatial relations' interpretation.

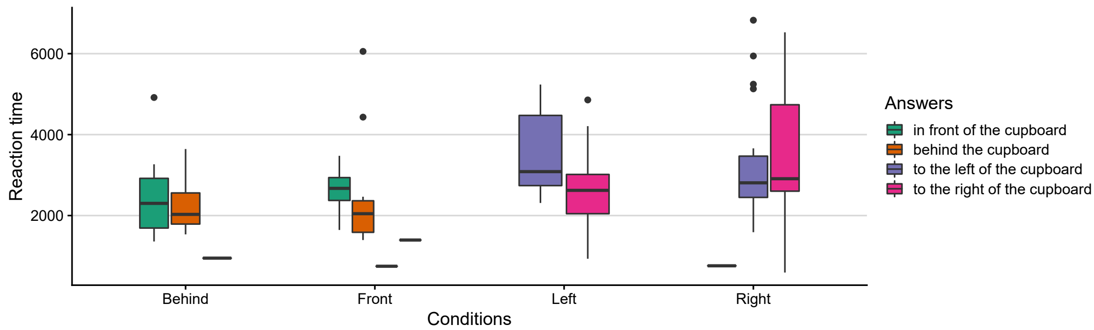


Figure 5.101: Reaction time for the spatial relations with the cupboard with the back side to the participants

The differences can be also recognized in the MAD.abs and AUC.abs values. Similar to the Italian data, the highest MAD.abs value, at ≈ 0.59, was found for the positive spatial dimension expression of the second horizontal axis, *to the right of*. This is followed by *in front of* with ≈ 0.44, *to the left of* with ≈ 0.40 and *behind* with ≈ 0.34. The outcomes show significant difference between the particular positions ($p > 0.037$) but no between the axes ($p > 0.11$).

In spatial relations embedded by verbs of positive semantics and the bottle *in front of* the non-canonically positioned cupboard, many participants (between 14 $\approx$ 41% and 20 $\approx$ 59%) selected the reflection / facing strategy from Hans point of view. This is approx. 25% fewer than for the rectangular table (between $\approx$ 71% and 82%). These results also indicate that the intrinsicality of the reference object plays an important role in the interpretation of spatial relations. However, between the semantically positive verbs some differences can be also observed. In the spatial relations embedded with the verb *know*, the participants selected the outside perspective most frequently (14 participants $\approx$ 41%). In contrast, the spatial relation described by the verb *believe* was interpreted less frequently in terms of the outside perspective (9 participants $\approx$ 26%). In general, the outcomes indicate that the choice of the number of responses choosing the reflection / facing strategy in positive complex relations has increased (from $\approx$ 38% to between $\approx$ 41% and 59%) in comparison to the simple spatial relations without Hans. These participants shifted the origo to Hans and interpreted the spatial reaction from his point of view.

The differences can also be seen in the MAD.abs and AUC.abs values as well as in the X- and Y-flips. The highest MAD.abs value is ≈ 0.48 within the verbs of the positive semantics applies for *believe* with Hans to the left of the cupboard. The lowest MAD.abs value (within the verbs of positive semantics) was computed for the verb *claim* with Hans on the right side of the cupboard (MAD.abs ≈ 0.36). There was no significant difference between the MAD.abs value for different verbs ($p > 0.67$), nor was there a significant difference between Hans' positions ($p > 0.96$).

The results for the English native speakers' interpretation of spatial relations with the bottle *behind* the cupboard with the back indicated that verb semantics influences the choice of answer (for *behind* aligned the outside perspective).

In the positive situations (with semantically positive verbs), several participants (between $17 = 50\%$ and $23 \approx 68\%$) selected the reflection / facing strategy. This is approx. 16% ($\approx$ 68% and 82%) less than with respect to the rectangular table. Also this result indicates that the intrinsicality of the reference object plays a role when interpreting the spatial relations. However, with the positive verbs too, some differences can be observed with the most accurate result for *claim* and the worst for *say*. In general, the outcomes indicate that the choice of the reflection / facing strategy of the relative frame in positive complex relations has increased (from $\approx$ 44% to between $\approx$ 50% and 68%) in comparison to the simple spatial relations without Hans. Also here, the participants used the strategy from Hans' point of view.

The differences can also be seen in the MAD.abs and AUC.abs values as well as in the X- and Y- flips. The highest MAD.abs value is ≈ 0.46 and was found for the verbs *claim* with Hans to the right of the cupboard. This is immediately followed by *say* and *think* with Hans to the right of the cupboard, with MAD.abs ≈ 0.45. The lowest MAD.abs value (within the verbs of the positive semantics) was computed for the verb *believe* with Hans to the right of the cupboard, with MAD.abs ≈ 0.33. In general, the outcome means that the maximal absolute deviation significantly does not differ between the verbs ($p > 0.53$). The result reveals neither significant difference between the positions of Hans ($p > 0.74$).

Furthermore, the results for the English native speakers' interpretation of spatial relations with the bottle *to the right* of the non-canonically positioned cupboard demonstrated that verb semantics influenced the choice of answer.

In the positive situations (with semantically positive verbs), most participants (between $18 \approx 53\%$ and $23 \approx 68\%$) selected the reflection / facing strategy from Hans' point of view. In contrast to the Italian and Polish data, there is no difference between the perspective choice for the answers of the first horizontal axis and *to the right of*. However, the outcomes demonstrate that intrinsicality is important for English native speakers, too. For the rectangular table with the bottle *to the right of*, between 71% and 85% of English participants selected the reflection / facing strategy from Hans' point of view – this means that English native speakers choose the reflection / facing strategy approx. 17% more frequently in the extrinsic constellations with the bottle *to the right of* the reference object than with the non-canonically positioned intrinsic cupboard.

The highest MAD.abs value, ≈ 0.52, was found for the verb *reckon* with Hans to the left of the cupboard. The lowest MAD.abs value for a semantically positive verb was computed for *believe* with Hans to the left of the cupboard, with MAD.abs ≈ 0.31. All in all, the outcome means that the maximal absolute deviation did not differ between the constellations with Hans to the right and to the left ($p > 0.69$). Any significant differences were found between the (positive) verbs ($p > 0.69$).

As with all constellations up to now, the results for the English native speakers' interpretation of spatial relations with the bottle *to the left of* the cupboard with the back side facing the participants indicated that verb semantics influenced the choice of answer (*to the left of* the cupboard using the outside perspective of the intrinsic frame of reference).

In the positive situations (with semantically positive verbs), most participants (between $20 \approx 59\%$ and $24 \approx 71\%$) selected the reflection / facing strategy. Also this outcome resembles the one for the *front* or *back* side. Nonetheless, the outcomes indicate that intrinsicality plays an important role too. For the rectangular and round tables with the bottle *to the left of* them, between 68% and 85% of English native speakers selected the reflection / facing strategy – this means that English native speakers selected the reflection / facing strategy from Hans' point of view approx. 15% more frequently in the extrinsic constellations with the bottle *to the left of* the reference object.

Some differences can also be found between the positive verbs. *Know* garnered the highest number of responses with respect to the reflection / facing strategy when Hans was located to the left of the cupboard. In contrast the verb *reckon* with Hans to the right of the cupboard, achieved the lowest outcome, with just 20 responses employing the reflection / facing strategy from Hans' point of view.

The highest MAD.abs value amounts to ≈ 0.50 and relates to the verb *say* with Hans to the left of the cupboard. The lowest MAD.abs value (within the verbs of the positive semantics) was computed for the verb *reckon* but with Hans to the right of the cupboard, with MAD.abs ≈ 0.31. In general, the outcome means that the maximal absolute deviation did not significantly differ between the constellations with Hans ($p > 0.21$). No significant difference was found between the (positive) verbs ($p > 0.41$).

5.9.4.2.2 Third null hypothesis

5.9.4.2.2.1 Analysis of simple spatial relations with animate vs. inanimate entities

Similar to the data analysis on the previous languages, the third null hypothesis is analyzed in the following way:

First, animate intrinsic spatial relations:

- Dog with the front to the participant

- Dog with the back to the participant

will be demonstrated.

Second, the results for the inanimate intrinsic spatial relations:

- Cupboard with the front to the participant
- Cupboard with the back to the participant (for this, please see the analysis 5.8.4.2.1.2)

will be summed up and contrasted with the results for animate data.

Dog with the front to the participants

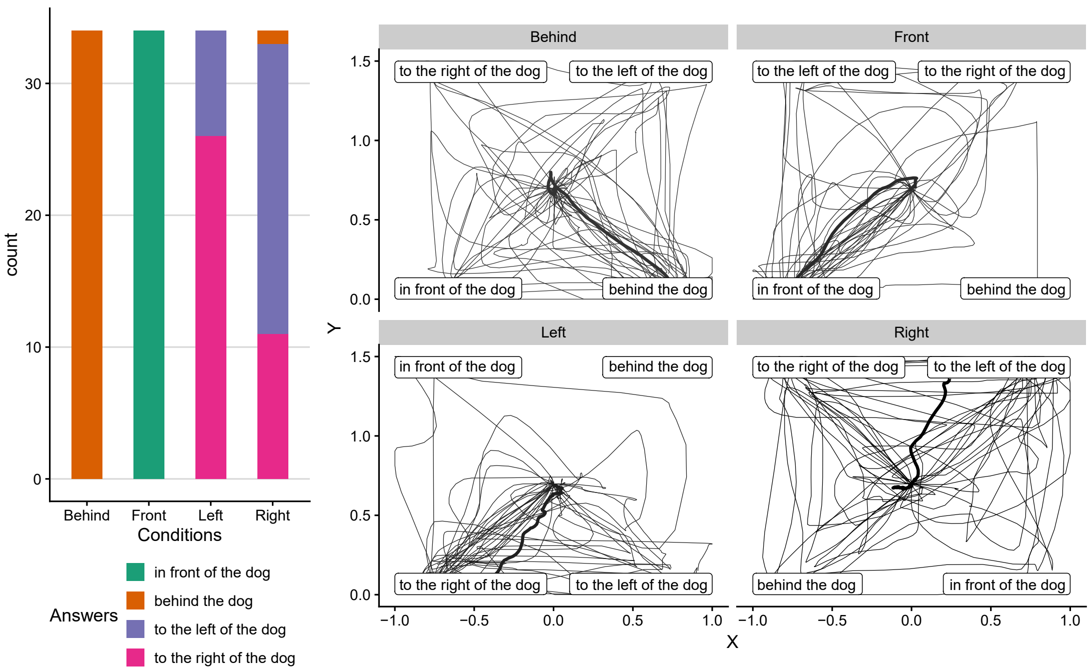
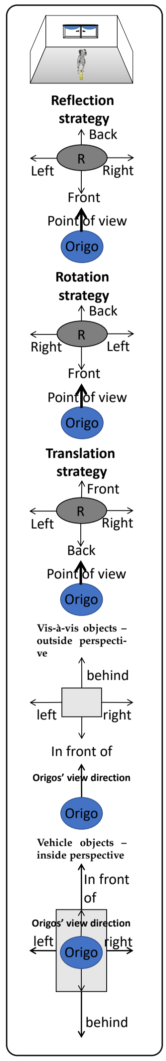


Figure 5.102: Answers for the simple intrinsic animate relation with dog: barplots with answers (left) and trajectories through the response with the mean trajectories (right)



As with the Polish and Italian native speakers, bar plots for the responses show that the English native speakers did not have any problems interpreting the canonical spatial constellation with the bottle *behind* or *in front of* the dog, where the intrinsic and relative (reflection / facing strategy) interpretations coincide. This is also reflected by the bar plots, which show that all English native speakers picked the intrinsic perspective for the both spatial relations of the first horizontal axis. The MAD.abs and AUC.abs values are significantly higher than for the previously analyzed languages (MAD.abs ≈ 0.35 and AUC.abs ≈ 0.22 for *in front of*; MAD.abs ≈ 0.47 and AUC.abs ≈ 0.3 for *behind*).

Like the Polish and Italian participants, the English native speakers seemed to have more difficulties deciding on the *right* and *left* side of the dog – their mean line deviated from the ideal line much more (see 5.102). Participants clearly considered two opposite responses, *right* and *left*. This is shown by the MAD.abs value of ≈ 0.56 for *to the right of* and ≈ 0.41 for *to the left of* and the AUC.abs value of ≈ 0.39 for *to the right of* and ≈ 0.41 for *to the left of*. Regarding the MAD.abs value, the lmer and ANOVA computations neither show significant difference between all positions, with $p \approx 0.06$ nor between the axes, with $p \approx 0.19$.

Approximately 32% of the English speaking participants picked the answer align the intrinsic reference frame for the interpretation of *to the right of* the dog and 24% for *to the left of* the dog. The result resembles the outcome of the Polish native speakers. However, it is significantly lower than the one of the Italian native speakers. The remaining participants selected the interpretation along reflection / the facing strategy. Analyzing the categorical data statistically, the results indicate significant differences between the individual spatial positions for the canonically positioned dog ($p < 0.0001$) as well as between the axes ($p < 0.0001$).

The RT was highest for *to the right of* and lowest for *in front of*. In contrast to the Italian data, this result confirms the assumptions of the spatial framework model (similar to the data for German and Polish), which states that space is conceptualized in terms of three axes: the axis *above-below* is perceived fastest, followed by *in front of-behind*, with *to the right-left of* being perceived slowest (see Franklin and Tversky, 1990). It follows that the model is confirmed for the interpretation of localization with respect to the body for German, English and Polish but not for Italian, which is a very important indication.

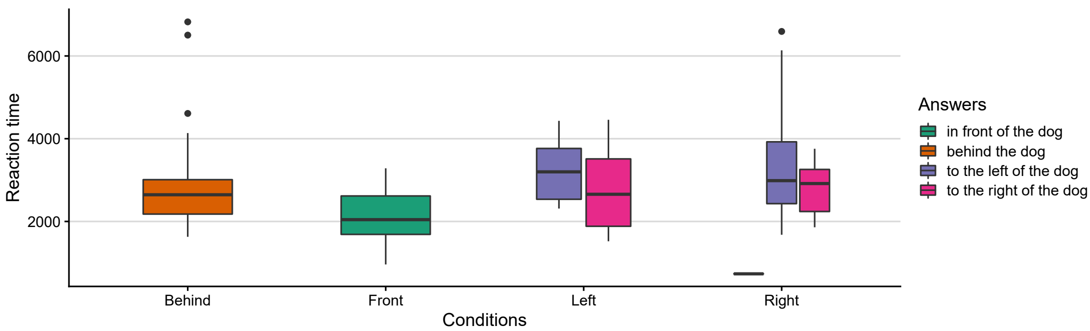
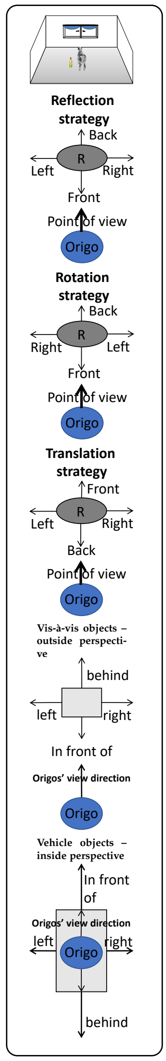


Figure 5.103: Reaction time for the spatial relations with dog facing the participants



Dog with the back to the participant

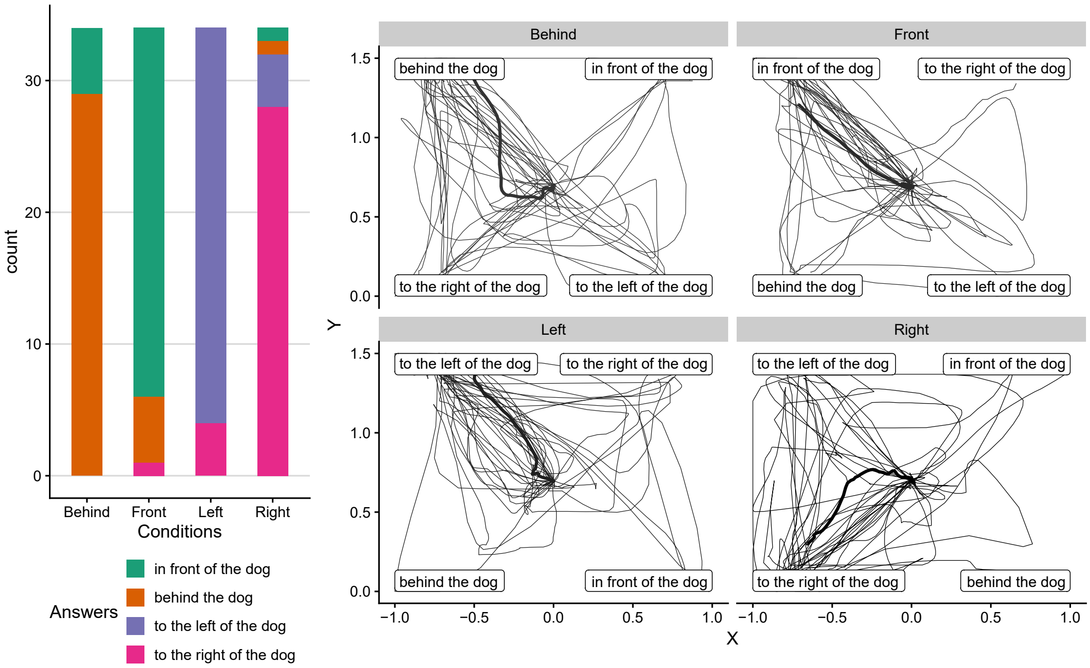


Figure 5.104: Answers for the simple intrinsic animate relation with dog: barplots with answers (to the left) and trajectories through the response with the mean trajectories (to the right)

Similar to the Italian data, the bar plots for the responses visualize very clearly that English native speakers most frequently selected answers along the intrinsic interpretation for the four localizations (*in front of* $\approx$ 82%, *behind* $\approx$ 85%, *to the right of* $\approx$ 82%, *to the left of* $\approx$ 88%). The statistical tests do not reveal any significant differences between the particular localizations ($p \approx 0.95$). Also, the results between the axes do not show any differences, $p = 1$.

On the mean trajectory of the trajectory plots, it can be clearly recognized that the participants had the fewest doubts when interpreting the spatial relation with the bottle *in front of* the dog – as applied for the Italian participants too. The MAD.abs values for the spatial relations with the dog positioned with the back facing the participant and the bottle in different positions were as follows: *in front of* ≈ 0.27; *behind* ≈ 0.40; *to the right of* ≈ 0.41; and *to the left of* ≈ 0.38. The lmer and ANOVA computations did not show any significant differences in the MAD.abs values between all positions, with $p \approx 0.26$. It also did not reveal any significancy between the axes with $p \approx 0.26$. In addition, the lowest AUC.abs ≈ 0.15 fits for the bottle positioned *in front of* the intrinsic front of the dog. It is followed by *to the left of* ≈ 0.18, *behind* ≈ 0.20, and *to the right of* with ≈ 0.21.

As with the Italian data, considering the bar plots of the English participants for the spatial relations including the dog, in summary, it can be said that the dimensional spatial expressions of the first horizontal axis (*front-back*) were significantly more frequently recognized as intrinsic than those of the second horizontal axis ($p < 0.0001$). The data also reveal significant differences between the four localizations with $p < 0.0001$.

As stated above, the animacy (cupboard with front / back vs. dog with front / back) influenced the perspective choice to English native speakers. It revealed overall statistical significance of $p < 0.0001$ (as shown for the Italian participants too). Considering the general results in greater details, the data shows the largest differences between the dog and the cupboard as reference objects when the bottle was placed *behind* the reference object (62 *correct* answers for the dog vs. 51 for the cupboard). However, the largest differences between the dog positioned canonically / non-canonically and the cupboard positioned canonically / non-canonically individually as reference objects are visible for the interpretation with the bottle *to the right* and *left of* the canonically positioned objects. A Fisher's exact test revealed large significant differences between both objects and positions ($p < 0.001$). In contrast to the Italian data, significant differences were found in categorical judgments for the second horizontal axis (*to the right of* vs. *to the left of*, $p < 0.0016$) and no for the first horizontal axis. It also applies for the canonical positioned reference objects ($p < 0.0001$). For the non-canonically positioned reference objects, a Fisher's exact test revealed significant differences for animacy and both positions (*to the right* vs. *left of*), with $p < 0.0001$. This also applies to the first horizontal dimension (*in front of* vs. *behind*) and both reference objects. This result is

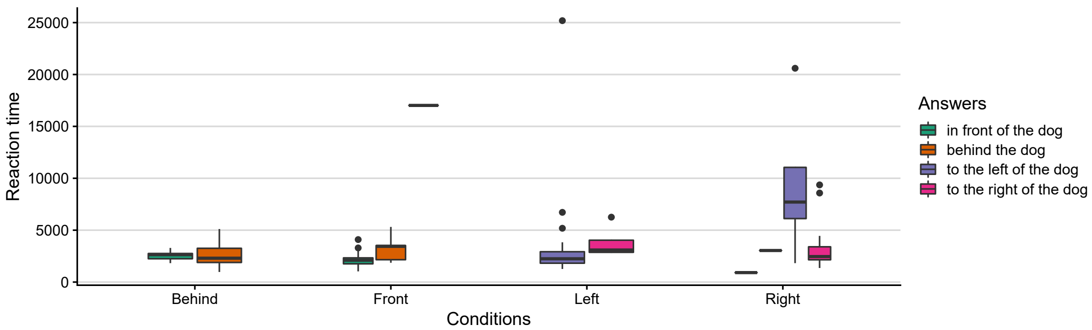


Figure 5.105: Reaction time for the spatial relations with dog facing with the back to the participants

similar to the one found in the German, Italian and Polish data. With the statistical analysis, the third null hypothesis can be rejected for the English participants as well: The animacy of relata does not affect the interpretation of spatial relations.

The MAD.abs values for the reference objects did not reveal any significant difference between the animate and inanimate reference objects ($p \approx 0.09$). However, the data for the axes and animacy indicate a strong significant difference ($p \approx 0.0008$) and strong difference for the individual positions ($p \approx 0.0002$).

5.9.4.3 Summary and conclusion

In this section, I show how English native speakers identify sides of a cupboard seeing it from *front* and *back*. In particular, I focus on the *front*, *back*, *right* and *left* side of the cupboard. I investigated the side identification using survey as an experimental method and asked participants to fill it in. It means, I asked the participants to mark the individual parts of cupboard: right side, left side, front side and back side. Additionally, I also asked the same English native speakers to participate in mouse tracking study. Here, I asked the participants to interpret spatial relations including the same cupboard. However, in the mouse tracking study the spatial relations included not only the cupboard but also a bottle as a localized object. The participants were asked to interpret the relationship between the localized object (bottle) and the reference object (cupboard). The motivation for the procedure was to explore whether English native speakers use the same side while side identification of an intrinsic object and the interpretation of the spatial relationships between the localized and reference objects. In the last step, I supplemented an artificial agent and embedded the spatial relation by an indirect speech. In this step, it was important to find out whether the English native speakers apply the intrinsic properties of the reference object while interpreting a spatial relation containing a reference object and localized object vs. a reference and localized object and an artificial agent.

Results of the survey indicate that the most English native speakers identify sides of the cupboard along the outside perspective seeing it from front. In contrast, seeing the same object from back English native speakers assign sides with respect to the inside perspective, which differ from the outside perspective along the *right-left* identification. Results of the spatial relations with cupboard as a reference object, bottle as localized object and Hans as artificial agent comparing to results of spatial relations without an artificial agent reveal that English native speakers use the outside perspective significantly more frequently in the latter one. It means that English native speakers investigated used the intrinsical properties of the cupboard in the spatial relations without an artificial agent more frequently for the interpretation. This allows rejecting the first null hypothesis: The presence of the third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift.

I also investigated whether animacy of a reference object influences the choice of spatial expressions. For this, I implemented the same spatial relations for dog as reference object and bottle as localized objects as for cupboard and bottle. The statistical analysis shows that the English native speakers used the intrinsic reference frame significantly more frequently for interpretation of spatial relations with animate reference object than inanimate (rejection of the third null hypothesis).

Finally, I also investigated how English native speakers interpret spatial relations including table (extrinsic) reference object and bottle as localized object. Also here, I tested interpretation of the four regions between the objects: front, back, right and left. In addition to these constellations, I added artificial agent (analogous to spatial relations with cupboard) in the next step. The motivation of these tasks was to explore how English native speakers interpret extrinsic spatial relation without artificial intelligence – which strategy they apply (reflection / facing, align / translation or rotation). In the next step, the aim was to find out, whether the English native speakers apply the same strategy in the spatial relations supplemented by Hans. The results show that English native speakers investigated tend to use the reflection / facing strategy to interpret static spatial relations with extrinsic reference object. It means that English native speakers tend to interpret both spatial relations described by static and dynamic verbs along the reflection / facing strategy (as shown by Perużyńska, 2012a for dynamic verbs). In the spatial relations supplemented by Hans, English native speakers tended to origo shift to Hans and to interpret the spatial relations from his point of view along the reflection / facing strategy. Also this result allows rejecting the first null hypothesis: The presence of the third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift.

5.10 Cross-linguistic study of German, English, Italian and Polish

In the previous sections, I analyzed the results for all the abovementioned languages individually and provided a few indications of the differences between them. Here, I test the cross-linguistic null hypothesis: The interpretation of dimensional spatial expressions does not depend on the native language [NH4]. I show which spatial relations were interpreted in the same way by speakers of the four languages and which differently. I put an emphasis on the significant differences. The order of analysis matches that of the previous analysis and brings to a close the data analysis for this thesis.

5.10.1 Statistical analysis

Statistical analyses were conducted in R (version 3.4.2, R Development Core Team, 2017). I used the ggplot2 (Wickham et al., 2013), lme4 (Bates et al., 2014), emmeans (R. Lenth and M. R. Lenth, 2017), and optimx (Nash et al., 2020) packages. For statistical analysis of the categorical answers, I implemented glmer (which accounts for the binominal nature of the data) supplemented by emmeans (a post-hoc test). Two models were run, one for the response and one for the continuous measure. The dependent variable was defined as the response (*error*) and the two independent factors and their interaction with language (*German*, *English*, *Italian*, and *Polish*), position of the localized object (*in front of*, *behind*, *to the right of*, *to the left of*) and position of the reference object (*canonical* vs. *non-canonical*). Speakers served as a random factor. For the absolute MAD.abs and AUC.abs values, similar models were calculated, which only differed with respect to using lmer instead of glmer, since the data were continuous.

The final statistical model was defined as follows:

$$\begin{aligned} model.XY < -glmer(&error \sim language \cdot localized\_object + (1|subject), \\ &data = XY, \\ &family = binomial(link =' logit')) \\ pairs(emmeans(&model.XY, \sim language|localized\_object)). \end{aligned}$$

Thereby *localized_object* stands for the position of the localized object along the defined strategy (outside perspective for cupboards, inside perspective for dog, reflection / facing strategy for tables from participants' point of view).

Additionally, I also used the glm model because the glmer model sometimes indicates warnings. All the data is presented together in appendix A.

5.10.1.1 Analysis of simple and complex extrinsic spatial relations

5.10.1.1.1 Round table

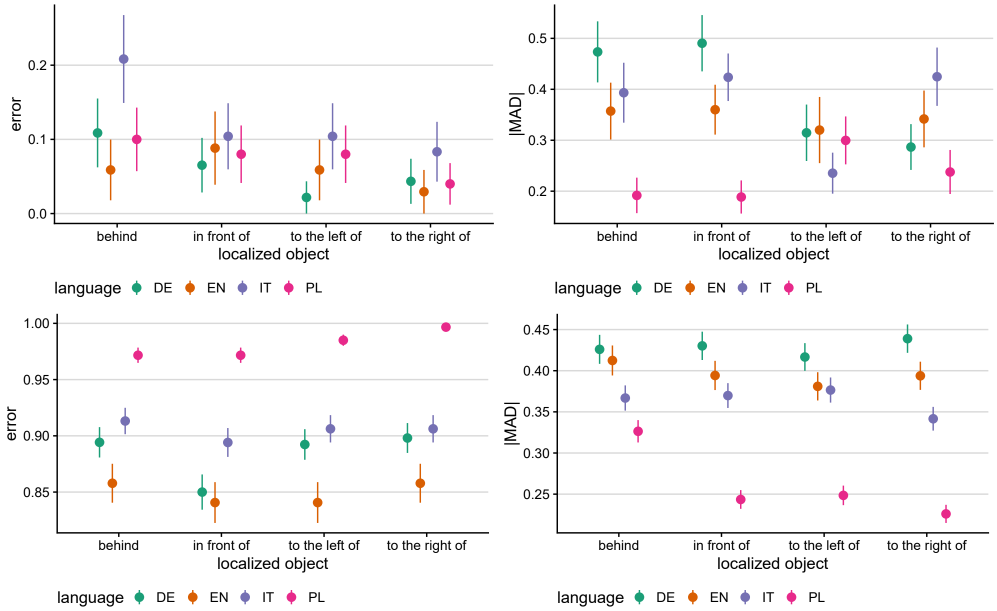


Figure 5.106: Participants' responses for the simple (top) and complex (bottom) extrinsic relations with a round table: Differences between categorical answers (left), and mouse trajectories (right), x-axis: position of the bottle, color legend = languages

The graphs on the left of 5.106 display the results for the four languages between the categorical responses for the particular spatial relations. The graphs to the right depict the results between speakers of the four languages with respect to the continuous measurements (MAD.abs) for the four individual spatial relations *in front of*, *behind*, *to the right of*, and *to the left of*. The graphs at the top in 5.106 depict the responses for simple spatial constellations with the round table and those at the bottom for the spatial constellations supplemented by Hans and introduced by semantically positive verbs (complex spatial relations).

As shown in A.1, no simple spatial relation demonstrated a significant difference according to the response. However, the continuous measurements showed significant differences for the bottle *behind*, *in front of*, and *to the right of* the table for the Polish and Italian native speakers. In addition, German and Polish native speakers showed significant differences for the bottle *behind* and *in front of* the table (see A.1). Overall, the continuous measures show that Polish native speakers demonstrated the lowest values for most of the spatial relations investigated.

With respect to the responses (for the categorical measurements), the graphs at the bottom clearly demonstrate that the largest differences were between Polish and English native speakers. This arose most frequently due to the shift of origo by Polish native speakers; this occurred less frequently with English native speakers. The German and Italian native speakers showed similar results for all the complex spatial relations with the round table. Seeing the bottle to the left of the table, Polish native speakers shifted the origo to the point of view of Hans significantly more frequently than did English native speakers ($p \approx 0.02$). When the bottle was placed to the right of the table, significant differences were found between Polish native speakers and all others (for PL–DE: $p \approx 0.01$; PL–EN: $p \approx 0.003$; PL–IT: $p \approx 0.005$).

Regarding the MAD.abs values, the graph shows that the largest differences arose between German and Polish native speakers. The Polish participants demonstrated the lowest MAD.abs values for all complex constellations, and the German the highest. For the spatial relation with the bottle behind the table, significant differences occurred

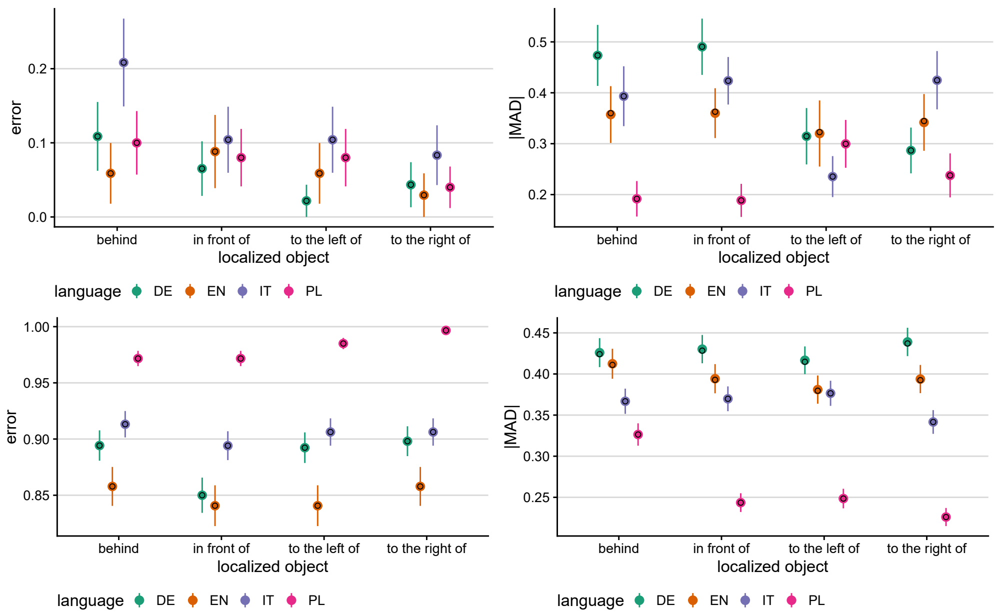


Figure 5.107: Predicted (dark dots) and actual results (colored dots) for responses for simple (top) and complex (bottom) extrinsic relations with a round table: Differences between answers according to language (left) and trajectories through the response (right)

between German and Polish native speakers ($p \approx 0.04$). The latter attained significantly lower MAD.abs values than did English, German and Italian native speakers for the spatial relations with the bottle in front of, to the right of, and left of the table (for all the situations, $p < 0.01$). For the spatial relations with the bottle to the right of the table, German and Italian native speakers also showed significant differences because Italian native speakers demonstrated considerably lower MAD.abs values ($p \approx 0.05$).

5.10.1.1.2 Rectangular table

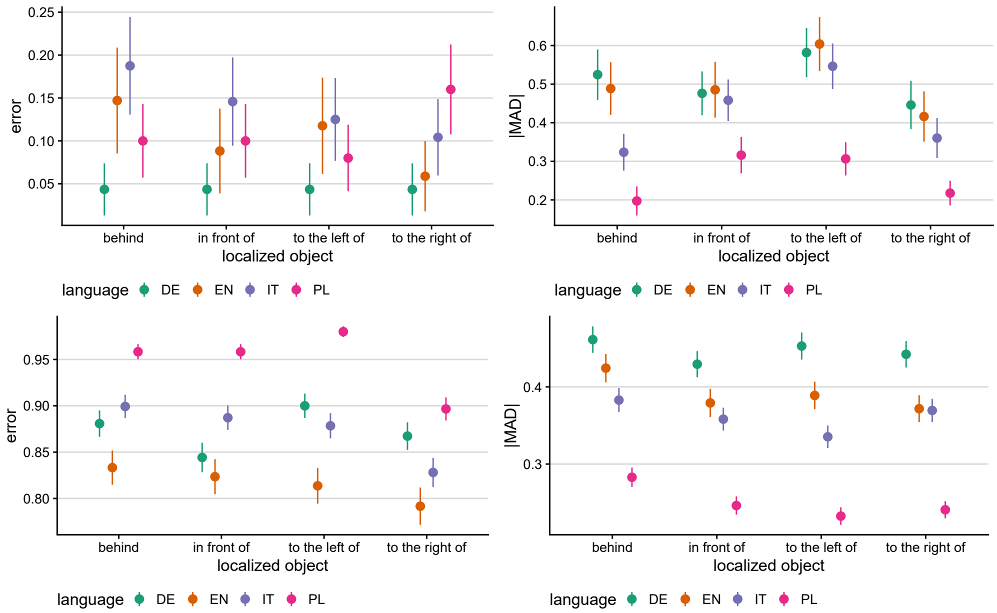


Figure 5.108: Responses for the simple (top) and complex (bottom) extrinsic relation with a rectangular table: Differences between the responses according to language (left) and trajectories through the response (right)

5.108 shows that the simple spatial relations with a rectangular table as a reference object caused few variations both between and within the languages. The German native speakers did not show any differences in their interpretations of the individual spatial relations. However, the results for the three other languages reveal a few differences between the four spatial relations (refer to the 5.9.4.2, 5.8.4.2, and 5.7.4.2 that follow for further detail). For the bottle located behind, in front of, and to the left of the table, the strongest differences were found between German and Italian speakers. The interpretation of the Polish and German native speakers differed the most for the spatial relation with the bottle to the right of the table. Nonetheless, no one spatial relation demonstrated significant differences between individual language pairs.

Again, the responses of the Polish speakers showed the lowest MAD.abs values. Significant differences were shown for German and Italian ($p < 0.05$), German and Polish ($p \approx 0.0001$), and for English and Polish ($p \approx 0.03$) native speakers for the spatial relation with the bottle placed behind the table. When the bottle was placed to the right of the table, only German and Polish native speakers ($p \approx 0.01$) demonstrated significant differences. In contrast, for the spatial relation with the bottle to the left of the table, Polish native speakers achieved significantly lower values than did the English ($p \approx 0.002$), German ($p \approx 0.02$), or Italian ($p \approx 0.008$) participants.

The results of the experiment with complex spatial relations yielded interesting differences. Again, the Polish native speakers most frequently shifted the origo to Hans and interpreted the spatial relations from his point of view. In contrast, the English native speakers most frequently selected the response using the facing / reflection strategy from their point of view. That is, English native speakers less frequently shifted the origo to Hans. Thus, the spatial relation with the bottle behind the table resulted in significant differences between Polish and English native speakers ($p \approx 0.05$). The language pairs, German and Polish ($p \approx 0.02$) and English and Polish ($p \approx 0.02$), showed significant differences in interpreting the spatial relation with a rectangular table and the bottle in front of it. The interpretation of the spatial relation with the bottle to the left of the table demonstrated significant differences between English and Polish native speakers ($p < 0.0001$) and between Polish and Italian native speakers ($p \approx 0.007$). I did not find any significant differences for the bottle located to the right of the table.

As with the complex spatial relations with the round table, the Polish native speakers achieved the lowest MAD.abs values for all spatial relations with the rectangular table. In contrast, the highest MAD.abs values were again achieved by the German native speakers. The results for these two languages reveal significant differences for all spatial relations with the rectangular table supplemented by Hans. Moreover, the results for the Polish native speakers indicate significant differences from all the other languages for all the spatial relations. In interpreting the spatial relation with the bottle to the left of the table, the German and Italian native speakers also achieved significantly different MAD.abs values (A.4).

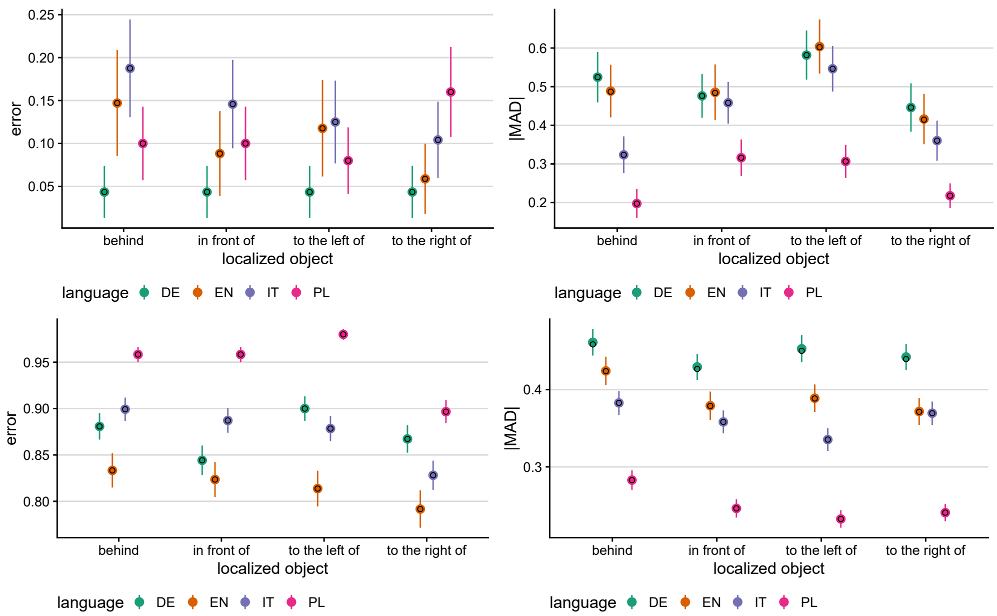


Figure 5.109: Predicted (dark dots) and actual results for responses for the simple (top) and complex (bottom) extrinsic relation with a rectangular table: Differences between answers and languages (left) and trajectories through the response (right)

5.10.1.2 Analysis of simple and complex intrinsic spatial relations

5.10.1.2.1 Cupboard - canonical position

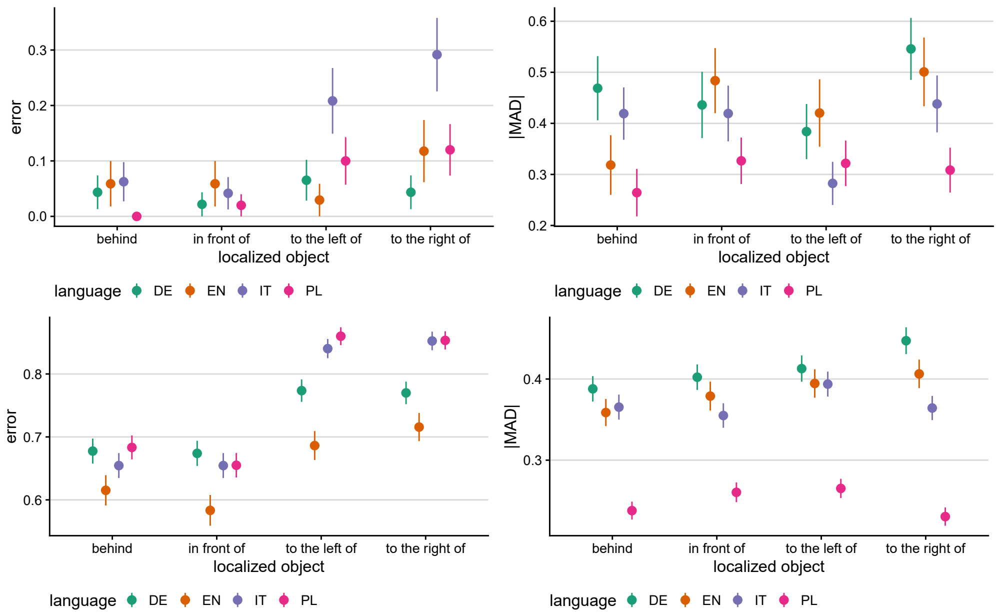


Figure 5.110: Responses for simple (top) and complex (bottom) intrinsic relations with a cupboard in a canonical position: Differences between the responses according to language (left) and trajectories through the response (right)

All of the graphs in 5.110 demonstrate variations between the languages in terms of both the categorical and continuous measures. Of all the participants, the Italian native speakers most frequently interpreted the bottle as being to the right and left using the inside perspective. A significant difference between German and Italian participants ($p \approx 0.02$) was found for the spatial relation with the bottle to the right of the cupboard.

The MAD.abs values indicate significant differences between German and Polish speakers for the spatial relation with the bottle placed behind the cupboard ($p \approx 0.03$) and to the right of the cupboard ($p \approx 0.008$). In interpreting these two spatial relations, Polish native speakers attained lower MAD.abs values than the Germans did.

In general, the chart for the categorical responses for the complex spatial relations demonstrates that the choice of perspective (inside vs. outside) depends on the dimensional spatial expression (*front-back*, *right-left*). Native speakers of the four languages more frequently selected the outside perspective of the intrinsic reference frame to interpret the spatial relations with the bottle in front of and behind the cupboard. They interpreted the left-right dimension less frequently with respect to this perspective. Considering the data in greater detail, the English native speakers less frequently shifted the origo to Hans' and interpreted the spatial relations with the cupboard from his point of view. This is similar to their interpretation of the relations with the tables. Of the four groups, the English participants most frequently interpreted the intrinsic spatial relations using the outside perspective. For the interpretation of the bottle being to the left of the cupboard, significant differences were found between Polish and English native speakers ($p \approx 0.02$).

The MAD.abs values again show that the Polish native speakers reached their answers almost directly without uncertainty. The MAD.abs values indicate the smallest aggregated outcomes. In contrast, the responses of the German native speakers revealed the highest values for all spatial relations. Significant differences were found between the Polish and all the other language speakers for all complex spatial constellations with canonically positioned cupboard (A.6).

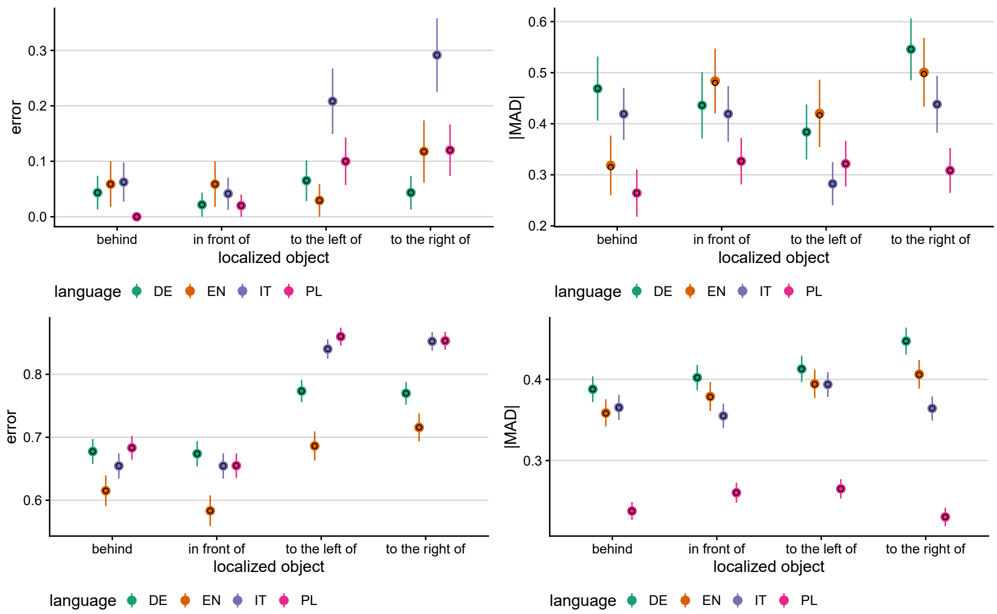


Figure 5.111: Predicted (dark dots) and actual results for responses for the simple (top) and complex (bottom) relation with a canonically positioned cupboard: Differences between responses according to language (left) and trajectories through the response (right)

5.10.1.2.2 Cupboard – noncanonical position

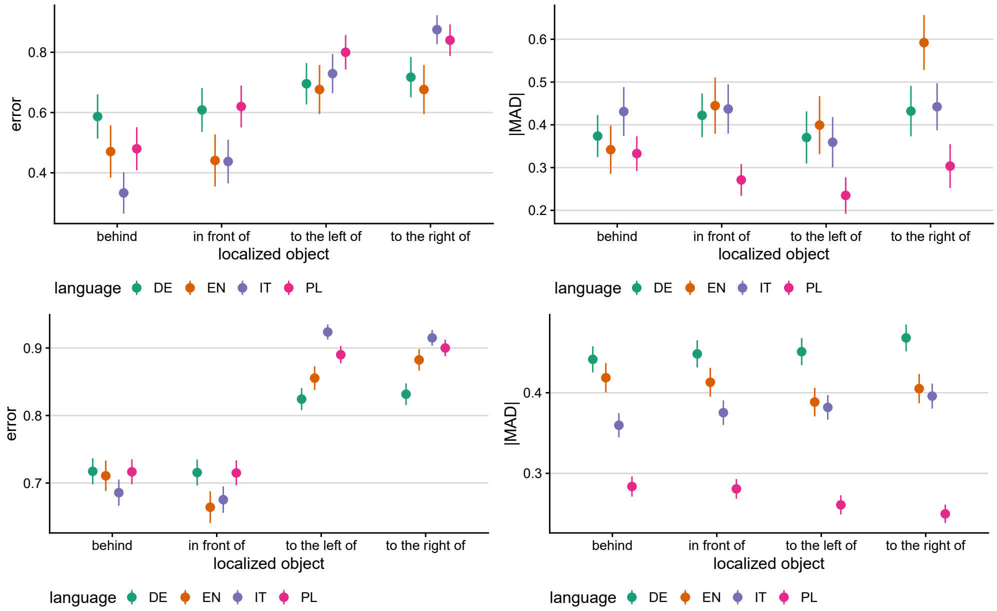


Figure 5.112: Responses for simple (top) and complex (bottom) intrinsic relations with a cupboard in a noncanonical position: Differences between the responses according to language (left) and trajectories through the response (right)

The charts depict the fact that native speakers of all languages had problems interpreting the simple and complex spatial relations with a noncanonically positioned cupboard. They also show the variety of the responses by participants for all the spatial constellations involved in this relation. The variations seem to depend on the spatial expression and the language. The Italian native speakers most frequently interpreted "in front of" and "behind" for the simple spatial relations using the intrinsic reference frame. In contrast, they selected the answers for "to the right of" and "to the left of" using the facing / reflection strategy, almost as often as the other native speakers. No significant differences were found for the four spatial relations.

The participants showed the strongest differences for the complex spatial relations with the bottle to the right and left of the cupboard. The Italian native speakers most frequently shifted the origo to Hans and interpreted the spatial relations from his point of view; the German native speakers did so less frequently. However, the glmer model does not report any significant differences between any of the language pairs (see A.8).

The MAD.abs values revealed significant differences between English and Polish native speakers for the simple spatial relation with the bottle to the right of the cupboard ($p \approx 0.002$). For all spatial relations with the noncanonically positioned cupboard supplemented by Hans, the Polish native speakers again consistently attained the lowest MAD.abs values. It means that they made the decision fastest and without any doubts about it. Statistically, the Polish native speakers showed significant differences from all the other languages for all spatial relations, except the Italian speakers for the bottle in front of the cupboard. Overall, the highest MAD.abs values were computed for the German native speakers (see A.8).

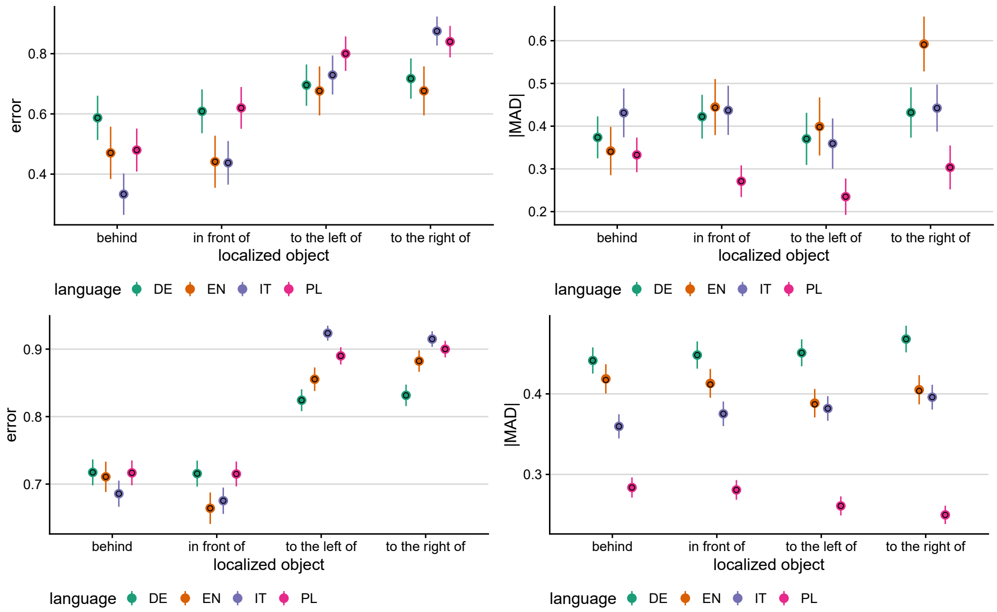


Figure 5.113: Predicted (dark dots) and actual results for responses for simple (top) and complex (bottom) relations with a noncanonically positioned cupboard: Differences between responses according to language (left) and trajectories through the response (right)

5.10.1.3 Analysis of spatial relations with an animate reference object

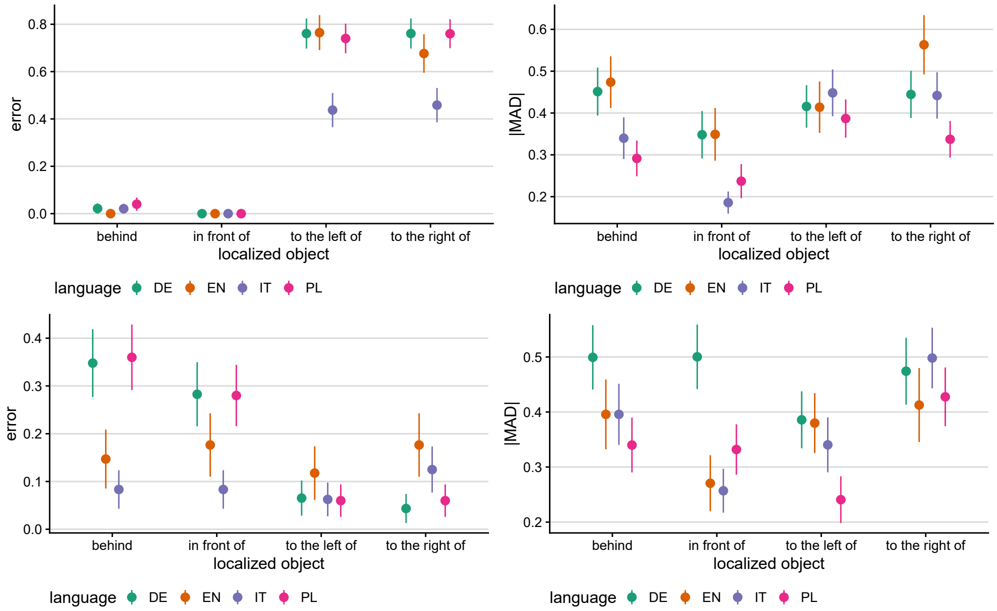


Figure 5.114: Responses for the relation with an animate object (a dog) positionally canonically (top) and noncanonically (bottom): Differences between responses according to language (left) and trajectories through the response (right)

The native speakers of all languages did not show any variation in their responses for spatial relations with a canonically positioned dog and a bottle in front of or behind it. All of them followed the assumptions of the intrinsic reference frame, which in this case coincides with the facing / reflection strategy. Conversely, the Italian participants showed strong differences from all other native speakers for spatial relations with the bottle located to the right and left of the dog: the Italian native speakers most frequently used the intrinsic reference frame (Left: DE–IT: $p \approx 0.0008$; EN–IT: $p \approx 0.0007$; IT–PL: $p \approx 0.0006$; Right: DE–IT: $p \approx 0.001$; EN–IT: $p \approx 0.01$; EN–PL: $p \approx 0.0006$).

The MAD.abs values showed significant differences between English and Polish native speakers for the spatial relation with the bottle to the right of the dog ($p \approx 0.02$).

Most of the English and Italian native speakers selected the responses aligned with the intrinsic reference frame when the bottle was located behind the noncanonically positioned dog – in contrast to the Polish and German native speakers. This led to significant differences between the German and Italian native speakers ($p \approx 0.02$) and between Italian and Polish native speakers ($p \approx 0.01$). The Italian participants were almost consistent in their response selection with the bottle in front of the dog – in contrast to all the other native speakers. The left and right positioning of the bottle – in relation to the dog – caused only few variations. The English native speakers most frequently selected the response indicating the facing / reflection strategy rather than the intrinsic reference frame. However, no language pair revealed significant differences.

The MAD.abs values show significant differences between German and English ($p \approx 0.02$) and German and Italian native speakers ($p \approx 0.006$) when the bottle was positioned in front of the dog.

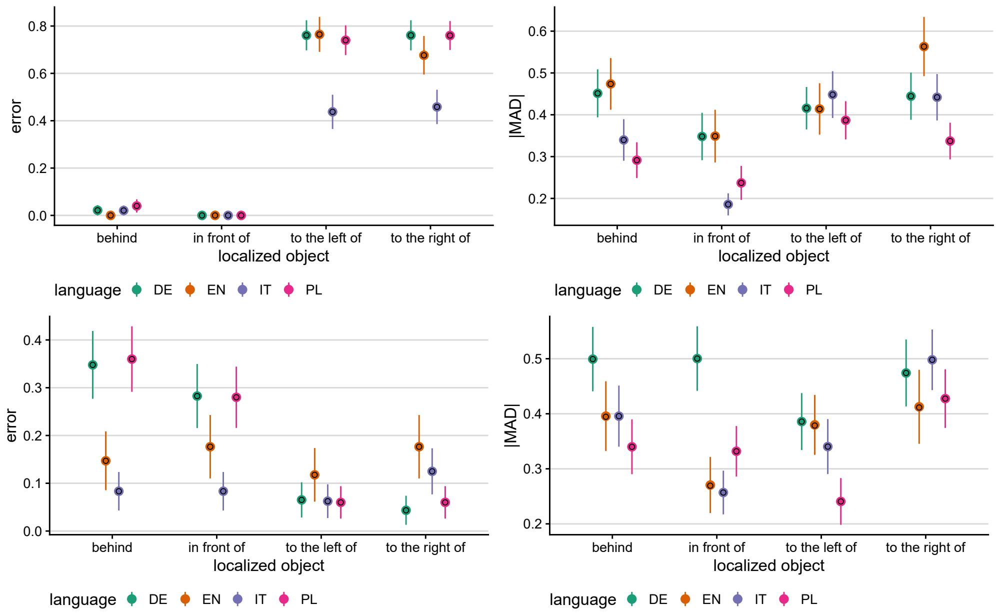


Figure 5.115: Predicted (dark dots) and actual results for responses for the canonically and noncanonically positioned dog: Differences between responses according to language (left) and trajectories through the response (right)

5.10.2 Summary and discussion

The focus of the section was to find out whether the interpretation of dimensional spatial expressions (*in front of*, *behind*, *to the right of*, *to the left of*) depends on the native language [NH4]. For this, I compared the interpretation of spatial relations by German, English, Italian, and Polish native speakers. In addition, I also investigated how these speakers identify sides of an intrinsic object (cupboard).

Fedden and Boroditsky (2012) have already shown the diversity of descriptions of spatial relation using examples from the Mian language. Native speakers of Mian apply the absolute reference frame in everyday situations using river directions as fixed reference directions (upriver / downriver). Levinson (2003a) has demonstrated a similar phenomenon with the Tzeltal language: It is possible to describe everyday spatial relations in this language using the intrinsic and absolute reference frames. The absolute one is distinguished by hill directions (downhill / uphill) and dominates descriptions of spatial relations in everyday life (Levinson, 2003a).

In German, English, Italian, and Polish, the intrinsic and relative reference frames are employed in everyday situations. The present studies show that the answer to the question, *Where is the bottle standing?* depends on the language used. This applies even to native speakers of languages that use the same part of speech and reference frame to describe spatial relations between at least two objects.

In this section, I discuss whether the interpretation of dimensional spatial expressions in static situations depends on the native language (5.10). This section of the thesis presents the statistical analyses for German, English, Italian, and Polish native speakers. To make the analysis reader-friendly, I match the structure of the analysis in this section with that in the previous sections.

First, I investigate how German, English, Italian, and Polish native speakers interpret static extrinsic spatial relations with a table as a reference object and a bottle as a localized object. The spatial relation was included in a room with a window. The results for the categorical measures indicate only a few variations between language pairs. No spatial relation revealed significant differences between the languages: static spatial relations with an extrinsic reference object and a localized object were predominantly interpreted using the facing / reflection strategy. This outcome expands the findings of Grabowski and Miller (2000), who investigated the interpretation of dynamic spatial relations by American English and German native speakers. They demonstrate that American English native speakers tend to use the facing / reflection strategy to interpret "in front of" more frequently than they do to interpret "behind." The English native speakers used the align / translation strategy to interpret dynamic spatial relation with an extrinsic reference object more frequently (Grabowski and Miller, 2000, p. 542). Results of the present thesis do not confirm this finding for the interpretation of static spatial relations with an extrinsic reference object. The finding demonstrates that British English native speakers interpreted spatial expressions for the description of dynamic and static spatial relations in a manner that is different to that in which American English speakers do. This contrasts with the German native speakers, who interpreted the spatial expressions for the description of dynamic and static spatial relations with extrinsic reference object using the facing / reflection strategy (see above for static spatial relations and Grabowski and Miller, 2000, p. 536 f.).

Second, I analyze the same extrinsic spatial relations supplemented by an artificial agent (Hans) and introduced by indirect speech. The results for these spatial relations led to greater variation both between speakers of the same language and for different languages. The Polish native speakers most frequently shifted the origo to Hans and interpreted the extrinsic spatial relations from his point of view. In contrast, English native speakers most frequently deviated from shifting the origo to Hans. With respect to the continuous measures, the results show that the Polish native speakers attained the lowest MAD.abs values for the interpretation of almost all extrinsic spatial relations (with and without Hans as an artificial agent). That is, the Polish native speakers showed a large amount of certainty in their responses. In contrast, when interpreting all the extrinsic spatial relations with Hans, the German participants had the highest MAD.abs values. These results expand on those of Perużyńska (2012a), who explored the interpretation of spatial relations introduced by a verb of dynamic semantics by German, English, Italian, and Polish native speakers. The spatial scenario was almost the same, though it did not include any bottle as a localized object. Participants were asked to tick a region they interpreted as *in front of* or *behind* the table. Their results show that in spatial relations introduced with a verb of dynamic semantics, English native speakers most frequently used the align / translation strategy. This leads to the conclusion that the interpretation of the dimensional spatial expressions *in front of* and *behind* depends on verb semantics. English native speakers more frequently used the align / translation strategy for spatial relations introduced by a verb of dynamic semantics (e.g. *stellen* 'put') than by a verb of a static semantics (e.g. *stehen* 'is standing'). The responses of the Italian participants were the opposite.

For static intrinsic spatial relations involving a cupboard as a reference object and a bottle as a localized object, I tested whether German, English, Italian, and Polish native speakers use one of the strategies of the intrinsic reference frame (inside and outside) or of the relative one (facing / reflection strategy, align / translation strategy, or rotation strategy). The results indicate a difference between Italian native speakers and Polish, English, and German native speakers with respect to the interpretation of spatial relations with the bottle to the right and left of a canonically positioned cupboard. In both situations, the Italian native speakers most frequently deviated from the interpretation aligned with the outside perspective. That is, these participants interpreted the spatial relations as they would for a vehicle and not a vis-à-vis object.

The results for all the languages for the interpretation of the spatial relations with a canonically positioned cupboard, a bottle as localized object, and Hans as an artificial agent indicate differences. However, of all the speakers, in all the spatial relations investigated, the English participants most frequently used the outside perspective of the intrinsic reference frame. Polish and Italian native speakers most frequently deviated from the outside perspective when interpreting complex spatial relations with the bottle to the right and left of the cupboard (more than 80%). That is, these native speakers shifted the origo to Hans and interpreted these spatial relations from his point of view using the facing / reflection strategy. Considering the MAD.abs values, the results indicate that the Polish native speakers again provided answers with the least variation (for both the canonically and noncanonically positioned cupboard, whether or not supplemented by Hans). The differences between all other native speakers were especially conspicuous for the interpretation of complex spatial relations. Perużyńska (2012a) also investigated spatial relations involving a cupboard. These were requested using a verb of dynamic semantics, and the German, English, Italian, and Polish participants were asked to tick a region they interpreted as being in front of, behind, to the right or left of the cupboard. [12] These results indicate that, for all the participants, and independent of the kind of relation (static or dynamic), the Italian native speakers most frequently used the inside perspective when interpreting the right and left region of a cupboard.

The German, English, Italian, and Polish native speakers in this study were also asked to interpret spatial relations with an animate reference object (a dog) and a localized object (a bottle) included in the same room as the cupboard or table. The results show that Italian native speakers interpret more frequently the right and left region of the dog facing the participants using the intrinsic reference frame than did the German, English or Polish ones. In contrast to the Italian native speakers, the German, English, and Polish native speakers more frequently interpreted the spatial relations with the bottle placed on the right and left side of the dog using the facing / reflection strategy. In addition, viewing the dog facing away from the participants, of all the languages investigated, the Italian native speakers most frequently interpreted the spatial relations using the intrinsic reference frame. Olloqui-Redondo et al. (2019) tested English and Spanish native speakers, exploring the influence of animacy of the reference object on the interpretation of dimensional spatial expressions. They found that English native speakers interpreted the expressions, to the right of vs. on the right side and to the left of vs. on the left side, depending on the syntactic structure (Olloqui-Redondo et al., 2019, p. 25). This result supports the findings of the study of Surtees et al. (2012), which demonstrate that, with non-human reference objects, English speakers tend to interpret *in front of* and *behind* using the relative reference frame.

Overall, the statistical analysis of the results indicates that the interpretation of dimensional spatial expressions depends on the native language. Thus, these results reject the assumptions of the fourth null hypothesis that the interpretation of dimensional spatial expressions does not depend on the native language.

[12] The task was: „Put the bottle in front of / behind / to the right / left of the cupboard".

6 Identification of objects' sides and interpretation of spatial relations by German, English, Italian and Polish native speakers – discussion and summary

The aim of this thesis was to explore how German, English, Italian and Polish native speakers identify sides of intrinsic objects and which reference frames they use to interpret everyday spatial relations. The four languages split into verb- and satellite-framed. Thereby, Italian belongs to the verb-framed languages and German, Polish and English to the satellite-framed languages. It means that native speakers of these languages could conceptualize motion and space differently (Talmy, 2000a; Talmy, 2000b; Slobin, 2006).

Space is everything around us. Every event occurs in a particular place at a particular time (Ehrich, 1992). This had already caught the attention of researchers thousands of years ago. The meaning of space in our everyday life is reflected in our language: The primary / source domain is the spatial domain, and from this the secondary / target domains are derived (e.g. Lakoff and Johnson, 1980; Boroditsky, 2001). The source domain serves as concrete and the secondary as abstract. In this manner, *time*, for instance, can serve as the secondary / target domain. Evidence for this assumption is derived for instance from language acquisition, which shows that children acquire the spatial meaning of prepositions before they acquire the temporal one (e.g. *vor* in German). The same applies to the question markers, *where* and *when* (e.g. Boroditsky, 2001; Clark, 1973; Lakoff and Johnson, 1980).

This thesis focuses on the interpretation of dimensional spatial expressions used by native speakers of German, English, Italian, and Polish to describe static spatial relations. The interpretation of spatial relations lead to a debate in the linguistics and spatial cognition (see chapters 2, 3, and 4). Levinson (1994b) indicates that the canonical orientation does not play any important role when assigning sides to objects. Grabowski (1999) points out that front plays the most important role in assigning sides. But the question, which arises here, is: where is the front of an object? As already shown by Harris and Strommen (1972), even participants of one native language can identify front different. According to Ehrich (1985) the intrinsic reference frame (object-centered) is preferred, when interpreting spatial relations. However, results of the study conducted by Tenbrink (2005a) indicate that German native speakers are more egocentric and English native speakers more object-centered. In contrast, the study results of Tappe (2000) reveal that German native speakers apply the viewer-perspective more frequently than the English ones, when interpreting front-back, right-left. Therefore, this thesis begins with the question, *Where is the bottle standing?* and with a possible answer *Hans says that the bottle is standing* ***to the right of*** *the cupboard but Thomas says that the bottle is standing* ***in front of*** *the cupboard.*

In the course of this thesis, I show what is important for answering this everyday question, and what the answer may depend on. First, the interpretation of dimensional spatial expressions, such as *to the right of* or *in front of*, used to describe spatial relations, depends on the objects it contains and on the relationship between them. The latter entails that the spatial relation can either be static or dynamic or be perceived as one of these. The dynamic spatial relation is more complex – it includes a route, source, goal, or a direction of a path (Pribbenow, 1991). Static spatial relations involve either motionless entities or their motion does not play any important role in the context. The abovementioned question and answers request and describe a static spatial relation, which is the focus of this thesis. In the languages I investigated in the course of this study, speakers first identify the origo of the particular spatial relation (the zero-point on the coordinate system, e.g. the point of view), then assign sides to the reference object (the cupboard in the relation above), then identify the regions of the reference object, and finally find the localized object (the bottle in the relation above). There are several rules for the choice of objects as the reference and localized objects (Ehrich, 1985; Grabowski, 1999; Maciejewski, 1996; Svorou, 1994; Perużyńska, 2012a; Fortis, 2010; Weiß, 2005; Timova, 2010; Stutterheim, 1990). One of these is that if only one of the objects is inherently determined by its sides (intrinsic objects, such as the cupboard in the example above), then it serves as the reference object for the particular spatial relation (e.g. Svorou, 1994, p. 12; Talmy, 2000a, p. 315 f.; Stoltmann, Fuchs, and Krifka, 2018). It follows that the object without inherently determined sides (the extrinsic object) serves as a localized object for the particular spatial relation (the bottle in the example above). In this manner, intrinsic objects are split into *vis-à-vis objects* (e.g. a cupboard) and *vehicle objects* (e.g. a car; Grabowski, 1999). Humans use various strategies to assign the right and left sides to both of these kinds of objects. These depend not only on the inherent features of the objects but also on their functionality (e.g. Tenbrink, 2005b; Levinson, 2003a; Herrmann and Grabowski, 1994; Retz-Schmidt, 1988). However, these assumptions do not apply to all languages. For instance, Tzeltal native speakers transfer the name of human body to inanimate objects (Levinson, 1994b; Levinson, 2003a).

The abovementioned region of an object is a characteristic spatial area, which partially belongs to the object. Speakers use it when they express the location of a localized object in relation to a reference object (Wunderlich, 1990).

To describe a spatial relation, speakers of German, English, Italian, and Polish use one of the three reference frames: absolute, intrinsic, or relative. They usually apply the absolute one for the description of geographical relations between entities (Tenbrink, 2005b). This is the only reference frame that comprises two axes rather than three (*north–south*; *east–west*; e.g. Brown and Levinson, 2000; Tower-Richardi et al., 2012). In everyday situations, German, English, Italian, and Polish native speakers use either the intrinsic or the relative reference frame. The intrinsic reference frame can be applied to the description of spatial relations that include an intrinsic reference object. On the other hand, the relative reference frame can be applied to both kinds of reference objects, extrinsic and intrinsic. This is one of the causes of the diverse interpretations of dimensional spatial expressions in descriptions of spatial relations.

In front of, *behind*, *to the right of*, and *to the left of* are components of secondary local deixis (e.g. Skibicki, 2007; Helbig and Buscha, 2001) and are also referred to as dimensional prepositions (e.g. Wunderlich and Herweg, 1991). Their meaning is derived with reference to the human body (e.g. Grabowski, 1999; Klein, 1994; Levinson, 2003a; Miller and Johnson-Laird, 1976). It is of interest that secondary local deixis does not shift when it is transferred from direct speech and embedded in indirect speech. Conversely, primary deixis has to be shifted when it is transferred from direct to indirect speech (Ehrich, 1992). The more complex scenarios investigated in this thesis were introduced using indirect speech to research origo shift, for example, *Hans says that the bottle is standing. . . .*

The first empirical aim of the present thesis is to determine how German, English, Italian, and Polish native speakers identify the sides of an intrinsic object when seeing it in a room with a window (the window made the room natural and indicated the room orientation). The results serve as a baseline for the analysis of the interpretation of spatial relations of two degrees of complexity that include the same cupboard. To this end, I asked participants to complete a survey and to assign sides to the cupboard. The results of the study indicate that German native speakers most frequently assign the sides to a cupboard using the expected strategy – the outside perspective of the intrinsic reference frame. This applies to both *front–back* and *right–left* axes. In contrast to the German native speakers, results for the Italian native speakers show that they most frequently deviated from the expected strategy when identifying *the right* and *left sides* of a canonically positioned cupboard. 33% of the Italian participants interpreted the cupboard as a vehicle object (e.g. a car). That is, they conducted a mental rotation of 180° not only during the assignment of *front* and *back* to the canonically positioned cupboard but also for the assignment of its *right* and *left*. For the identification of front and back of the noncanonically positioned cupboard, the English native speakers most frequently deviated from the expected strategy. Additionally, the Italian native speakers most frequently chose not to use the outside perspective when assigning the right and left sides to the noncanonically positioned cupboard.

	Cupboard—canonical				Cupboard—noncanonical			
language	Front	Back	Left	Right	Front	Back	Left	Right
German	100%	100%	90%	90%	97%	97%	69%	69%
Polish	100%	100%	82%	82%	88%	88%	48%	48%
Italian	100%	100%	67%	67%	88%	88%	31%	31%
English	100%	100%	91%	91%	82%	82%	47%	47%

Table 6.1: Assignment of sides to a canonically and noncanonically positioned cupboard by German, English, Italian and Polish native speakers using the outside perspective

It would be of interest to investigate other Germanic, Romance, and Slavic languages to ascertain whether these differences depend on the particular language family. German and English participants showed similarities when identifying the sides of the canonically positioned cupboard. Additionally, it would be important to determine how bilingual German–Italian speakers assign sides to objects in these languages. Finally, it would be important to investigate systematically how native speakers of these languages acquire the sides of objects – how are they taught what is *front*, *back*, *right* or *left of* an object (extrinsic and intrinsic).

The next goal of the present empirical study was to explore how German, English, Italian, and Polish native speakers interpret spatial relations between one reference object and one localized object in the same room as the cupboard described above. A bottle served as the localized object for all the spatial relations. The reference objects differed from one another as regards their animacy and inherently determined sides. *A dog* served as the intrinsic animate object, *a cupboard* as the intrinsic inanimate object, and *a table* as nonintrinsic (extrinsic) inanimate object (see third null hypothesis *the animacy of reference objects does not affect the interpretation of spatial relations* and fourth *the interpretation of dimensional spatial expressions does not depend on the native language*).

The results of the interpretation of the spatial relations with the cupboard as a reference object indicate that native speakers of all the languages less frequently interpreted the spatial relations with the noncanonically positioned cupboard using the outside perspective than they identified the sides of the cupboard (see above) with respect to this perspective.

Comparing the results in greater detail, in the mouse tracking experiment German and Polish native speakers most frequently deviated from the outside perspective when they interpreted spatial relations with a noncanonically positioned cupboard with the bottle *in front of* it or *behind* it. The results demonstrate that Italian native speakers more frequently interpreted spatial relations with the canonically positioned cupboard and the bottle *to the right / left of* it using the outside perspective than they assigned these sides to the cupboard using that perspective.

	Cupboard—canonical				Cupboard—noncanonical			
language	Front	Back	Left	Right	Front	Back	Left	Right
German	98%	96%	93%	96%	39%	41%	30%	28%
Polish	98%	100%	90%	88%	38%	52%	20%	16%
Italian	96%	94%	79%	71%	56%	67%	27%	12%
English	94%	94%	97%	88%	56%	53%	32%	32%

Table 6.2: Percentage of responses (with reference to all participants in a language) interpreting dimensional spatial relations with a canonically and noncanonically positioned cupboard by German, English, Italian and Polish native speakers using the outside perspective

These results (6.2) demonstrate that German, English, Italian, and Polish native speakers assign sides to an object using strategies other than those they apply to interpret spatial relations with the same object as a reference. This extends the results of Perużyńska (2012a), which shows that up to 25% of Italian native speakers use the inside perspective to interpret spatial relations described by a dynamic verb for a canonically positioned cupboard. In addition, the results for the spatial relations described by static and dynamic verbs for the noncanonically positioned cupboard demonstrated differences. Fewer Polish native speakers used the outside perspective to interpret static spatial relations with the cupboard and the bottle located in front of it (38% for static vs. 55% for dynamic). The same applies to German native speakers: they more frequently used the outside perspective to interpret spatial relations described by a dynamic verb for the noncanonically positioned cupboard with bottle located behind it (41% for static vs. 56% for dynamic). Conversely, more English and Italian native speakers used the outside perspective for static spatial relations with a noncanonically positioned cupboard (EN: in front of: 56% for static and 42% for dynamic; behind: 53% for static and 42% for dynamic; IT: in front of: 56% for static and 49% for dynamic; behind: 67% for static and 52% for dynamic). This indicates that motion of a spatial relation can influence the choice of the reference frame for its interpretation (see e.g. Eschenbach, 2005; Tenbrink, 2011).

In the present study, the same native speakers of the four languages were asked to interpret spatial relations with a canonically and noncanonically positioned cupboard supplemented by an artificial agent, *Hans* ([NH1]: The presence of a third person as artificial agent in a spatial relation expressed by indirect speech does not affect an origo shift). Hans, the artificial agent, stood either to the left or right of the cupboard, facing it. The spatial relations were introduced using indirect speech, for example, *Hans says that the bottle is standing...* The aim of the task was to research origo shift in relation to the reference object. The results indicate that, seeing the cupboard from the front, among all the participants, the English native speakers less frequently shifted the origo to Hans. This applies to all spatial constellations involving the bottle as localized object and the cupboard as reference object (*in front of, behind, to the right / left of*). Seeing the cupboard from the back, most participants across the languages investigated shifted the origo to Hans and interpreted the spatial relations from his point of view using the facing / reflection strategy. As regards the continuous measurements, Polish native speakers showed the lowest MAD.abs values when interpreting all the spatial relations with Hans and the cupboard (facing the participants from the front and back).

A universal interpretative hierarchy for the languages cannot be determined from these results. Rather, the results suggest a hierarchy that is language-specific. Participants from all the languages more frequently used the outside perspective of the intrinsic reference frame to identify the sides of the cupboard than they did to interpret a spatial relation with the object according to the outside perspective. This point arises as important factor. The results of a questionnaire regarding dynamic verbs (Perużyńska, 2012a) appear in the second position regarding the intrinsic spatial interpretations for German and Polish native speakers. In these local constellations, participants were asked to complete a questionnaire by drawing their decision in an ellipsis as putting the bottle in one of these positions (*in front of, behind, to the right of / left of*) in relation to the cupboard (6.1). In contrast to the German and Polish native speakers, English and Italian participants used the intrinsic reference frame more frequently when interpreting static spatial relations in the mouse tracking experiment.

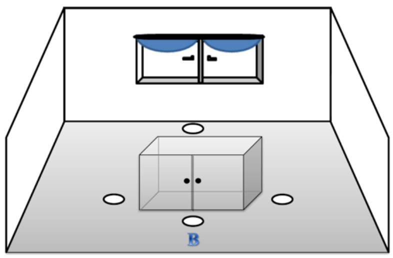


Figure 6.1: One of the situations from the survey experiment by Stoltmann (2014)

For the German and Polish participants, the responses for mouse tracking experiment clearly come last with respect to the interpretation aligned with the outside perspective. In contrast to the questionnaire study, in this study, the participants were asked to directly interpret a situation with a bottle and a cupboard. That is, they saw the localized and the reference object and were asked to interpret a static relation rather than a dynamic one.

Furthermore, results of the mouse tracking study also indicate that the presence of the artificial agent (Hans) affects shift of reference frame. For the complex spatial relations, the choice of the intrinsic reference frame decreased significantly compared to the simple spatial relation without Hans. That is, most participants shifted the origo to Hans' point of view, ignored the intrinsic properties of the reference object, and interpreted the spatial relations in terms of the facing / reflection strategy. The results also indicate that the shift of reference frame depends on the spatial relations. Participants more frequently selected the intrinsic reference frame in relations with the bottle *in front of* or *behind* than *to the right / left of* the cupboard (in relation to the intrinsic reference frame).

Grabowski (1999) indicates that humans do not have any problems in empathizing with higher animate entities. This thesis investigates the influence of the animacy of the reference entity on the choice of reference frame to interpret spatial relations. Of all the participants, the Italian native speakers most frequently interpreted the spatial relations with the dog facing with front as reference entity using the intrinsic reference frame – the significant differences arose for the relations with the bottle to the right and left of the dog. Front and back did not cause any significant differences between the languages because almost all the participants assessed the situations using the intrinsic reference frame. Most of the participants from all the languages answered the right and left position of the dog facing with back align the intrinsic reference frame. Significant differences were revealed between German and Italian and between the Italian and Polish participants for the interpretation of the spatial relations with the bottle behind the dog (facing the participants from the back) as most of the Italian native speakers opted for the intrinsic reference frame (as expected).

With regard to the interpretation of spatial dimensional expressions in relations with animate and inanimate intrinsic reference objects, two strong differences appeared for all the languages investigated. For canonical spatial relations with the cupboard and the bottle to the right / left of it, participants from all the languages significantly more frequently used the interpretation that aligned with the expected intrinsic reference frame than they did with the dog facing the participants and the bottle to the right / left of it. This result is surprising as the dog possesses pronounced sides on the second horizontal axis while cupboard does not. Conversely, seeing the dog or cupboard from the back, all the participants significantly more frequently selected the interpretation aligned with the intrinsic reference frame when the dog served as reference. This applies to all four spatial relations (*in front of / behind / to the right of / to the left of*). Of all the languages investigated, the Italian native speakers mostly used the intrinsic reference frame when assessing spatial relations with an animate reference object. Therefore, it would be of interest to further explore Romance languages to ascertain whether the strategy is typical for Romance languages more generally or whether it only applies to Italian.

	Dog facing with front				Dog facing with back			
language	Front	Back	Left	Right	Front	Back	Left	Right
German	100%	98%	24%	24%	72%	65%	93%	96%
Polish	100%	96%	26%	24%	72%	64%	94%	94%
Italian	100%	98%	56%	54%	92%	92%	94%	88%
English	100%	100%	24%	32%	82%	85%	88%	82%

Table 6.3: Interpretation of dimensional spatial relations by German, English, Italian and Polish native speakers with a dog as a reference object (facing the participants with front vs. back) using the inside perspective

The results of this study support and expand the assumption of Bowerman (1996; for the preposition *aan*), Feist and Gentner (1997; for *in*), Feist (2000), Hüther et al. (2016) and Baltaretu et al. (2016) that animacy influences the choice of spatial expression for both the first horizontal axis (front–back) and for the second one (right–left).

Finally, I also tested the German, English, Italian and Polish native speakers regarding how they interpret spatial relations with an extrinsic reference object (table). The results of these tasks aid understanding of whether speakers of these particular languages use the same strategy or different ones to interpret all kind of reference objects (e.g. intrinsic reference frame for intrinsic relations and relative reference frame for extrinsic relations). I used two kinds of tables – a round one (without any edges in the front–back or on the right–left) and a rectangular one (with four corners).

	Round table				Rectangular Table			
language	Front	Back	Left	Right	Front	Back	Left	Right
German	93%	89%	98%	96%	96%	96%	96%	96%
Polish	92%	90%	92%	96%	90%	90%	92%	84%
Italian	90%	79%	90%	92%	85%	81%	88%	90%
English	91%	94%	94%	97%	91%	85%	88%	94%

Table 6.4: Interpretation of dimensional spatial relations with extrinsic reference object (round and rectangular table) using the facing / reflection strategy by German, English, Italian and Polish native speakers

6.4 demonstrates that most of the participants interpreted the spatial relations with tables using the facing / reflection strategy. The answers of Italian native speakers most frequently differed from the expected ones – especially for spatial relations with the bottle located behind the table. In contrast to the German native speakers, the English native speakers less frequently used the facing / reflection strategy to interpret the spatial relation with the rectangular table than they did for the round table with the bottle behind it.

This result also expands on the results of the study of Perużyńska (2012a), which explored how German, English, Italian, and Polish native speakers judge spatial relations with tables using verbs of dynamic semantics. Her results indicate that, for the four languages, native speakers of English and Italian most frequently deviated from the facing / reflection strategy when judging the spatial relations with the bottle in front of and behind the table. Comparing the results of the present study and those of Perużyńska (2012a), the strongest difference arises for the Italian native speakers, who followed the assumptions of the facing / reflection strategy, more frequently judging spatial relations with the bottle in front of and behind a table using dynamic verbs rather than by static verbs.

Similarly to the spatial relations with the cupboard as reference, I also tested spatial relations with the table using two degrees of complexity. The above described (6.4) serves as simple spatial relation. In addition to the table as reference object and the bottle as localized object, the complex spatial relations include an artificial agent (Hans). These were introduced using indirect speech, for example *Hans says that the bottle is standing...*. The aim of this component of the study was to determine whether German, English, Italian, and Polish native speakers shift the origo to Hans and interpret static extrinsic spatial relations from Hans' point of view. The results show that most participants (up to 100%) shifted the origo to Hans and interpreted the static extrinsic spatial relations from his point of view using the facing / reflection strategy. Polish native speakers most frequently shifted the origo to Hans, thereby attaining the lowest MAD.abs values; English native speakers did so less frequently. This applies to the all static extrinsic spatial relations with Hans. The results indicate that German, English, Italian, and Polish native speakers systematically judge static extrinsic spatial relations differently.

To investigate the origo shift in further detail, it would be of interest to conduct a motion capture study using scenarios of different complexity: basic, of medium complexity, and complex. In the basic scenario, it would be of interest to explore how native speakers (mono- vs. bilingual) interpret spatial relations between one localized and one reference object (static) as well as which position they decide on when they are asked to put the localized object in front of / behind / to the right of / to the left of / close to the reference object. This step would aid understanding of which regions may serve to describe the relationships between localized and reference objects for situations in which the localized object is already positioned and for situations in which the participants are asked to localize the object. It would also show what determining this region depends on, for example, the intrinsicality of the reference object, the size of the reference object, or animacy. For complex spatial relations, it would be of interest to include two experiment instructors in the scenario, as in 6.2. The positions of the instructors (A, B) and the participants should be randomized. The aim of the scenario would be to explore which point of view the participants use to interpret dimensional spatial expressions – whether they use their own or whether they shift the origo to the instructor A or B on hearing a description from instructor A (assuming that instructor B cannot speak the relevant language). For example, "He asked me (instructor A) to ask you to connect the red Lego brick to the right side of the green Lego brick. … Finally, he asks you to place the tree to the right of the bridge."

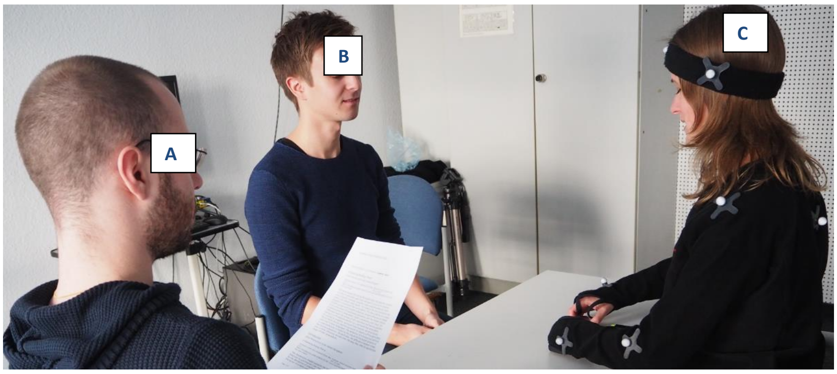


Figure 6.2: Possible complex scenario with two instructors (A, B) and one participant (C); photograph taken in the motion capture lab at the Leibniz-Zentrum Allgemeine Sprachwissenschaft

Motion capture as an experimental method would be advantageous because the areas between the localized and reference objects could be computed very precisely. Additionally, not only the hand movements but also head movements would be computed and a video recorded. Using motion capture as an experimental method, it would be possible to explore nonverbal language for description and interpretation of spatial relations between objects, for example, using pointing gestures. As a follow-up study of Janzen, Haun, et al. (2012), an fMRI study could be used to underpin the results.

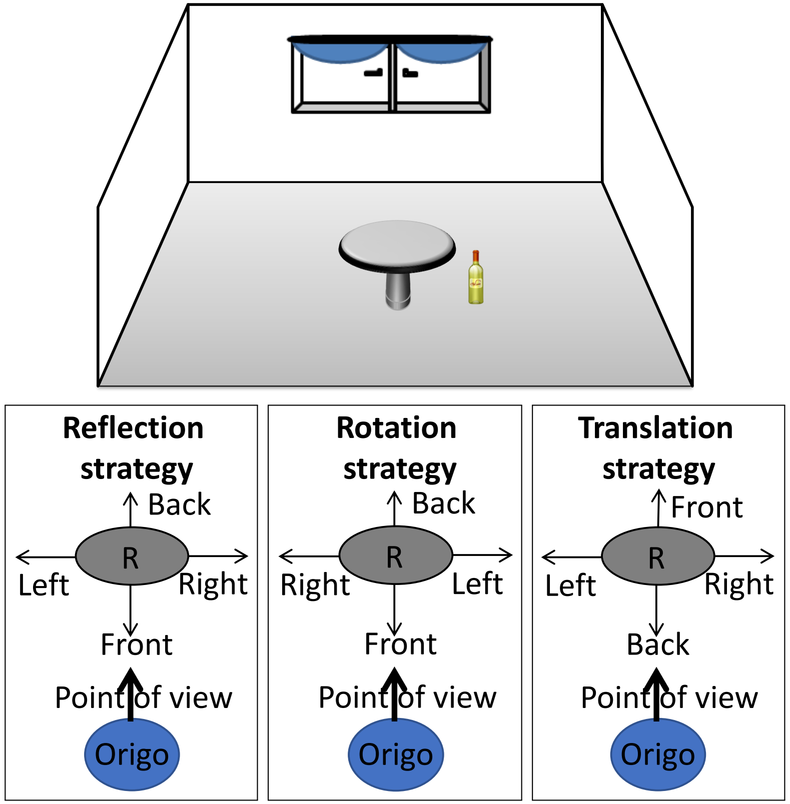
The question that arises is why should the interpretation of dimensional spatial expressions be researched in greater depth and who could benefit from it? As explained above, dimensional spatial expressions are used in our everyday life, in both private and professional situations. Considering professional situations, dimensional spatial expressions are used, for instance, during surgery. Hüther et al. (2016) researched how medical and law students interpret spatial relations with a person as a reference entity. They show that around 50% of the advanced medicine students use the intrinsic reference frame when interpreting spatial relations in such cases. This result is surprising both because humans are anthropomorphic and because such words are very important during surgery. The question which arises following the study of Hüther et al. (2016) is how should robots be implemented for human–robot interaction during surgery. As Tenbrink and Dylla (2017) point out, the investigation of spatial expressions is also important for communicating while sailing, a scenario which has not yet been examined. Dimensional spatial expressions are also used for instructions for assembling furniture, explanations of accidents, and instructions to taxi drivers (as shown by Grabowski, 1999 and Grabowski and Miller, 2000). In future, spatial expressions will be used for autonomous cars. In addition, from a basic research point of view, it would be of interest to test bilingual participants to ascertain whether the interpretation and description of spatial relations is language- or culture-specific – in a manner analogous to Boroditsky (2008) for metaphor theory. As a few results have already indicated, American English native speakers and British English native speakers follow different strategies (compare the results of the present study with those of Grabowski and Miller, 2000).

To answer the question in the introduction that was based in the research assumptions[1]: Thomas and Hans can refer to the same position using different spatial expressions – *in front of* and *to the right of* – even if the reference object is intrinsic.

[1] *Where is the bottle standing?* And the possible answers: *Hans says that the bottle is standing* ***to the right of*** *the cupboard, but Thomas says that the bottle is* ***in front of*** *the cupboard.* Can both of these speakers be referring to the same place?

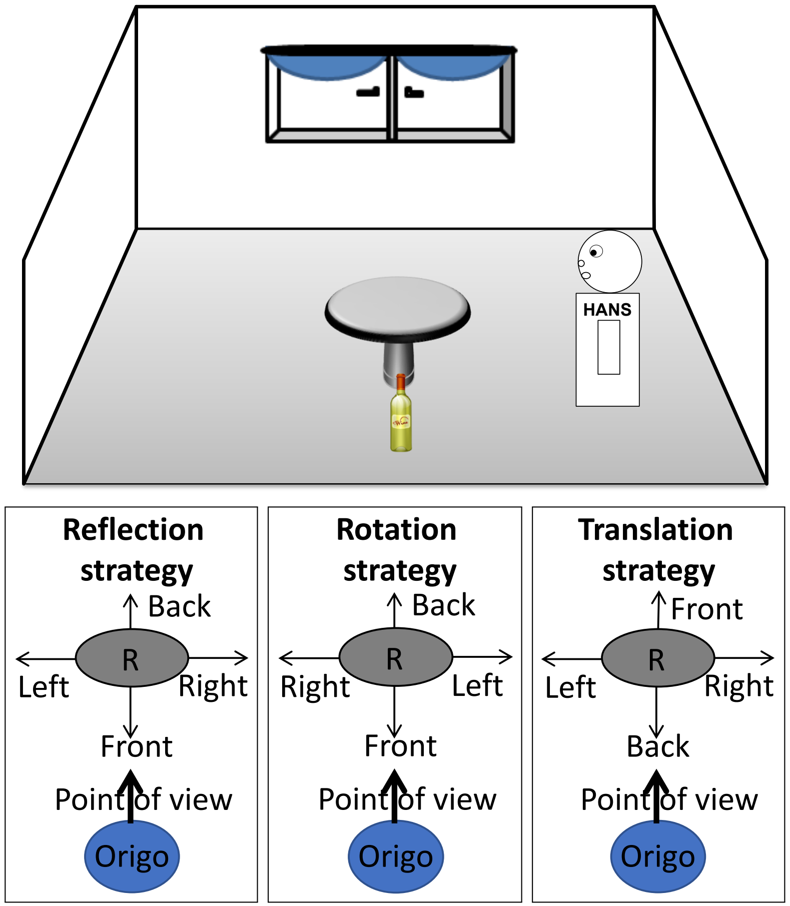
A Statistical analysis for cross-linguistic study on German, English, Italian and Polish

A.1 Round table: simple



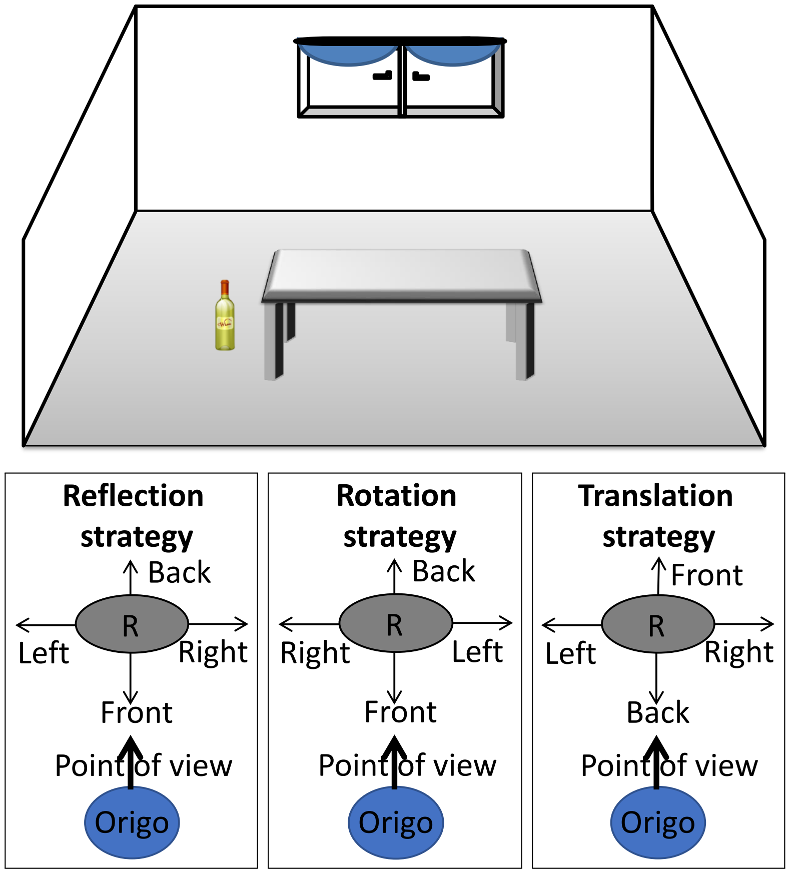
	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	t.ratio	p.value
behind															
DE - EN	0.8905	1.0542	Inf	0.8447	0.8331	0.6685	0.8693	Inf	0.7690	0.8685	0.1135	0.0759	636.6869	1.4953	0.4409
DE - IT	-0.5807	0.8281	Inf	-0.7013	0.8966	-0.7691	0.5922	Inf	-1.2988	0.5637	0.0802	0.0691	641.5043	1.1605	0.6520
DE - PL	0.7243	0.9210	Inf	0.7865	0.8606	0.0931	0.6683	Inf	0.1393	0.9990	0.2818	0.0684	641.5043	4.1184	**0.0003**
EN - IT	-1.4713	1.0236	Inf	-1.4373	0.4759	-1.4376	0.8109	Inf	-1.7728	0.2865	-0.0333	0.0752	636.5991	-0.4426	0.9710
EN - PL	-0.1662	1.0958	Inf	-0.1517	0.9988	-0.5754	0.8680	Inf	-0.6628	0.9110	0.1683	0.0746	636.5154	2.2560	0.1096
IT - PL	1.3051	0.8850	Inf	1.4746	0.4529	0.8622	0.5904	Inf	1.4605	0.4616	0.2016	0.0677	641.5043	2.9788	**0.0159**
in front of															
DE - EN	-0.4769	1.1286	Inf	-0.4225	0.9746	-0.3272	0.8498	Inf	-0.3850	0.9806	0.1277	0.0759	636.6869	1.6827	0.3337
DE - IT	-0.4603	1.0478	Inf	-0.4393	0.9717	-0.5108	0.7615	Inf	-0.6708	0.9081	0.0668	0.0691	641.5043	0.9672	0.7682
DE - PL	-0.0457	1.0843	Inf	-0.0422	1.0000	-0.2202	0.7927	Inf	-0.2778	0.9925	0.3019	0.0684	641.5043	4.4120	**0.0001**
EN - IT	0.0166	1.0546	Inf	0.0157	1.0000	-0.1836	0.7674	Inf	-0.2393	0.9952	-0.0609	0.0752	636.5991	-0.8093	0.8501
EN - PL	0.4311	1.0921	Inf	0.3948	0.9791	0.1070	0.7983	Inf	0.1340	0.9991	0.1742	0.0746	636.5154	2.3347	0.0913
IT - PL	0.4145	1.0047	Inf	0.4126	0.9763	0.2906	0.7036	Inf	0.4130	0.9763	0.2350	0.0677	641.5043	3.4731	**0.0031**
to the left of															
DE - EN	-1.9613	1.7752	Inf	-1.1048	0.6866	-1.0341	1.2464	Inf	-0.8297	0.8404	-0.0081	0.0759	636.6869	-0.1070	0.9996
DE - IT	-2.5579	1.6547	Inf	-1.5459	0.4100	-1.6549	1.1160	Inf	-1.4829	0.4478	0.0793	0.0691	641.5043	1.1474	0.6603
DE - PL	-2.2053	1.6703	Inf	-1.3203	0.5499	-1.3643	1.1375	Inf	-1.1994	0.6272	0.0149	0.0684	641.5043	0.2185	0.9963
EN - IT	-0.5966	1.1480	Inf	-0.5197	0.9544	-0.6208	0.8686	Inf	-0.7147	0.8913	0.0874	0.0752	636.5991	1.1620	0.6511
EN - PL	-0.2441	1.1730	Inf	-0.2081	0.9968	-0.3302	0.8961	Inf	-0.3685	0.9829	0.0231	0.0746	636.5154	0.3093	0.9897
IT - PL	0.3526	0.9855	Inf	0.3577	0.9843	0.2906	0.7036	Inf	0.4130	0.9763	-0.0643	0.0677	641.5043	-0.9507	0.7774
to the right of															
DE - EN	0.5780	1.5073	Inf	0.3835	0.9808	0.4055	1.2462	Inf	0.3254	0.9881	-0.0578	0.0759	636.6869	-0.7622	0.8714
DE - IT	-0.5648	1.1435	Inf	-0.4939	0.9605	-0.6931	0.8919	Inf	-0.7772	0.8648	-0.1380	0.0691	641.5043	-1.9976	0.1899
DE - PL	0.6361	1.3203	Inf	0.4818	0.9632	0.0870	1.0215	Inf	0.0852	0.9998	0.0490	0.0684	641.5043	0.7162	0.8907
EN - IT	-1.1429	1.4200	Inf	-0.8048	0.8522	-1.0986	1.1415	Inf	-0.9624	0.7708	-0.0802	0.0752	636.5991	-1.0659	0.7104
EN - PL	0.0580	1.5675	Inf	0.0370	1.0000	-0.3185	1.2454	Inf	-0.2557	0.9941	0.1069	0.0746	636.5154	1.4324	0.4795
IT - PL	1.2009	1.2179	Inf	0.9860	0.7574	0.7802	0.8908	Inf	0.8758	0.8174	0.1870	0.0677	641.5043	2.7638	**0.0299**

A.2 Round table: complex



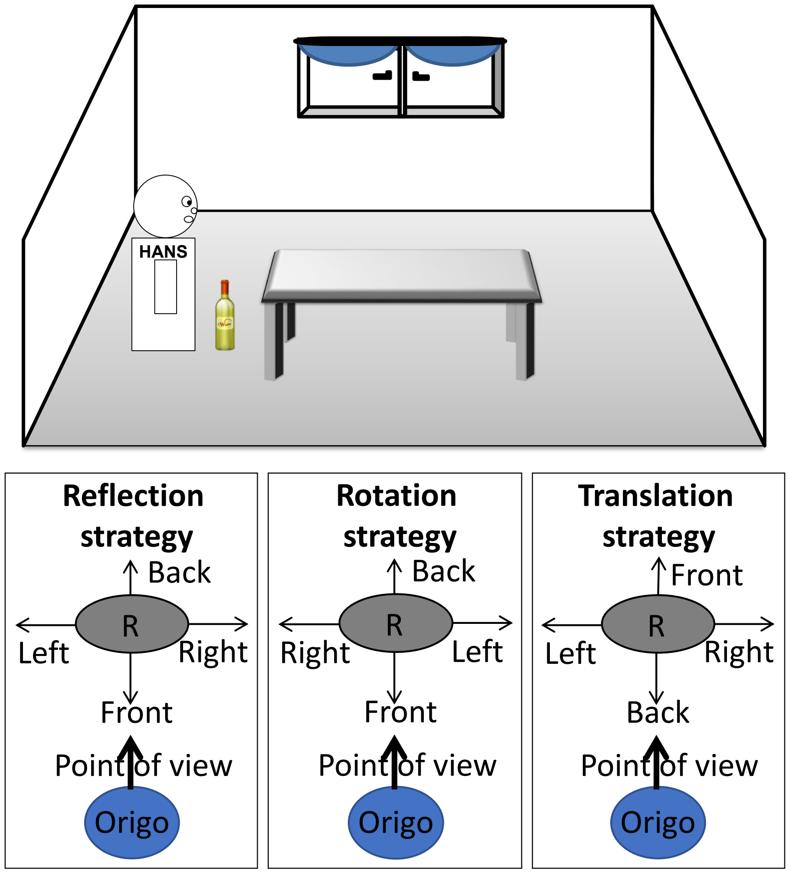
	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value
behind															
DE - EN	0.3077	0.7250	Inf	0.4245	0.9743	0.3372	0.2011	Inf	1.6771	0.3358	0.0130	0.0416	Inf	0.3135	0.9893
DE - IT	-0.1629	0.6726	Inf	-0.2422	0.9950	-0.2186	0.2055	Inf	-1.0636	0.7117	0.0573	0.0377	Inf	1.5186	0.4262
DE - PL	-0.8195	0.6819	Inf	-1.2018	0.6257	-1.4003	0.2844	Inf	-4.9240	**0.0000**	0.0978	0.0374	Inf	2.6155	**0.0441**
EN - IT	-0.4706	0.7250	Inf	-0.6491	0.9159	-0.5558	0.2049	Inf	-2.7120	**0.0338**	0.0443	0.0411	Inf	1.0766	0.7039
EN - PL	-1.1272	0.7334	Inf	-1.5371	0.4152	-1.7375	0.2840	Inf	-6.1186	**0.0000**	0.0847	0.0408	Inf	2.0770	0.1606
IT - PL	-0.6566	0.6815	Inf	-0.9635	0.7702	-1.1817	0.2871	Inf	-4.1156	**0.0002**	0.0404	0.0368	Inf	1.0983	0.6906
in front of															
DE - EN	-0.1243	0.7109	Inf	-0.1748	0.9981	0.0713	0.1827	Inf	0.3900	0.9799	0.0355	0.0416	Inf	0.8531	0.8289
DE - IT	-0.3826	0.6502	Inf	-0.5884	0.9356	-0.3987	0.1828	Inf	-2.1810	0.1285	0.0586	0.0377	Inf	1.5522	0.4063
DE - PL	-1.5450	0.6700	Inf	-2.3060	0.0966	-1.8004	0.2750	Inf	-6.5470	**0.0000**	0.1849	0.0374	Inf	4.9461	**0.0000**
EN - IT	-0.2583	0.7105	Inf	-0.3636	0.9836	-0.4699	0.1914	Inf	-2.4553	0.0671	0.0231	0.0411	Inf	0.5612	0.9435
EN - PL	-1.4207	0.7282	Inf	-1.9509	0.2069	-1.8716	0.2808	Inf	-6.6658	**0.0000**	0.1493	0.0408	Inf	3.6620	**0.0014**
IT - PL	-1.1624	0.6693	Inf	-1.7367	0.3045	-1.4017	0.2808	Inf	-4.9909	**0.0000**	0.1263	0.0368	Inf	3.4299	**0.0034**
to the left of															
DE - EN	0.6474	0.7209	Inf	0.8981	0.8058	0.4512	0.1957	Inf	2.3051	0.0968	0.0352	0.0416	Inf	0.8455	0.8327
DE - IT	0.0882	0.6674	Inf	0.1321	0.9992	-0.1542	0.2011	Inf	-0.7665	0.8696	0.0383	0.0377	Inf	1.0159	0.7401
DE - PL	-1.4714	0.7193	Inf	-2.0457	0.1714	-2.0701	0.3644	Inf	-5.6801	**0.0000**	0.1663	0.0374	Inf	4.4509	**0.0001**
EN - IT	-0.5592	0.7157	Inf	-0.7813	0.8630	-0.6053	0.1968	Inf	-3.0758	**0.0113**	0.0032	0.0411	Inf	0.0767	0.9998
EN - PL	-2.1188	0.7643	Inf	-2.7724	**0.0285**	-2.5212	0.3621	Inf	-6.9632	**0.0000**	0.1312	0.0408	Inf	3.2160	**0.0071**
IT - PL	-1.5596	0.7139	Inf	-2.1847	0.1275	-1.9159	0.3650	Inf	-5.2488	**0.0000**	0.1280	0.0368	Inf	3.4769	**0.0029**
to the right of															
DE - EN	0.5071	0.7267	Inf	0.6978	0.8980	0.3785	0.2028	Inf	1.8671	0.2423	0.0447	0.0416	Inf	1.0731	0.7060
DE - IT	0.2452	0.6697	Inf	0.3662	0.9832	-0.0926	0.2036	Inf	-0.4551	0.9687	0.0955	0.0377	Inf	2.5309	0.0553
DE - PL	-2.8598	0.9489	Inf	-3.0139	**0.0137**	-3.5244	0.7230	Inf	-4.8750	**0.0000**	0.2111	0.0374	Inf	5.6488	**0.0000**
EN - IT	-0.2619	0.7193	Inf	-0.3641	0.9835	-0.4712	0.2013	Inf	-2.3404	0.0890	0.0509	0.0411	Inf	1.2368	0.6033
EN - PL	-3.3670	0.9844	Inf	-3.4203	**0.0035**	-3.9030	0.7223	Inf	-5.4033	**0.0000**	0.1665	0.0408	Inf	4.0816	**0.0003**
IT - PL	-3.1051	0.9429	Inf	-3.2930	**0.0055**	-3.4318	0.7226	Inf	-4.7495	**0.0000**	0.1156	0.0368	Inf	3.1399	**0.0092**

A.3 Rectangular table: simple



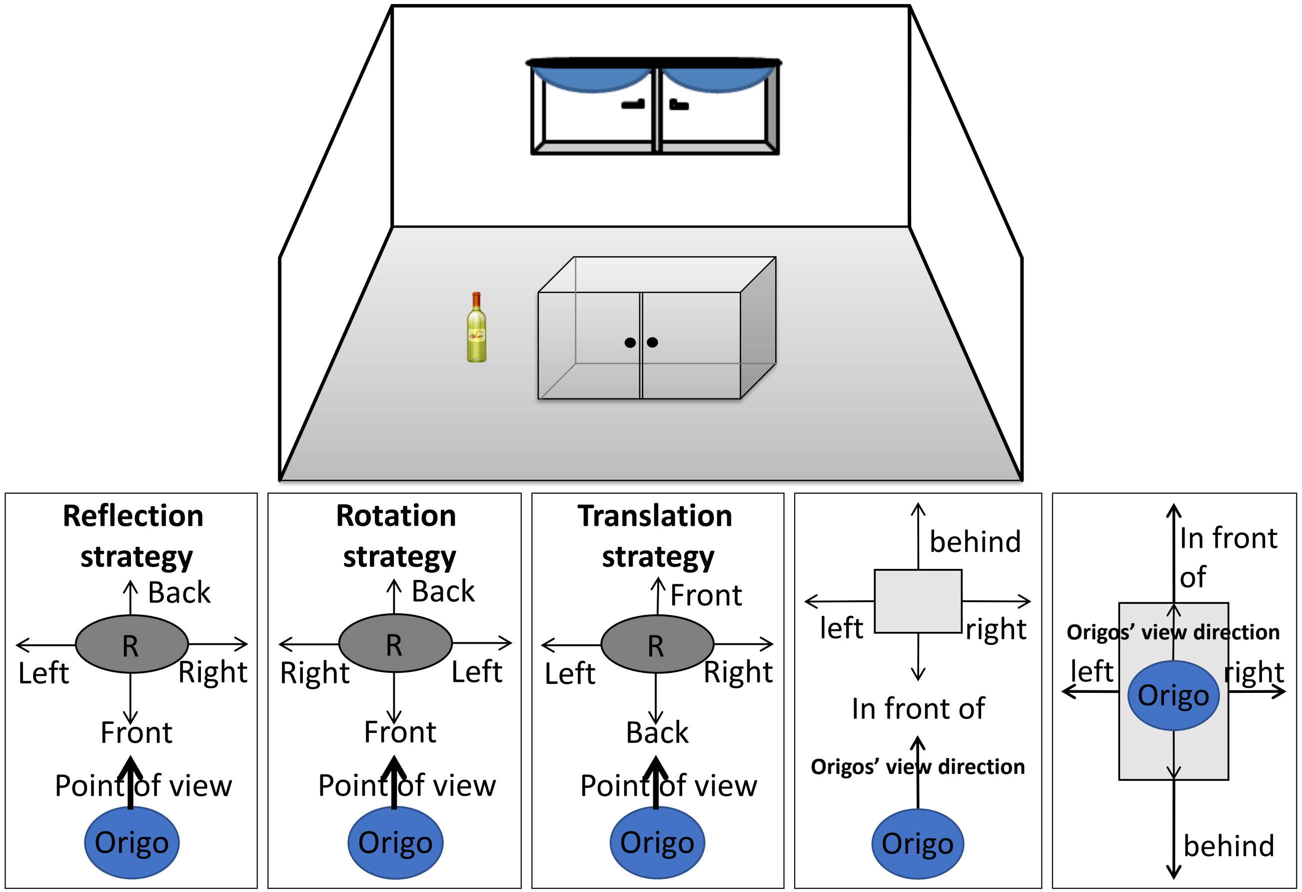
	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	t.ratio	p.value
behind															
DE - EN	-1.9055	1.1478	Inf	-1.6601	0.3450	-1.3332	0.8701	Inf	-1.5322	0.4181	0.0376	0.0837	600.5410	0.4490	0.9698
DE - IT	-2.3399	1.0767	Inf	-2.1732	0.1307	-1.6247	0.8120	Inf	-2.0009	0.1876	0.2010	0.0762	606.0393	2.6379	**0.0424**
DE - PL	-1.1024	1.1312	Inf	-0.9745	0.7640	-0.8938	0.8630	Inf	-1.0357	0.7285	0.3273	0.0755	606.0393	4.3369	**0.0001**
EN - IT	-0.4344	0.8549	Inf	-0.5081	0.9572	-0.2915	0.6093	Inf	-0.4785	0.9639	0.1634	0.0830	600.4416	1.9690	0.2010
EN - PL	0.8030	0.9333	Inf	0.8605	0.8252	0.4394	0.6758	Inf	0.6501	0.9155	0.2897	0.0823	600.3469	3.5189	**0.0026**
IT - PL	1.2374	0.8443	Inf	1.4657	0.4584	0.7309	0.5991	Inf	1.2199	0.6142	0.1262	0.0746	606.0393	1.6913	0.3291
in front of															
DE - EN	-0.6976	1.1410	Inf	-0.6114	0.9285	-0.7557	0.9424	Inf	-0.8018	0.8536	-0.0077	0.0837	600.5410	-0.0916	0.9997
DE - IT	-1.4445	1.0048	Inf	-1.4376	0.4758	-1.3234	0.8306	Inf	-1.5934	0.3824	0.0179	0.0762	606.0393	0.2352	0.9954
DE - PL	-0.6101	1.0559	Inf	-0.5779	0.9387	-0.8938	0.8630	Inf	-1.0357	0.7285	0.1601	0.0755	606.0393	2.1222	0.1472
EN - IT	-0.7469	0.9803	Inf	-0.7619	0.8716	-0.5677	0.7300	Inf	-0.7777	0.8646	0.0256	0.0830	600.4416	0.3084	0.9898
EN - PL	0.0875	1.0331	Inf	0.0847	0.9998	-0.1382	0.7667	Inf	-0.1802	0.9979	0.1678	0.0823	600.3469	2.0387	0.1750
IT - PL	0.8344	0.8826	Inf	0.9454	0.7803	0.4296	0.6241	Inf	0.6883	0.9016	0.1422	0.0746	606.0393	1.9055	0.2268
to the left of															
DE - EN	-1.0500	1.0960	Inf	-0.9580	0.7733	-1.0761	0.8977	Inf	-1.1987	0.6276	-0.0206	0.0837	600.5410	-0.2459	0.9948
DE - IT	-1.2697	1.0099	Inf	-1.2572	0.5903	-1.1451	0.8444	Inf	-1.3561	0.5271	0.0354	0.0762	606.0393	0.4647	0.9667
DE - PL	-0.2904	1.0853	Inf	-0.2675	0.9933	-0.6487	0.8912	Inf	-0.7279	0.8860	0.2753	0.0755	606.0393	3.6481	**0.0016**
EN - IT	-0.2197	0.9399	Inf	-0.2338	0.9955	-0.0690	0.6883	Inf	-0.1002	0.9996	0.0560	0.0830	600.4416	0.6748	0.9066
EN - PL	0.7596	1.0237	Inf	0.7421	0.8801	0.4274	0.7450	Inf	0.5737	0.9399	0.2959	0.0823	600.3469	3.5944	**0.0020**
IT - PL	0.9793	0.9331	Inf	1.0495	0.7202	0.4964	0.6799	Inf	0.7302	0.8850	0.2399	0.0746	606.0393	3.2138	**0.0075**
to the right of															
DE - EN	-0.2061	1.2136	Inf	-0.1699	0.9983	-0.3185	1.0266	Inf	-0.3102	0.9897	0.0315	0.0837	600.5410	0.3758	0.9819
DE - IT	-0.8749	1.0434	Inf	-0.8385	0.8361	-0.9393	0.8636	Inf	-1.0876	0.6971	0.0857	0.0762	606.0393	1.1251	0.6742
DE - PL	-1.5194	0.9891	Inf	-1.5362	0.4157	-1.4328	0.8194	Inf	-1.7487	0.2985	0.2284	0.0755	606.0393	3.0266	**0.0137**
EN - IT	-0.6688	1.1023	Inf	-0.6067	0.9300	-0.6208	0.8686	Inf	-0.7147	0.8913	0.0543	0.0830	600.4416	0.6538	0.9142
EN - PL	-1.3133	1.0511	Inf	-1.2494	0.5953	-1.1144	0.8246	Inf	-1.3513	0.5301	0.1969	0.0823	600.3469	2.3922	0.0796
IT - PL	-0.6445	0.8458	Inf	-0.7620	0.8715	-0.4935	0.6100	Inf	-0.8091	0.8502	0.1426	0.0746	606.0393	1.9112	0.2243

A.4 Rectangular table: complex



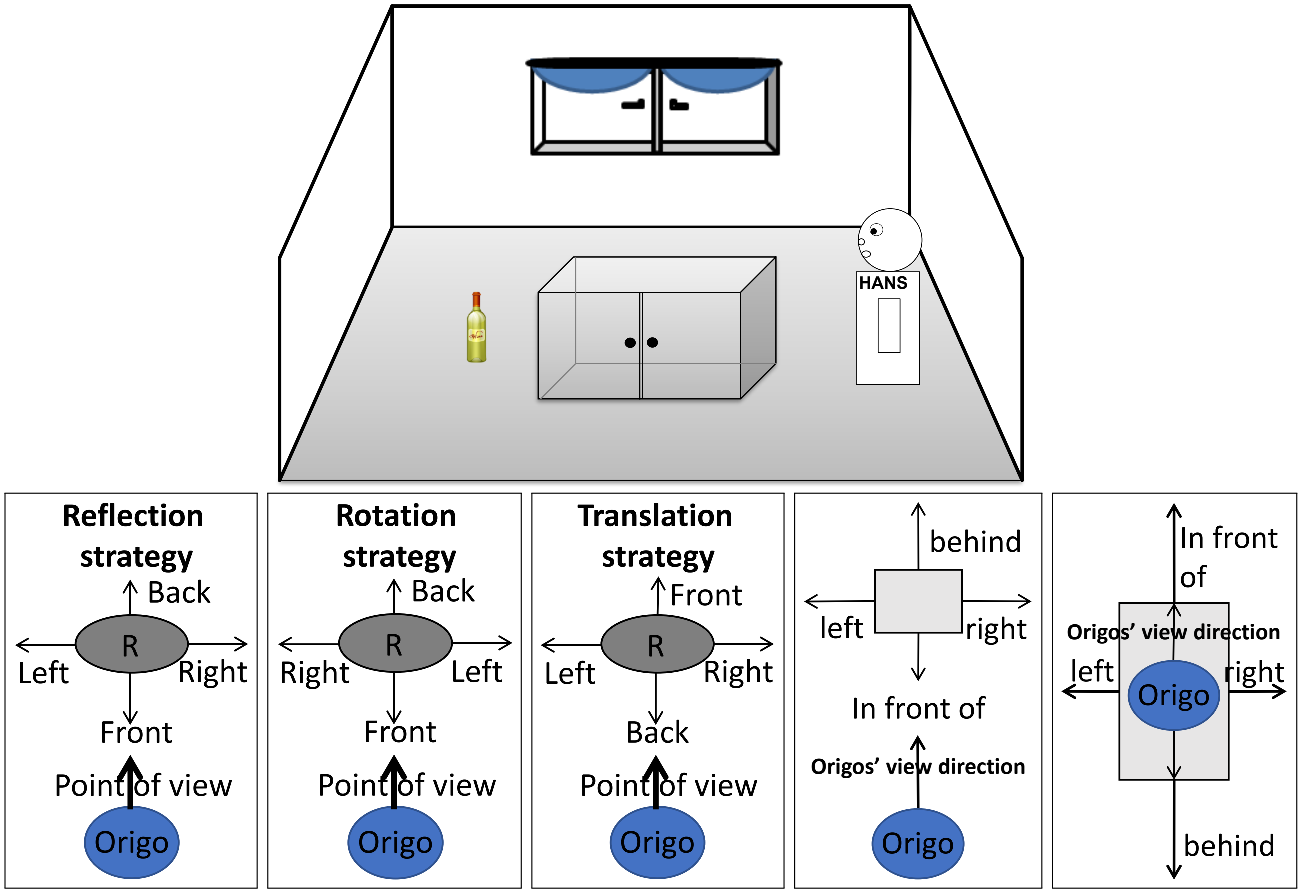
	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value
behind															
DE - EN	0.4822	0.4577	Inf	1.0535	0.7178	0.3903	0.1896	Inf	2.0582	0.1670	0.0346	0.0421	Inf	0.8224	0.8439
DE - IT	-0.3518	0.4315	Inf	-0.8154	0.8472	-0.1898	0.1936	Inf	-0.9803	0.7607	0.0757	0.0382	Inf	1.9821	0.1947
DE - PL	-0.7003	0.4355	Inf	-1.6080	0.3740	-1.1358	0.2451	Inf	-4.6347	**0.0000**	0.1757	0.0378	Inf	4.6469	**0.0000**
EN - IT	-0.8340	0.4611	Inf	-1.8088	0.2691	-0.5801	0.1919	Inf	-3.0232	**0.0133**	0.0410	0.0416	Inf	0.9866	0.7571
EN - PL	-1.1824	0.4648	Inf	-2.5437	0.0535	-1.5261	0.2437	Inf	-6.2622	**0.0000**	0.1411	0.0413	Inf	3.4184	**0.0035**
IT - PL	-0.3485	0.4391	Inf	-0.7936	0.8574	-0.9460	0.2468	Inf	-3.8329	**0.0007**	0.1000	0.0372	Inf	2.6850	**0.0365**
in front of															
DE - EN	0.1152	0.4475	Inf	0.2574	0.9940	0.1496	0.1775	Inf	0.8431	0.8339	0.0479	0.0421	Inf	1.1370	0.6666
DE - IT	-0.6162	0.4178	Inf	-1.4747	0.4529	-0.3719	0.1788	Inf	-2.0803	0.1595	0.0685	0.0382	Inf	1.7951	0.2756
DE - PL	-1.2002	0.4271	Inf	-2.8100	**0.0255**	-1.4454	0.2374	Inf	-6.0884	**0.0000**	0.1805	0.0378	Inf	4.7741	**0.0000**
EN - IT	-0.7314	0.4539	Inf	-1.6113	0.3721	-0.5215	0.1850	Inf	-2.8199	**0.0248**	0.0207	0.0416	Inf	0.4966	0.9599
EN - PL	-1.3154	0.4624	Inf	-2.8444	**0.0231**	-1.5950	0.2421	Inf	-6.5889	**0.0000**	0.1326	0.0413	Inf	3.2139	**0.0072**
IT - PL	-0.5840	0.4338	Inf	-1.3461	0.5334	-1.0735	0.2431	Inf	-4.4166	**0.0001**	0.1120	0.0372	Inf	3.0058	**0.0141**
to the left of															
DE - EN	1.0722	0.4596	Inf	2.3330	0.0906	0.7228	0.1937	Inf	3.7308	**0.0011**	0.0617	0.0421	Inf	1.4646	0.4590
DE - IT	0.3672	0.4298	Inf	0.8543	0.8283	0.2192	0.1940	Inf	1.1299	0.6710	0.1149	0.0382	Inf	3.0090	**0.0140**
DE - PL	-1.1659	0.4850	Inf	-2.4038	0.0763	-1.6946	0.3262	Inf	-5.1953	**0.0000**	0.2177	0.0378	Inf	5.7575	**0.0000**
EN - IT	-0.7050	0.4489	Inf	-1.5704	0.3956	-0.5036	0.1801	Inf	-2.7966	**0.0265**	0.0532	0.0416	Inf	1.2789	0.5764
EN - PL	-2.2381	0.5020	Inf	-4.4583	**0.0000**	-2.4174	0.3181	Inf	-7.5993	**0.0000**	0.1560	0.0413	Inf	3.7807	**0.0009**
IT - PL	-1.5331	0.4750	Inf	-3.2278	**0.0068**	-1.9138	0.3183	Inf	-6.0134	**0.0000**	0.1028	0.0372	Inf	2.7598	**0.0295**
to the right of															
DE - EN	0.8168	0.4462	Inf	1.8307	0.2588	0.5424	0.1777	Inf	3.0524	**0.0122**	0.0682	0.0421	Inf	1.6191	0.3677
DE - IT	0.5825	0.4075	Inf	1.4292	0.4810	0.3050	0.1700	Inf	1.7937	0.2763	0.0701	0.0382	Inf	1.8356	0.2566
DE - PL	0.1897	0.4037	Inf	0.4699	0.9657	-0.2834	0.1863	Inf	-1.5212	0.4247	0.1988	0.0378	Inf	5.2578	**0.0000**
EN - IT	-0.2344	0.4334	Inf	-0.5407	0.9491	-0.2374	0.1645	Inf	-1.4432	0.4723	0.0019	0.0416	Inf	0.0458	1.0000
EN - PL	-0.6271	0.4299	Inf	-1.4588	0.4626	-0.8257	0.1812	Inf	-4.5559	**0.0000**	0.1306	0.0413	Inf	3.1651	**0.0084**
IT - PL	-0.3927	0.3896	Inf	-1.0081	0.7447	-0.5883	0.1737	Inf	-3.3863	**0.0040**	0.1287	0.0372	Inf	3.4553	**0.0031**

A.5 Cupboard canonical: simple



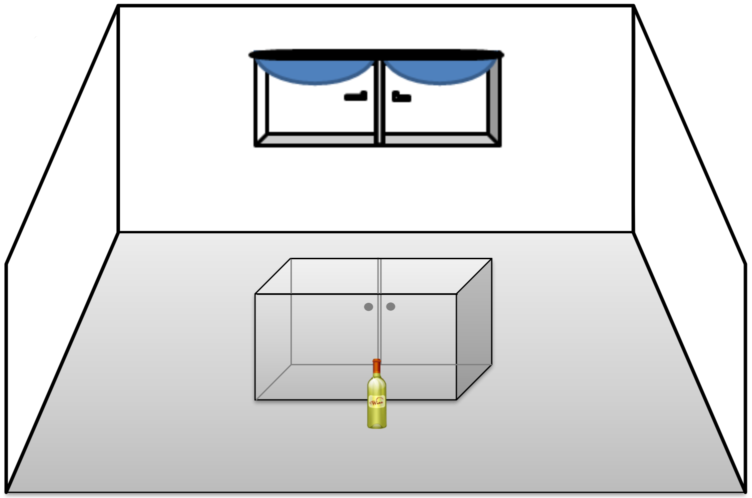
	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	t.ratio	p.value
behind															
DE - EN	-0.8875	1.2416	Inf	-0.7148	0.8913	-0.3185	1.0266	Inf	-0.3102	0.9897	0.1540	0.0827	626.7624	1.8631	0.2451
DE - IT	-0.7330	1.1713	Inf	-0.6258	0.9238	-0.3830	0.9372	Inf	-0.4087	0.9770	0.0497	0.0753	631.8159	0.6600	0.9120
DE - PL	13.2102	124.1826	Inf	0.1064	0.9996	15.4750	922.4407	Inf	0.0168	1.0000	0.2045	0.0745	631.8159	2.7442	**0.0316**
EN - IT	0.1545	1.1058	Inf	0.1397	0.9990	-0.0645	0.9417	Inf	-0.0685	0.9999	-0.1043	0.0819	626.6705	-1.2736	0.5801
EN - PL	14.0978	124.1858	Inf	0.1135	0.9995	15.7935	922.4407	Inf	0.0171	1.0000	0.0505	0.0813	626.5830	0.6211	0.9253
IT - PL	13.9432	124.1853	Inf	0.1123	0.9995	15.8580	922.4406	Inf	0.0172	1.0000	0.1548	0.0737	631.8159	2.1006	0.1540
in front of															
DE - EN	-0.6312	1.3595	Inf	-0.4643	0.9668	-1.0341	1.2464	Inf	-0.8297	0.8404	-0.0440	0.0827	626.7624	-0.5319	0.9513
DE - IT	-0.0271	1.3496	Inf	-0.0201	1.0000	-0.6712	1.2426	Inf	-0.5401	0.9492	0.0168	0.0753	631.8159	0.2230	0.9961
DE - PL	0.7445	1.5255	Inf	0.4881	0.9618	0.0852	1.4292	Inf	0.0596	0.9999	0.1094	0.0745	631.8159	1.4687	0.4571
EN - IT	0.6041	1.3247	Inf	0.4560	0.9685	0.3629	1.0262	Inf	0.3537	0.9848	0.0608	0.0819	626.6705	0.7415	0.8802
EN - PL	1.3757	1.5072	Inf	0.9128	0.7980	1.1192	1.2457	Inf	0.8985	0.8056	0.1534	0.0813	626.5830	1.8880	0.2342
IT - PL	0.7717	1.4911	Inf	0.5175	0.9549	0.7563	1.2418	Inf	0.6090	0.9292	0.0926	0.0737	631.8159	1.2571	0.5906
to the left of															
DE - EN	1.0020	1.4031	Inf	0.7141	0.8915	0.8339	1.1777	Inf	0.7081	0.8939	-0.0327	0.0827	626.7624	-0.3954	0.9790
DE - IT	-1.7602	0.9164	Inf	-1.9207	0.2193	-1.3276	0.6949	Inf	-1.9104	0.2236	0.1015	0.0753	631.8159	1.3487	0.5322
DE - PL	-0.5019	0.9669	Inf	-0.5191	0.9545	-0.4654	0.7608	Inf	-0.6117	0.9284	0.0623	0.0745	631.8159	0.8357	0.8375
EN - IT	-2.7621	1.3173	Inf	-2.0967	0.1541	-2.1615	1.0755	Inf	-2.0098	0.1843	0.1342	0.0819	626.6705	1.6377	0.3582
EN - PL	-1.5038	1.3472	Inf	-1.1162	0.6795	-1.2993	1.1192	Inf	-1.1609	0.6516	0.0949	0.0813	626.5830	1.1686	0.6470
IT - PL	1.2583	0.8326	Inf	1.5112	0.4307	0.8622	0.5904	Inf	1.4605	0.4616	-0.0392	0.0737	631.8159	-0.5323	0.9512
to the right of															
DE - EN	-1.4226	1.1236	Inf	-1.2660	0.5847	-1.0761	0.8978	Inf	-1.1986	0.6277	0.0486	0.0827	626.7624	0.5883	0.9356
DE - IT	-2.9570	1.0274	Inf	-2.8782	**0.0209**	-2.2037	0.7897	Inf	-2.7907	**0.0270**	0.1077	0.0753	631.8159	1.4317	0.4800
DE - PL	-1.2577	1.0546	Inf	-1.1926	0.6316	-1.0986	0.8439	Inf	-1.3019	0.5617	0.2373	0.0745	631.8159	3.1852	**0.0082**
EN - IT	-1.5344	0.8715	Inf	-1.7608	0.2924	-1.1276	0.6198	Inf	-1.8192	0.2642	0.0591	0.0819	626.6705	0.7214	0.8886
EN - PL	0.1649	0.9232	Inf	0.1786	0.9980	-0.0225	0.6876	Inf	-0.0327	1.0000	0.1887	0.0813	626.5830	2.3224	0.0940
IT - PL	1.6993	0.7966	Inf	2.1331	0.1426	1.1051	0.5387	Inf	2.0513	0.1694	0.1296	0.0737	631.8159	1.7584	0.2946

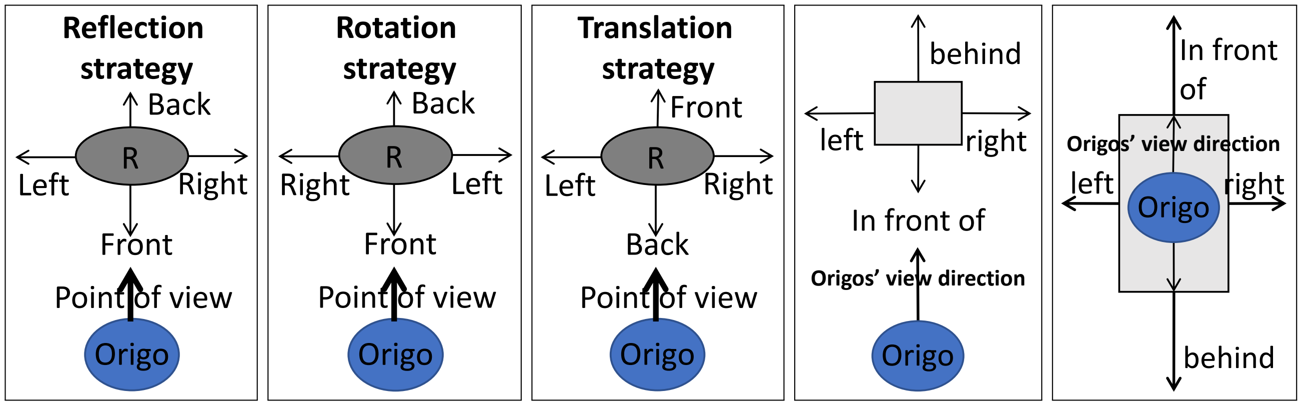
A.6 Cupboard canonical: complex



	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value
behind															
DE - EN	0.8831	0.8441	Inf	1.0461	0.7222	0.2733	0.1365	Inf	2.0012	0.1874	0.0298	0.0406	Inf	0.7350	0.8830
DE - IT	0.4124	0.7580	Inf	0.5441	0.9481	0.1035	0.1264	Inf	0.8193	0.8454	0.0226	0.0368	Inf	0.6132	0.9279
DE - PL	-0.1293	0.7576	Inf	-0.1706	0.9982	-0.0267	0.1265	Inf	-0.2108	0.9967	0.1501	0.0364	Inf	4.1229	**0.0002**
EN - IT	-0.4706	0.8275	Inf	-0.5687	0.9414	-0.1697	0.1343	Inf	-1.2640	0.5859	-0.0073	0.0402	Inf	-0.1809	0.9979
EN - PL	-1.0123	0.8271	Inf	-1.2239	0.6116	-0.2999	0.1344	Inf	-2.2321	0.1146	0.1203	0.0399	Inf	3.0154	**0.0137**
IT - PL	-0.5417	0.7393	Inf	-0.7327	0.8840	-0.1302	0.1240	Inf	-1.0498	0.7200	0.1276	0.0360	Inf	3.5422	**0.0022**
in front of															
DE - EN	1.2258	0.8423	Inf	1.4554	0.4648	0.3895	0.1354	Inf	2.8768	**0.0209**	0.0239	0.0406	Inf	0.5894	0.9353
DE - IT	0.3698	0.7577	Inf	0.4880	0.9618	0.0870	0.1262	Inf	0.6895	0.9012	0.0473	0.0368	Inf	1.2849	0.5726
DE - PL	0.1521	0.7561	Inf	0.2012	0.9971	0.0848	0.1250	Inf	0.6789	0.9051	0.1419	0.0364	Inf	3.8972	**0.0006**
EN - IT	-0.8560	0.8259	Inf	-1.0365	0.7280	-0.3025	0.1333	Inf	-2.2695	0.1052	0.0233	0.0402	Inf	0.5800	0.9381
EN - PL	-1.0737	0.8244	Inf	-1.3023	0.5614	-0.3046	0.1321	Inf	-2.3054	0.0968	0.1180	0.0399	Inf	2.9575	**0.0164**
IT - PL	-0.2176	0.7381	Inf	-0.2949	0.9911	-0.0022	0.1227	Inf	-0.0175	1.0000	0.0947	0.0360	Inf	2.6283	**0.0426**
to the left of															
DE - EN	1.2884	0.8539	Inf	1.5088	0.4321	0.4457	0.1474	Inf	3.0239	**0.0133**	0.0189	0.0406	Inf	0.4666	0.9663
DE - IT	-0.1714	0.7733	Inf	-0.2217	0.9962	-0.4318	0.1526	Inf	-2.8303	**0.0240**	0.0191	0.0368	Inf	0.5199	0.9543
DE - PL	-1.1197	0.7763	Inf	-1.4423	0.4728	-0.5868	0.1555	Inf	-3.7734	**0.0009**	0.1477	0.0364	Inf	4.0562	**0.0003**
EN - IT	-1.4598	0.8397	Inf	-1.7386	0.3036	-0.8775	0.1559	Inf	-5.6271	**0.0000**	0.0002	0.0402	Inf	0.0045	1.0000
EN - PL	-2.4081	0.8427	Inf	-2.8577	**0.0222**	-1.0325	0.1588	Inf	-6.5009	**0.0000**	0.1288	0.0399	Inf	3.2275	**0.0068**
IT - PL	-0.9482	0.7611	Inf	-1.2460	0.5975	-0.1550	0.1636	Inf	-0.9472	0.7793	0.1286	0.0360	Inf	3.5701	**0.0020**
to the right of															
DE - EN	0.7802	0.8555	Inf	0.9120	0.7984	0.2847	0.1492	Inf	1.9079	0.2246	0.0415	0.0406	Inf	1.0230	0.7360
DE - IT	-0.4077	0.7744	Inf	-0.5265	0.9527	-0.5459	0.1550	Inf	-3.5216	**0.0024**	0.0830	0.0368	Inf	2.2559	0.1086
DE - PL	-1.0617	0.7749	Inf	-1.3700	0.5182	-0.5531	0.1534	Inf	-3.6046	**0.0018**	0.2168	0.0364	Inf	5.9545	**0.0000**
EN - IT	-1.1879	0.8429	Inf	-1.4093	0.4934	-0.8306	0.1608	Inf	-5.1666	**0.0000**	0.0414	0.0402	Inf	1.0303	0.7316
EN - PL	-1.8419	0.8436	Inf	-2.1835	0.1278	-0.8378	0.1593	Inf	-5.2609	**0.0000**	0.1753	0.0399	Inf	4.3942	**0.0001**
IT - PL	-0.6540	0.7614	Inf	-0.8589	0.8260	-0.0072	0.1647	Inf	-0.0437	1.0000	0.1339	0.0360	Inf	3.7168	**0.0012**

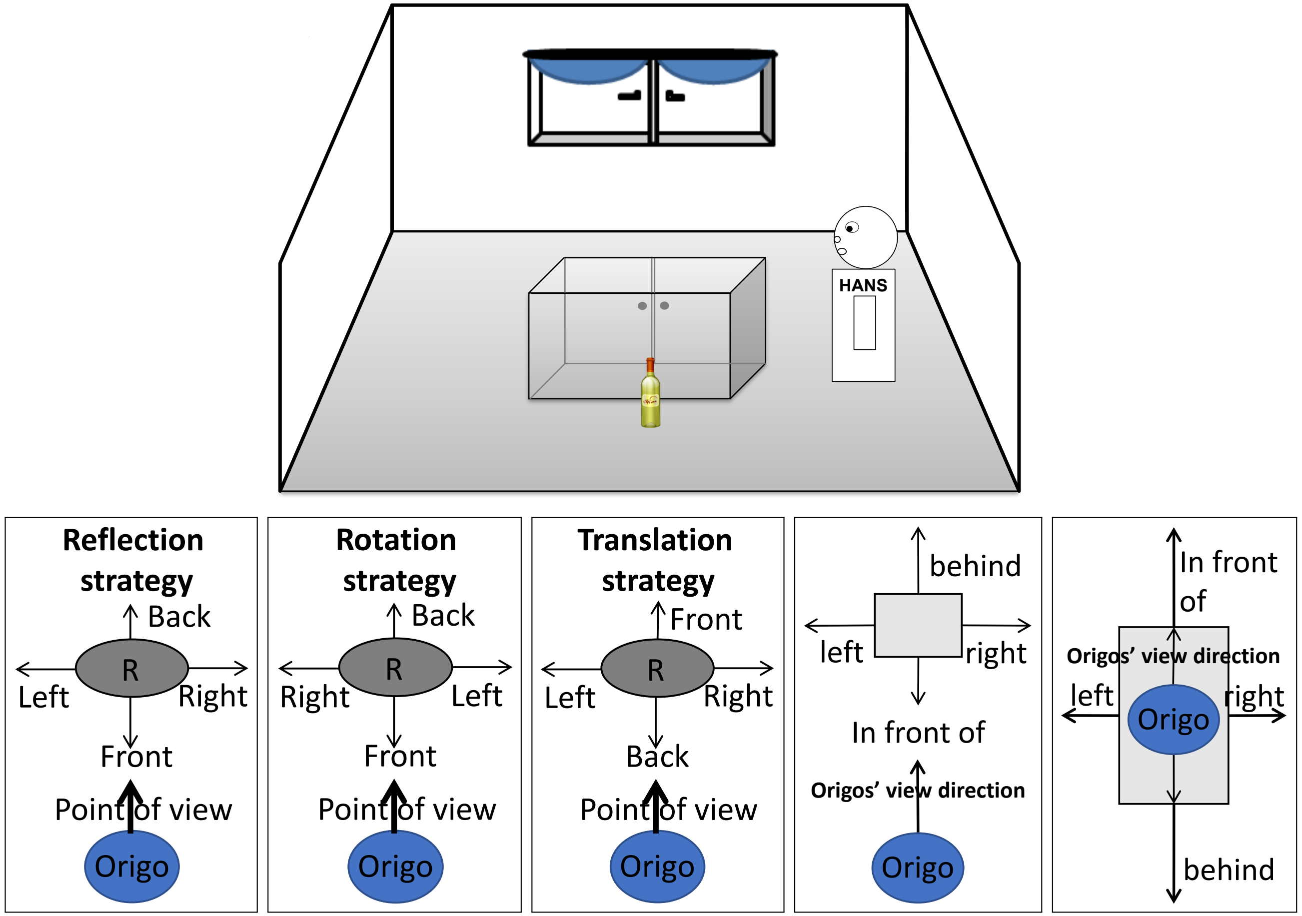
A.7 Cupboard non-canonical: simple





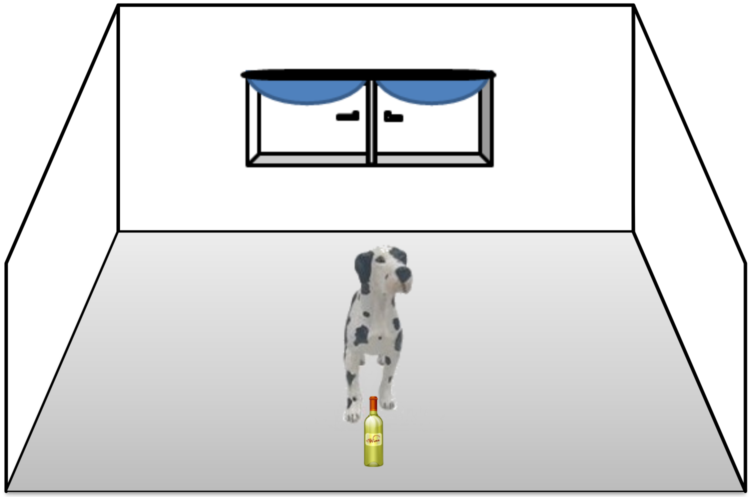
	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	t.ratio	p.value
behind															
DE - EN	0.9530	0.9632	Inf	0.9894	0.7555	0.4692	0.4558	Inf	1.0294	0.7322	0.0332	0.0821	625.8515	0.4049	0.9775
DE - IT	2.1482	0.9024	Inf	2.3806	0.0808	1.0445	0.4283	Inf	2.4390	0.0699	-0.0574	0.0748	630.9245	-0.7683	0.8687
DE - PL	0.9296	0.8764	Inf	1.0606	0.7135	0.4314	0.4121	Inf	1.0470	0.7217	0.0409	0.0740	630.9245	0.5530	0.9457
EN - IT	1.1952	0.9418	Inf	1.2691	0.5827	0.5754	0.4602	Inf	1.2502	0.5948	-0.0907	0.0814	625.7593	-1.1142	0.6809
EN - PL	-0.0234	0.9280	Inf	-0.0252	1.0000	-0.0377	0.4452	Inf	-0.0848	0.9998	0.0077	0.0807	625.6714	0.0952	0.9997
IT - PL	-1.2186	0.8577	Inf	-1.4208	0.4863	-0.6131	0.4170	Inf	-1.4703	0.4555	0.0984	0.0732	630.9245	1.3436	0.5355
in front of															
DE - EN	1.5060	0.9713	Inf	1.5506	0.4072	0.6782	0.4589	Inf	1.4780	0.4508	-0.0211	0.0821	625.8515	-0.2574	0.9940
DE - IT	1.5853	0.8852	Inf	1.7908	0.2777	0.6931	0.4194	Inf	1.6526	0.3491	-0.0148	0.0748	630.9245	-0.1980	0.9972
DE - PL	0.0293	0.8751	Inf	0.0335	1.0000	-0.0477	0.4197	Inf	-0.1137	0.9995	0.1510	0.0740	630.9245	2.0400	0.1745
EN - IT	0.0792	0.9299	Inf	0.0852	0.9998	0.0149	0.4516	Inf	0.0330	1.0000	0.0063	0.0814	625.7593	0.0779	0.9998
EN - PL	-1.4767	0.9374	Inf	-1.5753	0.3928	-0.7259	0.4519	Inf	-1.6065	0.3749	0.1721	0.0807	625.6714	2.1326	0.1439
IT - PL	-1.5560	0.8476	Inf	-1.8359	0.2564	-0.7409	0.4118	Inf	-1.7993	0.2736	0.1658	0.0732	630.9245	2.2647	0.1075
to the left of															
DE - EN	0.5010	0.9936	Inf	0.5043	0.9581	0.0891	0.4869	Inf	0.1830	0.9978	-0.0276	0.0821	625.8515	-0.3356	0.9870
DE - IT	-0.0206	0.9128	Inf	-0.0226	1.0000	-0.1637	0.4563	Inf	-0.3588	0.9842	0.0111	0.0748	630.9245	0.1487	0.9988
DE - PL	-0.8858	0.9376	Inf	-0.9447	0.7807	-0.5596	0.4772	Inf	-1.1728	0.6441	0.1354	0.0740	630.9245	1.8290	0.2606
EN - IT	-0.5217	0.9631	Inf	-0.5417	0.9488	-0.2528	0.4898	Inf	-0.5162	0.9553	0.0387	0.0814	625.7593	0.4752	0.9645
EN - PL	-1.3868	0.9934	Inf	-1.3960	0.5018	-0.6487	0.5093	Inf	-1.2737	0.5797	0.1629	0.0807	625.6714	2.0187	0.1821
IT - PL	-0.8652	0.9115	Inf	-0.9491	0.7782	-0.3959	0.4801	Inf	-0.8246	0.8428	0.1243	0.0732	630.9245	1.6973	0.3259
to the right of															
DE - EN	0.7361	1.0025	Inf	0.7343	0.8833	0.1940	0.4915	Inf	0.3946	0.9792	-0.1588	0.0821	625.8515	-1.9339	0.2149
DE - IT	-1.4627	1.0017	Inf	-1.4602	0.4618	-1.0144	0.5456	Inf	-1.8591	0.2459	-0.0102	0.0748	630.9245	-0.1367	0.9991
DE - PL	-1.1245	0.9683	Inf	-1.1613	0.6513	-0.7267	0.5060	Inf	-1.4361	0.4767	0.1286	0.0740	630.9245	1.7376	0.3050
EN - IT	-2.1988	1.0511	Inf	-2.0919	0.1557	-1.2083	0.5700	Inf	-2.1200	0.1467	0.1486	0.0814	625.7593	1.8257	0.2622
EN - PL	-1.8606	1.0196	Inf	-1.8248	0.2615	-0.9206	0.5322	Inf	-1.7300	0.3080	0.2874	0.0807	625.6714	3.5610	**0.0022**
IT - PL	0.3382	1.0137	Inf	0.3336	0.9872	0.2877	0.5825	Inf	0.4939	0.9605	0.1388	0.0732	630.9245	1.8964	0.2306

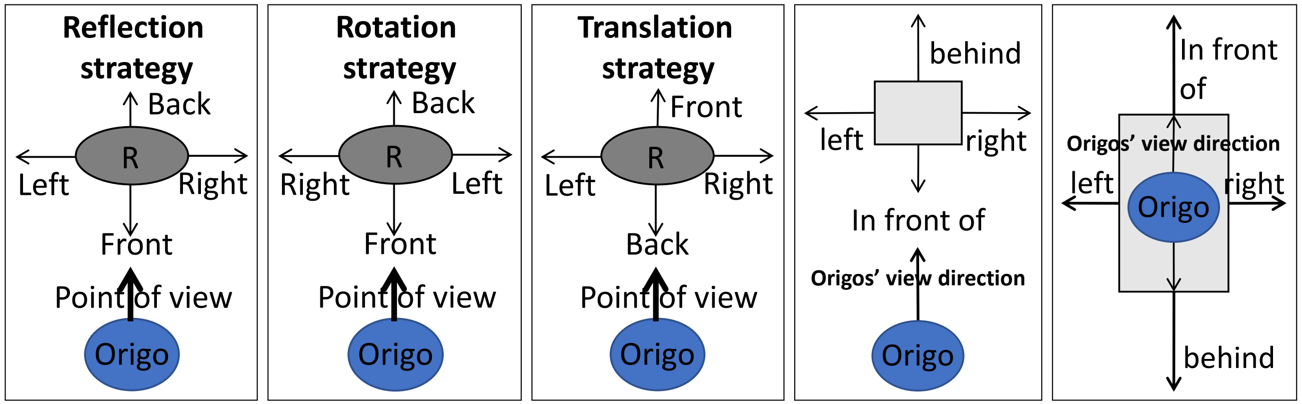
A.8 Cupboard non-canonical: complex



	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value
behind															
DE - EN	0.2672	1.0844	Inf	0.2464	0.9947	0.0324	0.1444	Inf	0.2241	0.9960	0.0241	0.0407	Inf	0.5926	0.9343
DE - IT	1.0508	0.9700	Inf	1.0834	0.6997	0.1512	0.1304	Inf	1.1597	0.6523	0.0817	0.0369	Inf	2.2140	0.1194
DE - PL	-0.2048	0.9926	Inf	-0.2064	0.9969	0.0036	0.1309	Inf	0.0273	1.0000	0.1576	0.0365	Inf	4.3127	**0.0001**
EN - IT	0.7836	1.0403	Inf	0.7533	0.8753	0.1188	0.1413	Inf	0.8405	0.8351	0.0576	0.0404	Inf	1.4264	0.4828
EN - PL	-0.4720	1.0667	Inf	-0.4425	0.9711	-0.0288	0.1419	Inf	-0.2029	0.9970	0.1335	0.0400	Inf	3.3338	**0.0048**
IT - PL	-1.2557	0.9514	Inf	-1.3199	0.5502	-0.1476	0.1275	Inf	-1.1573	0.6538	0.0759	0.0362	Inf	2.0996	0.1532
in front of															
DE - EN	0.9192	1.0820	Inf	0.8495	0.8307	0.2405	0.1410	Inf	1.7053	0.3208	0.0365	0.0407	Inf	0.8970	0.8064
DE - IT	1.1547	0.9697	Inf	1.1907	0.6327	0.1902	0.1297	Inf	1.4663	0.4580	0.0729	0.0369	Inf	1.9744	0.1977
DE - PL	-0.1912	0.9925	Inf	-0.1927	0.9975	0.0028	0.1307	Inf	0.0218	1.0000	0.1674	0.0365	Inf	4.5790	**0.0000**
EN - IT	0.2354	1.0371	Inf	0.2270	0.9959	-0.0503	0.1375	Inf	-0.3660	0.9832	0.0363	0.0404	Inf	0.9002	0.8047
EN - PL	-1.1105	1.0643	Inf	-1.0433	0.7239	-0.2377	0.1384	Inf	-1.7165	0.3149	0.1308	0.0400	Inf	3.2673	**0.0060**
IT - PL	-1.3459	0.9511	Inf	-1.4152	0.4898	-0.1873	0.1269	Inf	-1.4764	0.4518	0.0945	0.0362	Inf	2.6135	**0.0444**
to the left of															
DE - EN	0.1365	1.1083	Inf	0.1232	0.9993	-0.2319	0.1798	Inf	-1.2902	0.5692	0.0639	0.0407	Inf	1.5683	0.3969
DE - IT	-0.3686	1.0091	Inf	-0.3653	0.9833	-0.9469	0.1927	Inf	-4.9150	**0.0000**	0.0691	0.0369	Inf	1.8719	0.2402
DE - PL	-0.9812	1.0199	Inf	-0.9621	0.7710	-0.5452	0.1718	Inf	-3.1723	**0.0082**	0.1900	0.0365	Inf	5.1975	**0.0000**
EN - IT	-0.5051	1.0789	Inf	-0.4681	0.9660	-0.7149	0.2108	Inf	-3.3920	**0.0039**	0.0052	0.0404	Inf	0.1293	0.9992
EN - PL	-1.1177	1.0948	Inf	-1.0210	0.7371	-0.3132	0.1919	Inf	-1.6318	0.3606	0.1261	0.0400	Inf	3.1490	**0.0089**
IT - PL	-0.6127	0.9952	Inf	-0.6156	0.9271	0.4017	0.2040	Inf	1.9688	0.1998	0.1209	0.0362	Inf	3.3435	**0.0046**
to the right of															
DE - EN	-0.2620	1.1157	Inf	-0.2348	0.9954	-0.4185	0.1912	Inf	-2.1890	0.1262	0.0643	0.0407	Inf	1.5789	0.3907
DE - IT	0.0602	1.0067	Inf	0.0598	0.9999	-0.7789	0.1877	Inf	-4.1495	**0.0002**	0.0722	0.0369	Inf	1.9547	0.2054
DE - PL	-1.0572	1.0242	Inf	-1.0322	0.7305	-0.6008	0.1773	Inf	-3.3877	**0.0039**	0.2182	0.0365	Inf	5.9704	**0.0000**
EN - IT	0.3223	1.0816	Inf	0.2979	0.9908	-0.3605	0.2143	Inf	-1.6823	0.3330	0.0078	0.0404	Inf	0.1943	0.9974
EN - PL	-0.7951	1.1036	Inf	-0.7205	0.8890	-0.1823	0.2053	Inf	-0.8883	0.8110	0.1539	0.0400	Inf	3.8438	**0.0007**
IT - PL	-1.1174	0.9944	Inf	-1.1237	0.6749	0.1782	0.2021	Inf	0.8817	0.8144	0.1461	0.0362	Inf	4.0404	**0.0003**

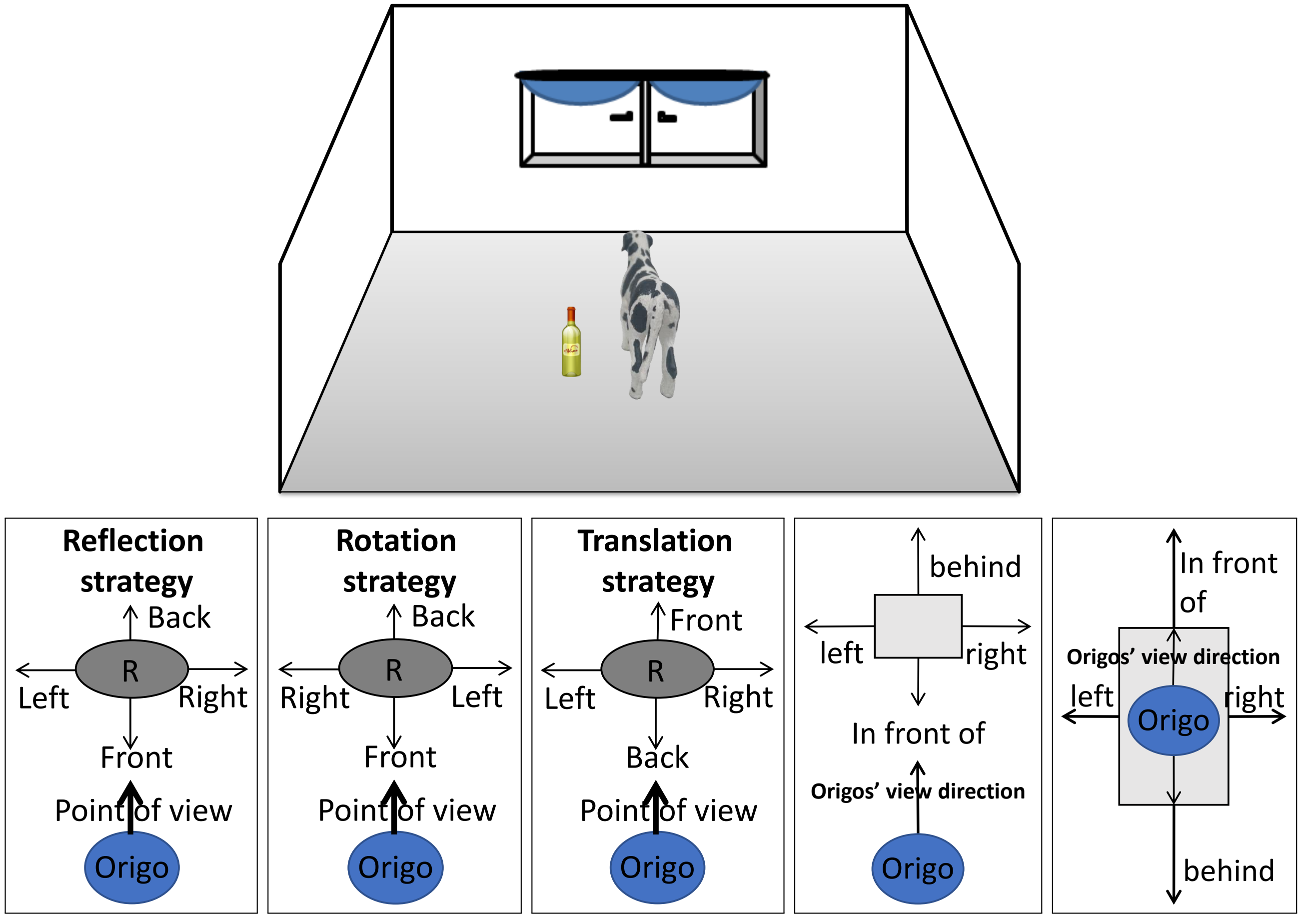
A.9 Dog: canonical





	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	t.ratio	p.value
behind															
DE - EN	20.8024	1.459468e+05	Inf	0.0001	1.0000	15.7594	1844.2983	Inf	0.0085	1.0000	-0.0224	0.0785	597.1283	-0.2849	0.9919
DE - IT	3.5539	5.473800e+00	Inf	0.6492	0.9159	0.0435	1.4295	Inf	0.0304	1.0000	0.1116	0.0715	602.6689	1.5607	0.4020
DE - PL	0.6744	5.354800e+00	Inf	0.1259	0.9993	-0.6286	1.2422	Inf	-0.5060	0.9577	0.1599	0.0708	602.6689	2.2588	0.1090
EN - IT	-17.2485	1.459468e+05	Inf	-0.0001	1.0000	-15.7159	1844.2983	Inf	-0.0085	1.0000	0.1339	0.0779	597.0282	1.7203	0.3140
EN - PL	-20.1280	1.459468e+05	Inf	-0.0001	1.0000	-16.3880	1844.2982	Inf	-0.0089	1.0000	0.1822	0.0772	596.9329	2.3604	0.0860
IT - PL	-2.8795	5.100500e+00	Inf	-0.5645	0.9426	-0.6721	1.2418	Inf	-0.5412	0.9489	0.0483	0.0700	602.6689	0.6901	0.9009
in front of															
DE - EN	-56.3159	1.096567e+07	Inf	0.0000	1.0000	0.0000	2432.1882	Inf	0.0000	1.0000	-0.0008	0.0785	597.1283	-0.0101	1.0000
DE - IT	-42.2288	1.384664e+07	Inf	0.0000	1.0000	0.0000	2218.8858	Inf	0.0000	1.0000	0.1623	0.0715	602.6689	2.2704	0.1061
DE - PL	325.8761	1.371045e+07	Inf	0.0000	1.0000	0.0000	2197.0617	Inf	0.0000	1.0000	0.1109	0.0708	602.6689	1.5677	0.3980
EN - IT	14.0871	1.077806e+07	Inf	0.0000	1.0000	0.0000	2410.5570	Inf	0.0000	1.0000	0.1631	0.0779	597.0282	2.0947	0.1560
EN - PL	382.1920	1.060253e+07	Inf	0.0000	1.0000	0.0000	2390.4834	Inf	0.0000	1.0000	0.1117	0.0772	596.9329	1.4473	0.4703
IT - PL	368.1049	1.356086e+07	Inf	0.0000	1.0000	0.0000	2173.0913	Inf	0.0000	1.0000	-0.0513	0.0700	602.6689	-0.7333	0.8837
to the left of															
DE - EN	-0.6245	1.986500e+00	Inf	-0.3143	0.9892	-0.0212	0.5319	Inf	-0.0399	1.0000	0.0019	0.0785	597.1283	0.0246	1.0000
DE - IT	6.4199	1.686400e+00	Inf	3.8068	**0.0008**	1.4088	0.4518	Inf	3.1180	**0.0098**	-0.0325	0.0715	602.6689	-0.4547	0.9687
DE - PL	-0.1590	1.865300e+00	Inf	-0.0853	0.9998	0.1115	0.4727	Inf	0.2359	0.9954	0.0289	0.0708	602.6689	0.4078	0.9771
EN - IT	7.0443	1.832000e+00	Inf	3.8452	**0.0007**	1.4300	0.4981	Inf	2.8708	**0.0213**	-0.0344	0.0779	597.0282	-0.4423	0.9711
EN - PL	0.4654	1.997900e+00	Inf	0.2329	0.9956	0.1327	0.5171	Inf	0.2566	0.9941	0.0269	0.0772	596.9329	0.3488	0.9854
IT - PL	-6.5789	1.699800e+00	Inf	-3.8704	**0.0006**	-1.2973	0.4343	Inf	-2.9871	**0.0149**	0.0614	0.0700	602.6689	0.8766	0.8170
to the right of															
DE - EN	0.6532	1.965000e+00	Inf	0.3324	0.9873	0.4199	0.5039	Inf	0.8333	0.8387	-0.1186	0.0785	597.1283	-1.5101	0.4320
DE - IT	6.1487	1.684900e+00	Inf	3.6494	**0.0015**	1.3245	0.4510	Inf	2.9369	**0.0175**	0.0025	0.0715	602.6689	0.0351	1.0000
DE - PL	-0.4801	1.868800e+00	Inf	-0.2569	0.9941	0.0048	0.4787	Inf	0.0100	1.0000	0.1072	0.0708	602.6689	1.5144	0.4294
EN - IT	5.4956	1.807200e+00	Inf	3.0410	**0.0126**	0.9047	0.4672	Inf	1.9362	0.2129	0.1211	0.0779	597.0282	1.5558	0.4049
EN - PL	-1.1332	1.979700e+00	Inf	-0.5724	0.9403	-0.4151	0.4940	Inf	-0.8402	0.8353	0.2258	0.0772	596.9329	2.9245	**0.0187**
IT - PL	-6.6288	1.702000e+00	Inf	-3.8948	**0.0006**	-1.3197	0.4400	Inf	-2.9997	**0.0144**	0.1047	0.0700	602.6689	1.4953	0.4409

A.10 Dog: non-canonical



	glmer/error					glm/error					lmer/mad.abs				
contrast	estimate	SE	df	z.ratio	p.value	estimate	SE	df	z.ratio	p.value	estimate	SE	df	t.ratio	p.value
behind															
DE - EN	1.4112	0.6912	Inf	2.0416	0.1728	1.1292	0.5747	Inf	1.9648	0.2014	0.1048	0.0810	623.9447	1.2942	0.5670
DE - IT	2.0001	0.6919	Inf	2.8906	**0.0201**	1.7693	0.6071	Inf	2.9144	**0.0187**	0.1036	0.0737	629.0576	1.4059	0.4961
DE - PL	-0.0810	0.5352	Inf	-0.1514	0.9988	-0.0532	0.4274	Inf	-0.1246	0.9993	0.1594	0.0730	629.0576	2.1834	0.1289
EN - IT	0.5889	0.7956	Inf	0.7402	0.8809	0.6400	0.7122	Inf	0.8987	0.8055	-0.0012	0.0803	623.8518	-0.0145	1.0000
EN - PL	-1.4922	0.6819	Inf	-2.1883	0.1264	-1.1825	0.5668	Inf	-2.0862	0.1576	0.0546	0.0796	623.7633	0.6856	0.9026
IT - PL	-2.0811	0.6826	Inf	-3.0488	**0.0123**	-1.8225	0.5996	Inf	-3.0395	**0.0127**	0.0557	0.0722	629.0576	0.7720	0.8671
in front of															
DE - EN	0.8320	0.6712	Inf	1.2395	0.6016	0.6089	0.5564	Inf	1.0943	0.6930	0.2309	0.0810	623.9447	2.8522	**0.0232**
DE - IT	1.7145	0.7052	Inf	2.4310	0.0714	1.4663	0.6164	Inf	2.3789	0.0811	0.2434	0.0737	629.0576	3.3016	**0.0056**
DE - PL	0.0507	0.5574	Inf	0.0910	0.9997	0.0129	0.4543	Inf	0.0284	1.0000	0.1684	0.0730	629.0576	2.3075	0.0974
EN - IT	0.8825	0.7837	Inf	1.1261	0.6734	0.8575	0.6893	Inf	1.2440	0.5988	0.0124	0.0803	623.8518	0.1546	0.9987
EN - PL	-0.7813	0.6624	Inf	-1.1795	0.6398	-0.5960	0.5492	Inf	-1.0852	0.6986	-0.0625	0.0796	623.7633	-0.7857	0.8610
IT - PL	-1.6638	0.6967	Inf	-2.3882	0.0793	-1.4534	0.6099	Inf	-2.3832	0.0803	-0.0749	0.0722	629.0576	-1.0381	0.7271
to the left of															
DE - EN	-0.5713	0.8814	Inf	-0.6482	0.9162	-0.6477	0.7999	Inf	-0.8097	0.8499	0.0072	0.0810	623.9447	0.0885	0.9998
DE - IT	0.0937	0.9063	Inf	0.1033	0.9996	0.0455	0.8439	Inf	0.0539	0.9999	0.0454	0.0737	629.0576	0.6166	0.9268
DE - PL	0.1683	0.9067	Inf	0.1856	0.9977	0.0889	0.8433	Inf	0.1055	0.9996	0.1451	0.0730	629.0576	1.9881	0.1935
EN - IT	0.6650	0.8872	Inf	0.7496	0.8769	0.6931	0.7993	Inf	0.8672	0.8218	0.0383	0.0803	623.8518	0.4770	0.9641
EN - PL	0.7396	0.8875	Inf	0.8334	0.8386	0.7366	0.7987	Inf	0.9223	0.7929	0.1379	0.0796	623.7633	1.7331	0.3073
IT - PL	0.0747	0.9123	Inf	0.0818	0.9998	0.0435	0.8427	Inf	0.0516	1.0000	0.0997	0.0722	629.0576	1.3805	0.5121
to the right of															
DE - EN	-1.5174	0.9133	Inf	-1.6614	0.3443	-1.5506	0.8514	Inf	-1.8211	0.2633	0.0627	0.0810	623.9447	0.7739	0.8663
DE - IT	-1.1465	0.8899	Inf	-1.2884	0.5703	-1.1451	0.8444	Inf	-1.3561	0.5271	-0.0239	0.0737	629.0576	-0.3244	0.9882
DE - PL	-0.2374	0.9815	Inf	-0.2419	0.9950	-0.3395	0.9366	Inf	-0.3625	0.9837	0.0466	0.0730	629.0576	0.6381	0.9196
EN - IT	0.3709	0.7277	Inf	0.5097	0.9568	0.4055	0.6268	Inf	0.6469	0.9167	-0.0866	0.0803	623.8518	-1.0787	0.7027
EN - PL	1.2800	0.8387	Inf	1.5261	0.4217	1.2111	0.7463	Inf	1.6228	0.3657	-0.0161	0.0796	623.7633	-0.2022	0.9971
IT - PL	0.9091	0.8131	Inf	1.1180	0.6784	0.8056	0.7383	Inf	1.0912	0.6949	0.0705	0.0722	629.0576	0.9764	0.7630

B Documents for Experiments

Research protocol for Mouse Tracking Experiment

1. Reading of: consent form and information sheet
2. Participant can ask questions regarding the documents and their content
3. Experiment leader explains the methodology to the participant
4. Participant attends example trials
5. The actual mouse tracking experiment starts. The participant is asked to select an answer (out of four alternatives) using a computer mouse. After every 20 sentences, the participant is asked to take a short break if needed. Additionally, after every trial, the participant decides when she or he is going to continue the experiment pressing the start button.
6. After the mouse tracking experiment, the participant is asked to fill in a very short survey (including some meta data: age/native language/birth place etc.)
7. The procedure is finished.

Figure B.1: Research protocol used for the ethical application in Glasgow

ZAS

Questionnaire for MT Experiment

1. What is your native language?

2. Are you bilingual?

3. Where were you born (country)?

4. Where did you grow up (country and city)?

5. How long have you lived in Scotland?

6. Where do you study?

7. What do you study?

8. How old are you?

9. Gender?

Figure B.2: Questionaire for participants, page 1

Z A S

10. Handedness:
    Please indicate your preferences in the use of hands in the following activities:
    Preferred: X in one column
    Always: XX in one column
    Indifferent: X in both columns

	Left Hand	Right Hand
Writing		
Drawing		
Throwing		
Scissors		
Toothbrush		
Knife (without fork)		
Spoon		
Broom (upper hand)		
Striking match (match)		
Opening box (lid)		

11. Please assign the sides to the cupboard:
    a) Front side
    b) Back side
    c) Right side
    d) Left side

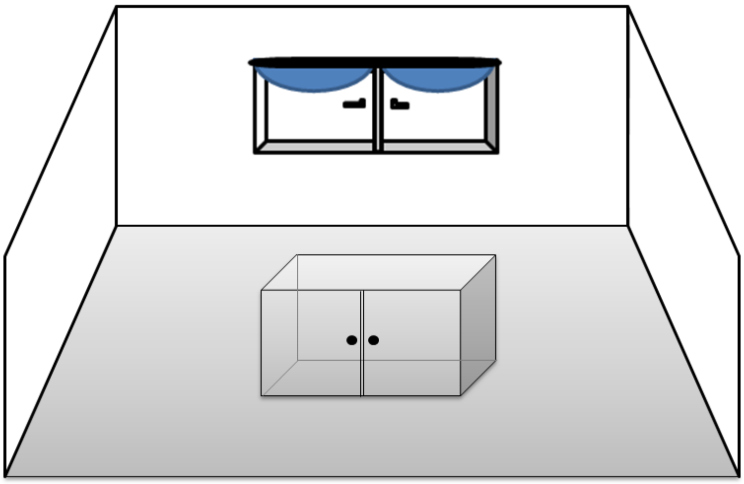


Figure B.3: Questionaire for participants, page 2

12. Please assign the sides to the cupboard:
    e) Front side
    f) Back side
    g) Right side
    h) Left side

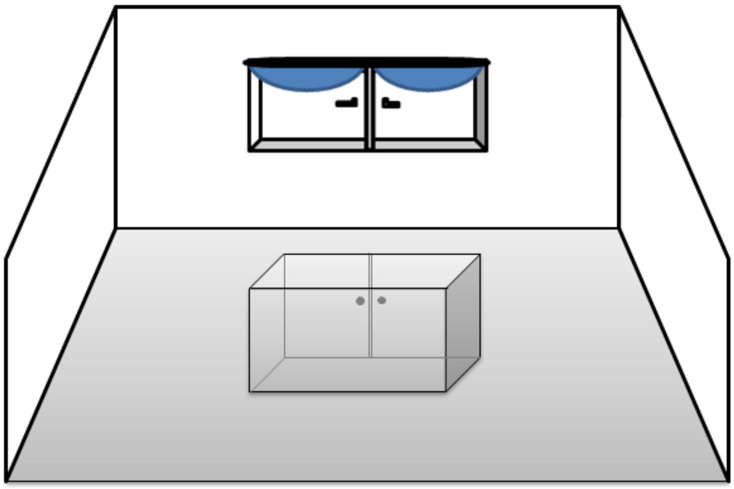


Figure B.4: Questionaire for participants, page 3

Z A S

Psycholinguistical Mouse Tracking Experiment: Information Sheet for Participants

My name is Katarzyna Stoltmann and I am PhD student from the Humboldt-University of Berlin as well as doctoral researcher at the Leibniz-Center General Linguistics in Berlin. As part of my degree, I am undertaking a research project for my Honours dissertation. The title of my project is: *Interpretation of Dimensional Spatial Expressions in German, English, Italian and Polish*.

This study will investigate the differences and similarities in space perception cross-linguistically.

The findings of the project will be useful for implementation of robots and automatic translations.

This research is being funded by Federal Ministry of Education and Research in Germany.

I am looking for volunteers students to participate in the project. There are no criteria (e.g. gender, age, or health) for being included or excluded – every student is welcome to take part.

The researcher is not aware of any risks associated with the experiment. The whole procedure should take no longer than one hour. You will be free to withdraw from the study at any stage and you would not have to give a reason.

All data will be anonymised as much as possible. Your name will be replaced with a participant number, and it will not be possible for you to be identified in any report of the data gathered. The data will be stored 10 years as required by the German Research Council in Germany.

The results will be published in my doctoral thesis, a journal or presented at a conference.

If you would like to contact an independent person, who knows about this project but is not involved in it, you are welcome to contact Dr Thomas McFadden. His contact details are given below.

If you have read and understood this information sheet, any questions you had have been answered, and you would like to be a participant in the study, please now see the consent form.

Figure B.5: Information Sheet for Participants

B.1 Examples of consent forms

ZAS

Consent Form

Name of department: **School of Psychological Sciences and Health**

Title of the study: **Psychological Mouse Tracking Experiment.**

- I confirm that I have read and understood the information sheet for the above project and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, up to the point of completion, without having to give a reason and without any consequences. If I exercise my right to withdraw and I don't want my data to be used, any data which have been collected from me will be destroyed.
- I understand that I can withdraw from the study any personal data (i.e. data which identify me personally) at any time.
- I understand that anonymised data (i.e. data which do not identify me personally) cannot be withdrawn once they have been included in the study.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project.

Signature of Participant:	Date:

Figure B.6: Consent form used for participants in Glasgow

Queen Margaret University

EDINBURGH

Participant Consent Form

Note: This is an example of a consent form. You will need to adapt it for your own study.

"Psycholinguistic Mouse Tracking Experiment"

I have read and understood the information sheet and this consent form. I have had an opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in this study.

I understand that I have the right to withdraw from this study at any stage without giving any reason.

I agree to participate in this study.

Name of participant: ___________________________

Signature of participant: ___________________________

Signature of researcher: ___________________________

Date: ______________

Contact details of the researcher

Name of researcher: Katarzyna Stoltmann

Address: Leibniz-Center General Linguistics
Schützenstr. 18
10117 Berlin
Germany

Email: stoltmann@leibniz-zas.de

Figure B.7: Consent form used for participants in Edinburgh

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