# Using Origos and Reference Frames in 3-D Route Descriptions

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# SUMMARY

The goal of the ANGELICA project at the University of Twente is to autonomously generate paired gestural and verbal output for Embodied Conversational Agents (ECA's). Its domain is route descriptions, with an ECA giving these descriptions in 3-D space as a test application. With route descriptions, the verbal instructions are likely to be accompanied by more pointing gestures than with other forms of discourse. Two important aspects of a pointing gesture are its direction and its origin.

Considering an everyday route description situation, when someone approaches us and asks which way to go, we intuitively turn - if necessary - so we face the direction to take (which makes it also easier for ourselves to imagine traversing the route) or at least adapt our perspective so that it matches that of the route seeker. Suppose we would remain opposite to the explainee, because the situation precludes turning around or raises other physical limitations (e.g one of the interlocutors is seated in a car facing the wrong direction). For ANGELICA this is an important design question because an ECA assumes a pre-determined position and orientation; possibly from a (didactic) tradition this is usually opposite to the viewer. Does this create an unnatural impression for the explainee? Does this confuse or distract him, so the instructions are harder to interpret or memorize and he chooses wrong directions during traversal? These questions form the basis of this report and are tested in an experiment showing a person giving route instructions (the route provider).
The experiment attempts to simulate a real route description situation by playback of film fragments in a virtual environment (on a computer monitor). In this experiment, a route description is being presented to the participant. The route description is a pre-recorded film, featuring a man giving verbal route instructions accompanied by gestures. By means of the angle between his body and the camera lens (120° and 180° conditions) the perspective with regard to the participant is manipulated. Also, traversal of the route is simulated (it was recorded beforehand by traversing the route on foot) and divided into film fragments; each film fragment stops at an intersection.. The participant is asked to choose the correct direction after each fragment, and then the next film fragment begins until the participant has 'traversed' the complete route.
From the results, we learn that participants take more correct turns in the 120° condition compared to the 180° condition, but not significantly. Possibly the route description was too complex to show a significant effect because it was hard to memorize, causing them to focus on the verbal instructions and ignore the accompanying gestures altogether.
Surprisingly, participants thought the way the route was described more natural in the 180° condition than in its 120° counterpart. This could be due to many previous confrontations with presented characters displayed on monitors or projection screens, explaining things to an audience. Perhaps the fact that it is more natural to make perspectives as similar as possible when explaining a route to someone perishes when this route is explained by somebody presented on a screen; a form of presentation in which we expect someone to be facing us.
Furthermore, female participants took more correct turns than their male counterparts.
This may be due to the route description itself, because it consisted of directions how to get from one intersection to the next and landmarks identifying these intersections; a design that facilitates a point-to-point way finding strategy that women are known to apply.
Finally, the higher educated participants took more correct turns than participants with lower educational levels. This result was significant and possibly amplified by personal characteristics usually concomitant with higher education (e.g. better concentration and memory training). Also, they may have more (everyday) computer experience, helping them to get quickly acquainted with the test method and controls used in this experiment.
Because of the virtual environment in which the experiment takes place, results are likely to be valid for ANGELICA too. Results so far suggest that to design a natural presentation of route instructions, the route provider should be facing the camera.

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## How to use this document

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Furthermore, this paper contains a number of keywords, most of them used throughout the various sections. The first time such a keyword is used, it is presented as a hyperlink in blue font, like this link. In the electronic version of this document, this hyperlink connects to the section titled Keywords.
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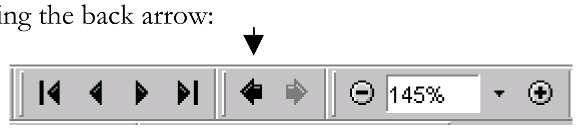


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# 1 INTRODUCTION

## 1.1 General

Gestures are part of everyday communication; they form a part of nonverbal expression. If they accompany speech, gestures can support, complement or even replace verbal expressions. They are so much part of our expression, that we are used to people making gestures while they speak and it may seem unnatural if their occurrence was changed or even omitted. Furthermore, in the absence of gestures, a less effective and efficient information transfer could be the result.
This report focuses on gestures that are part of a route description. Someone giving route instructions usually makes different kinds of gestures, ranging from facial expressions like raise of eyebrows to pointing in various directions (deictic) or indicating the shape of a building (iconic). The experiment described in this report narrows its focus on the latter two gesture types, because in route descriptions these two types are expected to occur more frequently in route descriptions than in general discourse. This does not mean that other kinds of gestures are excluded; it merely means that the occurence of other gestures is kept unchanged while pointing gestures are manipulated. Pointing gestures are characterized by a direction and an origin. For example, if a route instruction reads: "The church is to your left", it means that if you point to this building your arm represents the left direction, originating from your torso. If two people stand opposite to each other, and one of them makes a pointing gesture to accompany a verbal statement, the gesture refers to his own body, and not to the interlocutor's. Intuitively, someone describing a route turns so he or she faces the first direction to take in order to reach the destination or at least turns so both he and his interlocutor face the same direction. If not, does this interfere with a clear explanation of a route? Is it unnatural or even confusing if they face opposite directions?
These questions form the basis of this report.

## 1.2 ANGELICA Project

### 1.2.1 General

At the faculty of Computer Science of the University of Twente, an ongoing research project called ANGELICA[1] exists. This project uses an Embodied Conversational Agent (ECA); ECA's are increasingly often employed to support, complement or even replace pure between-humans communication with a natural communication between an ECA and a human being. With the term 'natural', communication is meant that approximates face-to-face communication as close as possible. So, in those applications where communicating between-humans is to be (partly) replaced by communicating with an ECA on a computer monitor, it is preferable if this communication is as similar as possible to face-to-face communication with a human being.
Various properties of the ECA attribute to this natural way of communicating (examples within brackets):

- its ability to interact
  (ECA's are usually suitable for two-way communication)
- its visual appearance
  (clothing, posture, face, proportions of limbs and body)
- its movement
  (walking, bending)
- its verbal expression
  (talking, grammar, voice, pronunciation, stress)

[1] **A N**atural-language **G**enerator for **E**mbodied, **LI**felike **C**onversational **A**gents.

- its non-verbal expression
  (facial expressions and various categories of gestures, see sections 2.2.1 and 2.2.2).

Kopp [Kopp et al., 2004, pg. 232] expresses the current state of research as follows: "Computer systems that support human-like communication (...) cannot afford to ignore the benefits of such coordinated language and gesture use. However, since gesture is spontaneously produced by speakers, and since gestures do not derive from a lexicon the way words do, multimodal systems research still struggles with the autonomous generation of paired gestural and verbal output in embodied agents."

### 1.2.2 Gestures

So, to create a more realistic ECA, there is a need for what Kopp refers to as "autonomous generation of paired gestural and verbal output"; this is the goal of the ANGELICA project. Its domain is route descriptions, with an ECA giving these descriptions in 3-D space as a test application. The goal of the experiment discussed in this report is to determine the best way to give these route descriptions, with the focus on the use of gestures.
Primarily, research on multimodal generation of language and gesture has been carried out within the context of ECA's [Pelachaud & Poggi, 2001].
The experiment described in this paper shows a pre-recorded film featuring a person giving route instructions; it shows no ECA but a virtual representation (i.e. on a computer monitor) of a real person. Although the experiment does not employ any ECA, the research questions proposed in Chapter 3 and the subsequent conclusions in Chapter 6 apply to the use of an ECA as interlocutor as well, albeit within the restrictions discussed in section 6.1.1.1.
This is valid because in this experiment, the focus is on the *gestures* that accompany the verbal expressions of the route description. The questions underlying the experiment can easily be transferred to ECA's: can gestures enhance the naturalness and/or other qualities of ECA's? And which gestures should be implemented in what way to reach this goal?
These are research questions connected to the ANGELICA project; but it goes without saying that they are the subject of other research as well.

## 1.3 Technical communication

This graduation study is conducted within the field of technical communication at the faculty of Communication Science. Creating, employing and testing route descriptions shares many aspects present within this field.
In a previous study [Michon & Denis, 2001] it is stated that the basic function of route directions is to prescribe actions. These actions succeed one another in a specific order, so the directions should facilitate performing these actions in the given order. Furthermore, route directions are regarded as part of the broad category of *procedural discourse*, which is intended to assist someone to perform actions with measurable, adaptive effects [Michon & Denis, 2001].
If someone generates route directions, it is with the objective to provide a combined set of *procedures* and *descriptions* that allow someone else using them to build an *internal representation* of the environment to be traversed. Therefore, the discourse should contain information that enables the user to create such an internal representation. Thus, the study conducted in this paper can contribute to the knowledge in the field of technical communication and communication science in general.

## 1.4 Structure of this report

This document has the following structure. Chapter 1 described how this study can contribute to knowledge in the field of (technical) communication and the ANGELICA project in particular. Chapter 2 describes previous research relevant to this field, leading to the questions, among others, presented in Chapter 3. Next, Chapters 4 through 5 discuss the research set-up and research results, respectively. Chapter 6 presents a discussion of the results of the study and the conclusions which can be drawn from them.

# 2 Previous Research

## 2.1 Structure

In this chapter, the setting of the subject of this study is explained. This study concerns itself with the (pointing) gestures of a route provider as part of the route information. This study's focus is on the perspective the route provider takes compared to that of the route seeker. This perspective will be connected to the concept of origo. If both interlocutors are opposite to each other, the gestures are mirrored; i.e. the explainer's left is seen as right by the explainee and vice versa. This fact may confuse or distract the route seeker. Furthermore, it is only natural for someone (who is about to explain a route) to turn to face the first direction indicated or at least to face the same direction as the route seeker. Suppose he would remain opposite to the explainee, because the situation precludes turning around or raises other physical limitations (e.g one of the interlocutors is seated in a car facing the wrong direction). For ANGELICA this is an important design question because an ECA assumes a pre-determined position and orientation. This could create an unnatural impression for the explainee, apart from confusing or distracting him. In general, some people have more trouble finding their way than others, so it is assumed that individual characteristics or orientation skills are also involved. How do these considerations relate to earlier studies?
Related findings from earlier research are discussed according to the following paragraph structure:

*Route descriptions*
To begin with, various aspects of route descriptions are discussed.

- section 2.2 explains the importance of using gestures while communicating route information;
- section 2.3 discusses the structure of route descriptions in practice. In this section, a route description is regarded as an instance of more general discourse;
- section 2.4 explains the phenomenon of common ground, regarding a route description as a means of information transfer;
- section 2.5 discusses a route description as a particular form of procedural discourse.

*Route seeker*
Next, the focus shifts to the individual who receives the discourse information and employs it: section 2.5 discusses which personal characteristics of the route seeker influence the way finding performance.

*Origo and reference frame*
Then, the terms origo and reference frame are discussed.

- section 2.6 explains these two phenomena, because these are key phenomena in this study;
- section 2.7 discusses different reference frames and the choice of one in particular - the egocentric reference frame, because it is used in this study;
- section 2.10 explains the consequences of different reference frames on cognitive load and the effect of minimizing the difference in origo's.

*Effect on way finding performance*
Finally, section 2.11 discusses possible methods to measure the effect of the route description on the way finding performance (or phenomena related to it) of the route seeker.

## 2.2 Using gestures in route descriptions

In this section, the way that gestures may contribute to communication is discussed and gestures are categorized according to their function. The relevance of discussing gestures is obvious because the ANGELICA project involves gestures (see section 1.2.2).

### 2.2.1 Gestures as a means for information transfer

A route description is based on transfer of route knowledge from the route provider to the route seeker (discussed in more detail in the section about common ground, section 2.4). In case of verbal route descriptions instead of using a map, the information is most likely presented in a point-to-point form. This form usually includes only aspects of the environment directly relevant to the route (e.g. objects *along* the route: route knowledge) without general environmental information like the global direction of the destination (i.e. information of the surroundings on a larger scale: survey knowledge). It has been proposed that also nonverbal (e.g. eyebrow raises, head nods) and paraverbal (e.g. "umm", "Uh-huh", functioning as feedback to the speaker) expressions might facilitate this transfer process. In this context, sign language for audibly impaired persons is excluded, as well as gestures which serve lexical retrieval; the latter gestures occur during retrieval failures in speech [Morsella & Krauss, 2001].
Gestures facilitate this transfer process for both the provider and the receiver of information for the following reasons:

- Gestures are important in providing additional information about the content of the discourse [McNeill, 1992];
- If the goal of employing gestures is to yield a more *efficient* route description, under certain circumstances non-redundant gestures aid in achieving this; e.g. (1) if the objects pointed at are within the range of vision, or (2) if an object or motion is easier to express non-verbally; to reach a more *effective* route description, these non-redundant gestures help to ensure that important parts of information get across [Theune, 2001];
- Contrastive or new information (like route information to guide somebody through an unknown environment) is conveyed using a combination of speech and gestures [Theune, 2001];
- The transfer process is facilitated by people's ability to communicate ideas through a free mixture of speech and iconic gestures [Koons & Sparrell, 1994];
- Apart from attributing to the actual contents of a discourse, gestures can emphasize important parts of a discourse by drawing attention to them. This helps the person who receives directions to interpret and memorize important clues [Kendon, 1994];
- In their retellings of a discourse, listeners reproduce a version of events that takes into account information conveyed only in gesture, or that attempts to reconcile conflicting information from speech and gesture [Cassell et al., 1998].

### 2.2.2 Gesture types

In the introduction (section 1.1), it was pointed out that somebody involded in describing a route uses deictic and iconic gestures more frequently than when involved in general discourse. This certainly does not exclude the occurrence of other gesture types. What other gesture types are there? Roughly, gestures can be classified using a taxonomy described by [Buxton, 2002]. This taxonomy (shown in Table 2-1) classifies gestures into three groups: ergotic, epistemic and semiotic, the latter group divided according to their function: symbolic, deictic, iconic and pantomimic gestures.

| Classification | Functionality | Description or characteristic |
|---|---|---|
| ergotic | | Manipulate the physical world and create artifacts |
| epistemic | | Learn from the environment through tactile or haptic exploration |
| semiotic | | Communicate meaningful information |
| | Symbolic[2] | single meaning, which is culture-dependent (e.g. 'OK' gesture) |
| | Deictic | pointing and/or directing the listeners or viewers attention to a specific event or object in the environment (e.g. 'Put that there') |
| | Iconic[3] | Convey information about size, orientation of the object of discourse (e.g. 'The plane flew like this')[4], depiction of visual information about an object or action, e.g. the extent of a building or the viewpoint from which it is described[5] |
| | Pantomimic | Show the use of movement of an invisible tool or object (e.g. 'I turned the steering wheel hard to the left') |

**Table 2-1 Taxonomy for Gestures**

McNeill [McNeill, 1992] proposed a more extensive taxonomy, which includes types of gestures related to the process of communication; *beat gestures* and *cohesives* (see Table 2-2). For example, beat gestures - next to intonations, nods, raises of eyebrows - are used to emphasize or focus on certain words; for example, a cohesive gesture can be pointing with one hand to an increasing number of fingers on the other while summing up various aspects of the same subject.

| Classification | Description |
|---|---|
| beat | hand moves up and down with the rhythm of speech |
| cohesives | variations of iconic, pantomimic or deictic gestures, used to tie together temporally separated but thematically related portions of discourse |

**Table 2-2 Additional Gestures**

To be able to understand these gestures, the need for accompanying speech varies according to the type of gesture. Regarding their speech/gesture dependency, gesture types can be classified according to Kendon's Continuum [Kendon, 1988 in Buxton, 2002]. This dependency is shown in the following figure:

Highly dependent on speech → Not dependent on speech

Gesticulation (Beat, cohesives) → Language-Like (Iconics) → Pantomimes (Pantomimic) → Emblems (Deictic) → Sign Language (Symbolic)

**Figure 2-1 Gestures and their dependency on accompanying speech**

Gesture is intimately related to speech, both in its reliance on speech for interpretation, and for its own speech like-qualities. Only symbolic gestures (see Table 2-1 and Figure 2-1) can be interpreted alone without further contextual information. For the other gesture types, this context has to be provided by speech in combination with the gesture. As an example, stretching out one's hands to

[2] Also called 'Emblems' in [Levinson, 2005]
[3] Also called 'Depictive gestures' in [Koons & Sparrell, 1994]
[4] In [Buxton, 2002]
[5] In [Cassell et al., 1996 in Kopp et al., 2004]

indicate the size of the fish somebody caught (iconic gesture) is meaningless without telling about the event. In this particular example, the gesture depicts the speech referent, i.e. the item talked about. Likewise, all gesture types mentioned in Table 2-1 and Table 2-2 can be categorized according to their relationship with speech [Buxton, 2002]:

| Classification | Relationship gesture ⇔ speech |
|---|---|
| Symbolic, deictic | Gestures that evoke the speech referent |
| Iconic, pantomimic | Gestures that depict the speech referent |
| Beat, cohesive | Gestures that relate to the conversational process |

**Table 2-3 Relationship between Gesture and Speech**

Table 2-3 indicates that in conversation or discourse, some words or conceptions are evoked by means of the gesture (deictic, e.g. pointing at an object within the interlocutor's field of vision) or by the gesture itself (symbolic).
Iconic and pantomimic gestures visually aid to understand, discriminate between or describe the shape of conceptions talked about.
Beat gestures and cohesives are not related to any specific speech referent but accompany the process of conversation in general. Although route descriptions form a particular kind of discourse (see section 1.3), they nevertheless contain various if not all of discourse's general characteristics like the occurrence of beat gestures and cohesives, albeit less.

## 2.3 Phases in route description practice

As in general narrative structure, in a route communication episode communicational patterns can be recognized. These patterns will form the basis for the method used in the experiment, described in section 4).
Some [Allen, 2000] regard the route description process as a slightly adapted version of a general narrative, others [Labov & Waletsky, 1967] use specific terms to specify the route description's phases and introduce a new discourse genre by doing so.
In this paper, the communication process takes place between two individuals: the route provider on the one hand, and the route seeker/wayfinder on the other.
A route communication episode can be divided into four phases [Allen, 2000]:

| Phase# | Description | Remarks |
|---|---|---|
| 1 | Initiation | |
| 2 | Route description | Core of the communication episode |
| 3 | Securing | Recapitulate instructions, landmarks, views and verify whether the route seeker has understood them |
| 4 | Closure | |

**Table 2-4 Phases in Route Communication Episodes**

Example (S is the route seeker, P is the route provider):

S: 'Excuse me, are you familiar here?'
P: 'Yes....'
S: 'Can you tell me how to find LaBrea Avenue?'
} Initiation phase

P: 'Sure, it's quite simple: you go down two blocks, then turn left (...), and finally turn right; that's LaBrea'.
} Route description phase

S: 'So, I go down two blocks, turn left (...) and then at my right it's LaBrea?'
P: 'Definitely.'
} Securing phase

S: 'Thank you, it's quite clear to me.'
P: 'No trouble, you're welcome. Bye.'
S: 'Bye.'

} Closure phase

Coming from a general approach of narrative structure (not specifically route descriptions), Labov and Waletsky [Labov & Waletsky, 1967] identify the phases: *Orientation*, *Complication*, *Resolution* and *Coda*. They remark that route descriptions distinguish themselves from general narrative structure in the *Complication* phase (see Table 2-5):

| Phase# | Description | Remarks | |
|---|---|---|---|
| 2 | Complication | General narratives: | description of events often presented in a linear chronological order |
| | | Spatial description: | descriptions of states rather than events; alternation between introduction of referents and expressions giving these referents spatial orientation |

**Table 2-5 Difference between Narrative and Spatial Description**

In this specific type of discourse, change of existing views (e.g. when turning 180º) and the appearance of entirely new scenes demands introduction of referents and their spatial orientation throughout this phase.

For example (P is the route provider, referents are <u>underlined</u>, spatial states are *in italics*):
P: '(...) and when the <u>railway station</u> *is on your left*, *you'll be facing* the <u>Automotive Building</u>. *From this position*, if you look right you should see <u>LaBrea Avenue</u> because it runs *in parallel with* <u>Lincoln Blvd</u>.'

The route description phases and structure described above guide the simulation of this process in the experiment (see section 4.2.4).

## 2.4 Common ground

### 2.4.1 General

One of the principles used to create effective route instructions is 'common ground' between interlocutors [Clark, 1992, 1996; Clark and Wilkes-Gibbs, 1990 in Allen, 2000]. In the literature this term is used for verbal characteristics of the route description, but it can as easily be applied to nonverbal and paraverbal characteristics as well. Kopp [Kopp et al., 2004] states that gestures that indicate the shape of buildings or outline a route to be taken by the listener are essential to the understanding of the directions. Most route directions can be expected to include a rich set of components (descriptions of scenes, objects, topological relationships between objects, relationships between objects and the moving agent) [Michon & Denis, 2001]. Despite the fact that the route seeker has less environmental knowledge than the route provider, this difference in knowledge relevant to the route should be minimized as efficiently as possible. Two properties of a route description help the route seeker in this respect [Allen, 2000]:

- inclusion of delimiters when communicating choice-points along the route:
  a delimiter provides discriminative information about an environmental feature
  (e.g. a distance designation, a direction designation or a temporal unit);
- inclusion of descriptives when communicating choice-points along the route:

a descriptive provides information about (relations among) environmental features along the route. The common form of a descriptive is a landmark.

Both items can be expressed verbally and/or nonverbally. The goal of communicating them is to reduce ambiguity when a decision point (an intersection in most cases) in the route has been reached. Both delimiters and descriptives can reduce the route seeker's uncertainty, which is at its largest at decision points. Both items should be included in the route description for the experiment, described in section 4.2.5, as many times as needed.

### 2.4.2 Landmarks

The importance of descriptives was emphasized by [Fujii et al, 2000 and Allen, 2000], who state that a route description should contain landmark information and directives and descriptives at each choice-point. The importance of these descriptives was, again, found by [Mäkelä et al., 2001]. In the guidance messages of their experiment, direct walking instructions (e.g. "Turn left, go seven meters forward, turn right") were used instead of mentioning landmarks. These guidance messages were found to be unsuccessful.
More important than the total length of the route to be traversed, is the number of landmarks mentioned in its description. After having navigated a route, participants of an experiment [Michon & Denis, 2001] were asked to generate route directions, intended to guide individuals totally unfamiliar with the environment as successfully as possible. Remarkably, traversal of a route of 700 meters and another of 1200 meters both resulted in a mean number of landmarks of 6.8.
Landmarks are generally considered to be key components for constructing the representations used during navigation [Michon & Denis, 2001].
Landmarks are essentially used in directions as sub-goals along the route [Michon & Denis, 2001]. The frequency with which landmarks were mentioned increased in the vicinity of the arrival point. Points where a change in direction was called for elicited numerous mentions of landmarks. This was also the case for some points, identified by describers as places where errors were likely to occur. Therefore, many landmarks were mentioned especially along long segments and at wide-open spaces resulting from major street intersections or squares [Michon & Denis, 2001].

## 2.5 Route descriptions and way finding

The route description and way finding processes involve a chain of mental transformations for both the route provider and the routeseeker/wayfinder, as will be explained in this section. Some of these transformations take place in a communicational context. The route provider, in order to fulfill his role, possesses spatial knowledge. This knowledge is in itself a product of perceptual (in case he studied a map) and, possibly, sensori-motor experience (in case he traversed the route himself). To describe the route, the route provider transforms this knowledge into verbal and non-verbal (or paraverbal) expressions.
In his turn, the route seeker should understand, memorize and follow these directions in order to construct an action plan and to refer to this plan during traversal. Thus, producing, understanding and following route directions are all part of a collaborative, goal-directed communication process [Clark, 1992, 1996; Golding et al., 1996].

Like all human skills, success in orientation and way finding tasks varies among individuals. Different characteristics of participants have been found to be of influence. In this paragraph the individual's way finding experience (section 2.5.1), gender (section 2.5.2), age (section 2.5.3) and general intelligence (section 2.5.4) are discussed.

### 2.5.1 Experience

In a doctoral study [Infield, 1991], individuals with varying degree of orientation and way finding experience participated in a spatial orientation test (Guilford-Zimmerman Test).

Three different groups participated: (1) undergraduate psychology students (regarded as inexperienced), (2) sports orienteers[6] experienced at a regional level and (3) sports orienteers experienced at an international level.
Observing the strategies used by these groups, Infield concludes that good wayfinders distinguish themselves from average or bad wayfinders in two ways:

- they quickly co-ordinate spatial information contained in separate views of an environment, i.e. recognize separate views as different perspectives of the same scene (as measured by the Guilford-Zimmerman Test);
- they memorize more location invariant items. When confronted with a scene, they memorize more invariable characteristics of this scene (e.g. buildings as opposed to parked cars).

### 2.5.2 Gender

Male superiority in acquiring configurational information (knowledge of the environment that reaches beyond mere positions linked together by traverse) was found in various experiments: retention of information after examining a scene [Arthur, Hancock & Chrysler, 1997], exploration of an area [Matthews, 1987] and traversal of a pre-specified route [Anooshian & Young, 1981]. Lawton [Lawton, 1994] found that men report noticing the global direction to and position of landmarks, while women report employing a strategy that holds descriptions of control points and cues to the route (like street signs).
According to [Baker, 1981, Bever, 1992] women are more sensitive to descriptives and landmark-to-landmark information (tracking information) than to distal or configurational information. The opposite tendency is being observed in men, who are sensitive to (cardinal) directions; cardinal directions are the directions indicated by a compass-card: east, west, north and south (see section 2.7.4).
It has been shown that women refer to and make use of landmarks more readily than men do [Denis, 1997, Galea & Kimura, 1993]. This fact concerns mainly 2-D landmarks[7] (streets, squares, i.e. public thoroughfares) [Michon & Denis, 2001].

[Hunt & Waller, 1999, pg. 44] conclude from these findings that "The male advantage in acquiring configurational information may at least partly be due to a difference in the strategy used during way finding (...): women tend to use strategies appropriate to tracking and piloting, while men use strategies appropriate for navigation."
Tracking, piloting and navigation are way finding strategies that differ in the kind of information they are based on:

- Tracking is a point-to-point way finding strategy that relies on information limited to environmental characteristics *along* the route (e.g. "The street sign indicating the railway station is opposite to the post-office")
- Piloting combines these environmental characteristics with self-centered orientation and direction (e.g. "If you're facing the main entrance, turn 75º to the right")
- Navigation uses configurational information: routes to destinations are derived from knowledge of the surroundings of the destination or its global position. This knowledge may be acquired through earlier visits to the same area or, for example, by studying a map of the area on a general level.

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[6] In an orienteering race, participants are given a map with six to ten control points marked on it. The locations of the control points typically define a 6 to 10 km. route, and are chosen so that a person standing at one control point cannot see any other points. The competitors, who start at fixed intervals and thus cannot see eachother, must visit each control point in order, but can choose their own route between control points.
[7] Michon and Denis discriminate 2D landmarks (e.g. streets, squares) and 3D landmarks (e.g. buildings, statues). In their experiment [Michon & Denis, 2001] women were found to rely on 2D landmarks more than men, while for 3D landmarks there was no difference.

A study (30 male vs. 34 female participants) by Witmer also showed men outperforming women in configurational knowledge [Witmer et al., 1996].

In a maze experiment [Waller, Hunt & Knapp 1998] male-female differences in pointing were indicated after three different types of experience with a maze environment.

- In the *Real* condition pointing took place in a real situation after practice in that same situation;
- The *Virtual* condition referred to pointing in a virtual environment after practice with that same virtual environment;
- In the *Transfer* condition pointing took place in a real environment after practice in an analogous virtual environment.

After exploring a real or a virtual maze, participants were asked to point toward unseen objects when they were in the real maze. Virtually all points that deviated more than 90º from the correct orientation were made by females.
This is an effect typically found in pointing studies: on some trials female participants feel 'turned around', meaning they point more than 90º away from the correct direction.

### 2.5.3 Age

Spatial orientation skills develop rapidly; while children under ten years of age easily get lost, by age twelve they learn as much as adults do from a guided walk through new surroundings [Cornell et al., 1994]. This could be the consequence of development of orientational skills and/or concentration ability. The contribution of the latter is suggested by the fact that spatial reasoning is an attention-demanding task [Money, 1993; Murphy et al., 1994].
In a previous study it was found that children performed notably better if their attention was directed to landmarks selected by adults than ones selected by other children [Siegel, 1981]. The ability to learn routes by traversing them appears to be fully developed by age twelve; younger children display difficulty in learning routes, at least in part because they are weak in identifying good landmarks [Cornell, Heth, and Alberts, 1994].
It has been claimed that orientation ability and way finding skills deteriorate with old-age [Salthouse, 1991], but there are few objective results to back this statement. Most adults aged above seventy show decay in both aspects, but usually this decay coincides with other deficiencies like dementia. Those elderly who take part in activities demanding spatial skills perform as good or better than young adults in recovering from loss of direction, but this fact also relates to experience (see section 2.5.1). Nevertheless, finding a destination after receiving instructions how to get there involves concentration and memorization apart from mere way finding skills. The ability to store and retrieve information in and from memory is likely to decrease with age. Therefore, it is expected that the capacity to find a destination after receiving route instructions decays with old-age.

### 2.5.4 General intelligence

To conclude human characteristics affecting orientation and way finding ability, in this section the correlation between an individual's general intelligence and orientation/way finding skill is discussed. Spatial-visual reasoning is one of the basic dimensions of intelligence [Carroll, 1993]. So how do spatial-visual reasoning abilities relate to an individual's general intelligence?
From experiments [Deary et al., 1996; Detterman & Daniel, 1989] individuals with IQs lower than 70 were found to display poor spatial-visual reasoning. However, IQs lower than 70 are abnormally low, and it has been established that the influence of general intelligence is more pervasive at the low end. Thus, it is expected that someone with, for instance, poor verbal skills possesses poor spatial skills as well. Concomitant with these poor verbal skills, usually attention and concentration ability is low. On the other hand, an individual with high general intelligence will not necessarily possess good spatial skills.

## 2.6 Reference frame, origo and reference direction

Many spatial expressions in both speech (verbal descriptions) and gestures (nonverbal or paraverbal descriptions) refer to an origin (point of reference). In Fricke [Fricke, 2003] this phenomenon is called origo. In both the verbal and nonverbal part of a route description, this origo can be the (body of the) speaker, the (body of the) addressee or (body of an) imaginary addressee, or an environmental feature. Consider the following examples of verbal descriptions:

*Speaker origin*

"(...) then *I* always go through the corridor and then up the stairs near the reception counter, but perhaps taking the elevator is faster."

*Origin of the addressee*

"The direction *you're* going is wrong. Please turn around so *you're* facing the church. See, there it is. Now, at *your* left, there's an intersection."

*Origin of the imaginary addressee (not personal, could be anyone)*

"(...) so after *you've* walked for about a mile, there will be a meadow with sheep on *your* right."

*Origin of the environment*

"This suburb is two miles *north of* Los Angeles' city limits."

In each situation, as described above, the origo is different. Each of these origo's belong to a particular reference frame. A reference frame is a combination of an origo and a reference direction. In the examples above, the quotation from the speaker's point of view is expressed using the egocentric reference frame; the one from the addressee's and the imaginary addressee's point of view is expressed using the locally intrinsic reference frame. None of these reference frames are fixed in time and space; if the speaker's body or the addressee's body move, so do their origins (and/or reference directions).

Finally, the last quotation is expressed using an allocentric reference frame. It is an example of a well known fixed reference frame, i.e. that of the cardinal directions: east, west, north and south. These are fixed directions with a fixed origo (equator and poles). In section 2.7.4 the reference frames will be explained in more detail.

## 2.7 Reference frames

### 2.7.1 Four classes of space

Before discussing reference frames and the one used in this study, it is necessary to briefly discuss the possible scale of 3D space and how it is referred to within this report [cf. Hunt & Waller, 1999]. An area that can be seen at a glance, without turning around or moving, is called a spatial scene. A spatial surround is the space consisting of all scenes visible during a turn of 360º without actually moving through this space. A set of spatial surrounds through which a wayfinder moves, while looking around, is called a neighbourhood. Finally, a geographic region is a geographically defined space, only known to someone by verbal description or scrutinization of a map (there was no experience with this area by visiting it).

### 2.7.2 Space and reference frames

Imagine someone standing in a room and pointing to each object within this room - during conversation - intending to clarify how objects relate to each other, saying: "*This* switch will turn on *that* bulb". That individual's deictic gestures are then referring to objects in the directly visible space (see section 2.7.1). [Koons & Sparrell, 1994] state that deictic or pointing gestures are used to select an element in the shared interaction space. Whether all objects to be pointed at are visible, depends on the spatial configuration of the objects and the observer's viewpoint. If all objects are directly visible, there actually is no need for a reference frame. If the person would say: "(...) and this one will

turn on all the lights in the *west* wing" or "this switch turns on the lamp *next to* the television set" then a reference frame is used (see section 2.7.4).
The term 'reference' in reference frame indicates the presence of an origo (something to refer to). Different kinds of reference frames have different origo's [Tversky, 1993]:

- The origo of the *egocentric* and the *locally intrinsic* reference frames is the point of view from which elements in the environment are located;
- The origo of the *allocentric* reference frame is an environmental feature from which other elements are located.

A reference frame helps to describe or clarify relations between objects. In the passage 'the lamp *next to* the television' an allocentric reference frame is used with the television as a kind of higher order environmental feature. In this case, a unique feature of the environment was chosen; if not unique, it may be impossible to unambiguously identify objects related to this environmental feature. Here, the allocentric reference frame helps to relate objects to each other in an environment which is not directly visible.

### 2.7.3 A route description situation

Somebody who gives route instructions is inclined to use more pointing gestures than in general discourse (see section 1.1). The experiment involves someone giving route instructions, accompanied by pointing gestures referring to his own body. If he points to his left, his arm makes a gesture with a left direction, originating from his own body. Likewise, if he points straight ahead or to his right, the directions of these gestures differ but their origo remains unchanged, i.e. his own body. Most objects along the route (buildings, streets, intersections) are not visible from the current location - where he explains the route - so a reference frame is needed (see section 2.7.2). If the route provider stands next to the route seeker and faces the same direction, the route provider's gestures still refer to his own body but almost to the interlocutor's body as well. If the route provider stands opposite to the route seeker, his gestures are mirrored with respect to the body of his interlocutor. The following section (2.7.4) describes three kinds of reference frames, from which the one most suitable to describe the experiment is selected in section 2.7.5.

### 2.7.4 Reference frame descriptions

Different notions for reference frames are mentioned throughout the literature. E.g., Levinson [Levinson, 1996] defines two different frames: the *relative* reference frame is regarded as opposite to the *intrinsic* reference frame. The *relative* reference frame relates objects and directions to the observer's position; within the *intrinsic* reference frame, objects or directions are related to another observer, to an object, or to properties of the environment.
In this report a hybrid from the reference frames of [Musto, 1999] and [Shelton & McNamara, 2004] is defined. This leads to the following descriptions:

- allocentric reference frame: external factors determine a fixed coordinate system. For example, in geographic space a certain point is determined by its distance from origo and the direction with respect to origo [Klatzky, 1998]; an example is shown in Figure 2-2.

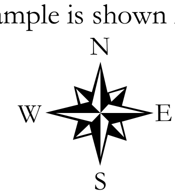



**Figure 2-2 Compass-card**

This picture illustrates the characteristics of an allocentric reference frame: a *fixed* coordinate system determined by external factors (in this case the *cardinal* directions, i.e. north, east, south and west). Its origo is fixed by the equator and the poles; regardless of somebody's position and orientation, exactly north always points in exactly the same direction with respect to earth (external).

- egocentric reference frame: as regarded by [Musto, 1999], crucial to this reference frame is the body of an observer, called 'ego'. The example shown in Figure 2-3 illustrates this situation. The picture shows a sketch of a person's head and nose. His head serves to indicate ego's position and the nose represents his orientation. Ego's reference direction is always 'straight ahead', as indicated by the (short, red) arrow in parallel with his nose. If he moves or points in a different direction, it is expressed as a direction at an angle with respect to the reference direction (long, black arrow).

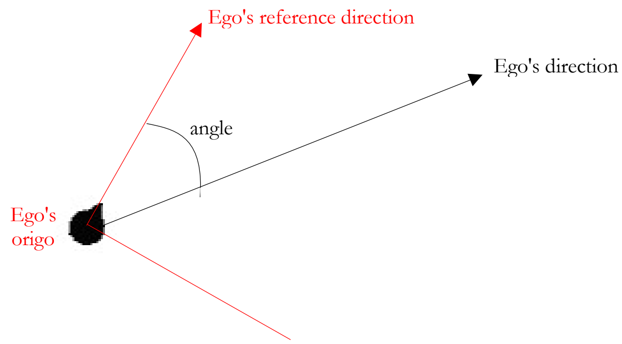



**Figure 2-3 Egocentric reference frame**

The egocentric origo is his own body (represented by his head); the egocentic reference frame is represented by the (short, red) reference direction arrow and the line perpendicular to it.
Figure 2-4 is meant to illustrate that the egocentric reference direction and origo change if ego moves.

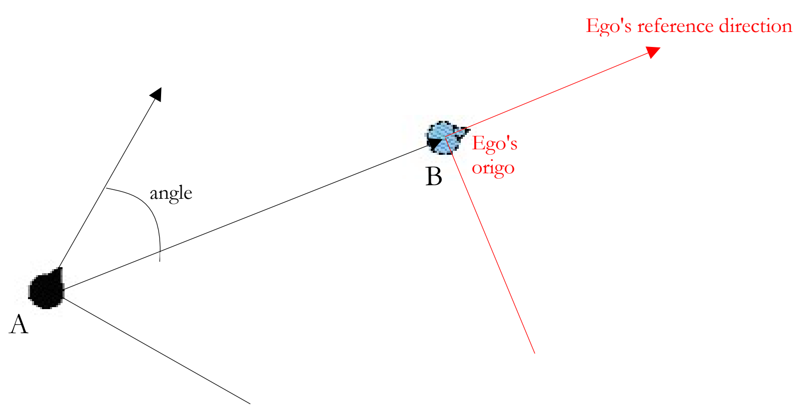



**Figure 2-4 Change of egocentric position and direction**

In this picture at bottom left (location 'A'), the (black) head shows ego in his first position with his "straight ahead" and "exactly sideways to the right" directions. After ego has moved to location 'B', his origo has moved because his (bodily) position changed; likewise his reference direction changed because his orientation altered (he turned). The position and orientation of ego's body define distance and direction, in the absence of an external coordinate system.

- locally intrinsic reference frame: this is a reference frame with its origo outside of ego, just like the allocentric one, but here the reference frame is *not* fixed. This is indicated by the word 'locally'. Its origo is neither situated in ego, nor determined by the equator or any other fixed environmental feature. Very generally speaking, any object can serve as origo. In the definition of Musto, the characteristics of any reference object, like its topology, size or shape determine the coordinate system. This report follows [Musto, 1999] where somebody called 'Other observer' serves as this reference object, the origo situated in his body and his nose determining his reference direction. Ego and this other observer differ in origo and - if both have different orientations - also in reference direction (see Figure 2-5).

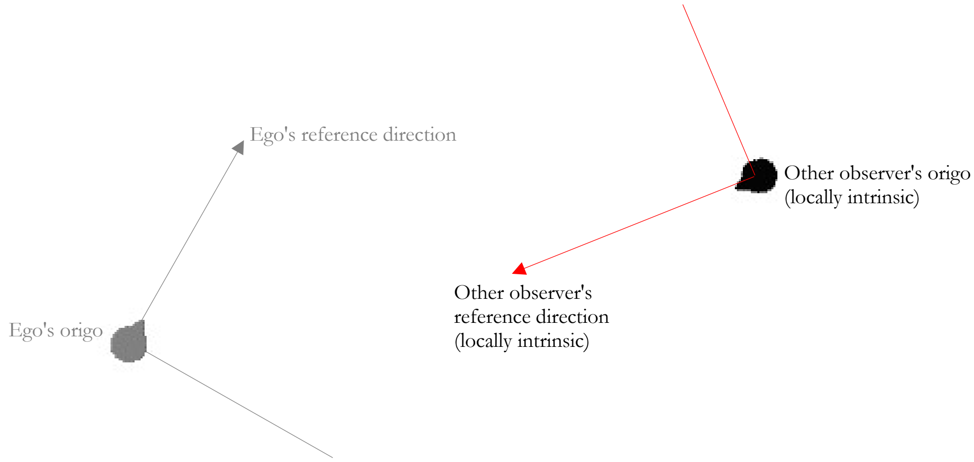



**Figure 2-5 Locally intrinsic reference frame**

The other observer can move just like ego, and thereby his origo and reference direction with respect to ego.

### 2.7.5 Reference frames in a route description situation

In case of a route description situation, ego (the route seeker) is joined by the route provider; both have different positions and - possibly - different orientations (see Figure 2-6). This route provider gives a verbal description of the route, accompanied by gestures to be interpreted by the route seeker.

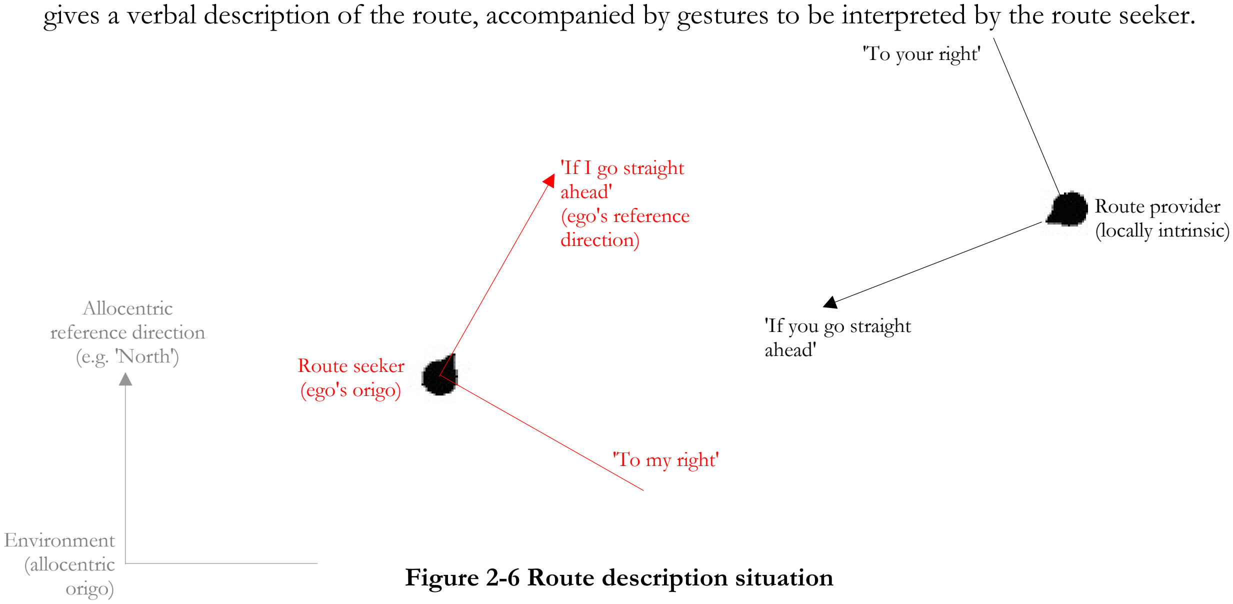



**Figure 2-6 Route description situation**

In this situation the route provider fulfills the role of other observer [Musto, 1999].
This route description situation can be considered from one of three possible perspectives:

(1) from the environment to be traversed,
(2) from the route provider and
(3) from the route seeker.

As shown in Figure 2-6, regardless of which perspectives is chosen, the spatial characteristics of the two others can be expressed as a function of the chosen perspective. In this report, the egocentric reference frame is selected, with ego being the route seeker.
In the first phase of the experiment (the route information exchange phase), ego is the one receiving the route description; in the second phase (the wayfinder phase) ego is the wayfinder. Both roles are fulfilled by the participant. In the first phase, the participant has to pay attention to the route provider (and memorize the route instructions); the route provider plays the role of "other observer". In the second phase, there is no other observer and the participant has to recall the route instructions and interpret them (combined with recall and recognition of environmental cues) to decide which turns to take.
The choice of an egocentric reference frame makes it possible to express the position, orientation and direction of the other observer as relative to ego. This is important because this relation is very suitable to fit in an experiment about gestures made by the route provider and their usefulness for the route seeker.

## 2.8 The extra effort of changing orientations

When describing a spatial scene, the explainer tends to adapt his perspective to the one of the explainee by physically turning so both (bodies) face the same direction. If this is physically impossible, then the explainer imagines what the scene looks like from the perspective of the explainee. One way to regard this tendency is to hypothesize that mentally adapting to someone else's perspective takes extra mental effort. This mental effort consists of changing the orientation of one's mental (spatial) map of the environment to the orientation of the environment presented by the interlocutor.
While the physical turn can be regarded as a switch (a short-term effort), the mental re-orientation is a continuous, long term effort lasting as long as the route description episode.
Obviously, if the physical angle between both orientations is nil (0º angle) there is no need for extra mental effort. But if not, then it is just a question of who takes the effort. The explainer tries to relieve the explainee from this effort by taking this effort upon himself, probably to make the explanation easier to comprehend and/or memorize for the other. But this is only valid for the verbal description; the explainer can provide the verbal part of the instructions from a locally intrinsic perspective (see Figure 2-6) but not his gestures, unless he turns his body.
So, this mental re-orientation has to be performed by the explainee, burdening him with this extra cognitive load. This cognitive process may interfere with other cognitive processes like memorization of the instructions. Thus, if this re-orientation is at its maximum (180° version), it may be at the cost of creating a mental map of the route to be traversed or memorizing the instructions. In that case, after the description phase has finished, someone may perform poorer during traversal.

## 2.9 Reference frames and effort

An experiment by [Shelton & McNamara, 2004] consisted of a spatial scene containing an arrangement of objects. One of two individuals could observe this spatial scene and was asked to verbally explain the arrangement to the other, who was oriented at a different angle and could not see the scene. It was shown that the explainer tried to describe the arrangement from the orientation of the explainee as if assuming this explainee's (the interlocutor's) position. Afterwards, this last person tried to draw the arrangement on a piece of paper.
The experiment of Shelton & McNamara shows that it is more effortful for a person to exchange his or her egocentric reference frame for someone else's perspective (if both interlocutors' perspectives have a non-0º angle). Earlier studies [Clark & Wilkes-Gibbs, 1986; Garrod & Anderson, 1987] showed a tendency by the information provider to relieve the information receiver of the burden of adapting perspectives. This means that the provider anticipates the extra effort for the receiver of adapting his or her perspective and therefore chooses the perspective of the receiver beforehand. Tentatively translating their research set-up to the pragmatic situation of someone describing a route

in 3D space to someone else, this means that the route provider tends to minimize the extra cognitive load of changing the orientation of the mental map on the part of the route seeker by choosing the reference frame of the latter. This means that the route provider has to provide the verbal part of the route instructions with a locally intrinsic reference frame. Obviously, his gestures remain egocentric, so if he omits turning his body, the route seeker is confronted with gestures which appear to him from a locally intrinsic perspective.
Adapting to a locally intrinsic reference frame requires the highest effort [Shelton & McNamara, 2004] (see Figure 2-7).

Least effort → Most effort

Egocentric → Allocentric → Locally intrinsic

**Figure 2-7 Reference frame and effort**

This additional effort in case of a non-0º angle can easily interfere with the route seeker's basic task of interpreting and memorizing the instructions offered by the route provider. The difference in orientation puts an extra cognitive load on the listener's mind, leaving less cognitive capacity for interpretation and memorization.

## 2.10 Sharing perspectives

The route provider or the route seeker (or both) can turn so they face the same direction. Then they have the same orientation and this may help to reduce ambiguity about the correct route (see section 2.4). The reason is that the reference directions of both interlocutors are similar. Any direction mentioned in the route description (by verbal and non-verbal expression) applies to the route seeker too. This phenomenon is manipulated in the experiment described in section 4. If all other features of the route description remain unaltered, do changes in the relative position (perspective) of the interlocutors affect the success of the traversal following the route description? For example, with both communication partners opposite to each other, a gesture to the left made by one is *seen* as a gesture to the right by the other. If the route provider adapts his position to the route seeker (standing next to him or her, facing the same direction), then both participants share gesture directions and come as close to shared reference frames as possible in this situation. Does this harmonization of perspectives help the route seeker to interpret and/or memorize the route instructions and find the destination? This will be the major research question proposed in section 3.2.

## 2.11 Way finding performance

The previous sections described aspects of route descriptions and way finding, including various factors supposed to affect somebody's way finding ability and skills. This section discusses methods to measure the ability to recall and reconstruct a route after route instructions have been given.

*Actual traversal*
The most direct means to determine how effective the route instructions are in finding a destination, is to let someone traverse the route. In [Allen, 2000] a procedure is described how to keep track of the actions of the participant during traversal in an experimental set-up. The participant is accompanied by an experimenter, making notes about incorrect turns - if any - and guiding the participant back on the correct track after an error. Although this method is very accurate (because actual traversal through a real 3-D scene is realised), it is very time consuming.

*Verbal account and drawing a map*
Another way of determining what particular information a person's mental representation holds, is to let this person solve a problem wherein this information is crucial. For example, in a study [Lynch, 1960 in Hunt & Waller, 1999] respondents are asked to verbally describe their home city and to draw a map of it. Both measuring instruments are less trustworthy than actual traversal, although face-valid. Verbal accounts are usually low in accuracy[8] (e.g. "a few blocks along and then to the right") and drawing a map requires drawing skills, which may vary considerably among respondents.

*Choice between correct and incorrect*
Also, a participant can be requested to choose between a correct and an incorrect map, or likewise between views of an area from a particular perspective. In this case, the interfering variation in personal skills as mentioned above is avoided but emphasis is put on recognition in stead of reproduction of information. Reproduction of route information becomes especially crucial in case a participant deviated from the correct route.

*Cueing*
As a compromise to avoid both drawbacks mentioned above, a cueing technique can be used. This means that participants should fill in blanks in an incomplete map. A drawback of this method is the crucial question of what to leave out when designing the incomplete map.

*Reconstruction*
Reconstruction offers a good alternative without the drawbacks mentioned above; it forms an intermediate between recognition and recall. In the experiment described in section 4, the correct route is divided into segments. The participant is confronted with one segment of the route at a time and has to reconstruct the entire route by deciding which direction to take at the end of each segment.

[8] In [Musto, 1999, pg. 10] this inaccuracy is referred to as 'Granularity'. It is stated, that "A route description is a description of a course of motion (...) in a coarse granularity. It abstracts from the fine structure of the course of motion one may perform while following the route."

# 3 RESEARCH QUESTIONS

## 3.1 Introduction

When someone approaches us and asks which way to go, we naturally turn - if necessary - so we face the direction to take (which makes it also easier for ourselves to imagine traversing the route) or at least adapt our perspective so that it matches that of the route seeker.
The experiment described in section 2.9 showed that it is more effortful for a person to exchange his or her egocentric reference frame for someone else's perspective (if both interlocutors' perspectives have a non-0º angle).
The fact that someone can imagine taking someone else's perspective is a precondition for the study, reported in the following sections of this chapter. In [Shelton & McNamara, 2004, pg. 417] it is stated that "Perspective taking provides a situation in which people have clearly demonstrated the ability to assume perspectives other than their own; it therefore allows us to observe the consequences associated with doing so." The explainer was free to choose any perspective from which to describe the scene, but probably chose the explainee's perspective to help the explainee imagining the spatial arrangement.
Will this tendency to minimize an orientational difference between the explainer and an explainee of a spatial scene help the route seeker to find his way during traversal? If the route provider turns so he faces almost the same direction as the route seeker, the gestures can be expressed as close to an egocentric perspective ('ego' being the route seeker) as possible.
If the orientational difference between both persons is at its maximum (standing opposite to each other), will the route seeker be less successful in traversal? All pointing gestures made by the route provider are mirrored in the eyes of the interlocutor. Does this configuration yield an unnatural effect, e.g. because of the normal (albeit perhaps unconscious) tendency to minimize this difference? These questions will lead to the hypotheses of section 3.5.

## 3.2 Origo and successful route traversal

During travel, a wayfinder relies partly on information from memory, both during traversal along a pathway and at intersections; usually, in case of the latter leaning more heavily on this information than during the first. Recall is sometimes facilitated by recognition (e.g. by landmarks described by the route provider), but even then he or she calls on information processed and stored during the exchange of route information with the route provider. At 180° difference in orientation, the reference point of the gestures deviates stronger (here: maximum) from the physical reference point (body) of the participant. So, the latter has to perform a mental re-orientation of 180° of the gestures, demanding extra cognitive effort. This effort is at the cost of other cognitive processes involved. The processing and storage of information is a cognitive task with which other cognitive tasks like adaptation to an opposite orientation may interfere. Assuming this effort is less if the orientational difference is less, does a smaller orientational difference result in more success during traversal?

### 3.2.1 Difference in origo

The difference in (bodily) orientation between the route seeker and the route provider determines the difference between the egocentric and the locally intrinsic reference direction (see Figure 2-6). Compared to the maximum difference (180° condition), it is crucial that conditions only differ in bodily orientation while eye contact remains the same and facial expressions remain visible; therefore a counterpart of 120° is chosen. If the difference would be 90°, not all gestures would be visible and to maintain eye contact could make the posture unnatural (this will be discussed in section 4.2.5 in more detail).

### 3.2.2 Successful traversal

As a measure for successful traversal, the number of correct turns is considered to be a suitable effectivity measure. The primary goal of route instructions is to guide and support finding a destination by traversal of the route described (see section 1.3). The more correct turns during traversal, the more effective the route description was in leading the way. In other words, a more effective route description leads to more correct turns at intersections.

## 3.3 Origo and naturalness

If approached by someone asking us to explain a route, we naturally tend to adapt our perspective (bodily orientation) to that of our interlocutor. Again, if the egocentric frame of reference is chosen and 'ego' is the route seeker, does manipulation of the difference in orientation result in differences in appreciation of the naturalness of the way the route is described (is one version regarded as more natural than the other)? Is a smaller orientational difference during the explanation of a route more natural to us because of our (intuitive) tendency to minimize this difference?

## 3.4 Orientation and way finding factors

Not only manipulation of perspective may be of influence on the performance of the participants, differences between the participants themselves can also affect their performance and appreciation. Relevant individual characteristics affecting orientation and way finding ability found in earlier studies were mentioned in section 2.5: do gender, age and educational level indeed affect participants' performance (their success in traversal and the certainty of their answers) and how do these factors influence what they regard as the most natural way for somebody to explain a route?

## 3.5 Hypotheses

The terms used in this section are:

- 120° version: the orientational difference between origo's of route provider and route seeker is 120°
- 180° version: the difference mentioned above is 180°, i.e. the route provider is standing exactly opposite to the route seeker.

1st *Hypothesis*
*Regarding the route description, the 120° version yields a more successful traversal than its 180° counterpart. A more successful traversal means more correct turns made by the participant.*

2nd *Hypothesis*
*Regarding the route description, the 120° version yields a more natural impression than its 180° counterpart.*

# 4 RESEARCH METHOD

## 4.1 Structure

This chapter describes the test material, the participants who attended it, the test procedure and the way the results were used to test the hypotheses of the previous chapter.
In section 4.2 the test material is explained; first by discussing its design (section 4.2.1), then by mentioning the parts of the test in general (section 4.2.3) and finally by explaining each part in more detail (sections 4.2.3 through 4.2.7).
Next, section 4.3 highlights the relevant characteristics of the participants' population, followed by a description of the test procedure (section 4.4). Finally, section 4.5 discusses the way the hypotheses are tested.

## 4.2 Test material

### 4.2.1 Introduction

The test material of this experiment makes use of a computer, in stead of situating the experiment in a real (live) environment. With respect to the ANGELICA project, situating the test scene and its traversal in a virtual environment (e.g. on a computer monitor) facilitates valid transfer of results, conclusions and recommendations to future work on behalf of this project. Furthermore, using a route description in a pre-recorded form ensures an unlimited number of reproductions of constant quality and contents. Using a virtual in stead of a real (live) environment yields the possibility of controlling the circumstances in which the experiment takes place. Also traversal of the test scene can be in a pre-recorded form. Real traversal took place only once, i.e. while the film was recorded.
Playback of the route by the participant from starting point to destination is divided into six segments. The first segment begins at the starting point of the route and ends at the first street crossing; each following segment starts where the previous one ended and the final ($6^{th}$) one ends at the destination.
This design of the test material puts limitations on the applicability of the results also (see section 6.1).
The scene - as it is presented on the computer monitor - is in reality located in a small town with short streets and plenty of landmarks. The short streets make long, tiresome traversal between decision points unnecessary.

### 4.2.2 General

The experiment consists of six parts, presented to the participant in the following order:

- a pre-questionnaire (to obtain the participant's characteristics regarded as relevant);
- an example question (to familiarize the participant with the question/answer structure and controls);
- an impression of the participant's current position in the scene ('Where am I?');
- a route description phase (consisting of an introductory text section and a pre-recorded route description). Two separate route descriptions were made, differing in origo but otherwise the same;
- a traversal phase, consisting of:
  - introductory text;
  - six pre-recorded traversal segments;
  - two questions after each segment about (1) which direction to take and (2) how certain the participant is about the direction just chosen;

- a post-questionnaire.

The test material is included as a series of stills in Appendix AAppendix A Questionnaire.

### 4.2.3 Pre-questionnaire

The experiment starts with participant-related questions: age, gender, educational level and familiarity with the area of traversal. Participants can answer the last question by rating it on a 5-point scale, ranging from *not at all familiar(1)...very familiar(5)*; if the participant would indicate to be moderately familiar or more, then his or her results would be discarded.

### 4.2.4 Description phases

In this experiment, it is more accurate to regard the route description part as a *presentational* in stead of a *communicational* episode. In fact, in this route description there is only one-way information transfer from the route provider to the participant and no interaction, so a collaboration of both parties to reach a successful information transfer is not possible. Nonetheless, the pre-recorded film of the route description together with preceding and successive text sections attempt to suggest a communicative process.

The phases mentioned in section 2.3 are realized as follows:

- *Initiation:* in a text section, the situation is described in which the participant is lost and approaches someone to ask the way.
- *Route description:* the description is pre-recorded and shows a person talking and gesturing in a film played in a pop-up window. This person makes pointing and beat gestures. The deictic gestures are made from the route provider's egocentric perspective, and the orientational difference between the camera view point and the participant is forced. All deictic gestures are accompanied by verbal directions. The verbal description mentions five decision points, each chronologically described by one or two characteristic landmarks. For example:

  "(...) Next, you walk straight ahead until you reach the ABN-AMRO and a sign reading 'Through traffic'. At the sign 'Through traffic' you turn left."

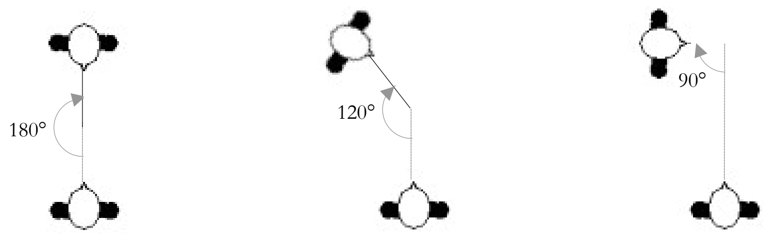
  The complete route description text is included in Appendix B. The representation is created in such a way that it reflects frontal views of the environment, as it will be viewed along the route (rather than survey views).
- *Securing:* because the route description phase admits one-way information transfer only, the participant cannot verify any ambiguities about the instructions by asking the route provider to repeat or clarify details. Neither is the route description summarized, nor are its highlights repeated. To compensate for this, participants are allowed to play the route description episode twice.
- *Closure:* a text section informs the participant that the description has ended and that he or she is about to traverse the route.

### 4.2.5 Two versions of the route description

Two pre-recorded films (each in one of two versions) of the route provider show a man explaining a route, his body:

- completely turned towards the camera lens (180° version, see Figure 4-1 a and Figure 4-2 a) so he faces the viewer (the participant) like a teacher facing a classroom, creating mirrored gestures (his left is seen by the participant as right and vice versa);
- somewhat turned towards the camera (120° version, see Figure 4-1 b and Figure 4-2 b) as if to adapt his orientation to that of the viewer (the participant).

The number of 120° is an indication of the actual angle, depending on the visibility of non-verbal signals. If he would assume a 90° orientation, pointing to his left (or right) would not be visible and to maintain eye contact could make his posture unnatural (see Figure 4-1 c).




**(a)** **(b)** **(c)**

**Figure 4-1 Angle between route provider and camera (viewer/listener)**

It is important that the 120° and the 180° condition only differ in bodily orientation while eye contact remains unchanged and facial expressions remain visible[9].
Each of the two pre-recorded films (see Figure 4-2) is included in a separate version of the experiment; except for these films, both versions are equal. The difference between both versions represents the orientational difference to test the hypotheses of section 3.5.


**(a) 180° version**


**(b) 120° version**

**Figure 4-2 Pre-recorded route description films**

[9] The presented information remains the same in both conditions; the origo of non-verbal information (pointing, beat gestures etc.) stays situated in the 'body' of the route provider in both conditions (his gestures are chosen from an egocentric frame of reference).

### 4.2.6 Traversal

*Confidence*

Directly after viewing the route description film (just before playing the films showing traversal), there is a single question: the participant is asked about the confidence in finding the destination (self-efficacy). The number of questions is limited to one to avoid distracting the participant between the end of the route description and the beginning of its traversal.

*Route segments*

Real traversal of the route is a very time consuming activity; therefore a reconstructive method was chosen (see section 2.11) to determine participants' ability to recall and reproduce the correct route. Furthermore, benefits of traversal in a virtual environment are explained in section 4.2.1. Participants 'traverse' the route by viewing pre-recorded route segments, showing a moving scene from an egocentric perspective - in this case 'ego' being the participant - as if he walks through the streets by himself, accompanied by street sounds. Each segment is shown in succession in a pop-up window (see section 4.2.4 and Figure 4-3) and starts after clicking the appropriate link.


**Figure 4-3 Traversal segment in a pop-up window**

Each route segment begins with an intersection, and ends with an overview of the next intersection and stops. The overview is realized by moving the camera viewpoint gradually so the entire intersection is shown. After each segment the participant has to:

- select the correct direction from a set of suggestions (left, straight ahead or right if applicable) and
- indicate how certain he or she is about the selected direction.

This last answer can discriminate between someone selecting a wrong direction simply by guessing, or if he or she takes a wrong turn e.g. because the route description is misleading at that point. After each set of these two questions, the participant virtually 'turns' the page by, again, clicking a link and is informed about which direction was correct. After this the next route segment can be started, proceeding route traversal with taking a correct turn to begin with (regardless whether the participant chose the correct direction or not). So, the participant always travels along the correct route regardless of mistakes in selected directions.

### 4.2.7 Post-questionnaire

After traversal the participant is confronted with a few sets of questions with 5-point scale answers, each set followed by an open question (the answer to these questions can be entered by keyboard). He or she is requested to indicate the appreciation of the route description (1st set of questions), the way the route provider acted (2nd set of questions) and the route itself (3rd set of questions). The scales of some answers were inverted to avoid arbitrary answers. Each open question offers the opportunity to comment on the previous answers. The open answers were intended to record participants' comments, to facilitate the analysis afterwards and to guide similar experiments and their questions in the future.

## 4.3 Participants

### 4.3.1 General

Following earlier research [Allen, 2000], individuals (previously) residing or working in a house, building or apartment that borders the route used in the study, are excluded beforehand. Furthermore, participants' results are excluded from the study afterwards unless they respond that they know 'very little' or 'nothing' about the neighbourhood in which the route is located when they are asked to rate their knowledge about this on a 5-point scale (see Appendix A).
It is proof of good representation if the ratio of male vs. female participants is 1:1; both sexes pay attention to different route description characteristics (see section 2.5.2).

### 4.3.2 Choice of participants

A total of 49 participants were involved in the experiment; their selection was controlled for gender (to obtain a 50% male - 50% female test population), being known as an influential factor in orientation and way finding characteristics. Apart from gender, they were randomly distributed among both versions. This test population's age had an average of 33 (Std. deviation 12.98) years, ranging from 20 to 64 years. So, none of the participants are younger than 12 or post 70, and no specific effect of age on spatial skills is expected [Hunt&Waller, 1999]. Average ages between groups did not differ much. Most of them attended university (55%), others higher (29%), middle (10%) or lower (2%) vocational training. The remainder (4%) had secondary school as highest education. This means that, on average, participants are fairly well educated. So, in general, neither poor spatial skills are expected nor is there any guarantee for good spatial skills (see section 2.5.4).
The group of participants was divided among the two versions as indicated by Table 4-1.

| | | Number of participants | |
|---|---|---|---|
| | | Male | Female |
| Version | 120° | 12 | 12 |
| | 180° | 11 | 13 |

**Table 4-1 Number of participants**

### 4.3.3 Virtual environment

Both the pre-recorded route description (film) and the traversal (film segments) are presented on a computer monitor. This virtual[10] set-up of the experiment was chosen to remain as close as possible to ANGELICA environment and goals (see section 1.2). Initially, this Web-based set-up was also preferred because it increases the number of subjects who can participate. Using a Web-based experiment, subjects could be selected even from abroad to sample their navigational preferences and skills [Vila et al., 2002]. Nevertheless it was decided that participants should be conducted during the experiment to ensure a correct proceeding and to note their comments, if any. Further, this set-up yields full control with respect to repeatability and the participation setting because of its playback nature. If people participate in a laboratory setting, the initial playback is exactly the same as the last. A possible disadvantage is the absence of sensori-motoric feedback during traversal. Also, during both the route description and the traversal, the participants' view is restricted and forced by that of the camera lens. Both phenomena may influence the participants' orientation and navigation impression.

[10] This environment is called 'virtual' for two reasons [Fricke, 2002]:
1 not really existent but at best modelled to match or simulate reality
2 larger than the current position or perspective of the viewer/listener suggests or visualizes (Fricke calls this 'imaginary').

## 4.4 Procedure

The experiment is performed by one participant at a time, seated in front of a computer in a room with as little distractions as possible. Participants are requested to comment or ask questions during and after the experiment. The experimenter is present to ensure a correct proceeding, to answer questions and to note comments, if any. The pre- and post-questionnaire, as well as the route description film and all route segments are shown on a monitor and answers are entered with a keyboard and mouse.

## 4.5 Measuring results

### 4.5.1 Successful traversal

With successful traversal the number of correct 'turns' (decisions made at an intersection, see section 3.2) is meant. In this interpretation, the decision to go 'straight ahead' is considered to be a turn also and has to be deliberately selected, just as left or right turns. A wrong turn does not result in a detour or getting lost, because the pre-recorded traversal segments always follow the correct route. The participant is merely informed that he or she took a wrong turn without further consequences; to actually let the participant abandon the correct track after a wrong turn would make the experiments' realization too complicated.
The route contains five decision points (intersections), so each participant has to take five decisions, his or her score ranging from 0...5 correct turns.

*Measure of effectiveness*
If successful traversal is measured as described above, it is a kind of effectivity measure. Each participants' score can be regarded as a measure of how effective the route description was in leading the way. So, a more effective route description leads to more correct turns at intersections.
This differs from the measure Fujii uses [Fujii et al, 2000]. He employs a movement failure rate, defined as Out/N, with Out meaning the number of times a participant lost way and was unable to return to the route and N is the number of trials. This is a rough method of effectiveness and *efficiency* measurement at the same time. In our experiment, each decision allows only one trial, after which the participant is informed about its correctness and then he or she starts the next traversal segment. This next segment remains unaltered, regardless of the preceding decision. The method used by Fujii was regarded to be too complicated in design and too confusing for the participants to be used in this experiment. In stead of more trials, the participants was offered to indicate the certainty of their decision. These indications can be used to discriminate instruction-based or orientation/navigation-based decisions from guessing. In this experiment, guessing could be quite successful because of the few alternatives at each intersection (often only two: a left or right turn).

### 4.5.2 Route description naturalness

After the participant had finished traversing the route, questions were asked about three different subjects:

- the route provider (e.g. whether the participant thought the person explaining the route was trustworthy)
- the route itself (e.g. whether the participant regarded the route as the shortest way to reach the destination or as a detour)
- the route description (e.g. how he or she appreciated the way the route provider explained the route).

Some of the questions combined two of these subjects.
One of these questions was:
“Do you think the route provider described the route in a natural way?”

The participant was asked to indicate the degree of naturalness on a scale from 1=very natural...5=very artificial. The answer reflects the impression the route provider made as a person as well as some aspects of the way he described the route, for example whether his gestures appeared natural or not (see section 6.1.3.2). All these questions were asked after the route traversal had ended, not directly after playing the pre-recorded route description. This was done to avoid distraction of the participant, because route instructions had to be stored in short term memory.
The questions asked during the experiment are included in Appendix AAppendix A Questionnaire.

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# 5 RESULTS

In this chapter the results of the experiment are stated and analyzed. Section 5.1 describes the results for the main and secondary questions of this experiment, while section 5.2 focuses on remarks on the test material.
All results, including participants' written answers to open questions, were collected into an Excel sheet. Then the results were analyzed using SPSS version 12.0.1 for Windows.
For reference, section 4.3.2 summarized the characteristics of the test population.

## 5.1 Objectives and results

### 5.1.1 Successful traversal

The first objective was to test the hypothesis of the influence of origo in route descriptions on the way finding performance of individuals (see section 3.5). A suitable dependent variable to employ as a direct measure is the number of correct turns these individuals take (see section 4.5.1). Gender has been proved to influence way winding ability strongly (see section 2.5.2). Therefore, to clarify the impact of origo on way finding ability, gender is accounted for as a fixed factor in the analysis to obtain more certainty in its outcome.
The results are summarized in Table 5-1.

| | Number of correct answers[1] | | |
|---|---|---|---|
| | 120° | 180° | Total |
| Male | 3.46 (0.88) | 3.27 (1.19) | 3.38 (1.01) |
| Female | 4.00 (1.04) | 3.62 (0.77) | 3.80 (0.91) |
| Total | 3.72 (0.98) | 3.46 (0.98) | 3.59 (0.98) |

[1] Results are presented as Means with Std. Deviations in brackets.

**Table 5-1 Main objective results**

Employing a two-way ANOVA[11] yields that neither version (F(1,45)=1.06, p=0.15, one-tailed), nor gender (F(1,45)=2.51, p=0.12, two-tailed), nor their interaction version*gender (F(1,45)=0.12, p=0.73, two-tailed) show significant differences.
A Mann-Whitney test produces similar results: neither version (Z=-0.88, p=0.19, one-tailed), nor gender (Z=-1.46, p=0.15, two-tailed) show significant differences.

[11] Here, a two-way ANOVA can be a suitable test because the dependent variable 'Number of correct answers' is a ratio-variable; conditions are that the populations have normal distributions with the same standard deviation. Because in this case the test populations are too small and the dependent variable's number of possible values is too limited (possible values: 0,1,2,3,4,5), these conditions cannot be verified. A non-parametric test (Mann-Whitney test) is done to check whether the outcome of the two-way ANOVA holds.

### 5.1.2 Route description naturalness

In Table 5-2, test results are shown for factors version and gender on route description naturalness. With these data a two-way ANOVA for the effects of version, gender and their interaction on naturalness was performed.

| | Naturalness[1] | | |
|---|---|---|---|
| | 120° | 180° | Total |
| Male | 2.62 (1.26) | 1.73 (0.91) | 2.21 (1.18) |
| Female | 2.75 (1.14) | 2.46 (1.13) | 2.60 (1.12) |
| Total | 2.68 (1.18) | 2.13 (1.08) | 2.41 (1.15) |

[1] Results are presented as Means with Std. Deviations in brackets.

**Table 5-2 Naturalness as a function of gender and version**

Naturalness was indicated on a scale from 1=very natural...5=very artificial. As shown by Table 5-2, version has an effect on participants' judgement of naturalness which is almost significant (two-way ANOVA; $F(1,45)=3.35$, $p=0.07$ two-tailed)[12]. The effect would have been significantly shown if it were the other way around. Surprisingly, the 180° version is experienced as being more natural than the 120° version. A two-tailed test was performed in spite of the one-sided hypothesis of section 3.5, because the effect was contrary to what was expected. Thus, the 2nd hypothesis is not supported. The effect of gender was not significant ($F(1,45)=1.83$, $p=0.18$, two-tailed), neither was the interaction of version and gender ($F(1,45)=0.87$, $p=0.36$, two-tailed).

### 5.1.3 Secondary objectives

#### 5.1.3.1 Mean certainty of the participants' answers, age, educational level and naturalness

In this section the results of other (regarded as secondary) effects on the number of correct answers are reported.
A test was performed to determine the correlation coefficient of these aspects and the number of correct answers given by the participants. These coefficients are summarized in Table 5-3.

| | | Number of correct answers[1] | |
|---|---|---|---|
| | | Corr. coeff. | Remarks |
| mean certainty of answers | 3.45 (0.76) | 0.228 | |
| age | 33.49 (11.98) | 0.084 | |
| | | -0.026 | Corrected for gender |
| educational level | | 0.307[2] | |
| | | 0.326 | Corrected for gender |
| naturalness | 2.41 (1.15) | -0.034 | |
| | | -0.075 | Corrected for gender |

[1] Results in the 2nd column are presented as Means with Std. Deviations in brackets;
[2] Significant on the $\alpha=0.05$ level.

**Table 5-3 Correlation coefficients with number of correct answers**

The first row of Table 5-3 reports the Spearman coefficient of the number of correct answers vs. the mean certainty of answers. Participants indicated the certainty of their answer from 1=very

[12] Again, first a Mann-Whitney test was performed because 'naturalness' is an ordinal variable. Its results are comparable (version: $Z=-1.72$, $p=0.09$ and gender: $Z=-1.38$, $p=0.17$, both two-tailed).

uncertain...5=very certain. The coefficient's value indicates that participants who perform better (higher number of correct answers) are more certain about their answers and vice versa; however, no significant linear relation exists between these two scores (p=0.06, one-tailed).
Nor did the Pearson coefficient of age produce significant differences (no correction p=0.57; corrected for gender p=0.86, two-tailed). So, no linear relation between age and the mean number of correct answers is detected, but this relation is not expected to be linear. Dividing participants into age categories and comparing the mean score of each category does not result in any significant difference.
Educational level did result in a significant effect, as shown by its Pearson coefficient (no correction p=0.03; corrected for gender p=0.02, two-tailed). Its value indicates that participants with higher education perform better (give more correct answers).
Naturalness did not result in a significant effect (Pearson; no correction p=0.82; corrected for gender p=0.62, two-tailed). The naturalness of the route presentation was indicated on a scale from 1=very natural...5=very artificial.

#### 5.1.3.2 Mean certainty and naturalness vs. version (and gender)

In Table 5-4, test results are shown for the effect of factors version and gender on the mean certainty of answers. With these data a two-way ANOVA for the effects of version, gender and their interaction on mean certainty of answers was performed.

| | Mean certainty[1] | | |
|---|---|---|---|
| | 120° | 180° | Total |
| Male | 3.51 (0.78) | 3.09 (0.69) | 3.32 (0.76) |
| Female | 3.65 (0.90) | 3.52 (0.65) | 3.58 (0.77) |
| Total | 3.58 (0.82) | 3.33 (0.69) | 3.45 (0.76) |

[1] Results are presented as Means with Std. Deviations in brackets.

**Table 5-4 Mean certainty vs. gender and version**

Mean certainty was indicated on a scale from 1=very uncertain...5=very certain. Neither version ($F(1,45)=1.56$, $p=0.22$) nor gender ($F(1,45)=1.74$, $p=0.19$, both two-tailed), nor their interaction ($F(1,45)=0.44$, $p=0.51$) show significant effects[13].

## 5.2 Participants' comments

The number of turns of the route to be traversed in this experiment was limited to five. Each turn was presented as a decision point, characterized by one or two landmarks and a direction. The route provider summed up each decision point and its characteristics in the order the participants would encounter them. Furthermore, he added some auxiliary hints of what to do in-between turns ("keep going straight ahead until you see a traffic sign") and some more details. Participants commented on this description as follows:

- almost all participants found the set of instructions given by the route provider hard to remember; some declared there were too many instructions, others thought there were too many (auxiliary) clues;
- some participants found the route description confusing because it contained an instruction to "go straight ahead" at one particular crossing; in general, they would have preferred a description that was limited to what turn to make at what point. If somebody should go straight ahead at some point, then it should be left out.

[13] First, a Mann-Whitney test was performed because 'mean certainty' is an ordinal variable. Its results are comparable (version: Z=-1.18, p=0.24 and gender: Z=-1.24, p=0.22, both two-tailed).

It appeared on several occasions that participants tended to look away from the monitor. Summarized, they declared they did this because:

- they tried to focus on the verbal instructions because the description was extensive;
- some participants found the gestures in the 180° version confusing or even annoying because of the mirrored directions the route provider gave. This led people to ignore the gestures made by the route provider.

# 6 DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The results described in Chapter 5 are discussed in section 6.1. In this same section conclusions are drawn. From these conclusions, together with participants' comments, recommendations can be made as described in section 6.2. Finally, proposals are made to help guide further research on this subject in section 6.36.2.2.

## 6.1 Discussion and conclusions

### 6.1.1 Limitations of this study

#### 6.1.1.1 Human-human versus human-ECA communication

Section 1.2 stated that this study can contribute to the ANGELICA project and there certainly are parallels between the two. Sections 4.2.1 and 4.3.3 noted that the experiment's virtual environment facilitates transfer of the results to ANGELICA; also both the experiment and the project share the subject of gestures and (their use in) route descriptions. Nevertheless, differences between this study and others connected to ANGELICA are evident.

Although there is some mechanized property in using a pre-defined video recording as compared to live face-to-face encounters, the research material used in this study is still showing real humans, albeit pre-recorded. This is still far from the situation in which an ECA is communicating with a user by means of an interface. Regarding the appreciation of the route provider and the way a route is described, significant differences were found between showing a pre-recorded human being providing route instructions and an ECA doing this. An experiment by [Ten Ham, 2005], comparing a pre-recorded route description featuring an ECA with one featuring a real person, showed that participants regarded the ECA as more competent. Furthermore, participants thought the ECA's presentation style was better, in terms of more relaxed, dynamic and interested and *less pretended*. This last characteristic could easily relate to the route provider's naturalness. They also regarded the ECA's route description as more interesting, useful, and comprehensible. A significant difference in way finding performance (in this case verbal account and drawing a curved line representing the correct route) after being instructed by an ECA in stead of a real person was not found.

#### 6.1.1.2 Difference in environment

A second limitation of the current experiment is the difference in the participant's environment and the scene he or she traverses. With regard to ANGELICA, it is intended that the route seeker is indeed situated in the scene to be traversed. In the current experiment the participant is seated in a laboratory setting in front of a computer monitor, which is completely different from the scene he traverses (the scene - as it is presented on the computer monitor - is in reality located in a small town). One of the consequences of this experiment's design is that the participants have to rely on the camera view completely to perceive the (yet unknown) surroundings for orientation and navigation because a direct match with reality is impossible. This is bound to affect their performance during traversal and their appreciation of the route instructions meant to guide them.

#### 6.1.1.3 Route providers' naturalness

Testing if origo affects the route providers' natural impression (2nd hypothesis, see sections 3.3 and 3.5) is done with the answer to only a single question: “Do you think the route provider described the route in a natural way?” To answer this, the participant selects an option ranging from *very natural(1)...very artificial(5)*. Judging a characteristic by analyzing answers to a single question introduces a risk of misinterpretation. Because some questions of the post-questionnaire appeared to be ambiguous, it was difficult to corroborate the difference in appreciation of the way the route was described, that was suggested by the difference in its naturalness.

### 6.1.2 Effect of origo on number of correct turns

On average, participants took more correct turns in the 120° version than in its 180° counterpart, but a significant effect of this difference in origo on the number of correct turns was not shown. The fact that there was no shown effect of origo on the performance of the participants does not necessarily prove that such an effect does not exist.
A possible explanation is the complexity of the route description. While the route itself consisted of five turns (well within the 7±2 range of short term memory), participants commented on being distracted by too much detail and found the set of directions hard to remember. Because the number of instructions of the route description was already a considerable load to attention and concentration, various participants found the gestures distracting. In the 180° version, some participants even declared they found the mirrored gestures annoying (see the recommendation in section 6.2.1.2). Both phenomena may have led them to ignore the gestures or look away from the monitor entirely. This fact impairs the effect of gestures and changes therein to be demonstrated by this experiment. Nevertheless, regardless of the comments about the route description being complex, participants' mean score was still farely good (all mean scores >3), so possibly an effect of origo on performance really does not exist.

On the other hand, the gestures accompanying the verbal statements of the route description were not necessary for understanding; they were meant to support these statements. All pointing gestures were accompanied by their verbal equivalents and therefore these gestures were redundant, in contrast with the statements of section 2.2.1. So, regarded from a pure informational point of view, these gestures were superfluous. In [Morsella & Krauss, 2001] it was stated that gesturing is not always intended to transfer information to the interlocutor, but facilitates the cognitive process of speaking, especially in case of spatial concepts like explaining a route in 3D space.

Finally, pointing gestures accompanying verbal route descriptions may often be overlooked in reality also. While in this experiment the field of view of the route seeker is forced to that of the camera, in reality somebody's gaze may follow the pointing direction of the route provider and this could cause missing subsequent gestures as well.

### 6.1.3 Gender, origo and naturalness

The impact of participants' gender (albeit not significant, see Table 5-1) on their mean number of correct answers and the surprising influence of origo on participants' opinion of naturalness (see Table 5-2) is made plausible in this section.

#### 6.1.3.1 Gender and navigational performance

In both versions, women perform (almost significantly) better than men do (see section 5.1.1); this difference is probably due to the following phenomena:

- the route description consisted entirely of landmarks to identify decision points and actions to be taken when encountering them (directions to take);
- both the route description and route traversal were presented in 2D (on a screen);
- participants' field of vision as well as movement was restricted and forced.

Men tend to pay attention to *bearings* - e.g. (estimates of) directions - while women often rely on descriptions of *control points* and *cues to the route* (e.g. landmarks) [Lawton, 1994]. The fact that women and men employ different strategies for way finding was also remarked by Hunt and Waller [Hunt &

Waller, 1999]: women's strategies are most suited for tracking and piloting, whereas men use strategies appropriate for navigation (cardinal directions).
The 2D presentation may inhibit acquiring configurational knowledge; its 2D character may particularly impede estimating global position, direction and distance. This is just the kind of spatial knowledge men rely on for orientation and way finding. The field of vision, restricted to the 2D representation offered by the camera, may impair the ability to orientate oneself. Finally, during this way finding experiment, the participant is seated in front of the monitor, thus lacking any opportunity for sensori-motor feedback while traversing the route. All these phenomena may favour a strategy of point-to-point decision making in stead of relying on a more general and global sense of direction, as in navigation. Therefore, the strategy that females already tend to employ in everyday life may be most suited in this experiment and hence their higher score.

#### 6.1.3.2 Effect of origo and naturalness

As this experiment uses two versions that differ in origo, the 120° situation could be regarded as an attempt by the route provider to adapt his angle of view and pointing reference direction to those of the audience, thereby matching the egocentric and locally intrinsic reference frame as much as possible. The findings from this experiment are that the 180° version of the route presentation is appreciated as more natural than its 120° counterpart. This outcome is contrary to what was expected, because in reality somebody (usually approached while opposite to the route seeker) indeed adapts his angle of view and pointing reference to the route seeker.
The outcome may be the result of many previous confrontations with presented characters (life-like, cartoonesk or other) displayed on monitors or projection screens, explaining things to an audience. Possibly even their trivial experience with classroom environments is crucial in what is expected and what not. Perhaps the fact that it is more natural to make origos as similar as possible when explaining a route to someone perishes when this route is explained by somebody presented on a screen; a form of presentation in which we expect someone to be facing us.
Also, in this experiment, both route provider and route seeker (the latter by means of the camera perspective) are exactly (180° version) or almost (120° version) perpendicular to the starting direction of the route. In a truly natural situation, whatever the orientation of both individuals, they both turn so they face the starting direction (possibly to identify nearby landmarks which may help during traversal). This situation was not suitable for simulation in the experiment, because in the 180° condition it would result in the route provider pointing backwards when he tried to indicate "straight ahead".
Furthermore, the fixed position of the camera during the route providing episode of the experiment may also interfere with its naturalness. If the route provider points into some direction, we tend to turn our heads to that direction, maybe in the assumption he will point at some landmark that can help us orientate or navigate. The fixed position of the camera, in contrast with the movement of the head and accompanying changing gaze of the route provider, may yield an unnatural combination.
Table 6-1 provides an overview of the effect of origo on way finding performance and route presentations' naturalness.

| | 120° | 180° |
|---|---|---|
| Way finding performance | + | – |
| Naturalistic route presentation | – | + |
| Remarks concerning gestures | none | annoying |

**Table 6-1 Overview different conditions**

As shown, way finding performance was found to be better after the 120° route description, but naturalness of this same route presentation was less; although the way the route was presented in the 180° condition was appreciated as being more natural, various participants also commented that they thought the mirrored gestures were annoying.

Does the finding of an effect of origo on naturalness contradict the effect on participants' way finding performance (albeit both non-significant)? The non-significance of the latter was explained by participants' ignoring or not relying on gestures during the route description episode, but how then can it affect its naturalness in the opposite direction? Possibly not the gestures or their origo are crucial for the naturalness, but the fact that the instructor is facing the audience or not, so whether his body is turned towards the audience - directly addressing them - or away from it.

### 6.1.4 Effect of age

Remarkably, no effect of age on the mean number of correct turns was demonstrated.
This experiment involved individuals between 20 and 64 years old (see section 4.3.2). Navigational skills are expected to be directly influenced by age only if the participant is younger than 12 or older than 70 years (see section 2.5.3). Only, this particular experiment appeared to require not only navigational skills, but was also a considerable load to concentration and memory; both were expected to be age dependent, but this dependency was not shown. Even if we assume orientational and/or navigational skills to be independent of age or at least dependent on many other factors that may compensate age differences, some effect of age was expected because the capacity of storing and retrieving information in and from memory is likely to decay with age.
It was concluded, that the majority of the test population was too young (53% was between 20 and 29 years and merely 10% was over 50) and the variety in age was too small to demonstrate age effects, if any.

### 6.1.5 Effect of educational level

A significant correlation between educational level and mean number of correct answers was found (see Table 5-3). The higher the participant was educated, the better he or she performed. This is no surprise, because usually people with higher educational background have occupations that require higher levels of concentration and memory training. Also, they may have more (everyday) computer experience, helping them to get quickly acquainted with the test method and controls used in this experiment. Thus, people with higher educational levels may experience less cognitive load (see section 2.8 for an explanation of this phenomenon) while performing the test and benefit from this by paying more attention to the contents of the route description.
Therefore, this finding could mean that highly educated individuals are better wayfinders than others, but not necessarily. Participants with higher education probably possess other skills from which they (also) benefit during this experiment.

## 6.2 Recommendations

### 6.2.1 Test material

#### 6.2.1.1 Examples and introduction

It is recommended that more example questions are incorporated in the test material. Participants should get the chance to get acquainted with the question/answer structure and get used to the controls to fill in their answers. In the current test material, the participant was requested to begin the experiment after practicing with only one example. Considering the participants' comments, it appeared that after having practiced with merely one example they were still unfamiliar with the question/answer structure and controls. After they clicked a link, pop-up windows with route fragments and stills of the scenery appeared and automatically disappeared. Especially the latter was said to be confusing. Also, they had to get used to the 2D representation of traversal in 3D space. These facts may have interfered with paying attention and focussing on crucial information in order to give the correct answers.
Therefore, it is important that the single example appearing in the current test material is expanded to at least three examples in the following order:

- a first example containing a link to a pre-recorded film fragment, overviewing an intersection. This intersection should be no part of the route to be traversed;
- a second example containing a link to stills (screen-shots) of the same intersection as above;
- a third example presenting the controls to select a direction to be taken at this intersection.

#### 6.2.1.2 Post questionnaire

To encourage participants to give their comments in open questions, each time a set of questions about a specific theme (e.g. the route description, the individual giving the description, the route itself) was concluded with an invitation to comment on the previous set. This was done to limit the amount of open questions and thus to avoid discouraging participants to answer them, as open questions take more time and require more initiative and consciousness. It appeared to confuse them, because this structure seemed to suggest that they had to comment on their previous single answer only. This leads to differences in interpretation of the questions and thus to (unintended) different answers, which impairs their analysis afterwards. It can be overcome by simply including an open question after each scale-type one, making crucial open answers compulsory and others optional.
With respect to ANGELICA, it is important to include in this post-questionnaire a specific question about the gestures used by the route provider. Only in the 180° condition participants commented that they noticed the gestures were mirrored and therefore declared that they found them annoying (see section 6.1.2). If their appreciation of the gestures was specifically asked for by a question in the post-questionnaire in stead of appearing in their (broadly varying) comments, their answers could be properly analyzed.

#### 6.2.1.3 Route description

It is best to adapt some route description characteristics as follows:

- a route description of this form offers merely one-way information transfer, so a dialogue as in section 2.3 is not possible. A recapitulation of the instructions can be added to compensate for the lack of a securing episode (see Table 2-4);
- the number of (verbal) instructions given should be limited to 7±2. The route itself was said not to be complex but its description contained superfluous directions and details;
- the route description should only include actual changes in direction (left or right turns);
- the route description should be based on a spontaneous explanation of how to reach the destination, provided that both versions must remain similar except for origo's. Prescribing route instructions to be uttered during recording of the film (intended to create two exactly similar descriptions) resulted in an unnatural verbal description and exaggerated gesturing.

### 6.2.2 ANGELICA Project

Because of the virtual environment in which the experiment takes place, results are likely to be valid or at least relevant for ANGELICA. A significant effect of orientational difference on the natural appearance of the route presentation was not shown, but this was due to a contrary expectation beforehand (see the 2nd hypothesis, section 3.5). Results so far point out (albeit tentatively, see section 6.3.2) that to design a naturalistic presentation of route instructions the route provider should stand opposite to and face the camera.
This recommendation is being provided in spite of:

- better way finding performance in the 120° condition, which *failed* to show a significant effect;
- comments of participants stating that the mirrored gestures in the 180° conditions annoyed them, but on the whole the 180° presentation was still appreciated as more natural.

## 6.3 Further research

### 6.3.1 Verify the effect of origo on way finding performance

The phenomenon of different origo's in route description practice was not shown to (significantly) affect way finding performance. This result may be due to the fact that in reality no effect exists, but it may also be caused by a route description that was by many participants said to be too complex. With a less complex description, participants may refrain from ignoring the gestures made by the route provider and thereby be susceptible to manipulation of gestures and origo. This way, an effect of origo on the number of correct answers may be indicated.
On the other hand, the route description being complex or not, participants scored farely well on taking correct turns in both conditions; this could be an indication that complexity was apparent but no obstacle to traverse successfully. Then the result already shown may be replicated.
To solve this ambiguity, the results can be verified by an additional experiment with an adapted route description (see section 6.2.1.3).

### 6.3.2 Corroborate the effect of origo on naturalness

In section 6.1.3.2, possible causes for the surprising effect of origo on the presentations' naturalness (experienced by the participants) were proposed. These are merely propositions; for the ANGELICA project, it is important to clarify the underlying cause(s) for this unexpected result (currently not yet shown to be significant as explained in the previous section) and the tentative recommendation of section 6.2.2 should be corroborated.
Regarding this issue, further research should verify if:

- the effect of origo on naturalness is shown if the participant is actually part of the scene to be traversed;
- this same effect is shown with an ECA explaining the route in stead of a real person.

### 6.3.3 Determine the cause of the educational effect

Concluding, a significant effect of participants' educational level on the way finding performance was indicated. What makes educated people perform better on this test? Again, in section 6.1.5, suggestions have been proposed that those individuals' ability to concentrate, their memory training and even everyday use of a computer may be beneficial during participation; but in general, are they better navigators? An experiment that includes traversal in a real 3D scene, allowing e.g. sensori-motor experience in a life-like situation is more suitable for answering this question. The current experiment with its virtual environment attempted to answer different questions.

# KEYWORDS

Allocentric
External factors, e.g. in geographic space, impose a fixed coordinate system. A given point in space is determined by its distance from the origin and the bearing from the origin [Klatzky, 1998 in Musto, 1999]

Axis of Orientation
The perpendicular with respect to the front side of the object, directed against this front side [Musto, 1999]

Bearing
The bearing from point A to B is the angle between the directed reference axis and a line from A to B. In an egocentric frame of reference, the reference direction is ego's heading

Complementary or non-redundant gestures
Gestures which express information not expressed in speech, as opposed to Redundant gestures

Configurational information or knowledge
Information or knowledge structured as positions from which distance and direction can be derived. With this knowledge it is possible to locate navigation points without the need to link them by a traverse.

Egocentric
Ego's physical configuration defines an egocentric distance and -direction, in the absence of an external coordinate system. When on the move, this frame of reference also changes in orientation and translation, so in that case its allocentric distance and direction change constantly

Embodied Conversational Agent or ECA
An interface with human-looking virtual characters that can use natural language and display nonverbal behaviours.
An ECA forms a communicational link (with a humanlike appearance) in virtual reality.

Deictic gestures
A deictic gesture is a pointing gesture with the objective to direct the listener's or viewer's attention to some specific event or object in the environment

Deictic Coordinate System
A deictic coordinate system employs a frame of reference that is imposed by an external observer [Musto, 1999]

Delimiter
Provides discriminative information about an environmental feature; e.g.
- distance designation
- direction designation
- temporal unit

Descriptive
Provides information about (relations among) environmental features along the route. The common form of a descriptive is a landmark.

Geographic Region
A geographically defined space, only known to someone by verbal description or scrutinization of a map

Heading
Facing direction, the direction that aligns our sense systems for effective guidance of locomotion. See Orientation.

Landmark
An object that can be identified by distinct shape, size and colour. Objects can give directional instructions thus becoming salient landmarks. Some objects have personal meaning and may become landmarks.

Navigation
A way finding strategy that relies on environmental cues and the global direction and position of these cues. An unknown position and direction can be estimated by deriving them from destinations visited in the past. This strategy builds on configurational knowledge.
Compare to other way finding strategies called Tracking and Piloting.

Neighbourhood
A set of spatial surrounds through which a wayfinder traverses, moving and looking around

Non-redundant or complementary gestures
Gestures which express information not expressed in speech, as opposed to Redundant gestures

Nonverbal
Examples of nonverbal behaviour within the context of this report are: eyebrow raises, eye gaze, head nods, intonation contours, posture shifts and gestures

Orientation
The orientation of an object in space is the angle between some directed reference axis external to the object (allocentric heading) and the object's axis of orientation.
To orientate oneself is to determine where one is with respect to nearby objects and the target location.

Origo
The origin of a coordinate system of subjective orientation. It is used to organize the personal, spatial and temporal structure of utterances [Bühler, 1934 in Fricke, 2002].

Paraverbal
Utterances that provide feedback to the speaker, like “huh?”, “umm” and “Uh-huh”

Piloting
A way finding strategy that combines self-centered directions with environmental information; the strategy relies on information about what somebody's orientation and direction should be after encountering a landmark.
Compare to other way finding strategies called Tracking and Navigation.

Redundant Gestures
Gestures which express the same semantic features as the accompanying speech, as opposed to Non-redundant gestures.

Reference frame
Point of view from which elements in the environment are located (egocentric) or higher order environmental feature from which other elements are located (allocentric) [Tversky, 1993 in Musto, 1999].

Route description
See Route direction

Route direction
The set of instructions that prescribe the actions required to execute that course, step by step, in a appropriate manner [Allen, 2000]

Route knowledge
Knowledge of the spatial relationship of objects limited *along* the route

Scene
An area that can be sensed at a glance, without turning around or moving

Surround
The space consisting of all scenes visible during a turn of 360º without actually moving through this space

Survey knowledge
Knowledge of the spatial relationship of objects selected *around* the route

Tracking
A way finding strategy that relies on local cues that identify a route. Local cues can be street signs, landmarks and other environment characteristics *along* the route. Compare to other way finding strategies called Piloting and Navigation

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# APPENDIX A QUESTIONNAIRE

The questionnaire used in the experiment is in Dutch, see the following seven pages. It was translated into English for this report only, see the next seven pages.

# 3D Routebeschrijving

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U gaat zo meteen deelnemen aan een experiment over routebeschrijvingen. De bedoeling van dit experiment is om te bepalen hoe geschikt een routebeschrijving is om iemand de juiste route naar een eindbestemming duidelijk te maken. Het experiment is bedoeld om de routebeschrijving te testen; het is niet de bedoeling uw individuele capaciteiten om de weg te vinden te toetsen. In dit experiment speelt u degene die in het stadje Delden loopt en de weg zoekt naar Hotel De Zwaan. U gaat de weg aan iemand vragen; die persoon zal u de juiste route maar eenmaal uitleggen. Van u wordt verwacht dat u de route onthoudt en daarna de route zelfstandig aflegt. Wilt u, voordat u aan het experiment begint, de volgende vragen beantwoorden?

**1.** Kent u de weg in het stadje Delden, in de buurt van Hotel De Zwaan?

1=Heel goed.....5=Totaal niet

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**2.** Wat is uw geslacht?

- ○ V
- ○ M

**3.** Wat is uw leeftijd?

[ ]

**4.** Wat is uw hoogst gevolgde opleiding (minstens twee jaar)?

- ○ Basis-/Lagere school
- ○ Middelbare school
- ○ LBO
- ○ MBO
- ○ HBO
- ○ Universiteit

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# 3D Routebeschrijving

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Tijdens dit experiment legt u een route af; u bereikt daarbij een aantal kruispunten. Op elk kruispunt gaat u de juiste richting proberen te kiezen. Om u daarbij te helpen verschijnen foto's die een aanzicht geven van elke mogelijke richting. Om te oefenen krijgt u nu een voorbeeldvraag. Deze vraag dient alleen als voorbeeld en is geen onderdeel van het werkelijke experiment.

Stel u voor dat u verteld wordt om "Bij het winkelpand op de hoek rechtsaf" te gaan. U kunt een overzicht van de kruising zien door "VOORBEELDVRAAG" aan te klikken; dit overzicht verschijnt dan 5 seconden lang. Daarna kunt u de vraag beantwoorden door een van de antwoorden aan te klikken.

VOORBEELDVRAAG

**VOORBEELDVRAAG**


**5.** Kies nu de juiste richting (als voorbeeld één van de mogelijkheden aanklikken).

- ○ Linksaf
- ○ Rechtdoor
- ○ Rechtsaf

**6.** Hoe zeker bent u van het gegeven antwoord?
(als voorbeeld één van de mogelijkheden aanklikken)

1=Heel onzeker.....5=Heel erg zeker

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

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# 3D Routebeschrijving

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U begint nu met het experiment. Stel u voor dat u te voet in Delden bent en u wilt naar Hotel De Zwaan. Als u op "HIER BEN IK" klikt krijgt u de plek te zien waar u iemand aanspreekt om de weg te vragen.

HIER BEN IK

**HIER BEN IK**


U krijgt nu de routebeschrijving te zien, gegeven door de persoon aan wie u de weg naar Hotel De Zwaan hebt gevraagd. Denk eraan dat u deze beschrijving maar één keer te zien krijgt en de route gaat afleggen zonder dat u de instructies nogmaals kunt afspelen. Wilt u de beschrijving starten, klik dan op "ROUTEBESCHRIJVING".

ROUTEBESCHRIJVING

**ROUTEBESCHRIJVING**


120º VERSIE

180º VERSIE


U hebt nu de routebeschrijving gezien. Nu gaat u de route afleggen.

**7.** Hebt u de indruk dat u de eindbestemming, hotel De Zwaan, zal kunnen vinden?

1=Beslist.....5=Vast niet

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

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# 3D Routebeschrijving

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De route is onderverdeeld in zes fragmenten; elk fragment eindigt bij een kruising. Zogauw u de kruising bereikt hebt kunt u kiezen welke richting u op moet om Hotel De Zwaan te bereiken. Om u te helpen verschijnen foto's die een aanzicht geven van elke mogelijke richting. U moet een van de antwoorden aanklikken.
U kunt met het eerste fragment beginnen door "FRAGMENT 1" aan te klikken.

FRAGMENT 1

**FRAGMENT 1**

**8.** U kunt een overzicht van de kruising zien door "OVERZICHT 1" aan te klikken; dit overzicht verschijnt dan 5 seconden lang. Daarna kunt u de vraag beantwoorden.

OVERZICHT 1

Kies nu de juiste richting.

- ○ Linksaf
- ○ Rechtsaf

**OVERZICHT 1**


**9.** Hoe zeker bent u van het gegeven antwoord?

1=Heel onzeker.....5=Heel erg zeker

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

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# 3D Routebeschrijving

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Het goede antwoord op deze vraag was: rechtsaf.

U kunt met het laatste fragment beginnen door "FRAGMENT 6" aan te klikken.

FRAGMENT 6

**FRAGMENT 6**


U hebt nu Hotel De Zwaan bereikt. Als afsluiting krijgt u nog een aantal vragen.

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**18.** Vindt u de persoon die de route heeft uitgelegd deskundig?

1=Heel deskundig.....5=Heel erg ondeskundig

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**19.** Vindt u de persoon die de route heeft uitgelegd betrouwbaar?

1=Heel betrouwbaar.....5=Heel erg onbetrouwbaar

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**20.** Wilt u uw antwoorden toelichten?

**21.** Vindt u de manier waarop de route werd uitgelegd goed?

1=Heel goed.....5=Heel slecht

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**22.** Vindt u de manier waarop de route werd uitgelegd prettig?

1=Heel prettig.....5=Heel onprettig

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

# 3D Routebeschrijving

**23.** Wilt u uw antwoorden toelichten?

**24.** Vindt u de manier waarop de route werd uitgelegd natuurlijk?

1=Heel natuurlijk.....5=Heel gekunsteld

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**25.** Vond u de routebeschrijving ingewikkeld?

1=Heel ingewikkeld.....5=Heel eenvoudig

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**26.** Vond u de routebeschrijving moeilijk?

1=Heel moeilijk.....5=Heel gemakkelijk

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**27.** Vond u de routebeschrijving boeiend?

1=Heel boeiend.....5=Heel saai

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**28.** Vond u van de routebeschrijving gestructureerd?

1=Heel gestructureerd.....5=Heel ongestructureerd

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**29.** Vond u de routebeschrijving bruikbaar?

1=Heel bruikbaar.....5=Heel onbruikbaar

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**30.** Vond u de routebeschrijving duidelijk?

1=Heel duidelijk.....5=Heel onduidelijk

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**31.** Wilt u uw antwoorden toelichten?

**32.** Vond u de routebeschrijving begrijpelijk?

1=Heel begrijpelijk.....5=Heel onbegrijpelijk

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**33.** Vond u de route moeilijk te onthouden?

1=Heel moeilijk te onthouden.....5=Heel gemakkelijk te onthouden

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**34.** Hebt u de indruk dat de route u rechtstreeks naar de bestemming leidde?

1=Heel rechtstreeks.....5=Heel omslachtig (omweg)

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

**35.** Wilt u uw antwoord toelichten?

Hartelijk bedankt voor uw medewerking!
U kunt uw vragenlijst versturen door op de knop 'Submit Survey' te klikken.

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Submit Survey

# APPENDIX B ROUTE DESCRIPTION TEXT

This section contains the verbal part of the route description. The original instructions used in the experiment are in Dutch, see below.

"Je gaat hier de straat in, je loopt vervolgens rechtdoor totdat je aan 't einde van de straat rechts de kerk om gaat.
Je loopt dan rechtdoor, totdat je aan je rechterhand een lantaarnpaal op een sokkel ziet.
Je gaat dan rechtdoor totdat je aan je linkerhand een groot wit geschilderd gebouw ziet; bij het witgeschilderde gebouw ga je linksaf.
Je loopt vervolgens rechtdoor totdat je de ABN-AMRO tegenkomt en een bord 'Doorgaand verkeer'; bij het bord 'Doorgaand verkeer' ga je linksaf.
Je loopt vervolgens rechtdoor tot aan een mannenmodezaak.
Bij de mannenmodezaak ga je rechtsaf en vervolgens zie je Hotel de Zwaan na ongeveer honderd meter aan je linker hand."

The description was translated into English for this report only, see below.

"You enter this street, then you walk straight ahead until you reach the end of the street and turn right, around the church.
Then you walk straight ahead, until you see a street light on a pedestal on your right hand.
Then you go straight ahead, until you see a large white painted building on your left hand; at the white painted building you turn left.
Next, you walk straight ahead until you reach the ABN-AMRO and a sign reading 'Through traffic'; at the sign 'Through traffic' you turn left.
Then you walk straight ahead up to a shop for men's clothing.
At this men's clothing shop you turn right and next you see Hotel de Zwaan after about one hundred meters on your left hand."