

Car navigation system via the telephone. Part 2: Navigating using spoken driving instructions

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Rapport no. 1020

Car Navigation System
via the Telephone

Part 2

A. Garlich

Dit rapport kwam tot stand in het kader van het afstudeerproject van A. Garlich. Het project gold als afsluiting van zijn opleiding Techniek en Maatschappij aan de Technische Universiteit Eindhoven, in de specialisatie Informatietechnologie en Gedrag. Drs. R. Gobits van de faculteit Wijsbegeerte en Maatschappijwetenschappen trad op als eerste begeleider. Tweede begeleider was Prof.dr.ir. F.L. van Nes, groepsleider Informatieergonomie op het IPO.

Car Navigation System via the Telephone

Part 2: Navigating using spoken driving instructions

A. Garlich

Abstract

This report is the continuation of the user interface study as laid down in IPO report no. 1011. The theory behind navigating using a telephone service and the results of the second experiment are presented. In this experiment subjects actually drove through a part of the city of Eindhoven using a software-implementation of the proposed car navigation service. Besides age-related effects, this experiment also focused on the content of the generated driving instructions. For practical reasons only one variable regarding the content was tested: half of the subjects got instructions containing redundant information that in research by others was indicated as being necessary, the other half of the subjects did not get the extra redundant information in their instructions. Subjects, half of them older than 65 and half of them younger than 65, were observed during the experiment and interviewed after the experiment. It was found that subjects liked the tested car navigation service, found it easy to navigate through a city using the system, and made few errors while using it. No differences were found between older and younger subjects. Also, there were no differences between subjects who got instructions containing the extra redundant information and subjects who did not get this information. Suggestions for improvement of the driving instructions are given.

Introduction

The study to several user interface aspects of a car navigation system via the telephone is divided into two separate experiments (Garlich and Tiritoglu, 1994). The first experiment dealt with the input part of the system, i.e. giving the names of the current location city and street, and the destination city and street. In this 'second' experiment, the output part of the system is tested, i.e. it was tested how well people performed in navigating through a city using a software-implementation of the proposed car navigation service.

First the theory behind navigating using a telephone service is discussed. For determining if a telephone service can guide people in city driving, two major questions have to be answered: First, is it possible to navigate through a city using spoken driving instructions? Second, is this possible without having an automatic vehicle location device?

Spoken driving instructions

The first question has been the subject of a lot of studies, initiated during the development of new VNA's. Davis and Schmandt e.g. tested the performance of drivers using a VNA which only generated real time synthetic spoken driving instructions (Davis and Schmandt, 1989). Results showed that the drivers successfully navigated in areas that were unknown to them, using this navigation system. Walker et al. tested the hypothesis that speech aids have an advantage over visual aids because the first leave the driver's eyes free for driving. Walker et al. found better performance with auditory VNA's than with visual ones, and the first being safer (Walker et al., 1991).

One can understand this by looking at the nature of the driving task. Driving mainly consists of a control task with emphasis on visual/spatial resources. Therefore, to minimize task interference, route instructions can best be presented auditorily. This is based on the assumptions that spatial and verbal tasks are entirely different cognitive tasks, and that it is more difficult to perform similar cognitive tasks simultaneously than it is to perform different cognitive tasks simultaneously (Freundschuh, 1989). Freundschuh cites a study by Brooks (Brooks, 1968), and subsequent studies replicating Brooks' results, as experimental evidence for these assumptions.

From an extensive literature study, Verwey concludes that route instructions should be presented auditorily because the heavily loaded visual channel then does not get extra load, and because verbal guidance instructions that are presented auditorily yield better performance than spatial instructions presented visually (Verwey, 1992).

Considering all the literature on this topic, it can be concluded that it is possible to navigate through a city using a VNA with auditory presentation of the driving instructions. More than that, using auditory output devices will yield better and safer VNA's.

All the studies so far used VNA's that had automatic vehicle location capabilities. Therefore, direction giving is very straightforward. For example when on a roundabout, at the right moment the VNA just says "Exit the roundabout now". In a VNA that has no automatic vehicle location equipment, 'now' cannot be determined. This has some major consequences for the content and the timing of the spoken driving instructions. In the above example for instance, the instruction on when to exit the roundabout has to be given before the driver even turns onto that roundabout, saying e.g. "Turn left at the roundabout" (which in Dutch would be "Neem de rotonde driekwart").

Navigating without automatic vehicle location

The absence of automatic vehicle location raises the question if, without it, in-city navigation is possible at all. In the literature only one study is known that answers this question. Because the VNA that was used in that experiment also used vocal route messages, and therefore is very much the same as the proposed VNA, this study by Streeter et al. is covered in more detail.

Streeter, Vitello, and Wonsiewicz (Streeter et al., 1985) explored the question of what would be the best way to present directions to car drivers. They compared four different groups of users that had to navigate through an area unknown to them, using: 1) taped instructions; vocal driving instructions generated before the actual journey, 2) customized route maps; maps only including information relevant to the particular route with the route to be driven traced in red, 3) taped instructions and customized route maps, and 4) regular maps of the area and whatever means subjects would normally use (the control group).

The taped instructions were provided on a regular cassette. Subjects operated the car tape recorder themselves, deciding when to play an instruction. It was also possible to repeat instructions. The modified tape recorder just had two buttons: one for playing the next instruction and one for repeating the last instruction. Results show that drivers using voice only instructions performed better than all the other groups. Table 1 shows the results for all the groups on total mileage, time used, and errors made per instruction.

Table 1 Results of Streeter-experiment (Streeter et al., 1985)

Measure	Conditions			
	Tape	Custom map	Tape + Map	Control
Miles	11.41	12.72	12.00	15.80
Time (min)	24.18	26.37	25.55	34.23
Errors	1.12	1.87	1.64	not recorded

Subjects in the tape-only group drove fewer miles than subjects using map-only and subjects in the control group. Subjects who used tape and map, did not differ significantly from both the tape-only and map-only group. The same rank ordering can be seen for time and errors per instruction. Errors that were typically made in all conditions were 'difficulty in finding location' (34.7% of all errors) e.g. subjects looking for a specific house number and passing the house, and 'see location while driving past' (19.5% of all errors). Differences between the three groups were reported mainly on one kind of error: turning in the wrong direction or onto the wrong road. Subjects in the map-only condition made 41 of these errors in total, compared to 30 in the map + tape condition and 10 in the tape-only condition. It seems that hearing which direction to turn

reduces the left/right reversals that are much more common in getting this information only from consulting a map.

All the results show that it was less useful to have a tape and map than to have a tape alone. Streeter argues that having both a tape and a map may have provided too much information. In this condition, attending to the map for taking decisions on where to turn and at what moment, produced errors.

So in summary, drivers using the taped instructions drove to their destinations in fewer miles, took less time, and showed about 70% fewer errors than the drivers using regular maps. Drivers using both taped instructions and customized maps, performed somewhere in between the voice-only and map-only drivers. These results indicate that not only it is possible to navigate through a city using only spoken driving instructions, but that this is even possible without the use of an automatic vehicle location device.

Discussing these results, Streeter et al. quite rightly state that the success of the tape-only condition cannot only be attributed to using verbal messages, but was in large measure due to the nature of the instructions. Streeter et al. based their instructions on findings from previous research on navigation and basic psychological findings. The precise wording of the instructions was the result of an iterative design process: "There is no guarantee that our rules for generating instructions are the best possible, only that they appear to work effectively, are easy to generate, and require information that might reasonably be expected to be contained in a good geographical data base" (Streeter et al., 1985, p 561). What then would be the most effective content of the Dutch messages to be used in the proposed telephone service?

Content of driving instructions

The 'previous research' used by Streeter et al. to shape their instructions, for the most part deals with wayfinding, i.e. "... the ability to learn and remember routes through the environment" (Blades, 1991, p 137). A good overview of the literature on wayfinding can be found in (Gluck, 1991); for a good overview of the strategies people use in navigating through unfamiliar cities, see (Schraagen, 1989). However, wayfinding differs from navigating as it is supposed to be done by people using the proposed telephone service. First, the telephone service is not meant for people who want to learn a particular route. Intended users are those who only want driving instructions that will take them as soon as possible, or whatever criterion desired, to a place they want to go. They do not care about not being able to drive the same route again without the help of the instructions. Second, the intended users of the telephone service will not be familiar, or want to be familiar, with the area in which they are driving. Wayfinding theories always assume that people will stay in an area for a longer period of time, so that learning a route is more efficient and becomes a need.

The literature on wayfinding, especially on cognitive (mental) maps, can give us some valuable hints, e.g. that errors in cognitive maps are generally metrical (distance) and rarely topological (relational), but do not yield general insight on how to construct driving instructions the right way.

Another starting point would be the literature on direction giving by humans. As the telephone service is comparable with a pedestrian giving driving instructions to someone who is looking for a street, research on the content of those instructions can give us some suggestions on shaping the messages of the telephone service. Such research, however, is hardly known in the literature.

Gluck did some analyses on the content of direction giving e-mail and voice-mail messages (Gluck, 1992). However, he was only interested in the knowledge representation frame that captures the directional and non-directional content of such messages. The same goes for Riesbeck who only wanted to construct software that would judge the clarity of man-made driving instructions (Riesbeck, 1980). He did an analysis on the structure of driving instructions that people normally use, and found that the instructions are made up of three components at maximum. These are:

1. Motions; that tell what to do. For example "Turn right" or "Go south to Midway".
2. Descriptions; that tell what a place looks like. For example "On the left is a gas station".
3. Comments; that give extra information. For example "You can't miss it".

The motion information is the crucial information in a driving instruction. The other two do not have to be in the instructions, but can give extra information that make the instructions more clear. However, it is also possible that the extra information turns out to be non-information or confusing information. Riesbeck was very much interested in this aspect of driving instructions.

Wunderlich and Reinelt analysed transcriptions of route giving by pedestrians in Frankfurt, Germany (Wunderlich and Reinelt, 1982). They were particularly interested in the interactional scheme of giving directions between the pedestrian and the person asking for route instructions. Also, the people asking for directions were pedestrians themselves. Wunderlich and Reinelt did not look in detail at the content of the route instructions, but found that the first move from the starting point and the last move to the destination were the most precise. In between, pedestrians gave somewhat vaguer instructions. If the amount of instructions became too large, pedestrians often said the way-finding person should ask another pedestrian at the point to which they had talked them. This is basically how the telephone service works: Only one instruction at a time is being given. After a driver has fulfilled that instruction, the next instruction is presented (the next pedestrian is asked).

Besides these papers, no research on the content of driving instructions given by people could be found in the literature. Also, experts at the "Verkeerskundig Studiecentrum Groningen", the "Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (SWOV)" in Leidschendam, and "TNO Technische Menskunde" in Soesterberg, did not know of any research on this particular topic. This is probably the reason that Streeter and her colleagues and also Davis and Schmandt based their driving instructions mainly on experience with older versions of their instructions: an iterative design process. Therefore, on the next pages I will deal with the 'conventions' used by these researchers for shaping their driving instructions. These guidelines will be discussed and put in a Dutch context. Because the navigation system used by Streeter et al. is the system that is best comparable to the proposed telephone service, the guidelines that can be found in (Streeter et al., 1985) for constructing the driving instructions will be used as a reference. The guidelines found in (Davis and Schmandt, 1989), and in (Riesbeck, 1980) will be compared to these.

Counting objects

Streeter et al. argue that instructions like "Turn at the fifth light" are often wrong or difficult to interpret. People's memory for numbers greater than three is often wrong and drivers following such directions are apt to lose track of e.g. the number of traffic lights. It can also be ambiguous at what point to start counting the lights. For these reasons Streeter et al. avoided instructions that depended on counting objects.

This guideline is supported by Davis and Schmandt who argue that street counts are imprecise or simply wrong. Riesbeck does not explicitly state that counting objects should not be used, but for clarity reasons extra information should be added, e.g. "Turn at the fifth light; it's the road just after the park".

Added to these arguments for not using instructions in which objects have to be counted, can be the fact that it is possible to start listening to the next instruction too late. When one just has passed a complex intersection with lots of traffic, it is possible that one has to keep one's attention on the road for a moment for safety reasons. When the next instruction is then started after already having crossed the first tributary street, the number of streets mentioned in the instruction to let pass before turning into the right one, is not correct anymore. Considering these arguments, in the proposed car navigation telephone system no counting of objects will be part of the instructions.

An exception to this rule could be the situation in which someone has to turn into the next street. It seems alright to use e.g. "Turn into the first street left" at such moments.

Interturn mileages

The reason that people give directions that include counting objects is probably that they do not know exact mileages between objects, while traffic lights and other objects are units that are available. It is widely accepted that people cannot estimate distances accurately; see e.g. (Gluck, 1991). Streeter et al. even found that some people had to be told what tenths were and what miles were on a standard odometer. However, Streeter et al. argue that because a good data base has

such exact information on mileage, this can be used in the instructions. They decided to give interturn mileages in tenth of a mile units.

Like Streeter et al., Davis and Schmandt found in their study of natural instructions that people almost never use distance as a cue for when to act. Therefore, in contrast with Streeter et al., Davis and Schmandt decided not to use exact mileages in their instructions. Also, they did not need to give this information because their system, due to the vehicle location device, always gives the route message at the right moment. Riesbeck states that in general abstract units like miles and hours are not clear enough to put in driving instructions.

There is one important thing that giving interturn mileages is very useful for: getting to know how long it will approximately take before one has to make the next turn. Without such information, people do not know whether they have to drive for about a minute before turning, or only having to drive for 10 seconds before the turn must be made. Because each car has an odometer, it is considered a good strategy to give interturn mileages; or kilometres in the Netherlands. Apart from the reading and calculation errors that can be made, the exact distances can aid users in finding the correct street to turn onto. A resolution of tenth of a kilometre units, the same resolution as a standard odometer, seems the most effective.

Use of landmarks

In their iterative design process, Streeter et al. found that people relied heavily on landmarks for navigation. Therefore they decided to give preference to 'notable' landmarks over street names. Landmarks were considered notable when they were situated on corners, were a business, church or apartment complex, and were listed in the telephone directory. This way, it could be reasonably expected that the selected landmarks were in a geographical data base.

Initially, Streeter et al. not only used landmarks at intersections but included intermediary landmarks between turns. This would assure drivers that they were on course. However, from preliminary testing, it was found that if drivers missed an intermediate landmark, they ceased looking for the next turn and continued looking for the missed landmark. So the intermediate landmarks were skipped from the instructions.

Davis and Schmandt also noted that people normally use a great variety of landmarks (including traffic lights, stop signs, other signs, buildings, and road features) in natural instruction giving. Therefore, Davis and Schmandt used landmarks in their automatic driving instructions. In doing so, they used a special strategy that I will call 'closest-backward-landmark'. Like Streeter et al., only landmarks at intersections were used, and in such a way that the landmark was used that was closest when looking backwards from the intersection. It was argued that this makes the landmark easier to remember.

Riesbeck recommends the use of landmarks, but adds to this that 'unknown' landmarks are not clear. A message containing such an unknown landmark is e.g. "On the left corner is some huge building". These unknown landmarks can be confusing and should not be included in the driving instructions.

Since it is known from more fundamental research on wayfinding that the use of landmarks can add to a great performance advantage when navigating through a city, see (Blades, 1991) for an overview, it is recommended to use landmarks in the driving instructions generated by the telephone service. Like Streeter et al. suggested, these landmarks should be notable.

Use of street names

Both Streeter et al. and Davis and Schmandt notice that street names are difficult to read from most street signs, if these signs are present at all and are oriented in the appropriate direction. Therefore they preferred to use landmarks. However, they still used street names in their instructions. Streeter et al. did not give arguments for this, but Davis and Schmandt state they kept them in for clarity reasons. A typical instruction then would be "Turn right after the underpass; it's Franklin Street". Riesbeck states that all labeled roadways are clear and therefore can be included in driving instructions.

It is the ambiguity argument that pleads for putting in the street names in the driving instructions. Sometimes no landmark is available as a reference for where to turn. In those cases street names can be the only way to resolve the resulting ambiguity. Another reason for putting in street names in the driving instructions is, that they can be used for confirmation purposes. While

no error detection can be performed by the telephone service, checking the street name can be used for error detecting by the drivers themselves.

Use of compass directions

Only Riesbeck mentions the use of "north", "south", "east", and "west" for constructing the driving instructions. He states that these compass directions can be used for major roadways and exits, but are not clear enough otherwise. The use for major roadways can be understood when looking at the road signs that are used in the United States. A lot of highways there have signs saying where the highways go to and in which compass direction. Therefore it is easy to determine which access or exit to take. In the Netherlands, however, such signs are not used.

Besides that, it is often very difficult to determine where a compass direction actually is. Therefore, it is advised not to use these in the driving instructions. There is, however, a situation in which giving a compass direction may be the only way to be sure all ambiguity is overcome: driving off in the right direction at the current location. While a user may be on either side of the street from where he or she will start, it must be made sure the driver will leave in the right direction. Giving a compass direction then may be the only solution.

Error recovery information

Streeter et al. decided to include information in the instructions that would allow drivers to determine if they had made an error. This was done by putting in a 'too far' comment. A typical example of an instruction including such extra information is: "Drive for 1 mile to Norwood Avenue and turn left. If you come to the town hall, you've gone too far".

Streeter et al. do not give arguments for putting in this extra information, but argue that these instructions probably helped the drivers in the tape-only condition, since they drove fewer miles past turning points than drivers in the map-only condition. However, as post-questionnaire results showed, many people did not like the 'too far' instruction. Streeter et al. argue that while these instructions yield better performance, subjects did not like what was good for them. Streeter et al. concluded that such information should be in the driving instructions to make error recovery possible.

Davis and Schmandt do not use 'too far' information in their instructions. However, they use a kind of co-presence remark to inform the driver he is still on course. As an example, when the road makes a sweeping bend a remark is made that says "Follow the road as it bends to the right". Even though the driver has no choice in what to do, hearing such a co-presence remark a driver can determine if he is still on course or has made an error somewhere.

The 'too far' instruction was explicitly used by Streeter et al. to allow the user some kind of error detection. As already mentioned, the name of the street one has to turn onto can also be used for this. However, because street signs are hard to read, the 'too far' instruction might be necessary to make sure an error can be detected. Apart from this, there is also a difference between the street names and 'too far' instruction functioning as a way for error detection. The use of street names will only enable drivers to determine that they have made a mistake. The 'too far' instruction does more than that. It implies a remedy: drive back to where you came from and try again. In comparison with the first method, this is a form of positive feedback.

Repetition of instructions

To make sure drivers would remember the motion information in the instructions, Streeter et al. included a summary message at the end of each driving instruction. In the summary the most essential pieces of information were repeated to aid memory. As is known from cognitive psychology, repeating a to-be-remembered item with no intervening items will only have a minor effect on later recall. However, repeating the item after presenting a number of other items increases later recall by almost 2 times (Melton, 1970). So, the sentence containing the critical information, i.e. turn direction, distance, and street name, should be presented first, and must be repeated at the last sentence. Doing this, the critical items will also benefit from the primacy and recency effects. This way, recall of the first few items and the last few items will be even more elevated.

Both Davis and Schmandt, and Riesbeck did not use summary messages in their driving instructions. For Davis and Schmandt this can be understood because their navigation system used

an automatic vehicle location device, and thus could suffice in giving the driving instructions just before a turn had to be made.

Considering the importance of the critical information, it is wise to repeat this part of the information at the end of a driving instruction.

Overlooking the preceding pages, the guidelines that are considered to be useful for constructing the driving instructions for the proposed car navigation system via the telephone, are:

1. No instructions will be used that force users to count objects.
2. Interturn mileages have to be given with a resolution of a tenth of a kilometre units.
3. Notable landmarks are to be used for informing the driver where a turn should be made.
4. For disambiguity reasons, street names should be included in the driving instructions.
5. No references to the compass directions will be used, other than at the starting point.
6. For error recovery, a 'too far' comment may be included in the instructions.
7. The critical information will be repeated at the end of a driving instruction.

To make things more clear, the way the instructions were constructed by Streeter et al. will be looked at in more detail. Each verbal driving instruction used by Streeter et al. was constructed of four components: 1) The critical motion information; 2) Extra descriptive information; 3) The 'too far' instruction; and 4) The summary information. The critical motion information consisted of the distance before a turn had to be made, the name of the street to turn onto, and the direction to turn. A typical driver instruction then would be:

"Drive for one mile to Norwood Avenue, and turn right (1). The Sadow Lawn Savings and Loan Co. is on the right corner (2). If you come to Third Avenue, you've gone too far (3). Remember: it's one mile to your right turn onto Norwood Avenue (4)."

If no landmark was available, the street before the street one was supposed to turn onto was taken as a reference. This street had to be on the same side as the street one had to turn onto. The descriptive information component than would say e.g: "Bath Avenue is the street before Norwood Avenue". Three other exception rules were used. First, for T-junctions the 'too far' instruction was omitted. Second, complex intersections were noted as "the tricky intersection of street 1, street 2, etc.". Third, turns that were separated by a tenth of a mile or less were described as "a quick right/left onto street x" and combined in one instruction set.

Problems of older drivers

Driving a car is a very complex task that involves both car-control subtasks and monitoring subtasks. Navigating in an unknown environment makes this an even more complex task with high mental workload. While physical condition deteriorates as a function of aging, older people face some extra problems while driving a car and navigating through a city. In this section these problems are discussed. I will not give an overview of all physical and mental changes while aging, but only those that have a direct relationship with driving and navigating.

First of all, older people suffer from the age-related declines in perception, quality of environmental representations, and spatial orientation (Ohta, 1980). Decline in perception not only visually (reduced sensitivity to low light levels, poor visual acuity, increased sensitivity to glare, decreased ability to discriminate colours, and a reduced binocular depth perception) but also auditorily (poor hearing).

Second, aging has major consequences on multiple-task performance. With aging the ability to divide attention between multiple inputs declines, so that less multiple tasks can be performed simultaneously. This is even more true when the complexity of the tasks involved, is increased (Korteling, 1994).

Third, due to decreased neuronal processing speed, older people are slower in almost everything they do. For driving a car, slower reaction times are the most dramatical example of this.

All these age-related effects have some major consequences on driving a car. For instance, the car-control task is a lot more difficult for older people. Holland and Rabbitt found that particularly the coordination of more than one control skill together, clutch control, gear changes,

reversing, and choosing the appropriate gear yielded more problems for older people than for younger people (Holland and Rabbitt, 1994). Also, older people have more difficulties in coping with complex traffic situations and steering and road position. From this, Holland and Rabbitt conclude that junctions are particularly dangerous places for older people, because at a junction all things mentioned above have to be brought in practice at the same time. This is supported by the high accident rate of older drivers at intersections.

Consequences for the navigation service

It is known that older drivers partly compensate for their growing limitations in their abilities by increased caution (driving more slowly and less frequently) and by avoiding problematic situations. The navigation service can also adhere to such a strategy. It is possible to avoid dangerous junctions in generating a route from the locations a user has entered into the service. However, there is another solution that may help to keep the extra danger that is introduced with making available a navigating device, as low as possible: information reduction.

Because the driving instructions discussed so far have redundancy, the amount of information that has to be remembered can be limited by taking out the redundant parts. While there is usually too much information to remember, and not all of this information can be transferred to long-term memory, some information has to be kept active in short-term memory. However, short-term memory has a limited capacity and the other tasks, such as car-control, also require attention. Therefore, some information will tend to be forgotten (Schraagen, 1989). This is even more true because information through a telephone is always presented serially. This places a heavy demand on short-term memory.

While on the one hand, older people are more experienced drivers and therefore can devote more attention to the navigation task, on the other hand older people have difficulties in performing multiple tasks. Therefore, it is a good strategy to keep the amount of information per driving instruction as low as possible¹. This can be done by skipping (part of) the non-crucial information. The 'too far' comment seems a good candidate for this. The message line containing this redundant information is fairly long and yields a new street name or landmark that has to be remembered. However, the 'too far' comment might be absolutely necessary to yield the performance Streeter et al. measured for drivers in the tape-only group. To test these assumptions and to see the differences between older and younger people navigating through a city using spoken driving instructions, an experiment was set up. In this experiment two hypotheses were tested:

1. Elderly people, i.e. people older than 65, will perform worse than younger people, i.e. people younger than 65, when navigating through a city using spoken driving instructions. Because of age-related effects they will make more errors navigating in a city, take more time, and travel more distance to get to their destination.
2. There will be no difference in the performance of people navigating through a city using spoken driving instructions with or without the, as such redundant, 'too far' comment (see section 4.3).

These hypotheses were tested in an experiment in which subjects actually drove through a part of the city of Eindhoven using an implementation of the proposed car navigation service.

Method

Subjects drove in their own car and used the driving instructions to get to certain destinations. The driving instructions were formulated before the experiment and put in a sampled form on a digital storage device. In generating the instructions, the seven guidelines derived in the introduction part of this report were used.

¹ Not showing low-priority information when a driver's workload is extremely high (when at an intersection or when talking on a car telephone) is a possibility with more intelligent VNA's. A lot can be learned from the way this is handled in aircraft cockpits.

Each driving instruction was made up of several components and had the same structure as the instructions used by Streeter et al. (Streeter et al., 1985) and, except for 'tricky junctions' the same exceptions; see the end of section 4.3. The Dutch form of the example shown there would be:

"Rij 1 kilometer en sla rechtsaf de Achterstraat in (1). Rechts op de hoek staat een Albert Heijn (2). Komt u bij de Rondweg, dan bent u te ver gereden (3). Dus: na 1 kilometer rechtsaf de Achterstraat in (4)."

The exact wording was chosen by asking several people within IPO to give their opinion on how they would say the specific parts of the instructions in Dutch, or how they thought would be the best way for people who had to deal with the instructions.

In total, each driving instruction consisted of four parts, and these parts were generated according to the pseudo-code of table 2. The first and the last instruction only consisted of one part each. The first instruction made people start in the right direction, saying: "Ga op {current_street} {Noord | Oost | Zuid | West}-waarts richting {first_street_to_turn_onto}." The last instruction always directed people to their destination, of which the address was written on a piece of paper, saying: "Rij naar uw bestemming op {destination_street}."

Table 2 Pseudo-code used to generate the driving instructions.

Part	Content
1	<p>Critical motion information</p> <pre> if turn has to be made then if roundabout then "Rij {x.x} (kilo)meter en sla op de rotonde {linksaf rechtsaf} {straat_naam} in." else "Rij {x.x} (kilo)meter en sla {linksaf rechtsaf} {straat_naam} in." else if street_name changes then "Rij {x.x} (kilo)meter en ga op {het kruispunt de splitsing de rotonde} rechtdoor." If turns had to be made in rapid succession, the second turn was put in the same instruction as the first one, saying e.g.: "Rij {x.x} (kilo)meter en sla {linksaf rechtsaf} {straat_naam_1} in en ga daarna direkt {linksaf rechtsaf} {straat_naam_2} in." </pre>
2	<p>Descriptive information</p> <pre> if turn has to be made then if landmark available then "{links op de hoek rechts op de hoek recht vooruit} staat {landmark}." else if there is a street before the street to turn onto then "{naam_straat_ervoor_aan_dezelfde_kant} is de straat voor {straat_naam}." else "Het is de eerste straat aan uw {linkerhand rechterhand}." else if street_name changes then "{straat_naam_1} gaat hier over in {straat_naam_2}." </pre>
3	<p>'Too far' comment</p> <pre> if turn has to be made and not at T-junction then "Komt u bij {landmark_te_ver hoofdweg_te_ver}, dan bent u te ver gereden." </pre>
4	<p>Summary</p> <pre> if turn has to be made then "Dus: na {x.x} (kilo)meter {linksaf rechtsaf} {straat_naam} in." else if street_name changes then "Dus: na {x.x} (kilo)meter {rechtdoor} {straat_naam} in." </pre>

Half of all the subjects got messages containing all the four parts, the other half got messages in which the third part (the 'Too far' comment) was omitted. To keep the necessary number of subjects as low as possible, no control group of subjects using standard road maps was tested. The

reason for this was that, due to insurance problems, it could be expected that only a small amount of people would be willing to participate in the experiment. Especially finding older subjects seemed a problem.

The routes that subjects had to drive, were constructed from the DriverGuide software of EGT, using the Eindhoven database. After having assembled routes of which it could be expected the subjects were not familiar with (none of the subjects lived in the part of Eindhoven in which the routes were chosen), the routes were driven by the experimenter to include landmarks in the instructions (landmarks in the EGT-database were not accessible by the DriverGuide software). In total, 5 routes were constructed in the North-West part of Eindhoven (residential quarters "Mensfort", "Prinsejagt", "Woenselse Heide", and "Jagershoeft". Four of the routes took about 10 minutes to complete and contained approximately 11 instructions, 9 turns, and 5 landmarks. One route took about 5 minutes and had 8 instructions, 6 turns and 4 landmarks. In total, the routes lasted for about 50 minutes in which 19 kilometres had to be travelled.

Implementation

In this experiment a software implementation of the proposed telephone system was used. Programming was done in Hypertalk on an Apple MacIntosh, using HyperCard 2.1. In the car an Apple notebook was used which had the telephone system software and the driving instructions generated before the experiment. These instructions were put on the harddisc of this computer by sampling the voice of a woman who read the instructions aloud. See appendix A for a copy of the driving instructions for each route.

The driving instructions were made audible to the drivers through a speaker attached to the notebook via an amplifier. The driver only had to operate a two-button interface: one button for playing the next instruction and one button for repeating an instruction. The two-button box was attached to the dashboard of the car, and was within arm-reach.

Subjects

The subjects used in this experiment were 20 people from outside IPO. Half of them were younger than 65 (average age 38.4), half of them were older (average age 69.1); see table 3 for further details. Also, half of all the subjects in both age groups were men and half of them were women. They participated in this experiment using their own car. Subjects were selected from the IPO subjects list and were paid Dfl 8,- an hour and Dfl 0,19 per kilometer. The fear of not being able to find enough subjects was not confirmed.

Table 3 Age of all the subjects.

	Subjects younger than 65 (N=10)										Subjects older than 65 (N=10)									
Age	21	25	26	32	37	40	46	51	52	54	66	66	67	67	67	68	71	72	72	75

Procedure

In the experiment, subjects drove in their own car from a certain street in Eindhoven to another street in Eindhoven following one of the generated routes. The destination address was handed to the subjects on a piece of paper. All subjects drove all the routes that were generated.

Before subjects started driving the first route, they were told how to operate the two-button interface. They were also asked to try out the interface. Instead of hearing driving instructions, when doing this subjects heard dummy messages saying "This is message x". This practice made sure that differences, that might be expected between younger and older subjects operating the interface, were gone before the actual experiment started. At this time, also the volume at which the instructions were played was adjusted to a level regarded as comfortable by the subject.

Each subject drove the five routes in the same order; i.e.: 1) from "het Eeuwsel (IPO)" to "Cuwaertlaan no. 40", 2) from "Cuwaertlaan" to "Juliusstraat no. 28", 3) from "Juliusstraat" to "Twentelaan no. 18", 4) from "Twentelaan" to "Rietveldlaan no. 13", and 5) from "Rietveldlaan" to "het Eeuwsel (IPO)".

Measurements

Both objective and subjective measurements were performed. Objective measurements recorded were time and distance needed to complete each route, distance travelled beyond an error turn, the number and the nature of errors made, and the number of repetitions of each instruction. These measurements were performed by the experimenter who sat in the back seat of the car, opposite the driver. The drivers were told they could not ask the experimenter any questions. When subjects did ask questions despite this instruction, they were not answered. For measuring the distances travelled beyond a wrong turn, the experimenter took notes using landmarks and street names to indicate how far a subject drove too far. After the experiments the experimenter redrove these demarcations of the optimum route to convert the indications into real distances. Appendix B has a copy of the observation form that was used.

Subjective measurements were collected by interviewing the subjects after the experiment. They were asked if the voice reading the instructions was intelligible, if the content of the instructions was clear, and how they liked navigating through a city using the mock-up telephone navigation service. When subjects showed unexpected behaviour during the experiment, they were asked why they did so. See appendix C for a copy of the interview form that was used.

Results

When asked how they liked the tested car navigation system, all subjects reacted positively (good, nice, effective, marvellous). Often, subjects added to this that in the beginning they had to get used to the system and the way the instructions were given. After a while, the subjects got more used to the system and started to adhere to the 'canvas' of it: when they had to stop for a traffic light at which they had to turn, they already listened to the next instruction that told them what to do after the turn they still had to make. A lot of subjects said they had the feeling they were taking a lesson in order to get their driving license again. Some of them also felt they were participating in a touristic rally.

All subjects said that navigating through Eindhoven using the tested system was easy or very easy, although most of them said they had to concentrate harder in comparison with regular driving. This concentration problem probably led to the fact that four of the subjects did not automatically switch gear anymore. Compared to navigating through cities using maps, all younger subjects said they needed to concentrate less hard using the tested system. The older subjects had very divergent views on this. Three of them said they needed less concentration, three of them said they needed the same amount of concentration, and four of them said they had to concentrate harder with the tested system in comparison to navigating using maps.

Content of the instructions

Almost all subjects said the content of the instructions was clear enough. Two subjects had another opinion and especially disliked the part of the instructions that mentioned the name of the street before the street they had to turn into.

Of the 20 subjects only 7 said they had used their odometer all the time or regularly in order to perform the instructions. Another 7 subjects had only used their odometer for measuring large distances (over 1 kilometre). The remaining 6 subjects said they had not used their odometer at all. The main reason for this was that subjects felt they needed too much concentration in coping with the odometer (looking at the reading of the odometer and calculating). Paying attention to both the odometer and the traffic was considered difficult by these subjects. Only one subject reset the trip clock to zero three times in order to measure the to be travelled distance.

Five subjects said that instead of distances they preferred to have instructions that would refer to the counting of streets or traffic lights and to "the end of the street". Most of the subjects liked the use of the name of the street that was just before the street to turn into. Especially with getting into the right lane, this part of the instruction was said to be handy. Two subjects complained that with including the 'before street', another name was introduced that had to be remembered.

None of the subjects thought the landmark part of the instructions was superfluous. Most subjects thought of them as being very useful for confirmation purposes. Half of the subjects said that the compass directions in the first instruction of each route was very hard to deal with. Two of

them proposed the use of house numbers (ascending or descending) to make sure people would start in the right direction. After listening to the first instruction, subjects often started driving in the direction mentioned and only stopped when they had already reached the street that was mentioned in the first instruction. At that point, while stopping, subjects would listen to the second instruction. In the routes that the subjects had to drive, this was not a problem because this turn always was at the end of a street. However, this can yield some problems when a person is not supposed to drive all the way to the end of the street, but should turn somewhere before that. Also, stopping at a junction to listen to the next instruction should be avoided. The solution to this is putting the first and second instruction of each route together into one instruction. In doing so, the trouble with the compass directions might also be overcome: when already seeing in the distance what is said in the second instruction, one is more certain about the direction in which to start off.

All subjects said the voice reading the instructions was well intelligible. Most of the subjects also said it was a pleasant voice. This could be the reason why some subjects did not 'dare' to interrupt an instruction when they actually did not want to listen to that instruction; for instance when the repeat button was pressed by mistake. While some subjects already had their finger on the other button, they did not press it until the voice had finished reading the complete instruction.

Repetition of instructions

In this experiment, subjects could repeat the instructions as often as they liked. The older subjects made more use of this feature (162 times) than the younger ones (127 times). Two instructions were repeated often by a lot of subjects: the instruction that can be linked to the error situation in the first route (see "Age groups") and the instruction that said 2.5 kilometres had to be travelled before a turn should be made. During this long straight drive, most subjects repeated this instruction two times.

The repetition rate of the instructions probably would have been higher if the instructions would not have ended with the summary part ("Dus ..."). During the experiments it was observed that some subjects wanted to repeat an instruction (had their finger on the repeat key already), but just before they pressed the key the summary information was read to them. Because at that time the critical motion part of the instruction was already repeated to them, they did not really press the repeat key to listen to the complete instruction again.

Age groups

Beside the subjective data, also objective data on the performance of the subjects was collected. Table 4 shows the time subjects needed to complete each route, the distance that was travelled in order to complete the route, and the number of errors made during each route. In the table the two age groups are compared. The times and distances are the average within the age groups. The numbers of errors are the total numbers of errors within each age group.

In the first column in table 4 between brackets is the distance that was travelled when the routes were driven without making any error. The times and distances are logically coupled to the number of errors made: when making an error it takes some time and hence some extra distance to get back on the right track.

Table 4 Performance data for each route; comparison between age groups.

	Older than 65 (N=10)			Younger than 65 (N=10)		
	Time (s)	Distance (km)	Errors	Time (s)	Distance (km)	Errors
Route 1 (5.1)	717	6.44	10	607	5.59	9
Route 2 (3.3)	506	3.57	6	401	3.61	4
Route 3 (4.4)	453	4.57	2	429	4.54	2
Route 4 (1.9)	244	1.94	1	228	1.96	1
Route 5 (4.2)	529	4.36	5	475	4.31	2
	2451	20.87	24	2141	20.02	18

As can be seen, the older subjects took more time, travelled a longer distance, and made more errors in completing the routes than did the younger subjects. However, only the difference in time for route 2 is significant (Mann-Whitney U test, $p=0.0191$). The rest of the differences is not significant ($p>0.5$)! So, due to the high amount of variance in each age group, the differences can be explained by the individual driving style of the subjects. Some subjects, elderly and youngsters, drove slowly and cautious, while other subjects, both older and younger people, drove smoothly and racy.

All subjects who made errors were able to determine that they had made an error, recovered from the errors made, and got back on the right track. Subjects did this by driving back to the point where they thought they had made the error. By back-reasoning they figured out what would be the correct turn. While no such aid was available, some subjects said they would have liked having an extra button that would allow them to jump back in the instructions already read to them. Having such an aid would help them in the back-reasoning process.

The high amount of errors made in the last route is due to the bad provision of signposts at the campus of the Eindhoven University of Technology where that route ended at the IPO. Also, some subjects were familiar with the campus because they had been there several times. Because of habit, some of them drove the route they normally took to get to the IPO.

The errors that were made can be divided into eight categories. Table 5 shows the number of errors for each category. As could already be expected from the fact that most subjects did not use their odometer regularly, most of the errors were made because subjects misjudged the distance they had to travel before a turn.

Table 5 Type of errors made.

Type of error (N=20)	Errors
left/right substitution	4
did not know compass direction	3
missed road; started listening to instruction too late	2
missed road due to misjudging of distance	11
missed road because saw street sign too late	6
missed road; wrong or missing street sign	9
missed road because street before was missed	3
habit / too familiar	4

Errors from the sixth category "missed road; wrong or missing street sign", were only made in the first and the last route. Those made in the last route are already discussed. The high number of these errors in the first route was due to a wrong sign placed at a street that subjects had to turn into. When subjects saw the wrong sign, they did not continue the turn but drove on, or they turned in the opposite direction from the one mentioned in the instruction. Subjects would then drive until the next tributary street and come to the conclusion they had made a mistake. Turning and ignoring the wrong street sign then got them on the right track again (some subjects took several attempts in doing so). At the same instruction in the first route another type of error was often made: these subjects had been at that point very often (it was one of the major roads in Eindhoven) and had always turned right there (two subjects had a child living there, one always took that road to the village of Nuenen). In spite of the fact that the instruction told the subjects to turn left, because of rut these subjects turned right there.

'Too far' instruction

Of the ten subjects who got the extra 'too far' information, three said there was too much information in the instructions. All three of them said the 'too far' part of the instructions was responsible for that. They all thought that they could also do without this extra information. This is confirmed by the performance of both groups. Table 6 shows the performance data with a comparison between the two groups.

Table 6 Performance data of each route; comparison regarding 'too far' instruction part.

	With 'too far' part (N=10)			Without 'too far' part (N=10)		
	Time (s)	Distance (km)	Errors	Time (s)	Distance (km)	Errors
Route 1 (5.1)	644	6.00	9	681	6.03	10
Route 2 (3.3)	494	3.86	9	414	3.31	1
Route 3 (4.4)	423	4.40	0	460	4.70	4
Route 4 (1.9)	245	2.00	2	228	1.90	0
Route 5 (4.2)	506	4.37	4	499	4.30	3
	2311	20.63	24	2281	20.25	18

Since none of the differences that can be seen in table 6 is significant (Mann-Whitney U test, $p > 0.5$), it did not matter whether or not subjects got instructions containing the extra 'too far' information. Both groups of subjects took the same amount of time, travelled the same number of kilometres, and made the same number of errors. Also, the distance travelled beyond an error turn did not differ between the two groups.

These results suggest that the argument used by Streeter et al. to have a 'too far' comment in their instructions because it would assure that people would drive less distance beyond an error turn (Streeter et al., 1985), is not valid. So, the differences found by Streeter et al. are probably caused by the simple fact that both groups had different navigational aids.

For the sake of completeness: no differences were found in the data between male and female subjects.

Discussion and conclusions

As this experiment showed, people liked the tested car navigation system, found it easy to navigate through a city using the system, and did not make many errors while using it (1 error at 23 instructions on average). When errors were made, all subjects were able to get back on the right track again. However, an extra button allowing users to skip back through the instructions might help them recovering from an error more quickly. Such a button is recommended.

While the error rate is quite low, when using the system for the first time most errors are made. In this experiment the first route had a very error-prone turn that accounts for most of those errors. Such imperfections can have a major impact: making errors when using the system for the first time can have a strong negative influence on the acceptance of the system.

The results from this experiment do not show any differences in performance between elderly people, i.e. over 65 of age, and younger people, i.e. younger than 65. Also, there were no differences in the performance of people who got instructions containing extra error recovery information (the 'too far' comment) and people who did not get this extra information. Since the information load can be reduced by not giving the 'too far' information, it is recommended to skip that part from the instructions.

It is recommended to keep the other parts of the instructions unchanged. That is, the critical motion part because this is the crucial information necessary for making a turn, the descriptive part because people think of this as very useful information for confirmation purposes, and the summary part because people show the desire to have the critical motion information repeated. It is not clear if distances are to be kept in the instructions. On the one hand, they are not used by a lot of people and are misjudged often. Also, by providing distances in the instructions, people are forced to look at their odometer to measure these distances. So, despite the auditory character of the tested system, there still is a distraction in the visual field away from the traffic. On the other hand, giving this information is a cue for the user how long he or she has to drive straight on before a turn should be made. When the distance to travel is e.g. 1 kilometre, the driver knows he or she does not have to pay close attention to the street signs for a while and therefore can drive

more relaxed. Further research is necessary to determine the necessity of distances in the guidance instructions.

To resolve the problems that are caused by referring to compass directions and avoiding that people have to stop to listen to instructions, it is recommended to combine the first and second instruction of a route into one instruction.

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Appendix A Driving instructions for each route

Route 1

Van: Het Eeuwsel (IPO)
Naar: Cuwaertlaan (no. 40)

- 1 Ga op Het Eeuwsel Zuidwaarts richting De Zaale.
- 2 Rij 200 meter en sla op de rotonde rechtsaf De Zaale in.
Het is de eerste straat aan uw rechterhand.
Komt u bij De Wielen, dan bent u te ver gereden.
Dus: na 200 meter rechtsaf De Zaale in.
- 3 Rij 400 meter en sla rechtsaf Den Dolech in.
Links op de hoek staat het TUE-Auditorium.
Dus: na 400 meter rechtsaf Den Dolech in.
- 4 Rij 300 meter en sla rechtsaf John F. Kennedylaan in.
Het is de eerste straat aan uw rechterhand.
Dus: na 300 meter rechtsaf John F. Kennedylaan in.
- 5 Rij 1,8 kilometer en verlaat John F. Kennedylaan rechts via de uitrit.
Recht vooruit is het Viaduct Sterrenlaan.
Komt u bij het Viaduct Airbornelaan, dan bent u te ver gereden.
Dus: na 1,8 kilometer John F. Kennedylaan rechts verlaten.
- 6 Rij 100 meter en sla linksaf Winston Churchilllaan in.
Het is de eerste straat aan uw linkerhand.
Komt u bij het Viaduct Airbornelaan, dan bent u te ver gereden.
Dus: na 100 meter linksaf Winston Churchilllaan in.
- 7 Rij 1 kilometer en sla rechtsaf Genovevalaan in.
Rechts op de hoek staat de Torro-supermarkt.
Komt u bij Ferdinand Huyckstraat, dan bent u te ver gereden.
Dus: na 1 kilometer rechtsaf Genovevalaan in.
- 8 Rij 800 meter en sla linksaf De Vier Heemskinderenlaan in.
Moriaenstraat is de straat voor De Vier Heemskinderenlaan.
Komt u bij Bisschop Bekkerslaan, dan bent u te ver gereden.
Dus: na 800 meter linksaf De Vier Heemskinderenlaan in.
- 9 Rij 200 meter en sla rechtsaf Elkerlyclaan in.
Heimostraat is de straat voor Elkerlyclaan.
Dus: na 200 meter rechtsaf Elkerlyclaan in.
- 10 Rij 50 meter en sla rechtsaf Firapeellaan in.
Rechts op de hoek staat Chinees Indisch Restaurant Sun-On.
Komt u bij Koning Arthurlaan, dan bent u te ver gereden.
Dus: na 50 meter rechtsaf Firapeellaan in.
- 11 Rij 150 meter en sla linksaf Cuwaertlaan in.
Coppestraat is de straat voor Cuwaertlaan.
Komt u bij Roelantlaan, dan bent u te ver gereden.
Dus: na 150 meter linksaf Cuwaertlaan in.
- 12 Rij naar uw bestemming op Cuwaertlaan.

Route 2

Van: Cuwaertlaan (no. 40)

Naar: Juliusstraat (no. 28)

- 1 Ga op Cuwaertlaan Zuidwaarts richting Elkerlyclaan.
- 2 Rij 150 meter en sla rechtsaf Elkerlyclaan in.
Tibeertstraat is de straat voor Elkerlyclaan.
Dus: na 150 meter rechtsaf Elkerlyclaan in.
- 3 Rij 200 meter en ga op de splitsing rechtdoor.
Elkerlyclaan gaat hier over in Koning Arthurlaan.
Dus: na 200 meter rechtdoor Koning Arthurlaan in.
- 4 Rij 300 meter en sla rechtsaf Ferdinand Huyckstraat in.
Rechts op de hoek staat een politiebureau.
Komt u bij een RoomsKatholieke Kerk, dan bent u te ver gereden.
Dus: na 300 meter rechtsaf Ferdinand Huyckstraat in.
- 5 Rij 200 meter en ga op het kruispunt rechtdoor.
Ferdinand Huyckstraat gaat hier over in Gerretsonlaan.
Dus: na 200 meter rechtdoor Gerretsonlaan in.
- 6 Rij 700 meter en sla linksaf Oude Bosschebaan in.
Rechts op de hoek staat een RoomsKatholieke Kerk.
Komt u bij Vitruviusweg, dan bent u te ver gereden.
Dus: na 700 meter linksaf Oude Bosschebaan in.
- 7 Rij 400 meter en ga op het kruispunt rechtdoor.
Oude Bosschebaan gaat hier over in Doctor Berlagelaan.
Dus: na 400 meter rechtdoor Doctor Berlagelaan in.
- 8 Rij 500 meter en sla rechtsaf Barrierweg in.
Rechts op de hoek is het Economisch Lyceum Eindhoven.
Komt u bij Het Dag en avondcollege Eindhoven, dan bent u te ver gereden.
Dus: na 500 meter rechtsaf Barrierweg in.
- 9 Rij 500 meter en ga op het kruispunt rechtdoor.
Barrierweg gaat hier over in Minckelersplein.
Dus: na 500 meter rechtdoor Minckelersplein in.
- 10 Rij 50 meter en sla linksaf Minckelersplein in en ga daarna direkt rechtsaf Minckelersstraat in.
Rechts op de hoek staat Shoarma/Snackbar UNO-1.
Komt u bij Wattstraat dan bent u te ver gereden.
Dus: na 50 meter linksaf Minckelersplein in en daarna direkt rechtsaf Minckelersstraat in.
- 11 Rij 100 meter en sla linksaf Juliusstraat in.
Het is de eerste straat aan uw linkerhand.
Komt u bij Groenewoudseweg, dan bent u te ver gereden.
Dus: na 100 meter linksaf Juliusstraat in.
- 12 Rij naar uw bestemming op Juliusstraat.

Route 3

Van: Juliusstraat (no. 28)

Naar: Twentelaan (no. 18)

- 1 Ga op Juliusstraat Zuidwaarts richting Franklinplein.
- 2 Rij 200 meter en sla op de rotonde linksaf Wattstraat in.
Recht vooruit staat De Islam Slagerij.
Komt u bij Galvanisstraat, dan bent u te ver gereden.
Dus: na 200 meter linksaf Wattstraat in.
- 3 Rij 150 meter en sla linksaf Boschdijk in.
Recht vooruit is Een Begraafplaats.
Dus: na 150 meter linksaf Boschdijk in.
- 4 Rij 2,5 kilometer en sla rechtsaf Marathonloop in.
Jacob van Campenweg is de straat voor Marathonloop.
Komt u bij Ambachtsweg, dan bent u te ver gereden.
Dus: na 2,5 kilometer rechtsaf Marathonloop in.
- 5 Rij 1,2 kilometer en ga op het kruispunt rechtdoor.
Marathonloop gaat hier over in Ellertsveldstraat.
Dus: na 1,2 kilometer rechtdoor Ellertsveldstraat in.
- 6 Rij 100 meter en sla rechtsaf Meierijlaan in en ga daarna direkt linksaf Oldambtstraat in.
Rechts op de hoek staat het Economisch Lyceum Eindhoven.
Komt u bij Sallandlaan, dan bent u te ver gereden.
Dus: na 100 meter rechtsaf Meierijlaan in en daarna direkt linksaf Oldambtstraat in.
- 7 Rij 50 meter en sla rechtsaf Peellandlaan in.
Het is de eerste weg aan uw rechterhand.
Dus: na 50 meter rechtsaf Peellandlaan in.
- 8 Rij 100 meter en sla linksaf Twentelaan in.
Het is de eerste weg aan uw linkerhand.
Komt u bij Sallandlaan, dan bent u te ver gereden.
Dus: na 100 meter linksaf Twentelaan in.
- 9 Rij naar uw bestemming op Twentelaan.

Route 4

Van: Twentelaan (no. 18)
Naar: Rietveldlaan (no. 13)

- 1 Ga op Twentelaan Oostwaarts richting Veluwelaan.
- 2 Rij 100 meter en sla rechtsaf Veluwelaan in.
Recht vooruit staat een C1000-supermarkt.
Komt u bij Waddenzeelaan, dan bent u te ver gereden.
Dus: na 100 meter rechtsaf Veluwelaan in.
- 3 Rij 400 meter en sla rechtsaf Roelantlaan in.
Rechts op de hoek staat Een Hoogspanningsmast.
Dus: na 400 meter rechtsaf Roelantlaan in.
- 4 Rij 300 meter en sla linksaf Huizingalaan in.
Rechts op de hoek staat Een Hoogspanningsmast.
Komt u bij Vijfkamplaan, dan bent u te ver gereden.
Dus: na 300 meter linksaf Huizingalaan in.
- 5 Rij 500 meter en sla rechtsaf Gerretsonlaan in.
Rechts op de hoek staat Een Spar-supermarkt.
Komt u bij 1e Lieven De Keylaan, dan bent u te ver gereden.
Dus: na 500 meter rechtsaf Gerretsonlaan in.
- 6 Rij 200 meter en sla linksaf Sansovinostraat in.
Rozenburgstraat is de straat voor Sansovinostraat.
Komt u bij Oude Bosschebaan, dan bent u te ver gereden.
Dus: na 200 meter linksaf Sansovinostraat in.
- 7 Rij 200 meter en sla rechtsaf Rietveldlaan in.
Het is de eerste straat aan uw rechterhand.
Komt u bij Isidorusstraat, dan bent u te ver gereden.
Dus: na 200 meter rechtsaf Rietveldlaan in.
- 8 Rij naar uw bestemming op Rietveldlaan.

Route 5

Van: Rietveldlaan (no. 13)

Naar: Het Eeuwsel (IPO)

- 1 Ga op Rietveldlaan Westwaarts richting Neumannlaan.
- 2 Rij 50 meter en sla linksaf Neumannlaan in en ga daarna direkt linksaf Isidorusweg in.
Het is de eerste straat aan uw linkerhand.
Dus: na 50 meter linksaf Neumannlaan in en daarna direkt linksaf Isidorusweg in.
- 3 Rij 200 meter en sla rechtsaf Boostenweg in.
Dominee Paul Bellotweg is de straat voor Boostenweg.
Komt u bij Van Dormaalstraat, dan bent u te ver gereden.
Dus: na 200 meter rechtsaf Boostenweg in.
- 4 Rij 100 meter en sla linksaf 1e Lieven De Keylaan in en ga daarna direkt rechtsaf Doctor Cuyperslaan in.
Rechts op de hoek staat Garagebedrijf Obam.
Komt u bij Winston Churchillaan, dan bent u te ver gereden.
Dus: na 100 meter linksaf 1e Lieven De Keylaan in en daarna direkt rechtsaf Doctor Cuyperslaan in.
- 5 Rij 1,2 kilometer en ga op het kruispunt rechtdoor.
Doctor Cuyperslaan gaat hier over in Kloosterdreef.
Dus: na 1,2 kilometer rechtdoor Kloosterdreef in.
- 6 Rij 500 meter en sla linksaf Pastoriestraat in.
Links op de hoek staat een VSB-bank.
Komt u bij Woenselse Markt, dan bent u te ver gereden.
Dus: na 500 meter linksaf Pastoriestraat in.
- 7 Rij 400 meter en ga op het kruispunt rechtdoor.
Pastoriestraat gaat hier over in Onze Lieve Vrouwestraat.
Dus: na 400 meter rechtdoor Onze Lieve Vrouwestraat in.
- 8 Rij 500 meter en sla rechtsaf John F. Kennedylaan in.
Rechts op de hoek staat De Hogeschool Eindhoven.
Komt u bij het Texaco-tankstation, dan bent u te ver gereden.
Dus: na 500 meter rechtsaf John F. Kennedylaan in.
- 9 Rij 300 meter en sla linksaf Den Dolech in.
Het is de eerste straat aan uw linkerhand.
Komt u bij Het Rabobank Hoofdkantoor, dan bent u te ver gereden.
Dus: na 300 meter linksaf Den Dolech in.
- 10 Rij 300 meter en sla linksaf De Zaale in.
Rechts op de hoek staat het TUE-Auditorium.
Komt u bij De Wielen, dan bent u te ver gereden.
Dus: na 300 meter linksaf De Zaale in.
- 11 Rij 400 meter en sla op de rotonde linksaf Het Eeuwsel in.
Links op de hoek is een plein.
Komt u bij De Rondon, dan bent u te ver gereden.
Dus: na 400 meter linksaf Het Eeuwsel in.
- 12 Rij naar uw bestemming op Het Eeuwsel.

Appendix B Observation form that was used

Dagteller in auto? Ja Nee

Dagteller actief gebruikt; d.w.z. steeds op nul gedrukt? Ja Soms Nee

Doorrijden na foute afslag:

Route	Instructie	Fout	Hoever doorgereden

Onverwacht gedrag:

	Route	Instructie	Gedrag
a			
b			
c			
d			
e			
f			

Metingen:

Route	Benodigde tijd	Afgelegde afstand
1		
2		
3		
4		
5		

Andere observaties:

Appendix C Interview form that was used

1 Hoe is het U bevallen om via gesproken route-aanwijzingen door U onbekende delen van Eindhoven te rijden?

2 Hoe makkelijk of moeilijk vond U het navigeren door de stad m.b.v. de aanwijzingen?

Erg makkelijk Makkelijk Makkelijk/Moeilijk Moeilijk Erg moeilijk

3 Had U meer of minder concentratie nodig dan bij normaal autorijden?

Veel minder Minder Evenveel Meer Veel meer

4 Had U meer of minder concentratie nodig dan bij het autorijden waarbij u een kaart moet raadplegen?

Veel minder Minder Evenveel Meer Veel meer

5 Heeft u de kilometer-teller (of dagteller) gebruikt om de aanwijzingen uit te voeren?

Ja Nee

6 Was de stem die de aanwijzingen oplas, goed verstaanbaar?

Ja Nee

7 Waren de aanwijzingen qua inhoud duidelijk genoeg?

Ja

Nee; Wat had duidelijker moeten? _____

8 Alleen als onverwacht gedrag werd geobserveerd.

a) Op een gegeven moment (zie observatieformulier onder a)

Waarom deed U dat? _____

b) Op een gegeven moment (zie observatieformulier onder b)

Waarom deed U dat? _____

c) Op een gegeven moment (zie observatieformulier onder c)

Waarom deed U dat? _____

d) Op een gegeven moment (zie observatieformulier onder d)

Waarom deed U dat? _____

e) Op een gegeven moment (zie observatieformulier onder e)

Waarom deed U dat? _____

f) Op een gegeven moment (zie observatieformulier onder f)

Waarom deed U dat? _____

9 In welk jaar bent U geboren? _____

10 Geslacht [niet vragen]: _____

11 Heeft U nog opmerkingen?

