Onderzoek naar Routekeuzes van Oudere Fietsers

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Samenvatting

Ouderen in het verkeer zijn meer dan twee keer zo vaak betrokken in een ongeluk veroorzaakt door menselijk falen. Ook worden zij in 63% van alle verkeersongevallen in het ziekenhuis opgenomen. Van alle dodelijke verkeersongelukken onder ouderen zat 57% op de fiets.
Wanneer men ouder wordt veranderen zowel fysieke en mentale vaardigheden. Dit zijn onder andere verminderde visuele vaardigheden (bijvoorbeeld het opmerken van contrasten), slechter gehoor en verminderde spierkracht, stabiliteit en flexibiliteit. De gevolgen van deze verminderde vaardigheden kunnen beperkt worden op twee manieren. Ten eerste moet men zich bewust zijn van de verminderde vaardigheden, zodat er gecompenseert kan worden voor deze vaardigheden door bijvoorbeeld langzamer te gaan fietsen. Ten tweede beïnvloed ook het ontwerp van infrastructuur hoe ouderen zich bewegen in het verkeer, en zou zo ontworpen kunnen worden dat deze ruimte geeft aan ouderen om te kunnen compenseren. Dit heeft bijvoorbeeld te maken met kleurcontrasten en hoogteverschillen in het wegprofiel, of de kwaliteit van wegmarkeringen en complexiteit van verkeersituaties.
Verschillende onderzoeken naar verschillen in route preferenties en route keuzes tussen jongere en oudere fietsers constateren dat vergeleken met jongere fietsers oudere fietsers afstand, reistijd, kwaliteit van het wegdek, geregelde kruispunten en aparte fietsinfrastructuur belangrijker vinden. Aan de andere kant hechten jongere fietsers juist meer waarde aan directheid van fietsroutes, snelheid en het aantal stopmomenten (in dit geval zo laag mogelijk). Dit onderzoek richt zich op het in kaart brengen van verschillen in fietsroutes tussen jongere en oudere fietsers.
De data die in deze paper gebruikt is komt van het B-Riders programma, welke tracht woon-werkverkeer uit de auto op de fiets probeert te krijgen. Participanten konden via GPS-tracking punten sparen, en hadden toegang tot een e-bike. De belangrijkste resultaten uit dit onderzoek zijn, ookal gelimiteerd aan het aantal bruikbare routes van de dataset:

- Oudere fietsers neigen directere routes te fietsen.
- Oudere fietsers fietsen vaker via de bebouwde kom, waardoor ze vaker andere verkeersstromen tegenkomen.
- De meeste routes zijn ontworpen met separate fietsinfrastructuur. Wanneer dit niet het geval is moeten ouderen vaak gebruik maken van 30 km/h wegen in woongebieden, terwijl jongere fietsers vaker gebruik moeten maken van 60 km/h wegen in landelijke gebieden.
- Jongere mensen gebruiken meer routes met bochten in het wegprofiel, terwijl oudere fietsers vaker routes gebruiken waarop ze kruispunten tegenkomen.
- Oudere fietsers fietsten vaker via hobbelige wegen, wat erop duidt dat ouderen minder gevoelig zijn voor ongelijke wegen dan wat voorgaande onderzoeken uitwezen.

1. Data Explanation

This report is part of a research on older bicyclists, and is based on data coming from the so called 'B-Riders' programme. This traffic management project was set up by the Province of North Brabant, The Netherlands, in order to promote cycling as mode of transport when commuting. Participants received an e-bike free of charge, which they had to use for commuting instead of using the automobile. One of the conditions to participate in the programme was that people had to make their phone available for GPS tracking. This was for instance needed to make sure that participants were actually using the bicycle. The GPS data tracking also led to a substantial amount of data on cycling routes throughout the day, spread out over the whole of North Brabant. As all GPS data was collected and categorised per participant, it enables the possibility to use the data for this research. It means that each trip can be categorised by for example age or gender. This poses some privacy issues as well, which are taken care of by the fact that categorisations of participants must be dealt with in such a way that it is not possible to identify individuals during the data analysis. It implies that the first and last couple of hectometres of a trip were not added to the GPS tracking (randomly cut 0-400 metres from origin/destination).

Trips are primarily made for commuting, as this was the main reason for providing e-bikes to the participants. However, next to this the GPS tracker also recorded other cycling trips like (social-)recreational tours and trips to grocery stores or other shops. This results in a diverse data collection that includes various trip purposes, resulting in hundreds or in some cases even a thousand recorded cycle trips per participant.

Participant Characteristics

This study focusses on differences between older cyclists and younger adults in order to find and analyse (potential) differences between these age groups. People that have participated in the programme have agreed to use an e-bike instead of the automobile for their commutes. This implies that most participants are still mentally and physically active enough to cycle on a daily basis, thusly suggesting that the sample group (B-Rider participants) could be fitter than the total population.

Participants have been categorised according to age. Due to privacy concerns, it was important to make sure that individuals were not retraceable from the trips they made. This is why the exact age of each participant is not given per route, but in three age categories. These age categories were divided into people over the age of 55, people between the age of 40-55, and people younger than 40 years old (figure 15). The youngest participant is 20 years of age, while the oldest participant included in the data set is 69 years old.

Figure 16 shows how the sample size (2077 B-Riders participants) is distributed by age, and how it represents the total population of North Brabant and The Netherlands. It shows that people under the age of 40 years old and people above the age of 55 are underrepresented. On the other hand, people between the age of 40-55 years old are overrepresented[1].

Sample Size			Population North Brabant			Population Netherlands		
Age	Quantity	%	Age	Quantity	%	Age	Quantity	%
< 40	299	14,4	< 40	433619	29,3	< 40	4287658	42,9
40 - 55	1283	61,8	40 - 55	565493	38,2	40 - 55	2538745	25,4
55 >	495	23,8	55 >	479880	32,4	55 >	3161273	31,7
Total	2077	100	Total	1478992	100	Total	9987676	100

Figure 1: Age division B-Riders participants, North Brabant and The Netherlands

Rijlabels	Aantal van leeftijd
3	1
4	1
21	1
22	1
23	1
25	7
26	3
27	7
28	6
29	9
30	11
31	15
32	10
33	19
34	14
35	28
36	24
37	25
38	28
39	35
40	31
41	39
42	39
43	39
44	50
45	64
46	76
47	81
48	87
49	72
50	110
51	122
52	129
53	95
54	129
55	149
56	138
57	126
58	123
59	111
60	106
61	112
62	95
63	67
64	69
65	43
66	20
67	23
68	11
69	6
71	1
74	2
Eindtotaal	2611

Figure 2: Division of ages

[1] The total population size only includes people between the age of 20 and 69, as younger/older people are not represented in the B-Riders data.

2. Analysis Criteria & Research Method

Analysing the B-Riders data will be done in two steps. First, a more general data analysis (paragraph 4.1) will give insight into the kind of trips are cycled: what is the average length, distance, and travel speed. This results in the first insights into differences between for instance younger and older participants. The analysis will be on a provincial scale level, meaning it will include all participants, containing people living in urban areas as well as in rural regions. Items that will be analysed in this phase of the study are distance, travel time and cycling speed. Excel and SPSS software will be used to process and provide most of the information needed for the general data analysis.

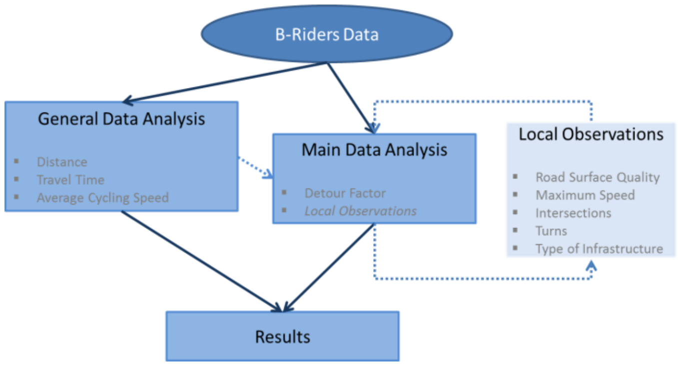

Figure 3: Research model B-Riders data analysis

The next step is to go further into detail by refining the data, being the main data analysis (paragraph 4.2). Going deeper into certain topics results in more detailed analyses on road types and things that affect cycling routes while commuting or non-commuter trips. This step of the analysis includes parameters like directness (detour factors), and is analysed on selected routes based on origin and destination. A couple of routes are also selected based on differences between older and younger people, what requires more in-depth research. Local observations will be made in order to for example obtain information about the quality road surfaces and safety concerns that are encountered.

2.1 Pre-analysis Expectations

By examining route preference reports and studies that tracked cyclists, a couple of expectations can be made before analysing the B-Riders data. These expectations are given as hypotheses below:

- The average **distance** of cycle trips decrease at a higher age.
- The average **travel time** of cycle trips decreases at a higher age.
- Elderly people prefer cycling routes that include more **segregated cycling infrastructure**.
- Elderly people prefer cycling routes that include more **signalised intersections** at busy intersections.
- **Directness** of cycle routes is not as important for elderly people than for younger ages.
- Older people value **speed** of cycle routes less than younger people, leading to for instance less avoidance of **stopping moments**.
- Older people prefer using routes with low **traffic volumes** and, if no separate infrastructure is available, low **traffic speeds**.

When looking at the type of participant included in the B-Riders data it is clear that the amount of people working is highly overrepresented: all participants are still employed. Commuters value speed and less amount of stopping moments more than recreational road users (Broach et al., 2012), as the factor 'time' is much more important for this group, and is not only limited to cyclists.
This influences the representability of the participants on the total population. These factor influence what can be expected from the data analysis, again formulated into two hypotheses:

- Trips made by non-commuters have a higher **detour factor** than commuters.
- Routes of commuters are less adaptive to avoid **busy/unsignalised intersections**.

As stated in other literature, the growing ownerships of e-bikes amongst (older) cyclists means that a shift within route preferences is assumed to become prevalent. However, no research on this topic is yet available (Overdijk, 2016). two hypotheses arose relating to older people riding e-bikes:

- Non-distance route factors like **signalised intersections** or the **quality road** surface becomes more important once riding an e-bike.
- Distance route factors like **distance**, **travel time** and the **amount of stopping moments** become less important route conditions for people riding an e-bike.

After researching the B-Riders data, these hypotheses will be used in order to reflect on the outcomes, and whether these assumptions, which are based on whether research papers on route preference and route choices are in line or whether there are differences. Furthermore, it reflects on the usability of for instance route preference studies, and whether people are actually able to consider these aspects.

3. Data Processing

The initial data set includes 304.504 routes that were spread out over 266.542 network links. However, some routes are irrelevant for this research assignment, and will thus be erased from the final data set. In this study, only routes within the province of North-Brabant will be analysed, meaning that trips recorded abroad or other Provinces were removed from the data set. Additionally it also means that trips crossing the province's border were removed from the data set. This resulted in another 8010 routes and 287 network links being removed (figure 5). Especially in and around the cities of Nijmegen (Gelderland) and Weert (Limburg) it meant that trips were removed as well, resulting in routes being removed that either passed or started/ended in Oss and to a lesser extend in Eindhoven. However, even in cities close to the province's borders there are still plenty of routes to make for a representative and usable data set.

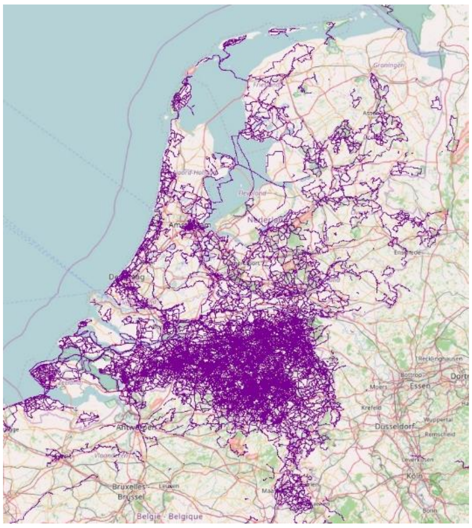

Figure 4: Routes in The Netherlands before removing routes outside North Brabant.

Now that only routes within the province of North-Brabant remain, route variables have been checked and cleaned. Some routes were only 50 metres long, which was caused by two things:

- Starting and ending points of routes have been shortened by 0-400 metres, meaning that in some occasions routes relatively became a lot shorter.
- Some routes were not recorded properly by GPS.

Trips that are too short are not useable in this study, as they will not be used later on in the assignment anyways, and the chance that routes were not recorded correctly increases. This is why it was decided that routes shorter than 500 metres were removed from the data set.
Each trip also includes information about the average cycling speed. However, some trips registered either a very high or very low average cycling speed that must be removed from the data set as well. Average speeds less than 10 km/h have been removed. One could argue that some trips encountered many obstacles/stopping moments, however, such a low average speed is very unlikely to occur. Furthermore, one cannot be sure that the recorded trip actually was made by bicycle. GPS tracking could have also occurred while the participant was walking.

Trips entailing an average cycling speed of over 33 km/h have been removed as well, as there is a chance that the participant was in an automobile or mode of transport other than a car. Most trips removed due to this would have been erased from the final data set anyways, for instance because it was in combination with a trip that is less than 500 metres. After erasing these trips, 216 more trips were removed from the data set as well, because there was no age category added to the participant, while it is necessary to have this information to execute this study. Cleaning up the data has resulted in a total data set of 272.756 routes that used 219.314 network links (figure 5), being 10,4% and 17,7% less compared to the initial data set respectively.

	Routes	%	Network Links	%
Before Cleaning	304504	100	266542	100
Through North Brabant	297337	97,65	219601	82,39
OD in North Brabant	289327	95,02	219314	82,28
Relevant Trips	272972	89,64	219314	82,28
With age specification	272756	89,57	219314	82,28

Figure 5: Number of routes and network links that are useable

4. Data Analyses

4.1 General data analysis

Distance

Figure 6 shows the distribution of trip distances, which shows a distance decay as expected, as the skewness of the left tail demonstrates (figure 7). Most trips have a maximum distance of 15 kilometres, with a high amount of trips being around one kilometre. The average distance cycled is around 8,2 kilometres long, where the data shows that participants below the age of 40 years old cycled a bit shorter than average (7,8 kilometres), while the other two age categories cycled a bit longer than average (8,3 kilometres).

		Distance (kilometre)			
		Percentile 25	Mean	Percentile 75	Standard Deviation
Age	< 40	3,0	7,8	11,2	5,6
	40 - 55	3,6	8,3	11,6	5,8
	55 >	3,5	8,3	11,8	5,8

Figure 6: Distribution of distances

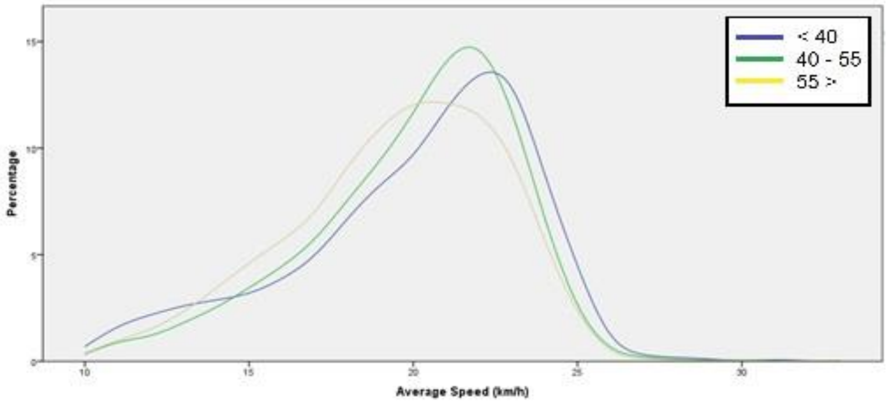

Figure 7: Average speeds per age category

Average Cycling Speed

		Average Speed (km/h)			
		Percentile 25	Mean	Percentile 75	Standard Deviation
Age	< 40	18,0	20,1	22,7	3,6
	40 - 55	18,1	20,0	22,3	3,2
	55 >	17,4	19,5	21,9	3,3

Figure 8: Distribution of average speeds

Small differences can be seen between age categories. Participants above the age of 56 on average cycled slower than younger participants (figure 8). This trend also seems to appear between the age categories of 40-55 and <39. Participants below the age of 40 on average cycled 20 km/h, whereas people above the age of 55

had an average cycling speed of 19,5 km/h. The standard deviation was slightly higher for the youngest age group, due to a higher skewness in the right tail.
The average cycling speed of this sample size is higher than of the total population; while the B-Riders participants easily cycled 19,5-20 kilometres per hour averagely, the national average ranges between 16 km/h (CBS, 2002) and 18 km/h (CROW, 2011). This is likely caused by the fact that the participants all had an e-bike available for their trips, meaning that most trips were made on this type of bicycle. Research shows that the average cycling speed increases for e-bikes compared to the conventional bicycle (Vlakveld et al., 2014). In The Netherlands, e-bikes are allowed to have pedal support up to a speed of 25 km/h (ANWB, n.d.).

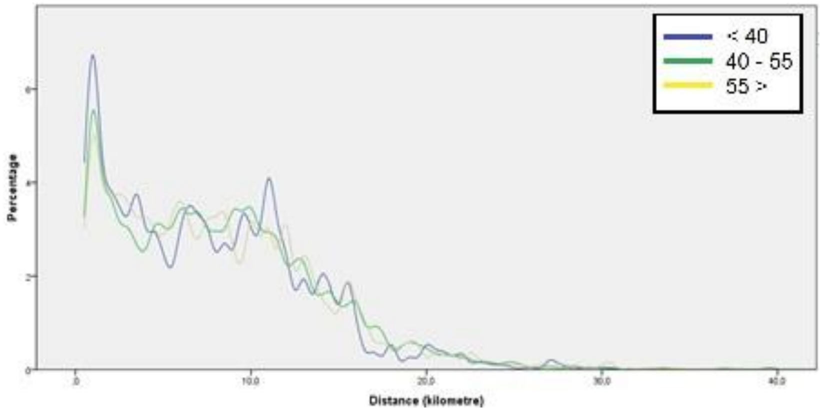

Figure 9: Cycling distances per age category

Travel Time

		Travel Time (minutes)			
		Percentile 25	Mean	Percentile 75	Standard Deviation
Age	< 40	12	23	30	16
	40 - 55	12	24	36	17
	55 >	12	25	36	17

Figure 10: Distribution of Travel Time

A certain trend is visible which shows that a lot of trips only take either 5-10 minutes or 25-30 minutes. Travel times suggest that older participants make longer trips (timewise) than younger participants., though differences are once more very small.

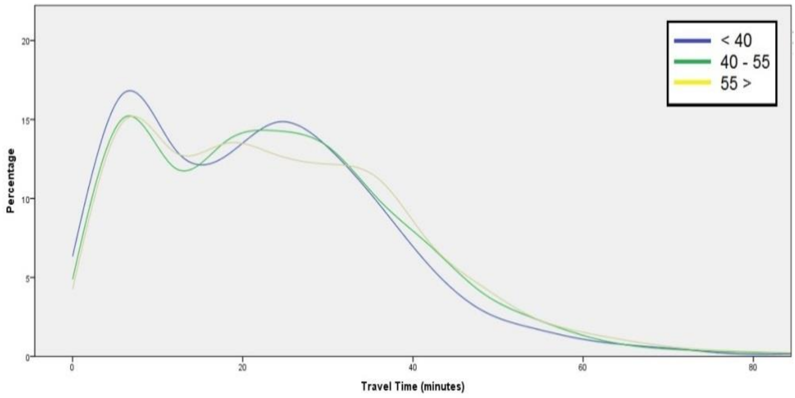

Figure 11: Travel Times per age category

The mean figure for the oldest age group is almost 2,5 minutes longer than for the youngest age group (25,12 to 22,78), and is also slightly higher than for the middle age category which is 24,48. As seen in the graph (figure 11), older people have bigger percentages of either short or longer trips, whereas the younger age categories have another peak for travelling between 20-30 minutes.

Significance

Further research was performed about to what extent the variables 'distance', 'travel time' and 'average speed' significantly differ when compared to the three age categories. It shows that almost all factors significantly variate between each other with a factor of 0,000. Only at the factor 'distance' the significance value of 0,339 between older participants and participants between the age of 40 and 55 shows that there is no significant difference regarding the average cycling distance. Conclusion thus is that in most cases there are significant differences when categorising on age.

Correlation

Pearson's Correlation shows whether two data variables correlate with each other based on the total sample size. "1" indicates a high correlation, while "0" means that there is no correlation (Rumsey, n.d.). Figure 12 shows the level of correlation for the above-mentioned factors. The highest correlation can be found between cycling 'distance' and 'travel time', which is logical: one naturally requires more time to cycle a bigger distance. 'Distance' and 'speed' have a correlation of 0.341. This indicates that there is a weak to moderate (positive) relation between the two, meaning that the longer a trip is, the faster one cycles. However, most statisticians like to see a figure of at least 0,5, as only then one can say that there is a somewhat high relation between two factors (Rumsey, n.d.). This could be caused by for instance more stretches of infrastructure without delays are included in one's route. No real correlation was found between 'speed' and 'travel time'. Adding 'age' as factor to analyse, one can see that there is a significant correlation amongst the conditions (figure 12).

Correlations

		Speed (km/h)	Distance (kilometres)	Travel Time (minutes)
Speed (km/h)	Pearson Correlation	1	,341**	,138**
	Sig. (2-tailed)		,000	,000
	N	272756	272756	272756
Distance (kilometres)	Pearson Correlation	,341**	1	,958**
	Sig. (2-tailed)	,000		,000
	N	272756	272756	272756
Travel Time (minutes)	Pearson Correlation	,138**	,958**	1
	Sig. (2-tailed)	,000	,000	
	N	272756	272756	272756

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 12: Correlation between 'Speed', 'Distance' and 'Travel Time'

4.2 Detailed Data Analysis

Figure 13 shows an example of how trips are distributed throughout the City of Breda, where blue lines mark people below the age of 55, and red lines mark people above the age of 55. It shows that the distribution of trips is more or less spread out evenly, without big differences between younger and older people. In order to compare route differences between younger and older participants, not all trips used in the general data set can be used. This is due to the fact that on a local level certain aspects or traffic situations in one's route can result in a completely different cycling route. The task thus is to select those routes that were used by both age categories and base the study on route choices for these particular routes.

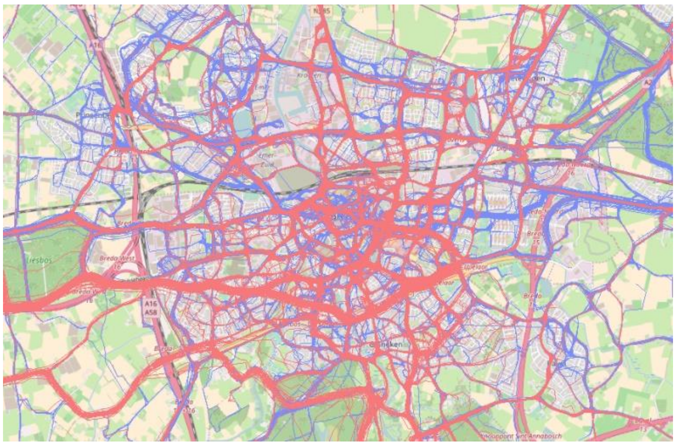

Figure 13: Example of how routes are distributed in Breda, seen in GIS (Red: aged 55 >, blue: aged < 55)

In order to be able to select these routes, zip codes of both origin and destination locations were added to each route-id. By doing so, one has better insight into where routes start and where they end, and makes it possible to easily select them based on their location. Zip codes based on five figures were used, as four figure zip codes would have resulted in areas being too big, while areas split up by 6-figure zip codes would have been too small in order to include enough participants from one area to another. Ranking the routes as described has resulted in a new based on location. Figure 14 shows the OD routes with the highest amount of different participants:

Routes with ten or more participants results in a smaller data set that makes it possible to analyse the data in a correct manner. For this study it is necessary to have both participants below and over the age of 55 having the same origin and destination, because it is not possible to compare the routes based on age otherwise. This is why only OD routes that include two or more participants were used. The result is a new, much smaller, data set with 1671 individual trips spread out over North Brabant.

Rijlabels	n.a.	< 40	40 - 55	55 >	Total
5223D5223G		5	8	6	19
5504D5656A		4	12	3	19
5211G5223G		1	12	5	18
5388H5406P		3	10	5	18
5503L5656A		3	10	4	17
5406P5406P		1	12	3	16
5211J5223G		3	6	6	15

Figure 14: Highest amounts of participants between origins and destinations plus age division

First thing that has been analysed with the new data set is the detour factor: the cycled distance compared to the distance between origin and destinations (in a straight line). This analysis has been performed by adding a new attribute (shortest distance) to the data via the ArcGIS toolbox. The detour factor has been calculated via Excel. It was necessary to remove a couple of trips due to 1) recreational trips are at this point not representative for the data set, as they show a detour factor of up to 8, and 2) due to the random cutting of begin and end points of trips by 0-400 metres, some routes only use one stretch of road that makes for an unreliable detour factor.
The data analysis shows that comparing age does not show differences in detour factors. This is similar to the fact that for most OD routes people cycle via the same route, resulting on only small differences due to the exact location where they live. Commuters on average have a smaller detour factor with mean difference of 0,036 (3,6%). When further dividing commuters and non-commuters, one see that there are differences between people cycling in the afternoon and people cycling in the evening or midnight; bicyclists cycling in the afternoon have much higher detour factors than people cycling at the end of the day. The average detour factor of people cycling in the evening and during midnight is in some cases even lower than for commuters. ANOVA has been used to test significance levels regarding age, detour factor and a combination of those factors. The difference between commuters and non-commuters is significant (value of 0,001). Furthermore, age has a significance value of 0,072, meaning that there is a possibility that there are significant differences due to the factor age. Combining the factors age and (non-) commuter did not result in a difference that is significant (value of 0,317)

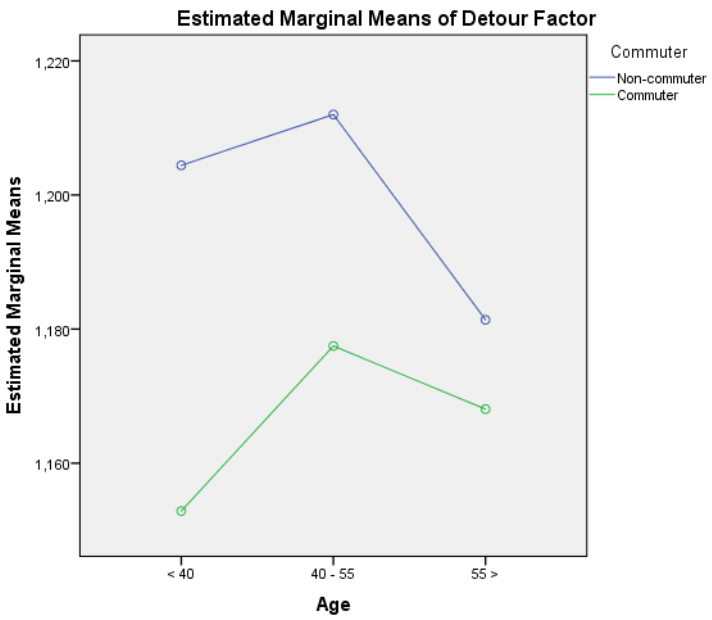

Figure 15: Differences in means amongst ages

4.3 Local observations

Due to the small amount of routes and trips usable for this part of the study it is more difficult to base outcomes on statistical analyses, which is why local observations of a couple of OD routes have been included in the study. OD routes have been selected according to differences between age categories. OD routes where older people make use of the same route as younger participants are less interesting than routes that differ between participants. By analysing differences in routes it should become clear whether a certain trend can be seen during the analysation of this part of the study.

Figure 16: Local observation locations

The map in figure 16 shows which areas have been selected for the local observation, and includes Hilvarenbeek (1), Den Bosch (2), Nistelrode (3), and Tilburg (4). These locations have been ranked according to the extent of how routes differ amongst younger and older participants; on first glance there are bigger differences noticeable in Hilvarenbeek than in Tilburg.

The first location that was observed was ***Hilvarenbeek***, where people cycled between the cities of Hilvarenbeek and Diessen. Whereas older participants originated from Diessen, most participants below the age of 55 ended at the industrial area to the south of Diessen (figure 17). Trips recorded between Hilvarenbeek and Diessen are not necessarily commuter trips, as they were mostly made in the afternoon. The timestamp is, however, the same for each different route, meaning that the trips are still comparable to each other.

Figure 17: Distribution of trips between Hilvarenbeek and Diessen.

The map shows that there are differences in route choices; whereas older people (red lines) cycled from Hilvarenbeek via N395, a through road, younger participants (blue lines) cycled via the south side of Hilvarenbeek by using roads designated for more rural and agricultural traffic (distributor road).

The N395 consisted of cycle paths that were segregated from motorised traffic, meaning that while this is a busy road, cyclists are not affected by this. The concrete cycle path was just renewed, and cyclists have right of way at intersections, which are priority intersections controlled by signs. Most other roads in not consist of segregated cycling infrastructure, and is mixed with traffic that is allowed to drive a maximum speed of 60 km/h. Within Hilvarenbeek and Esbeek, cycle lanes provided cyclists with their own space while traffic was allowed to drive 50 km/h, while in Diessen people made use of the normal streets in 30 km/h zones, caused by the fact that cyclists made use of residential streets that are designed for local traffic. The street between Hilvarenbeek and Esbeek consisted of semi-segregated cycle lanes.

No traffic lights or other types of signalised intersections were found during the observation, meaning that at all intersections priority was arranged by national right of way-regulation, supported by signs or road marking.

The road surface quality was identified as good for most parts of the routes; only the cycle path seen in the middle of the picture middle was ranked moderate, as tree roots have affected the smoothness of the asphalt. Differences are noticeable between rural and urban areas, as the road quality in rural areas was better than in urban areas. A lot of cycle paths have been renewed in the rural areas, making for smooth asphalt or concrete roads. On the other hand, within the towns of Hilvarenbeek and Diessen roads were made from bricks, making for a bumpy road surface.

While Hilvarenbeek includes bicyclists making inter-urban trips, participants in ***Den Bosch*** cycled within the city limits only. Trips included in this study were driven between the city centre and both Koning Willem I college, a post-secondary college, and the Jeroen Bosch Hospital. When looking at figure 18, one can see that routes are divided by the railway tracks, as part of the bicyclists cross the railway on the north side of the station, while others cross at the south side.

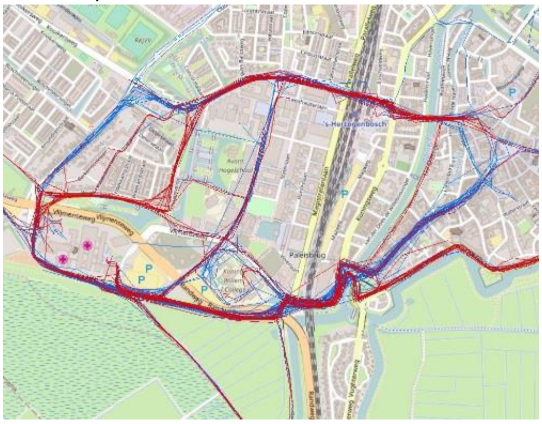

Figure 18: Distribution of trips in Den Bosch

Differences between age categories can be seen on both sides of the railway tracks, but to some extent show similar characteristics. Older participants made use of more quiet routes. Especially in the city centre the fact that pedestrians and bicyclists (partly) make use of the same infrastructure makes for a complicated traffic situation. Particularly noticeable are the high pedestrian volumes when a lot of people visit the city centre to for instance go shopping or have a drink at one of the cafés, which older people appear to try and avoid on their route.
Trips driven via the north side of the station are divided according to the same principle as well, meaning that older participants cycled via residential streets with little traffic volume, while younger participants followed the distributor road with higher amounts of motorised traffic. However, this distributor road does include separated cycle lanes.
The road surface in Den Bosch consists of a mixture of asphalt roads as well as brick paving. The residential roads were made of brick paving, while segregated cycle paths were made of asphalt. Brick paving makes for rougher road surfaces, especially when improperly maintained. In Den Bosch roads are well maintained, meaning that no real concerns regarding the road surface emerged.
The maximum speed limit within the city of Den Bosch is either 30 km/h or 50 km/h. during the local observation it became clear that roads without segregated infrastructure or brick paving were categorised as 30 km/h streets, whereas on streets with segregated cycling infrastructure traffic is allowed to drive 50 km/h.
Intersections controlled by traffic lights are found at through roads and distributor roads, and are not necessarily included more in routes of either younger or older participants. Routes that crossed residential zones only passed unsignalised intersections organised by national right of way regulations.

The third location observation entailed routes cycled around ***Nistelrode***. Routes included in the observation were cycled between Heesch and both the city centre and Bernhoven Hospital in Uden. Figure 19 clearly shows the difference between younger and older bicyclists, as participants older than 55 years old cycled via the town of Nistelrode, whereas people below the age of 55 primarily cycled via the nature area on the other side of the highway. Trips cycled between Heesch and Bernhoven Hospital/Uden were cycled by commuters, which is clearly shown by the fact that trips are made on weekdays either at 7:00-8:00 in the morning, or 16:00-18:00 in the afternoon.

Figure 19: Distribution of trips between Heesch

The route on the east side of the highway for the biggest part consisted of separate cycling infrastructure through a nature area with restricted accessibility for motorised traffic. Towards the town of Uden bicyclists have to cycle on distributor roads without dedicated cycle space. However, traffic volumes on these roads are low. People cycling from Heesch to Nistelrode cycle on segregated cycle paths that are rather wide. Parts of the network have been renewed and are of excellent quality. When entering Nistelrode, these segregated cycle paths become cycle lanes on roads that have brick paving. Depending on the route one cycles (according to the map multiple variants have been used) one only makes use of these cycle lanes on busy through roads and distributor roads, while other routes pass residential neighbourhoods where bicyclists share residential streets with other modes of transport. Between Nistelrode and Uden, one-way cycle paths on each side of the road separate bicyclists from other (motorised) traffic. There are differences in quality concerning road surface quality. As said before, part of the cycle paths between Heesch and Nistelrode has been renewed and is very smooth. Other road sections outside city limits are of good quality as well. Within Nistelrode, most streets have brick paving that is not maintained properly and affected by heavy vehicles. It has resulted in bumpy cycle lanes that are defined as poor road quality. The cycle route via the east side of the highway is split up into two categories; the cycle paths are narrow and bumpy due to roots of trees, while the distributor roads towards Uden are much smoother.
No intersection came across by the routes were signalised, and instead are priority intersections. Between Nistelrode and Heesch, and between Nistelrode and Uden bicyclists had right of way on the cycle paths. The municipalities of Bernheze and Uden both classified the rural distributor roads on the east side of the highway as 60 km/h zones, while within city limits the maximum speed was either 50 km/h or 30 km/h. Outside city limits, the maximum speed limit was 80 km/h when bicyclists are separated from motorised traffic.

Tilburg is the sixth-largest city of The Netherlands with 212.900 inhabitants (Gemeente Tilburg, n.d.). The city invests a lot in upgrading its cycling infrastructure by for instance designing fact cycle routes and bicycle streets (in Dutch: 'Fietsstraat'). Routes being observed in this urban area are cycled between the suburban neighbourhood Reeshof on the west side of Tilburg and the southeast side of the city centre. Again, the trips have at timestamp of being recorded on weekdays either during morning or evening rush hour, meaning that the participants are classified as commuters.


Figure 20: Distribution of trips in Tilburg

Older participants primarily used the fast cycling route situated parallel to the railroad. This wide two-way cycle path is mostly separated from other modes of transport and makes of an easy connection between Reeshof and the city centre. As can be seen in figure 35 younger participants, again marked by the blue lines, also make use of other routes on the south side of the railway tracks. This route partially consists of segregated two-way cycle paths as well as bicycle streets. Towards the city centre, bicyclists are increasingly mixed with other modes of transport, especially pedestrians. Participants above the age of 55 cycled those routes that consist of little mixture with other modes of transport. On the one hand, it means that they choose to cycle on dedicated cycling infrastructure, while in the city centre it results in routes that avoid the larger pedestrian flows. Younger cyclists more often cycled via streets with shops, resulting more pedestrians that visit these shops.
The quality of the road surface in Tilburg is good, especially at cycle paths. The segregated cycling infrastructure and bicycle streets are made from asphalt, while streets in the city centre consist of brick paving that are well maintained.

Just like in Den Bosch, participants only rode on streets without separate infrastructure when the maximum speed limit was 30 km/h. In fact, most 50 km/h roads in Tilburg provide segregated infrastructure for bicyclists.
The fast cycling route next to the railway makes use of bridges to cross roads. On the other hand, bicyclists cycling via the south side of the railroad in most cases had right of way when crossing streets. Towards to city centre traffic lights are used to regulate busier intersections, which are run into at all routes. Within the city centre, priority rules at uncontrolled intersections is arranged according to national priority rules are both found back on routes used by younger participants as well as by older participants.

Overview of local observations

When reflecting on the local observations it appears that directness is taken into account more by older cyclists; For instance when looking at the map, only in the case of Den Bosch no real differences regarding directness can be seen. It also results in younger people making more turns than older people do. Additionally, routes that younger people use also have more curves in road sections as well.
In general, the quality of road surfaces were best in rural areas and in the cities of Tilburg and Den Bosch. The asphalt infrastructure was new and well maintained. On the other hand, road surfaces within smaller urban areas were of lower quality, mostly caused by bricks that shifted from each other. In all four local observations, older participants used more of these brick-paved roads than younger participants, meaning that for older people the conditions 'quality of road surface' is less of a reason to cycle a different route.
Most parts of the network included in the local observations consisted of dedicated cycling infrastructure either being cycle paths (mostly rural) or cycle lanes (mostly urban). Something that is noticeable is that when there is no separate infrastructure available, younger people more often have to use the roadway in rural zones with a maximum speed of 60 km/h. On the other hand, older people more often have to make use of the normal roadway due to no separate infrastructure being available in urban residential areas. Both types of roads have in common that traffic volumes are low on these road sections. Especially when looking at the observations in Tilburg and Den Bosch, a trend can be seen showing that older people tend to avoid roads that they need to share with pedestrians. Both in the city centres of Tilburg and Den Bosch older participants avoid main shopping streets while younger people do make use of them. Older participants also cycled routes with less turns, for which the case of Tilburg is a good example, where older participants cycled via the fast cycling route while younger people more often used other cycle lanes and bicycle streets to get to their destination. This, however, does not necessarily mean that older people pass fewer intersections, as younger participants also had to cycle more corners due to the design of the roadway. As older people tended to make more use of residential neighbourhoods and villages, the amount of unsignalised intersections people pass per kilometre is higher than for younger participants. In addition, given that older people cycled via the town of Nistelrode while younger participants cycled via a nature area means that older people passed more busy intersections as well.

5. Conclusion

As already suggested in the studies of Joolink, Overdijk and Broach, stated route preferences are only taken into account to some extend in actual cycling routes (Overdijk, 2015). This is partially caused by the fact that people tend to select the most optimal route that combines several route preferences (Joolink, 2016). The overlapping of route preferences also makes it difficult to retrieve what route attribute was key to choose a particular route, as it is in most situations not possible to talk with the participant anymore. Below, the assumptions that derived from literature research are compared to the outcomes of this study, showing whether the data set showed similarities or contrasts compared to what was expected.

*The average **distance** of cycle trips decreases at a higher age.*
According to the B-Riders data set, older people cycled the same distance as younger people (mean value of 7,772 (<40), 8,297 (40-55), 8,256 (55>)). Due to the distribution of these values and the standard deviation overlapping the minor differences (page 40) one can not directly conclude that older people cycle either shorter or longer distances than younger people. By using ANOVA it was shown that there are significant differences amongst age categories.

*The average **travel time** of cycle trips decreases at a higher age.*
The general data analysis on page 40 shows that the distribution of travel times are rather similar between age categories, meaning that there is no substantial difference between younger and older participants. The small difference, however does vary significant according to the ANOVA sample.

*Elderly people prefer cycling routes that include more **segregated cycling infrastructure**.*
The local analysis showed that the biggest parts of the road network in North Brabant provides dedicated cycling infrastructure in the form of segregated cycle paths outside city limits. Within cities, (semi) segregated cycling infrastructure is available most of the times as well, while in smaller villages bicyclists are able to cycle on cycle lanes on the side of the road. When bicyclists need to make use of the normal roadway instead of dedicated infrastructure, for younger people this more often occurs in rural areas where motorised traffic is allowed to drive 60 km/h. On the other hand, older people are instead more often cycling on roads without cycling infrastructure in residential areas with a maximum speed limit of 30 km/h.

*Elderly people prefer cycling routes that include more **signalised intersections** at busy intersections.*
No real difference has been found during the data analysis that backs this assumption. The local observations also saw no difference between age categories, though older cyclists did pass more unsignalised intersections as they more often cycled via urban areas. Only in the town of Nistelrode older participants encountered relatively more priority intersections.

***Directness** of cycle routes is not as important for elderly people than for younger ages.*
The main data analysis did not show this difference, mainly because most OD routes were overlapping regardless of age. When these routes do differ, the local observations showed that routes cycled by older people tend to be more direct than those of younger people. Only in the case of Den Bosch no differences could be spotted.

*Older people value **speed** of cycle routes less than younger people, leading to for instance less avoidance of **stopping moments**.*
The general data analysis showed that average cycling speed was a bit lower for older participants (mean = 19,5 km/h) than for younger participants (mean = 20 km/h), though this difference is not noteworthy enough to base conclusions on, also due to the fact that the standard deviation makes for a lot of overlapping. The Local observations, however, do suggest that older people do not avoid potential stopping moments, as they more often cycled via agglomerations and thus ran into more different traffic flows and intersections.

*Older people prefer using routes with low **traffic volumes** and, if no separate infrastructure is available, low **traffic speeds**.*
Most routes used in in the analysis consisted of cyclists being able to use dedicated cycling infrastructure. However, if this is not available for elderly people it was at those

locations where they had to make use of residential streets (30 km/h zones) instead. Younger people on their turn more often used roads without cycling infrastructure outside urban areas (60 km/h zones). Thusly, the analyses show that if there is no cycling infrastructure available, older people have to use streets with a lower maximum speed limit than younger people.
According to the local observations, older people tend to try to avoid pedestrian flows as well, as is shown in the cases of Tilburg and Den Bosch.

*Trips made by non-commuters have a higher **detour factor** than commuters.*
There are differences between times of day that trips were cycled. In the evening and during midnight detour factor are lower than for trips cycled during rush hours and in the afternoon.

*Routes of commuters are less adaptive to avoid **busy/unsignalised intersections**.*
The data set used to perform analysis did not have enough information to back conclusions on. For example, the local observation around Hilvarenbeek was the only location where non-commuter trips were made, but there were no signalised intersections on (potential) routes. It was also not possible to say something about this based on the other locations.
After this data analysis it is still difficult to conclude differences between people riding on e-bikes and those who cycle on 'conventional' bicycles, as information on the type of bicycle has not been added to the data set. As most B-Riders participants are expected to have used an e-bike, an attempt was made to answer the two assumptions regarding the type of bicycle used nevertheless:

*Non-distance route factors like **signalised intersections** or **quality of road surface** becomes more important once riding an e-bike.*
In the local observations older people more often cycled routes leading through urban areas with rougher road surfaces, already being contrary to what literature suggests. Given the fact that one does not know the type of bicycle that was used for a trip, as most people are expected to have used e-bikes in the B-Riders programme this is even more in contrast with expectations.

*Distance route factors like **distance**, **travel time** and the **amount of stopping moments** become less important route conditions for people riding an e-bike.*
Again, it is not possible to make reliable conclusions on this statement based on this study. The average cycling distance is rather large, especially those included in the local observation. As people cycle bigger distances on e-bikes, it could be possible that the factors 'distance' and 'travel time' indeed become a less dominant condition.

One can argue that while there are only minor differences between younger and older people in the general data analysis, while on the other hand the local observations suggest much bigger differences. This is caused by the fact that for the local observation only routes with enough participants, which also differ between young and older, have been selected. There are also many OD routes that do not differ when looking at age. A lot of those cycling routes have only little alternatives. As this research was set up to study whether there are differences in route choices, and if so what kind of differences. It means that there are still many trips that bicyclists of all ages cycle via the same route. Observing those routes that actually differed were interesting to investigate during this assignment, and resulted in the outcome given above.

Multiple studies have found that there are differences between younger and older people regarding route preferences. Important route attributes for young people are conditions like directness of routes or travel speed, while older people find presence of cycling infrastructure or travel time more important.
When bicyclists actually have to decide what route to cycle, they may be less able to take these route preferences into account. Furthermore, routes with specific attributes may be

overlapping, making it more difficult to retrieve which route condition was most important to choose this route. In addition to this, alternatives can be limited between origin and destination, meaning that one is not able to cycle another route than the one they would otherwise favour less. Several studies suggest that bicyclists cycle the most optimal route based on all route conditions. Distance factors (like 'distance' or 'travel time') mostly affect route choices, while non-distance factors (like the presence of signalised intersections) are taken less into account.

At the age of 55 mental and physical abilities are not yet significantly affected by ageing. Furthermore, the fact that they participate in the B-Riders programme and, thus are able to use the bicycle for commuting as well as for other trips instead of the car, means that participants do most likely not yet have problems with cycling or other physical/mental tasks. However, this does not make this study irrelevant for researching how to make the traffic network safer for elderly bicyclists. As this study looked into differences between people younger and older than 55 years, some trends/changes are already noticeable, which can be taken into account when designing new cycle routes. Furthermore, as the B-Rider participants can be expected to cycle more than the average person, these people are also expected to become "the senior cyclist of tomorrow", meaning that they are more likely to keep on cycling until a higher age. This research shows the first insights into route choices of this group of bicyclists.

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