“Do I need Google Maps for this?”: Studying differences between Dutch and international student cyclists when navigating while cycling in Groningen

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Abstract

Cycling is a common form of transportation in the Netherlands, but there remains limited research into aspects such as the effect of nationality and dual task performance. The present study seeks to address this research gap by researching the differences between Dutch and international student cyclists in Groningen when navigating while cycling as a form of dual-task performance. Twenty-nine participants of Dutch and non-Dutch nationality cycled on a route divided into four segments, each with a different navigation device. Dependent measures were their cycling speed and self-reported mental effort. The study found that the two groups differed in cycling speed, but no differences in mental effort were found. The devices were also found to have an effect on the two measures. Proposed explanations for this difference are that internationals lack practice in cycling compared to their Dutch counterparts, meaning cycling behaviour was less automated and more mental effort had to be allocated to both cycling and navigating, leading to slower speeds. It was concluded that the Dutch and international student cyclists differed in their cycling behaviour when navigating at the same time and this has implications towards future research in cycling and policy making to address issues concerning international cyclists in Groningen.

Keywords: Cycling, Navigation, Dual task performance, Mental effort, Cycling behaviour, Traffic, Traffic Psychology

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The automobile today as a form of transportation for both persons and logistics is slowly being reconsidered with more sustainable alternatives such as cycling. This growing movement can be attributed to global climate change becoming an ever-salient issue in the minds of the population and those tasked with public policy. Cycling as a form of climate-change mitigation at the expense of carbon-emitting automobiles has also been advocated by cycling advocacy groups (Delrive, 2021). In the Netherlands, the bicycle is associated with more than its utility than the common view of it being a tool for recreation and sports outside of the country. The number of bicycles in the country (23 million) outnumber the population (17 million) and 27% of daily trips are made with bicycles as opposed to other forms of transportation like driving or taking the bus (Harms & Kansen, 2018). In recent years, businesses have also looked into further utilising bicycles for “last mile deliveries”, demonstrating that its role in society can be expanded to fit into the changing paradigms of supply and logistics and not just limited to being a convenient and environmentally-friendly form of transportation (van Lopik et al., 2020).

Despite the extensive use of bicycles in the country, little attention has been directed towards the issue of foreign cyclists and their differences when compared to native cyclists in the Netherlands. De Waard et al. (2020) previously investigated differences in cycling performance and mental effort and found that differences between the two groups in terms of cycling performance and mental effort to be non-significant. Interestingly, the study also found that Dutch cyclists committed more, albeit minor rule violations while non-Dutch cyclists tended to commit less, but more major rule violations that can come with adverse risks. Despite this new wealth of data and insight into the divide, no studies have been done to highlight dual task performance amongst Dutch and non-Dutch cyclists. This is an issue that

is relevant and salient to many Dutch cities, including Groningen, as these cities often receive new inexperienced cyclists on a regular basis. In the case of Groningen especially, many new international students are often inexperienced in cycling in busy cities alongside other road traffic and some may even be cycling for the first time in their lives. These cyclists are often perceived to pose a threat to other road users due to their unpredictability (Zaal, 2021). Alongside this inexperience, these new student cyclists are very much unfamiliar around the city and end up having to rely on navigation apps on their smartphones to get around. Previous literature has already indicated that performance of a certain task can be worsened in the presence of another concurrent task which implies that the lowered performance of inexperienced cyclists on bicycles could be further exacerbated by their need to navigate at the same time (Salvucci, 2013). Dutch or native cyclists on the other hand, have often already started cycling from a very young age and are familiar with their surroundings, Dutch cycling infrastructure and the rules and regulations on the road, thus reducing the effort it takes for them to commute by cycling (van der Kloof, 2019). As such, solutions need to be built in order to deal with the issue of inexperienced cyclists and their multitasking, especially with more internationals coming to both Groningen and the Netherlands as a whole to study (Statistics Netherlands, 2022).

Literature on the topic of multitasking would classify the dual task performance of using a device to navigate while cycling as concurrent multitasking, in which multiple tasks are performed at the same time (Salvucci, 2013). The act of cycling which involves a multitude of processing sources such as motor, perceptual, cognitive, can be adversely affected with interference of perceptual and cognitive processes associated with navigation with a phone. Dancu et al. (2015) has stated that the navigation should not be thought of as a passive activity, but rather one that should be considered skill, requiring the aforementioned processing sources and thus interfering with the other simultaneous task. In looking at

performance, de Waard et al. (2014) found that cyclists in conditions which required them to simultaneously operate a device cycled significantly slower compared to those in control conditions in which a device was not operated simultaneously. Additionally, the use of devices while cycling led to more instances of failures to detect peripheral objects (de Waard et al., 2014, van Lopik et al., 2020). While those instances came mostly in the form of signs and the failure of their detection was inconsequential in the study, these failures could possibly manifest in the real world as failures to detect dangerous objects on the road (i.e., glass, debris) or even people due to the need to simultaneously operate a device while cycling, leading to potential accidents. Concerningly, the use of a device while cycling is not an uncommon phenomenon in the Netherlands with Goldenbeld et al. (2012) finding that 55% of the population in the Netherlands had at least occasionally used their phones while cycling. With the advent of cheaper and more technological advanced smartphones, it is likely that figure would be even higher today. It is important to also note that the use of devices while cycling is not only limited to the Netherlands, where cycling is very prominent and that the phenomenon has appeared or has been noted to occur in other countries such as Brazil and the United States (Wolfe et al., 2016).

While dual task performance while cycling remains a focal point in research, as mentioned previously, dual task performance in the form of navigating while cycling and the differences in navigation behaviour between international cyclists and Dutch cyclists remain limited. In a study looking at cycling while navigating, de Waard et al. (2017) looked into how different forms of navigation devices affected subjective effort and performance. The mental effort of participants when using paper maps was found to be higher compared to electronic devices, but speed was not affected by the different systems. This is despite previous research indicating that speed in car drivers could be lowered in order to compensate for secondary task requirements (de Waard et al., 2001). As mentioned, previous research on

cycling performance differences of Dutch and international student cyclists found that there were no significant differences in terms of speed and mental effort while cycling through different segments of a typical cycling journey between the two groups (de Waard et al., 2020). Despite this, it is important to note that in the study they focused on performance over several types of common cycling segments in a typical cycling route without another concurrent task like navigating on a smartphone, possibly reducing the amount of mental effort needed for a cyclist at a given time.

The aim of the present study is to follow up on the previous studies on distracted cycling and to hopefully fill in the research gap in terms of navigation on bicycles and the differences of navigation behaviour between Dutch and non-Dutch cyclists in Groningen, with a focus on expanding on previous findings found by de Waard et al. (2020) on the study regarding cycling performance between Dutch and non-Dutch cyclists. The aim is to then investigate the differences in speed and the subjective mental effort of the two groups over different navigation devices.

Most of these devices often utilise the turn-by-turn (TBT) method in which users are guided along the quickest or shortest possible road with instructions directing participants towards a particular turn appearing as the participant approaches a turn. A more novel form of navigation is the as-the-crow-flies (ATCF) which points the user in a general direction towards the target destination has also seen it being utilised in some devices (Savino, 2020).

It is first hypothesised that there are differences between the Dutch and international student cyclists in Groningen. It is reasoned that the relative inexperience of international student cyclists compared to their Dutch counterparts will make the simultaneous task navigation to be harder, causing them to cycle slower in order to compensate as per the findings of de Waard et al. (2001). The second hypothesis is that Dutch cyclists will indicate

to have less subjective mental effort across the different conditions in comparison to their non-Dutch counterparts. Similar to the first hypothesis, it is reasoned that the experience of Dutch cyclists will mean that less mental effort is invested in cycling, thus reducing the overall mental effort needed to be allocated when they are also required to use a navigation aid at the same time.

Method

Participants

Participants for the study were recruited through word of mouth by the experimenters as a form of convenience sampling. A total of 30 participants were recruited in the end. The participants were divided into two groups: Dutch (*M* age = 24, *SD* = 5.2) and non-Dutch cyclists (*M* age = 25.6, *SD* = 6.3). Dutch cyclists consisted of 13 male participants and two female participants with a further two self-identifying as non-binary. Non-Dutch cyclists meanwhile consisted of six male and six female participants with one more participant identifying as non-binary. Participants in the experiment were not financially compensated with participation in the study being entirely voluntary.

Design

A repeated measures design was used with navigation devices and nationality of the participants as the two independent variables. The navigation devices were a within subject factor with participants being recorded over four different types of navigational methods while nationality was a between subject factor with two levels: Dutch and non-Dutch. The dependent variables are cycling speed and mental effort.

Measures

Navigation devices

The four different navigation devices were (1) Google Maps (Figure 1) which represented the turn-by-turn (TBT) method, (2) auditory instructions from Google Maps (Figure 2) for the auditory TBT instructions, (3) the Beeline (Figure 3) which is a novel and the only navigation device operating on the as-the-crow-flies method and (4) textual instructions from Google Maps (Figure 4) that represented the text TBT instructions conditions.

Figure 1

iPhone used to display Google Maps

Figure 2

Headphones used to deliver audio instructions from Google Maps

Figure 3

Beeline device

Figure 4

Paper/Text instructions in the paper holder attached to handlebars of a bicycle

Cycling behaviour

Cycling behaviour in this study was measured using average speed in kilometres per hour (km/h). This was recorded with the use of a Contour +2 camera (Figure 5) that would track the GPS position of the participants as they cycled through the segments. The average speed of each participant was later calculated by averaging the speed of the participant over a minute of uninterrupted cycling in a particular segment. The original figure coming from the calculation, which comes out as metres per second (m/s), is converted to kilometres per hour (km/h) by multiplying the figure by 3.6.

Figure 5

Contour +2 Camera

To take care of conditions where the camera would fail to operate normally or run out of battery, a rudimentary measure of speed through calculating the time of completion, recorded by a stopwatch carried by the cycling observer following the participant over the distance of a segment was also included.

Mental effort

Mental effort of the cyclists for each navigational aid was measured through the RMSE or Rating Scale of Mental Effort (Ziljstra, 1993). This scale is unidimensional and it ranges from 0 to 150. Scores from 0 indicate *absolutely no effort* was allocated in a task while

scores higher than 120 and continuing until 150 indicates that *extreme effort* was allocated in a task.

Demographic measures

Basic demographic questions were nationality, age, gender. In addition, demographic questions asking about their cycling habits were also included. Confidence as a cyclist (ranging from *not comfortable at all* to *extremely comfortable*) were asked along with the frequency of their cycling in a week (ranging from *none* to *4 or more*). Additionally, questions regarding the cycle friendliness of the cities or towns where they grew up (ranging from *not bicycle-friendly at all* to *extremely bicycle-friendly*) and their familiarity of Vinkhuizen (ranging from *not familiar at all* to *extremely familiar*) was included.

Materials

Participants taking part in the experiment were instructed to use their own bicycles for the study. In most instances, participants used their own typical Dutch city bicycle which ensured some level of control over bicycles as a potential confound with the aforementioned bicycles commonly sharing characteristics between each other (Dutch city bicycles tend to be rather simple in design as opposed to other more specialised or pricier bicycles).

A prequestionnaire was used to assess demographic data. With reference to appendix B, included in the prequestionnaire were several questions asking the participants basic demographic questions, cycling habits and their familiarity with the area.

A face-pointed Contour Camera +2 attached to the handlebar of participants' bicycles that was for the purpose of recording the eye-fixations of participants for another experimenter was also used to record the GPS position of participants (See Van der Moolen, 2022). The GPS data would then be used later to calculate the average speed of the

participants in different conditions. A stopwatch was also used by the observer to record the time of completion of each participant over a segment as a backup.

As mentioned earlier, Google Maps, Auditory instructions, the Beeline device and paper text instructions were used as navigation devices The former three navigation devices were used on or connected to an iPhone smartphone which would be attached to handlebars of bicycles, although the Beeline itself was a separate device that had to be attached to handlebars despite needing to be connected to the smartphone for its GPS position. The textual instructions were printed onto paper and were attached to the bicycle with a paper holder.

A post-condition or segment questionnaire (see appendix C) assessing a participant's mental effort with a certain navigation device included the aforementioned Rating Scale of Mental Effort developed by Zijlstra (1993).

Location

Vinkhuizen was chosen as the location for the experiment to be run due to its relative seclusion and light traffic density compared to the busy streets of city centre of Groningen, though the traffic density of Vinkhuizen had a tendency to fluctuate during the early morning and early evening traffic rush hours. This was done in order to both reduce the traffic density as a disturbing variable in the study as much as possible and to reduce the risks of accidents while running the experiment. Additionally, the experiment would not be conducted if it was dark or it was raining.

The route that had to be cycled by each participant was an idealised 5.8-kilometre cycling route calculated through Google Maps that was then divided into four segments for each navigational aid that was tested. The first segment (figure 6) was 1.7 kilometres long, followed by the 1.6 kilometre-long second segment (figure 7) with the third segment (figure

8) measuring 1.4 kilometres and the final segment (figure 9) being 1.1 kilometres long. Each segment did not have a navigational device specifically assigned to it. Instead, the order of navigational devices assigned was randomised for each participant in order to balance the conditions against possible disturbing variables coming mostly in the form of varying infrastructure (e.g., Roundabouts, busy road crossings) and additional variables such as traffic and weather (e.g., strong winds)

Figure 6

Segment 1

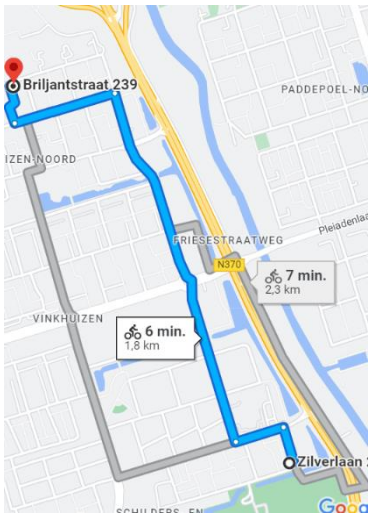


Figure 7

Segment 2

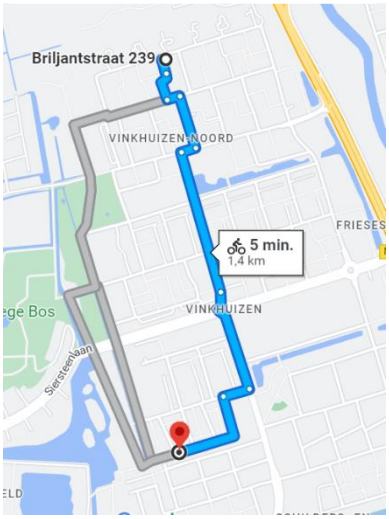


Figure 8

Segment 3

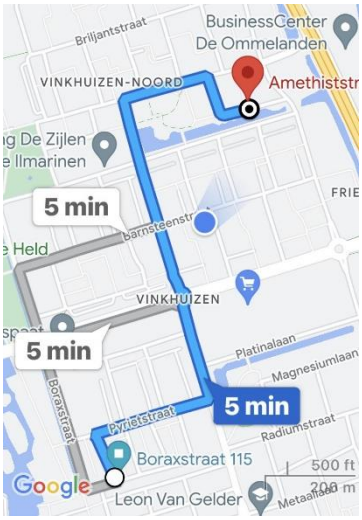
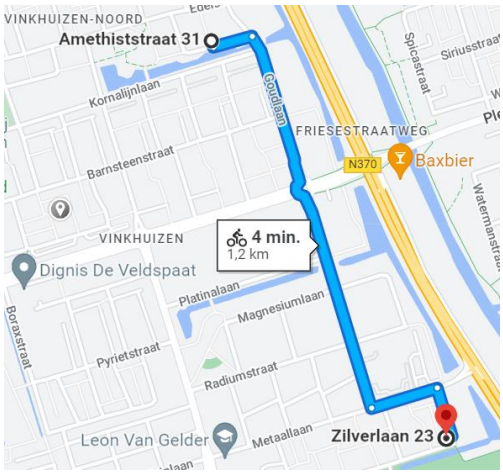


Figure 9

Segment 4



Procedure

The study was conducted by psychology undergraduate students from the University of Groningen after being given approval to run the experiment by the ethics committee of the Psychology faculty.

Before running the experimental trials with the participants, the experimenters ran several pilot studies and trials. This was done in order to test the decided upon experimental design and to work out any potential issues prior to actual testing upon the voluntary participants.

Prior to the experiment, participants were emailed information regarding the study along with the consent form informing the participants of their rights to confidentiality and anonymity. On the day of the experiment, participants were instructed to fill out the consent form followed by the pre-questionnaire form while the experimenters installed the face-pointed camera, the phone and the initial navigation device on the handlebars of the bicycle of the participant.

Afterwards, participants were given a briefing on the instructions of the study which included instructing the participants to not communicate their thoughts to the experimenters after each condition so as to not affect the experiment as a whole and an opportunity to ask any questions. Upon the conclusion of this briefing, they were then instructed to begin cycling the route as an observer followed two to three bike-lengths behind to measure the time each participant was taking on each segment and to ensure that they remained safe throughout the entire trial. They were also told that the observer could intervene in cases in which participants found themselves to be lost, although this option was not encouraged and participants were expected to complete the route on their own.

Upon completing the first segment, participants were instructed to fill out a post-condition questionnaire in relation to the navigational device that they had used as the experimenter positioned at the first stop replaced their initial navigational device with another. Once completed, the participants were told to continue on the route with the new navigational aid, with this process repeating itself for the remaining segments and the navigation devices that were to be used.

Once the participants had completed all of the segments of the route, they were given a post-experiment questionnaire to fill out. Shortly afterwards, the participants were debriefed on the experiment and were given an opportunity to comment or ask questions regarding the experiment. The experiment ran from the 19th of April 2022 to the 3rd of May 2022, with trials being run over 10 days in that period.

Results

Descriptive statistics

The final sample of our data consisted of 29 participants (table 1) following the withdrawal of a participant mid-way through a trial. The withdrawal of the participant, who was an international, meant that the international group (*M* age = 25.6, *SD* = 6.6) was left with 12 participants from its original 13 while the Dutch group (*M* age = 24, *SD* = 5.2) did not have dropouts from the study. Of the remaining participants, the Contour camera failed to operate as per usual for eight participants for their trials. As such, the backup speed measure mentioned in the methods section was utilised and the data from the eight were integrated into the main dataset.

Table 1

Descriptive Statistics of age and gender

	Age		Gender	
	Dutch	**International**	**Dutch**	**International**
Valid	17	12	17	12
Missing	0	0	0	0
Mean	24.0	25.6	1.4	1.6
Std. Deviation	5.2	6.6	0.7	0.7
Minimum	19.0	20.0	1.0	1.0
Maximum	39.0	43.0	3.0	3.0

Both groups were relatively unfamiliar with the area of Vinkhuizen (the rating scale ranges from 1 to 5 with lower scores indicating more unfamiliarity (table 2). See appendix B for the questionnaire), with Dutch participants (M = 1.9, SD = 0.9) indicating they are only very slightly more familiar compared to their international counterparts (M = 1.8, SD = 0.8). This relative unfamiliarity with the area ensures that familiarity with Vinkhuizen is potentially not a confounding variable in the study. Additionally, international participants (M = 1.6, SD = 0.9) rated the cycle-friendliness of their home cities and town (on a scale of 1 to 5 with lower scores indicating less bicycle-friendliness) much lower compared to their Dutch counterparts (M = 4.3, SD = 0.6).

Table 2

Descriptive statistics of demographic questions concerning cycling

	CycFreq		CycCon		CycBack		Vink	
	Dutch	**International**	**Dutch**	**International**	**Dutch**	**International**	**Dutch**	**International**
Valid	17	12	17	12	17	12	17	12
Missing	0	0	0	0	0	0	0	0
Mean	4.8	4.6	4.3	3.8	4.3	1.6	1.9	1.8
Std. Deviation	0.5	1.2	0.6	0.6	0.6	0.9	0.9	0.8
Minimum	3.0	1.0	3.0	3.0	3.0	1.0	1.0	1.0
Maximum	5.0	5.0	5.0	5.0	5.0	4.0	4.0	4.0

Note. CycFreq, CycCon, CycBack and Vink refers to cycling frequency, cycling confidence, cycle-friendliness in home city or town and familiarity with Vinkhuizen respectively.

Further demographic questions (see table 2) indicated that both groups cycle on a similar frequency per week, but international participants (M = 4.6, SD = 1.2) have a bit more variation in their cycling frequency (on a scale of 1 to 5 with higher ratings indicating more frequent cycling) compared to the Dutch participants (M = 4.8, SD = 0.5). Finally, Dutch participants (M = 4.3, SD = 0.6). indicated that they were more confident cycling (on a scale from 1 to 5 with higher scores indicating more cycling confidence) compared to their international counterparts (M = 3.8, SD = 0.6).

Cycling behaviour

To analyse the collected data, a repeated measures ANOVA (refer to appendix A for assumptions checks) was utilised with the navigation devices as the within subject factor and the nationality as the between subject factor. A significant effect was found for the main effect, which indicates that there is a significant difference between the cycling speeds when using different forms of navigation devices in this sample which means that different navigation devices had an effect on cycling speed, with a medium effect size $F(2.718, 73.392) = 3.954$, $p = 0.014$, $\eta^2p = 0.128$. The between subject factor, nationality, which is the main focus in the present study also had a significant effect, with a large effect size $F(1, 27) = 5.421$, $p = 0.028$, $\eta^2p = 0.167$. This indicates that there is a difference between Dutch cyclists and international cyclists in terms of cycling behaviour in this sample and that nationality affects the cycling behaviour, thus confirming the first hypothesis.

Table 3

Descriptive statistics of cycling speed (km/h)

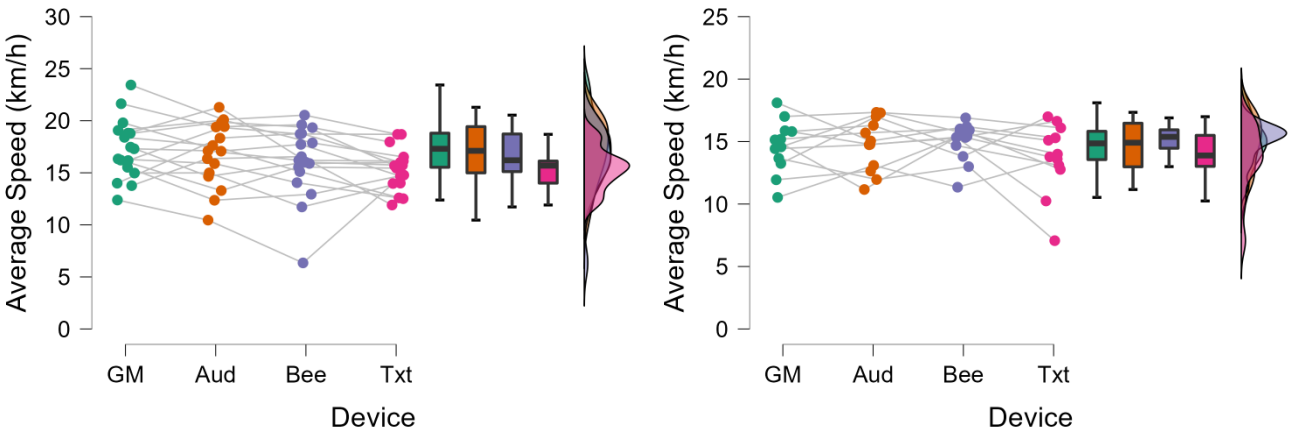
Device	Nationality	Mean	SD	N
GM	Dutch	17.3	2.9	17
	International	14.6	2.1	12
Aud	Dutch	16.9	3.0	17
	International	14.8	2.1	12
Bee	Dutch	16.1	3.5	17
	International	14.9	1.6	12
Txt	Dutch	15.4	2.0	17
	International	13.7	2.8	12

Note. GM, Aud, Bee, Txt refers the to the four conditions which are Google Maps, Auditory, Beeline, Text respectively.

The raincloud plots (figure 10) below provide a visual indication of the difference in cycling speed between the two nationality groups. Additionally, it is interesting to note (table 3) that there appears to be more variation cycling speed in the Dutch group (M = 15.4, SD = 2.0) compared to the international group (M = 13.7, SD = 2.8) in the text or paper map condition.

Figure 10

Raincloud plots of the cycling speeds of the Dutch (left) and international (right) participants



Note. GM, Aud, Bee and Txt refers to Google maps, Auditory, Beeline and Text conditions respectively, the four navigation devices used in the study

Mental effort

It was found that there was a significant main effect for the within-subject factor, thus indicating that there exists a significant difference between the self-rating of subjective mental between the navigation devices in this sample which indicates that the devices had an effect on subjective mental ratings, with a rather large effect size $F(2.521, 68.071) = 11.875$, $p < .001$, $\eta^2p = 0.305$. In terms of the between subject effect, which is of interest in the present study, it was found that there was not a significant effect $F(1, 27) = 0.071$, $p = 0.792$, $\eta^2p = 0.003$. This indicates that there is no significant difference between the two groups, indicating that nationality did not affect the subjective mental ratings which means that our second hypothesis concerning mental effort is rejected.

Table 4

Descriptive statistics of subjective mental effort

Devices	Nationality	Mean	SD	N
GM	Dutch	23.3	12.5	17
	International	27.8	15.8	12
Aud	Dutch	47.5	29.9	17
	International	44.8	31.6	12
Bee	Dutch	50.1	29.9	17
	International	47.2	28.9	12
Txt	Dutch	67.5	25.5	17
	International	62.8	28.9	12

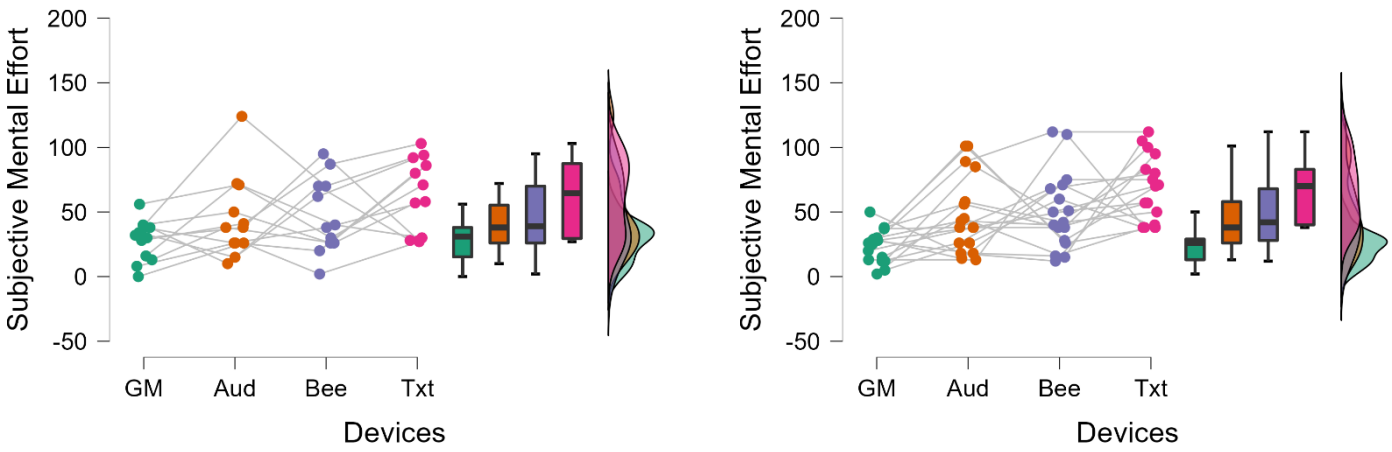
Note. GM, Aud, Bee, Txt refers the to the four conditions which are Google Maps, Auditory, Beeline, Text respectively.

The raincloud plots (figure 11) provide a visual indication of the difference in subjective mental effort ratings between the two nationality groups. Of note, there appears to be smaller variation (table 4) in both Dutch ($M = 23.3$, $SD = 12.5$) and international groups (M

= 27.8, *SD* = 15.8) in the Google maps condition compared to the other conditions which also happens to the be the condition with the smallest subjective mental effort ratings.

Figure 11

Raincloud plots of the subjective mental ratings of Dutch (left) and international (right) participants



Note. GM, Aud, Bee and Txt refers to Google maps, Auditory, Beeline and Text conditions respectively, the four navigation devices used in the study

Discussion

Summary

The goal of the present study was to expand upon the previous findings by de Waard et al. (2020) and to research the differences between Dutch and International cyclists in Groningen when navigating while cycling as a form of dual task performance. This goal led us to two different hypotheses, each dealing with a separate aspect of cycling in context of the dual task performance. The first hypothesis is that the cycling behaviours of Dutch and international student cyclists in Groningen are comparably different when navigating while cycling.

The second hypothesis meanwhile concerns the mental effort allocated when cycling while navigating which we hypothesised to also be comparably different when comparing Dutch and international student cyclists in Groningen.

Interpretation

The analysis of the data on cycling behaviour indicated that nationality, as in the group membership of being Dutch or an international cyclist, had an effect on the cycling speed. These results are therefore in line with the first hypothesis in which it was predicted that there would be a significant difference between the two groups. It is important to note, however, that the results did not mirror the findings of the study that the present study seeks to expand upon (de Waard et al., 2020). This difference might come down to the fact that in the previous study, participants were actively being instructed by the experimenters on the routes that they would have to take, thus eliminating a second or concurrent task that they had, meaning that they would have more mental resources to commit to just cycling. This is in contrast to the present study in which the participants had to work on their own to navigate with little to no assistance from the observer.

Shifting to the current study, there could be a few reasons why there exists a difference between the two groups with regards to cycling behaviour. Cycling, which already requires a number of mental resources such cognitive, visual and motor processing resources, in this instance may have been interfered by the concurrent task of navigating, which also consumes similar mental resources as cycling, might lead to the degradation of performance (Salvucci, 2013). In this case, cycling to Dutch student cyclists, who already have years of experience prior to this study, may have become increasingly automated and required less effort (Wierda & Brookhuis, 1991). This in turn means that they have more resources to commit to navigating without worrying about their cycling. International student cyclists on

the other hand lack the prior experience of their Dutch counterparts and would have to allocate more attention to both their cycling and navigational tasks, thus slowing them down significantly compared to Dutch cyclists. Related to this point, international cyclists could have possibly slowed down in comparison to the Dutch cyclists as a way to compensate for the requirements of their navigational tasks (de Waard, 2001).

The data analysis on mental effort, meanwhile, indicated that there were no significant differences between the two groups. While our second hypothesis, which posited that there would also be a difference in terms of mental effort, is rejected, the results are in line with de Waard et al's. (2020) previous study. A possible explanation for the lack of significant differences between the two groups could be that due to a large part number of the participants had already resided in Groningen for extended periods of time and therefore had more time to practise their cycling skills through repeated daily cycling. Through this process, cycling becomes much more automated and less resources are then allocated to the act of cycling (Wierda & Brookhuis, 1991). The deficit in experience and training to their Dutch counterparts might mean that these processes are automated, but not to a higher extent and might explain the reason as to why there exists a difference in cycling behaviour despite the similar levels of exerted mental effort.

Limitations

The current study brought about interesting new insights to a topic of research that has thus far been limited in focus. This, however, does not prevent the fact that our present student had encountered several limitations throughout the experimental process with those limitations being divided into ones concerning the practical side of things and more conceptual concerns. When looking into the practical matters, one of the more important limitations to consider is the utilised method of sampling for the experiment. Our sample for

the present study was a convenience sample with each experimenter recruiting a handful of participants with them being friends of each experimenter. Despite maintaining a level of diversity in the international student cyclist group in terms of representation from several regions of the world (e.g., East Asia, Southeast Asia, Central Europe, Eastern Europe, North America, Africa), the majority of those recruited had already resided in the Netherlands for extended periods of times.

There could be an argument to be made these long-term temporary residents are representative of a large chunk of the international student population, most of whom are residing in the city of Groningen and the Netherlands in general for a little over three years. With the present study, however, we are more concerned with the more recent arrivals to the city, international students who are more often inexperienced and unfamiliar with the city, its cycling infrastructure and rules and regulations and have often been the topic of much debate due to their unpredictability and danger on the road. It should also be noted, that the majority of the participants were educated at the University of Groningen, meaning that the study is limited in its generalisation to the student population of Groningen as the Hanze University of Applied Sciences also makes up a significant part of the student population.

In terms of conceptual limitations, the present study was rather limited in its measures for cycling behaviour. In this instance, average speed was used as the measure for analysing the differences between Dutch and international student cyclists. While it remains a usable measure and has given us more insights in an area of research that has been so far limited, average speed does not allow for much interpretation aside from working out which group might be faster. Additionally, the subjective mental effort scale, RSME (Rating of Subjective Mental Effort) as devised by Ziljstra (1993) came with the issue that it was difficult to compare the two mean group ratings. Although it does provide a basis for comparison for within-subject contexts, as seen in the data analysis with regard to the four different

conditions, the RMSE is not an absolute measure thus making it difficult to make between-subject comparisons.

Future research

As a considerable issue that might obfuscate results, the topic of sampling methods ought to be an issue that is to be addressed in future research. The present snowball sampling method was utilised due to its convenience and cheap costs, but it presented generalisability as issue with the majority of participants being recruited afforded longer periods of time to get habituated to the city of Groningen and to gain experience in cycling as opposed to newer and inexperienced student cyclists. As such, a more random sampling method with a focus on newer inexperienced cycling participants should be utilised in future research to improve the prospects of generalisability for future research.

Going off on what was already stated in the limitation section, future research into the Dutch-International student cyclists divide should have more extensive measures into cycling behaviour that could give future studies more room for interpretation of results and deeper insights. Measures such as mistakes made while navigating or lateral position to roadside kerbs, which was used in previous studies (de Waard et al., 2014, de Waard et al., 2020). Furthermore, to address the issues group comparison when using a subjective mental effort scale (the RSME scale in this instance) to measure mental effort, future research could look into utilising more objective mental effort measures (See Van der Moolen, 2022).

Conclusion

Today's study indicates that there exists a difference between Dutch and international student cyclists in Groningen when navigating while cycling, though this is more in regard to cycling behaviour (speed) rather than mental effort. These findings also hold several implications. The first of which is that it helps expand the current amount of research into the

field of cycling, which remains hitherto rather limited. In addition, this research also has implications for future public planning in Groningen. As previously mentioned, international cyclists were shown to be slower compared to their Dutch counterparts which could mean potential reductions in the flow of traffic in the city, especially when in higher traffic density. With the number of international students in Groningen projected to grow in the coming years, it is especially vital for policy makers to address current deficits in how they approach the issue before it becomes an epidemic that could put otherwise flowing traffic in the city to a halt (Statistics Netherlands, 2022).

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Appendix A

Cycling Behaviour

Repeated measures ANOVA for cycling behaviour

Within Subjects Effects

Cases	Sphericity Correction	Sum of Squares	df	Mean Square	F	p	η^2_p
Device	Greenhouse-Geisser	35.072	2.718	12.902	3.954	0.014	0.128
Device ✻ Nationality	Greenhouse-Geisser	10.013	2.718	3.684	1.129	0.340	0.040
Residuals	Greenhouse-Geisser	239.492	73.392	3.263			

Note. Type III Sum of Squares

Between Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Nationality	101.963	1	101.963	5.421	0.028	0.167
Residuals	507.804	27	18.808			

Note. Type III Sum of Squares

Test for Equality of Variances (Levene's)

	F	df1	df2	p
GMAvg	1.337	1	27	0.258
AudAvg	1.673	1	27	0.207
BeeAvg	3.057	1	27	0.092
TextAvg	0.537	1	27	0.470

Note. GM, Aud, Bee and Txt refers to Google maps, Auditory, Beeline and Text conditions respectively, the four navigation devices used in the study. Avg refers to average speed per device in kilometres an hour

Test of Sphericity

	Mauchly's W	Approx. X^2	df	p-value	Greenhouse-Geisser ε	Huynh-Feldt ε	Lower Bound ε
Device	0.862	3.829	5	0.575	0.906	1.000	0.333

Post Hoc Comparisons - Device

			95% CI for Mean Difference				
		Mean Difference	Lower	Upper	SE	t	p_{holm}
GM	Aud	0.106	-1.134	1.346	0.458	0.231	1.000
	Bee	0.446	-0.794	1.685	0.458	0.972	1.000
	Txt	1.416	0.176	2.655	0.458	3.088	0.017*
Aud	Bee	0.340	-0.900	1.580	0.458	0.741	1.000
	Txt	1.310	0.070	2.550	0.458	2.857	0.027*
Bee	Txt	0.970	-0.270	2.210	0.458	2.116	0.150

* p < .05

Note. P-value and confidence intervals adjusted for comparing a family of 6 estimates (confidence intervals corrected using the bonferroni method).

Note. Results are averaged over the levels of: Nationality.

Note. GM, Aud, Bee and Txt refers to Google maps, Auditory, Beeline and Text conditions respectively, the four navigation devices used in the study.

Mental Effort

Within Subjects Effects

Cases	Sphericity Correction	Sum of Squares	df	Mean Square	F	p	η^2_p
Devices	Greenhouse-Geisser	22302.916	2.521	8846.312	11.875	< .001	0.305
Devices ✻ Nationality	Greenhouse-Geisser	344.019	2.521	136.453	0.183	0.878	0.007
Residuals	Greenhouse-Geisser	50708.877	68.071	744.939			

Note. Type III Sum of Squares

Between Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Nationality	60.245	1	60.245	0.071	0.792	0.003
Residuals	22942.721	27	849.730			

Note. Type III Sum of Squares

Test for Equality of Variances (Levene's)

	F	df1	df2	p
GMME	0.654	1	27	0.426
AudME	0.027	1	27	0.870
BeeME	0.069	1	27	0.794
TextME	0.460	1	27	0.504

Note. GM, Aud, Bee and Txt refers to Google maps, Auditory, Beeline and Text conditions respectively, the four navigation devices used in the study. ME refers to the subjective mental ratings for each device.

Test of Sphericity

	Mauchly's W	Approx. X^2	df	p-value	Greenhouse-Geisser ε	Huynh-Feldt ε	Lower Bound ε
Devices	0.694	9.380	5	0.095	0.840	0.934	0.333

Post Hoc Comparisons - Devices

		Mean Difference	SE	t	p_{holm}
GM	Aud	-20.588	6.671	-3.086	0.011 *
	Bee	-23.120	6.671	-3.466	0.004 **
	Txt	-39.630	6.671	-5.941	< .001 ***
Aud	Bee	-2.532	6.671	-0.380	0.705
	Txt	-19.042	6.671	-2.855	0.016 *
Bee	Txt	-16.510	6.671	-2.475	0.031 *

* p < .05, ** p < .01, *** p < .001

Note. P-value adjusted for comparing a family of 6

Note. Results are averaged over the levels of: Nationality

Note. GM, Aud, Bee and Txt refers to Google maps, Auditory, Beeline and Text conditions respectively, the four navigation devices used in the study.

Appendix B

Pre-questionnaire: A 2 minutes survey

Thank you for taking the time to fill in this questionnaire; it should only take 2 minutes. Your answers will be treated with complete confidentiality, and unless you choose to provide an e-mail address, will be entirely anonymous.

Please fill in the blanks or place an X or checkmark next to the word or phrase that best matches your response.

1. Please indicate your age: _____
2. Please indicate your nationality: _____
3. Which languages are you capable of speaking fluently? (you can select more than one)
   - ☐ Dutch
   - ☐ English
   - ☐ _____
4. What gender do you identify as?
   - ☐ Male
   - ☐ Female
   - ☐ _____
   - ☐ Prefer not to answer.
5. How many times per week on average do you ride a bike?
   - ☐ None (I do not ride)
   - ☐ Less than one (1 to 3 times per month)
   - ☐ 1
   - ☐ 2 to 3
   - ☐ 4 or more
6. How long do you cycle per ride on average?
   - ☐ Less than 5 minutes
   - Around 10 minutes
   - ☐ Around 15 minutes
   - ☐ More than 20 minutes

7. How much do you rely on cycling for transportation? Cycling is my least used form of

- ☐ transportation
- ☐ I sometimes rely on cycling for transportation
- ☐ I often rely on cycling for transportation
- ☐ Cycling is my most used form of transportation

8. Do you use any navigation apps?

- ☐ Yes
- ☐ No

9. If you use navigation apps, which navigational aids do you usually use while cycling?

- ☐ Google Maps
- ☐ Google Maps voice mode
- ☐ Beeline
- ☐ Text instructions
- ☐ Others: _____

10. How many times per week do you use your preferred navigational aid?

- ☐ Less than once a week (I can remember my usual routes)
- ☐ 1
- ☐ 2 to 3
- ☐ 4 or more

11. How familiar are you with your preferred navigational aid?

Not familiar at all

- ☐ Slightly familiar
- ☐ Moderately familiar
- ☐ Very familiar
- ☐ Extremely familiar

12. How comfortable do you feel while using your preferred navigational aid?

- ☐ Not comfortable at all
- ☐ Slightly comfortable
- ☐ Moderately comfortable
- ☐ Very comfortable
- ☐ Extremely comfortable

13. How comfortable do you feel as a cyclist?

- ☐ Not comfortable at all
- ☐ Slightly comfortable
- ☐ Moderately comfortable
- ☐ Very comfortable
- ☐ Extremely comfortable

14. How confident do you feel as a cyclist?

- ☐ Not confident at all
- ☐ Slightly confident
- ☐ Moderately confident
- ☐ Very confident
- ☐ Extremely confident

15. How bicycle-friendly was the city that you grew up in?

- ☐ Not bicycle-friendly at all
- ☐ Slightly bicycle-friendly
- ☐ Moderately bicycle-friendly
- ☐ Very bicycle-friendly
- ☐ Extremely bicycle-friendly

16. How familiar are you with Vinkhuizen?

- ☐ Not familiar at all
- ☐ Slightly familiar
- ☐ Moderately familiar
- ☐ Very familiar

Extremely familiar

Appendix C

Which navigation is used in this part?_____

Questionnaire after each cycling part

You have cycled a part of our route with a certain way of navigation. We now have a few questions for you. Please refrain from discussing your answers with the researcher present.

Your answers will be treated with complete confidentiality.

Please circle the number that best describes your choice.

Please rate how comfortable you felt using the navigational aid in this cycling part:

Not sure	1	2	3	4	5	Very sure

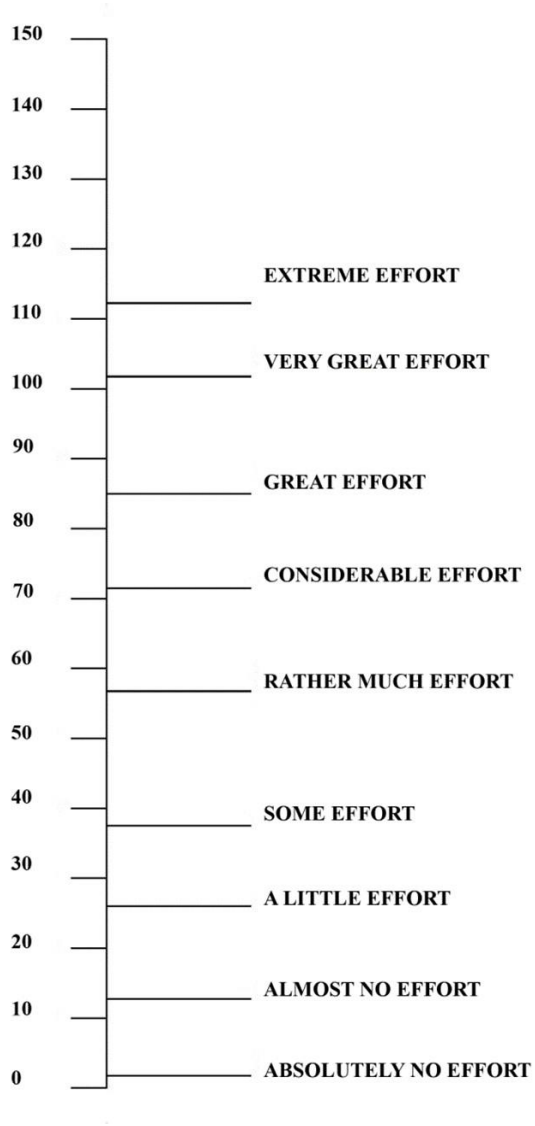
Please rate how much you trusted the instructions during this cycling part:

I did not trust them	1	2	3	4	5	I fully trusted them

Very unlikely	1	2	3	4	5	Very likely

Please rate how likely you are to use the navigational aid from this cycling part in the future:
How much mental effort did navigating this way cost? Please place an X on the scale that you think applies to this navigation device. Do the same for the scale of frustration.

Mental Effort: **Frustration:**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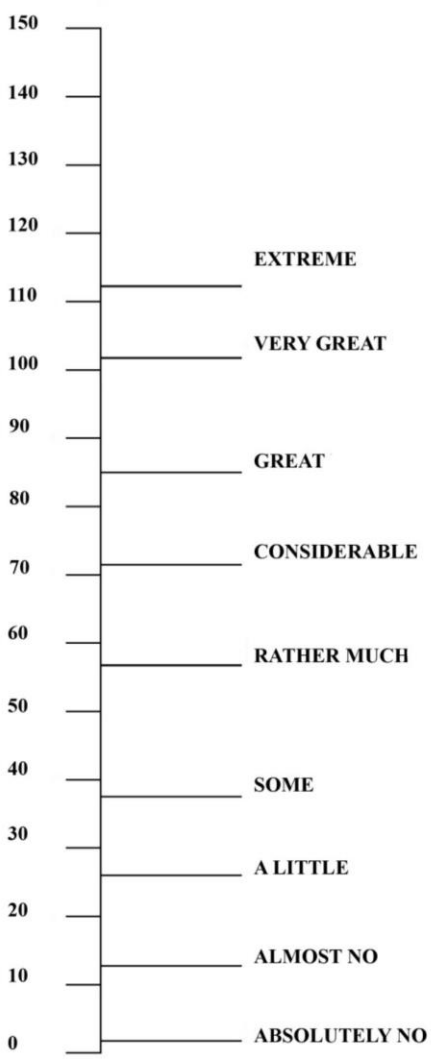
ABSOLUTELY NO EFFORT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