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Investigation of behavioral aspects stimulating cycling: A Flanders, Belgium case study

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Abstract

To elevate adoption levels various interventions, programs and stimulants are being introduced in developed countries. In Flanders such programs exist but current accidents, lower safety perceptions raise ambivalence over their effectiveness and raise urge to evaluate them. To address this a survey was conducted. Results imply that aging category is more concerned about safety, infrastructure, while younger age groups are more inclined towards measures i.e. stimulants, environment and social outlook. Working age class has a delicate transition from youth to aging category with evolution of social economic circumstances. Older age individuals also rely more on peer support, while relative younger people like more of an individualist approach. Intervention programs aiming to reduce traffic interaction, exposure between weak and strong road users stimulates in reducing risk perception among cyclists. Results shall be treated as a guideline for programs implicating safety perception, reduce determinants which effect cycling and ultimately elevating cycling levels.

Keywords: Bicycle Safety; Behavioral aspects; Risk; Infrastructure; Transportation Demand Measures.

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1. Introduction

Cycling is a promising solution addressing mobility, health and environmental issues as well as having a socioeconomic impact. Cycling yields significant health benefits, reduces approximately 6500 deaths per year, increasing the life expectancy by half a year and yielding 3 % of the gross domestic product in terms of health benefits. Thus, the investment in pro-bicycle policies leads to a higher cost-benefit (Fishman et al., 2015). Still, work needs to be done to assess other behavioral aspects which influence cycling adoption. In 2018, the European commission has introduced a strategic plan for 2030 to reduce traffic related fatalities and injuries by half. Moreover, in this plan Connecting Europe Facility (CEF) was created which supports active mobility users and invests into infrastructural intervention programs encouraging cycling (Townsend, 2018).

Previous studies (Ogilvie and Goodman, 2012, Bere et al., 2008, Børrestad et al., 2011, Moudon et al., 2005, Saelens et al., 2003, Ul-Abdin et al., 2018) have investigated the impact of socio-demographics, economics, land use, infrastructure, neighborhood, ethnicity, seasons, distance and physical condition as critical predictors for bicycle use.

Flanders is an interesting area to look into attitudinal aspects for bicyclists. Road users possess significant income and have sufficient accessibility options. The terrain is furthermore flat and a good cycling culture as well as car/bicycle possession level exists and serious mobility issues are present i.e. congestion and fatalities.

The urge to validate current safety levels and their contra-relationship with motivations, barriers, level of service, fears, peer pressure, environment, TDMs, and stimulants is quite important. This has not yet been investigated previously, hence it may lead to interesting conclusions. Table 1 reveals the overview of the motivators, barriers, conditions and stimulants being considered for this study.

Table 1. Overview of the motivators and hindrance for cycling in the study

Motivators and Barriers	**Features incorporated for the study**
Suggestions for improvement	Separate paths Paths with dashed lanes, A change to a bicycle street, Banned entry for cars
Factors implicating motivation	Accessibility, Cost, Congestion, Financial stimulants
Cognitive factors for changing traffic modes	Infrastructure, Safety, Policy, Weather
Alternatives to bicycle use	Public Transport, Bicycle Sharing Program, Taxi, Peer help
Perceived safety levels new Transport Development Measures	Safe, Needs improvement, Convenient but needs improvement, Disaster
Hindrance towards use	Dangerous intersections, Uneven surfaces, Waiting time, Hilliness

Critical features for infrastructure	Sharp curves, Uneven surface, Presence of Cars, Lesser road width Hilliness
Prioritized factors for use	Distance, Infrastructure, Security Repair facilities
Current safety levels	Extremely safe, Safe, Risky, Extremely Risky
Impact of weather	Rain, Snow, Ice
Impact of surface conditions	Potholes or uneven surface
Peer violations	Limited visibility, Not obeying stop signs and priority markings, Red light violation, Driving under the influence of alcohol
Peer pressure	Influence of peer behavior to cycling for utilitarian needs
Impact of surrounding vehicles	No effect, Uncomfortable, Delay, Change of transport mode
Preference for Surface	Asphalt, Concrete, Stones, Earthen Surface
Comparative critical cognitive factors	Safety by numbers, Green environment, Traffic calming measures, Prioritized bicycle path
Impact of TDMs	20 km/h, Dashed colored separate trails, Bicycle street , Banned car entry
Policy implications	Free electric bicycle, Tax reduction, Shower facilities, Per km paid policy, Secure sheds, Third party liability insurance

2. Materials and Methods *2.1.*

Methodology

A stated preference questionnaire survey was designed to assess behavioral aspects for cyclists in Flanders. All age categories were invited to send answers, except cyclists less than 18 years old, since most are not aware of the local traffic and mobility regulations which may induce bias. Respondents in this study were recruited through a combination of campaigns i.e. online advertisement through social media networks, posters, emails and community events. The language of instruction was English and Dutch as per their preference.

This research aims to investigate attitudinal factors influencing cycling among all frequent commuters in Flanders. The investigated variables were sought from the area of sociodemographic, TDMs, risk perception, experience, hindrance, motivation and the influence of infrastructure.

2.2. Pilot study

The developed survey was subjected to a critical evaluation, asking for suggestions, improvements and linguistics remarks. Transportation safety professionals, bicycle clubs' mentors, safety enforcement agents (n=10) who use/monitor cycling on regular basis, were invited to provide a detailed insight in the questionnaire. After receiving this critical analysis and suggestions, it was further improved in terms of content and linguistics.

2.3. Design

The questionnaire was designed to gauge the causal relationship between motivations, barriers, stimulants and features considered critical that exist among cyclists in the Flemish cycling area. A total of 817 respondents were recorded with 55 % of them being female and 45% male. 45% of the respondents felt Safe and 44% of respondents felt risky using the current infrastructure. The majority of the population were educated with a master's (41 %) or bachelors level (35 %). The division for main mode of transport was as follows: cyclists (61.19%), car users (18.60 %), public transport users (18 %), carpooling (0.36%) and foot users (1.46 %). The respondents were only allowed to select one answer. The statistical analysis was done through Microsoft Excel and SPSS version 25 for inferential and summary statistics.

The *socio-demographic* parameters investigated are related to age, gender, income, main mode of commute, household structure for number of cars/bicycles and education.

For evaluating the *attitude towards specific stimuli*, the answers are related to motivation, perception of new mobility regulations, suggestions for safety, influence of vulnerable road users and impact of environmental factors.

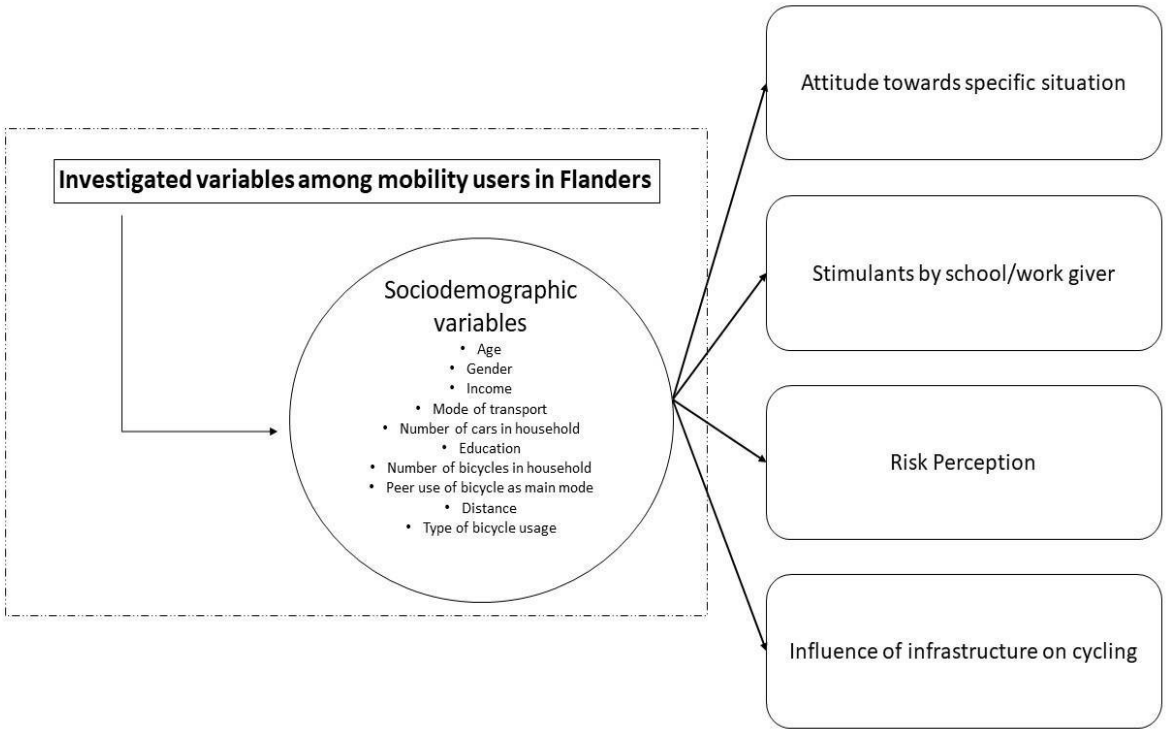


Fig 1. Thematic diagram for investigated variables

For evaluating the risk *perception*, responses were related to modal shift, current safety levels, violations, hindrance and direct objective feeling of Rain, Snow, Ice and uneven potholes. For the questions related to current safety levels, respondents were asked to rank their attitudes according to the scale from Extremely Safe, Safe to Risky and extremely risky. The questions in this analysis had responses more directed towards hypothetical interventions which lessens the chance of ambiguous responses.

For evaluating the *stimulants* by providers, possible responses were related to free first e-bike, tax reduction, shower facilities, secure bicycle sheds, medical insurance, and per paid km policy.

For evaluating the *infrastructural attributes* responses were related to impact of infrastructural features, surface preference, hindrance related to exogenous variables, cognitive motivational & influential factors and intervention programs. For *stimulants* and *infrastructural* attributes the pre-requisite responses were no effect, I will cycle more, cycle more & influence my peers, I will walk more often or I will consider other options i.e. PT/taxi/carpooling.

2.4. Outlier Analysis

The presence of unusual values inside datasets raises concern over the carried out statistical analysis and may induce bias. The presence and removal of outlier variables is a common practice in the scientific community. In this study the abnormalities in this dataset were explored through bar plot stacking.

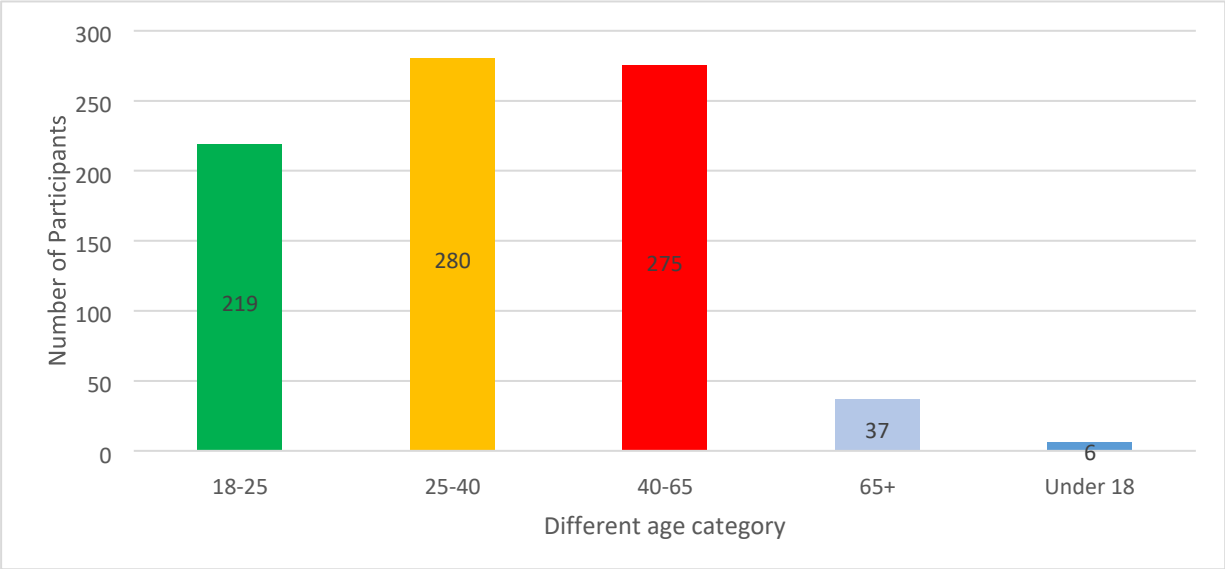


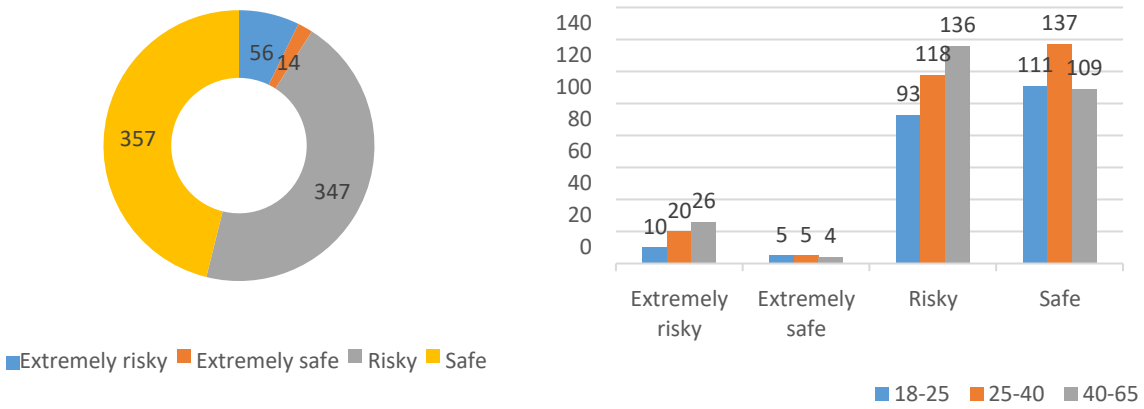
Fig. 2 Age distribution among the participants

Figure 2 represents the age distribution among the participants. The dataset contains substantial responses from age category 18-65 (94.73%) which is the active commuting population of Flanders. The 43 (5.55%) respondents from under 18 (N=6) and 65+ (N=37) were under-represented and possessed some irregularities (i.e. high education and income levels), so these answers were removed.

3. Results

The collected dataset was subjected to a normality test to check the randomness of the results. Afterwards, the dataset is discussed based on the correlation between variables by means of the Chi-square test of independence and the Krukal-Wallis H Test for differences. The Chi-square test of independence determines whether there is a link between two nominal variables. It does this by comparing the observed frequencies in the cells to the frequencies one would expect if there was no association between the two variables. The Kruskal-Wallis H test is a nonparametric test which determines significant differences among group of variables. It predicts whether samples have the same distributions or not. It compares two or more independent samples of equal or different sample size. The Kruskal-Wallis H test determines the stochastic dominance of a specific sample but it does not determine its occurrence, number of pairs or the group for the stochastics dominance.

Figure 3 (a) shows the current risk perception about the Flemish cycling conditions. Overall the Flemmish cyclists rate the cycling conditions as “Risky” (N=347, 44.83%), especially Risky and Extremely risky ratings are combined (N=403, 52.06%). Figure 3 (b) shows the current risk perception considering various age categories. This is also evident and shown by the Krukal-Wallis H test value (2)= 8.011 and p-value = 0.018, which implies that age category responses vary. A higher number of participants among the aging group (40-65) rate the current infrastructure as “Risky” (N= 136, 39.19%), and “Extremely Risky (N=26, 46.42%”), whereas cumulatively they become as (N=162, 40.19%).



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

Fig. 3 Current risk perception with respect to different age categories. (a) Risk perception reviewed by Flemish cyclists (b) Risk perception according to different age categories.

Table 2. Chi-square test of independence.

Investigated Variables with χ^2 test considering age group	**Pearson Chi square Value**	**df**	***p*-value**	***Cramer's V Value***
Socio-demographics				
Gender	9,48	4	0,05	0.07
Income	98,08	10	0,00	0.25
Cars family	164,37	10	0,00	0.32
Main mode transport	43.15	8	0,00	0.16
Education	142.94	10	0,00	0.30
Cycled Antwerp	9,59	2	0,00	0.11
Number of Bicycles	73,54	10	0,00	0.21
Family member uses bicycle	20,64	6	0,00	0.11
Type of road user	29,13	6	0,00	0.13
Distance	73,83	10	0,00	0.21
Preferred bicycle type	82,92	12	0,00	0.23
Attitudes towards specific stimuli				
Motivation bicycle use	44,46	16	0,00	0.16
Attitudes towards problems related cycling	47,12	6	0,00	0.17
Attitude towards new mobility regulations	19,00	8	0,02	0.11
Suggestions for improving safety at intersections	8,80	6	0,19	0.07
Perception importance of safety during busy periods	5,76	6	0,45	0.06
Stimulants				
Secure bicycle sheds	17,89	8	0,02	0.10
Full insurance	24,32	8	0,02	0.12
Paid per km policy	106,77	8	0,00	0.26
First free e-bike	33,32	8	0,00	0.14
Tax reduction	47,83	8	0,00	0.17

Showers arrangements	69,77	8	0,00	0.21
Extra safety at train stations for bicycle users	23,45	8	0,03	0.12
Risk perception				
Important factor for modal shift to bicycle use	38,22	6	0,00	0.157
Current perception of safety	10,51	6	0,10	0.082
Traffic violations by peers	62,00	8	0,00	0.2
Environmental external exogenous factors for bicycling	15.67	6	0,01	0.101
Obstacles in cycling	25.63	8	0,00	0.129
Infrastructural attributes				
Infrastructural factors effecting bicycling	25.42	8	0,00	0.128
Preferred bicycle surface	9,11	6	0,16	0.077
Perceived behavioural factors for cycling	58.97	6	0,00	0.195
Twenty km/h rule	9.92	6	0,12	0.08
Delineated coloured bicycle paths	10.66	6	0.09	0.083
Perceived behavioural infrastructure	6.15	6	0.40	0.063

Table 3. Kruskal-Wallis H Test for differences between mean according to age group

Tested Variables differences	**Kruskal-Wallis H**	**df**	**Asymp. Sig.**
Socio-demographics			
Gender	6,43	2	0,04
Income	40,72	2	Less than 0.05
Main mode transport	0,36	2	0,83
Cars family	56,68	2	Less than 0.05
Education	33,64	2	Less than 0.05
Cycled in antwerp	9,58	2	0,08
Number of bicycles	41,97	2	Less than 0.05
Family member uses bicycle	2,56	2	0,27
Type of road user	17,34	2	Less than 0.05
Distance	54,46	2	Less than 0.05
Preferred bicycle type	56,30	2	Less than 0.05
Attitudes towards specific stimuli			
Motivation bicycle use	3,90	2	0,14
Attitudes towards problems related cycling	20,33	2	Less than 0.05
Attitude towards new mobility regulations	9,67	2	0,08
Suggestions for improving safety at intersections	3,49	2	0,17
Perception importance of safety during busy periods	0,75	2	0,68
Stimulants			
Secure bicycle sheds	7,37	2	0,02
Full insurance	11,65	2	0,03
Paid per km policy	81,18	2	Less than 0.05
First free e-bike	23,37	2	Less than 0.05

Tax reduction	28,50	2	Less than 0.05
Showers arrangements	45,22	2	Less than 0.05
Extra safety at train stations for bicycle users	11,20	2	0,00
Risk perception			
Current perception of safety	8,01	2	0,01
Important factor for modal shift to bicycle use	16,07	2	Less than 0.05
Environmental external exogenous factors for bicycling	10,68	2	0,00
Traffic violations by peers	12,14	2	0,00
Obstacles in cycling	5,39	2	0,06
Infrastructural attributes			
Perceived behavioural factors for cycling	50,47	2	less than 0.05
Twenty km/h rule	0,72	2	0,69
Preferred bicycle surface	6,23	2	0,04
Infrastructural factors effecting bicycling	13,35	2	0,00
Delineated coloured bicycle paths	4,62	2	0,09
Perceived behavioural infrastructure	1,14	2	0,56

The results are discussed in detail with respect to each sub-category in the following section.

4. Discussion

The purpose of this research was to establish an overview for behavioral perceptions towards multiple aspects considering cycling. This included calculating exploratory and inferential aspects of cycling as explained in the thematic diagram as explained in figure 1. This manuscript investigates in detail different behavioral aspects acting cognitively, socially, physically and their adoption towards cycling attitudes. It was difficult to generalize and tabulate a cross-relationship of variables onto each other in detail. However, an elaborated effort was sought, explaining relationship of variables sighted in thematic diagram in figure 1 according to its population demographics.

4.1. Socio-demographics

For this research majority of responses came from educated and higher income levels. For majority of responses under this age category for both statistical test *p*-value was less than 0.05 as shown in table 3 and 4. Respondents possessed education of above bachelor's level (N= 600, 77.51%) and income (N= 323, 41.73%) of above € 28000. Moreover, this investigated pupils were pro-cycling having a good access to a car at home. This finding confirms with (Teyhan et al., 2016, Fitch et al., 2018) that pupil with higher education tend to incline towards positive cycling behavior and act as a responsible peer.

Trip distance were randomly distributed according to age category. Working and Ageing category tend to opt for longer distances, while younger pupils tend to opt for shorted distances (N=86, 39.26%) which is considered very interesting since their physical and social condition has an advantage over others. This aligns with Bere et al. (2008) that trip distance is a significant predictor among young cyclist. These preferences are due to school, grocery, social lifestyle. In Flanders most young pupil are enrolled in school/college for education which lie in urban periphery where basic necessities are not far away. It's a common culture in Flanders pupils at such age hire a temporary student flat in Flanders, which makes the proximity already close to their respective activity centers.

With the introduction of speed bicycles and electric bikes aging population may opt to commute for longer distances. In Flanders employers have already introduced mostly paid per km policy for cyclist average as € 0.22. It is already a topic of debate whether those policies are effective or not, but for aging individuals this possess "no effect" (N= 171 ,62.18%). On average older population of Flanders due to their lifestyle opt not to live in urban

centers, they are more concentrated outside the cities which makes it evident to opt to commute for longer distances. Whereas working class also tend to opt to commute for larger distance.

4.2. Attitudes towards specific stimuli

4.2.1. Motivation & Hindrance for Bicycle Use

Questions related to attitudes towards specific stimuli p-value was not less *than* 0.05 for both statistical tests as shown in table 3 and 4. Significant association among age and motivation to cycle was found $\chi2(16) = 44.46$, $p < 0.00$. Meaning responses vary with varying age. While non-significant association was found for median clusters of age with motivation $\chi2(2) = 3.906$, $p = 0.142$, means that majority had a trend towards a specific measure "Accessibility and Parking". Figure 4(a) show investigated Flemings tend to opt for accessibility (41%), other (24%), lesser congestion (14.17%) and relative cost for Public transport (12.14%).

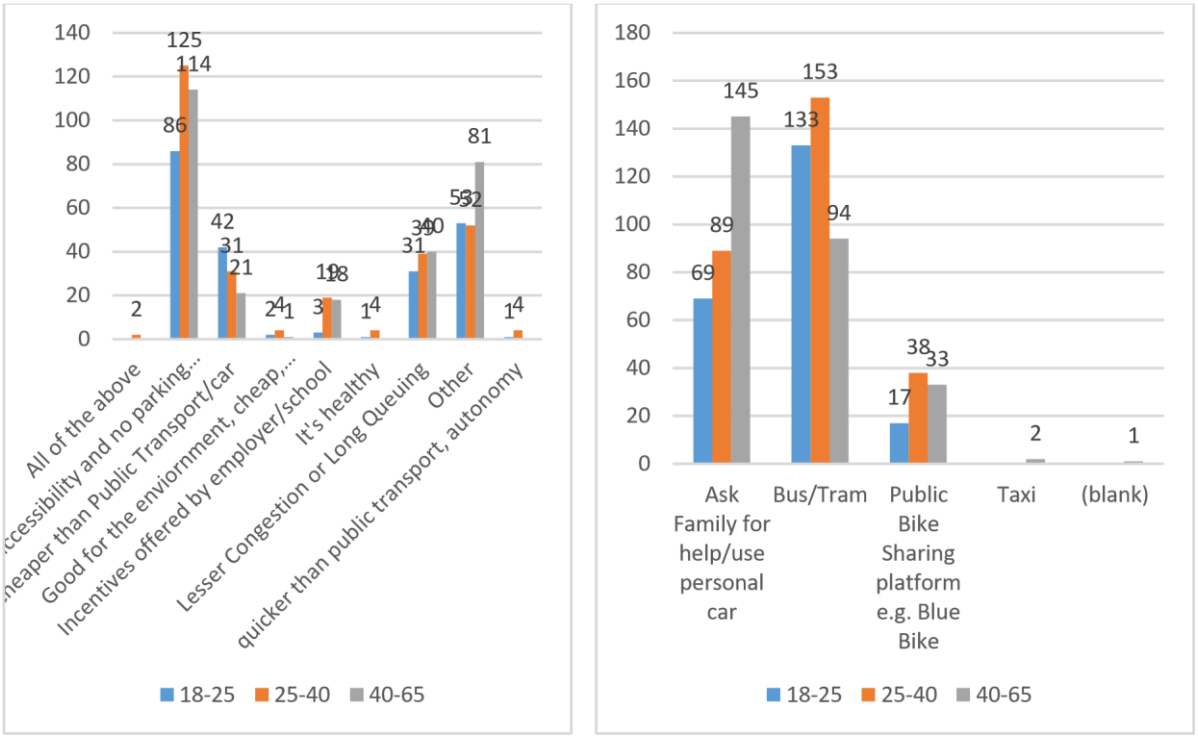
Working age class (25-40) opted for cycling due to mobility issues i.e. Accessibility (N=125, 38.61%) and Congestion (N=39, 35.45%). Table 8 shows contra-multivariate reasons for hindrance and motivation for cycling. Since motivation and hindrance to cycling are interrelated issues but the factors behind are different. Motivation to cycle is more inclined towards mobility issues i.e. accessibility, congestion, distance, appeal of nature, whereas hindrance to cycling is related to risk perception i.e. coherency and infrastructure, presence of car users, separate prioritized bicycle path, hilliness and Blind spots.

Table 4. Represent contra-multivariate reasons for cycling

Critical factors for cycling behavior	**Reason**
Motivation	Accessibility, Congestion, other, nature, distance
Hindrance	Coherency & depth of Infrastructure, Presence of car users and prioritized bicycle path, Hilliness , Longer distance, Blind spots

Hindrance associated with cycling which leads not to cycle are presence of car users and exogenous factors. These factors are considered critical for deciding risk levels. Factors behind hindrance aligns with the findings of Jacobsen (2015) that risk perceptions are dependent on the phenomenon of Safety in numbers. Here it does not have negative association if presence of same mode of transport i.e. more cycle users. But certainly, is negatively associated if presence of opposite number of transport mode i.e. car users. Further risk levels are also associated with "road width" due to the fact that it reduces exposure for cyclists to overcome possible collision and attracts comfortable cycling.

In case a problem arises while cycling, figure 4 (b) shows all groups opted for Public Transport (N=380, 49%). Ageing category opted for more personalized care (N=145, 47.85%) in case of issue. The working category (N=153, 40.26%) and younger category (N= 133, 35%) opt to travel with more independence therefore choosing for PT option, this may be inferred as family members or peers at such age tend to work and are not available. Whereas for older age segments peers tend to be available because children have entered the adult zone, and friends or partners may adopt for self-independent activities.



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

Fig. 4 Responses towards "motivation to cycle" and "new mobility regulations" (a) Motivation to cycle with respect to different age categories. (b) Attitudes towards new mobility regulations with respect to different age categories.

Flemings on average tend to be overall satisfied with the new mobility regulations but yet consider ample room for improvement (N= 560, 72.35%). Ageing category are most concerned about the current regulations and still rate it as "Risky" (N=111, 40.36%).

In case of abundant car users aging category (40-65) are concerned the most having the highest tendency to consider a delay (48.88%) and change of travel mode (38.57%). Whereas working age group (25-40) consider travelling with car users are uncomfortable and tend to be more careful (N=134, 35.82%).

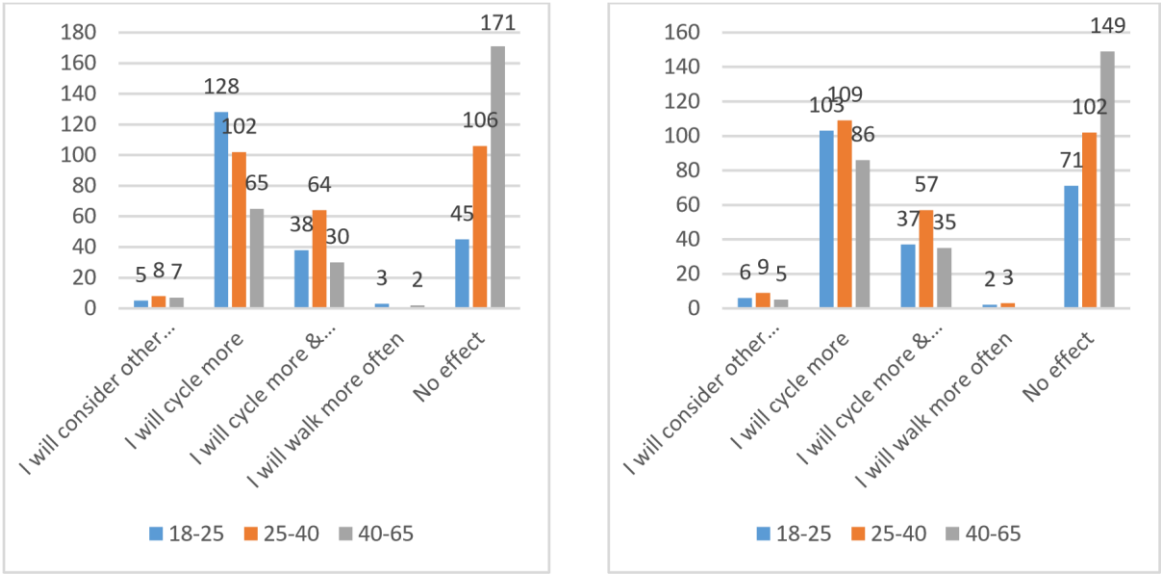
To be noted Flemings tend to opt separation over priority in terms of cycling. This is a very interesting finding, since mostly Flemish government are introducing bicycle streets which share road with cars and have priority over traffic. The stated intervention is certainly not highly regarded among active cycling groups who demand for more freedom and space with current traffic state. This finding confirms with Hamilton-Baillie and Jones (2005) that giving more freedom and separation from regular traffic increases safety perception and attracts more cyclists.

4.3. Stimulants

4.3.1. Influencing factors for choice adoption

For stimulants p-value was less than 0.05 for both statistical tests as shown in table 3 and 4. Responses varied among different age categories. Figure 5(a) shows "*paid per km policy*" ageing group category (40-65) (N=171, 53.1 %) had the highest cluster among "no effect". A further explanation is aging individuals, have already developed a habit of cycling as seen earlier and prefer to cycle for higher distance, are educated and work. They are already engaged in an active physical behavior of cycling, and they don't find this stimulant as a profound factor for arousal. Therefore, this stimulant is not considered to have any prominent effect on aging individuals. Whereas younger age category (N=128, 43.38%), have the highest cluster for response "I will cycle more".

Currently in Flanders paid per km policy is not yet being introduced for education institutions. Hence it can be explained that younger people tend to have positive reflection for this stimulant. Working class age category (N=64, 48.48%) have the highest cluster for the response category "I will cycle more and influence my peers". This is very promising result since this age category already have access to car, children at home, and classified as working category which means they do not have monetary issues. The stimulant "*paid per km*" has a positive influence on younger and working-class age category. Whereas older age has no effect due to the factor their habits have already being developed.



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

Fig 5. Responses towards stimulants "paid per km policy" and "electric bicycle" (a) Stimulant paid per km policy according to different age categories. (b) Stimulant first free electric bicycle according to different age categories.

In figure 5 (b) electric bicycle policy ageing group category (40-65) (N=149, 46.27 %) had the highest cluster among "no effect". A further explanation is that this age category, has already developed a habit of cycling as seen earlier that they prefer to cycle at for higher distance and has a good peer support as well. They continue to exhibit cycling habit due to work, rely on peer support. They don't find this stimulant as a profound factor for arousal as response to intensify habit or influence peers for cycling. Whereas younger age category (N=103, 34.56%), responded "I will cycle more". Currently in Flanders free electric bicycle is only functional for working class. Hence it can be explained that younger people tend to have positive reflection for this stimulant. Working class age category (N=109, 36.57%) have the highest cluster for the response category "I will cycle more". N=109, 36.57% for response "I will cycle more and influence my peers". Working class is considered to have positive reflection towards stimulant "electric bicycle". In figure 5 (b) the stimulant "*electric bicycle*" has a positive influence on young and working-class age category. Whereas older age group tend not to intensity for no effect to due losing the sportive perception towards cycling through electric bicycle.

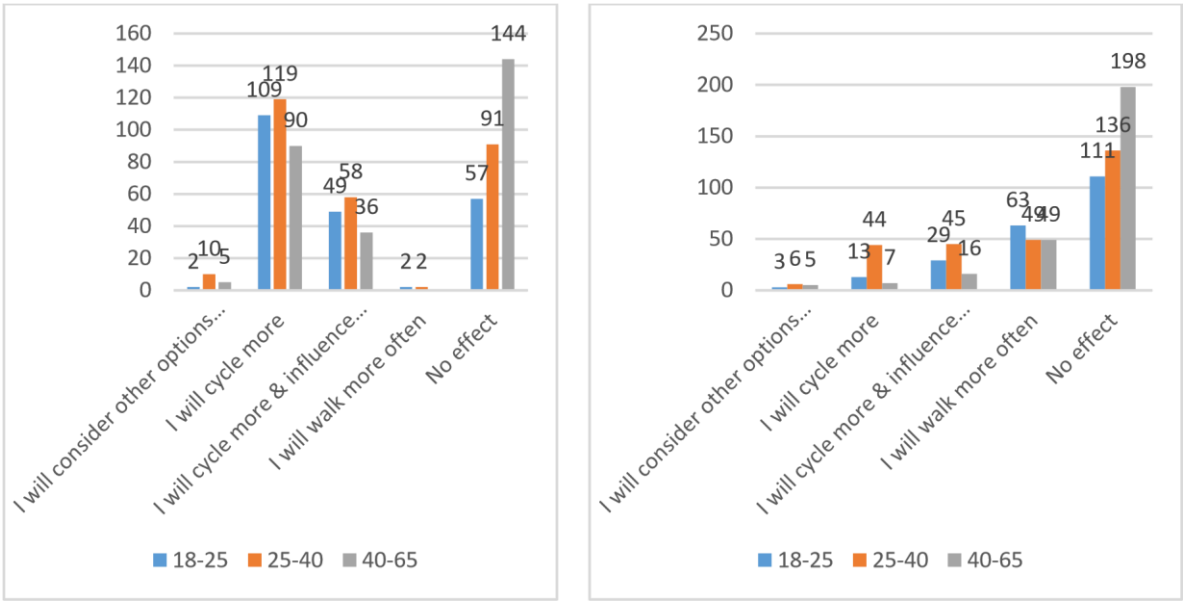


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Fig 6. Responses towards stimulants "tax reduction" and "Showers arrangement" (a) Stimulant tax reduction policy according to different age categories. (b) Stimulant Showers arrangement according to different age categories.

In figure 6 (a) "tax reduction" stimulant ageing category (N=144, 49.31 %) had the highest cluster of among "no effect". A further explanation is that this age category, has already developed a habit of cycling as seen earlier that they prefer to cycle at for higher distance, and have a good peer support as well. They continue to exhibit cycling habit due to work, rely on peer support, and not get influenced by tax reduction. Whereas working (N=119, 42.5%) and younger age category (N=109, 34.27%), have the highest cluster for response "I will cycle more". Currently in Flanders tax reduction policy is only functional for working class. Hence it can be explained that younger people tend to have positive reflection & welcoming behavior for tax reduction. A sufficient explanation of this means that younger people due to their open to knowledge thinking tend to intensify habit and influence peers by this habit. The stimulant "tax reduction" has a positive influence on working group and young age category. In figure 6 (b) only the stimulant "Shower arrangement" had "I will walk more often" response (N=161, 20.80%). With younger age group with the highest cluster (N=63, 28.76 %). With the introduction of the stimulant "Showers arrangement" people may reveal the tendency of engaging in fitness related activities i.e. running. The exercises eventually create sweat and later a respondent may use the opportunity to get fresh. These findings confirm with (Jaffe, Mata et al. 2017) that incentives stimulate mobility behavior and yield prospect benefits for organizations offering them.

4.4. Risk perception

Risk perception varied according to age category in most cases with $p < 0.05$ for both tests as shown in table 3 and 4. This laid a foundation for variation among responses. Overall aging category (40-65) (N= 136, 39.19%) was concerned about the current level of infrastructure leading to risk engagement. Whereas relative younger individuals ranging from 18-40 (N= 248, 69.46%) considered it safe and tend to be satisfied with infrastructure. Cross validation of satisfaction levels for recent mobility regulations (N=560, 72.35%) also considered it convenient. These finding are in accordance DiGioia et al. (2017) that risk perception changes due to change in level of service within different locations. Further variation in risk perception may be noted due to varying lifestyle, distinct proximity, individual experiences and etc. Respondents possessed handsome accessibility of car (N=607, 78.42%) and bicycle (N= 762, 98.44%) at home. Due to presence of more than three bicycles at home (N=384, 49.61%) Flemings had a good peer support for cycling at home (N= 463, 60%) leading to participation in leisure, school and work activities. While for pupils having non availability of bicycle at home may opt for BSS platforms which are also widely available in Flanders. Relatively young Flemings (18-40, N= 113, 14.59 %) even despite of

good arrangements at home for bicycles and cars, tend also to opt for PT options for both Utilitarian and leisure purposes.

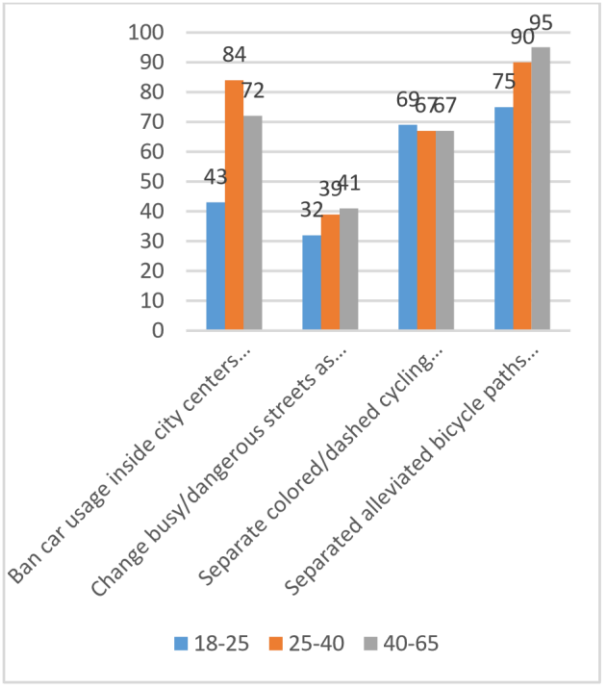
According to figure 3(b) user risk perception changes according to their relative experience. Higher number of cycled km's lead to more exposure to various conditions i.e. infrastructure, environment, cyclist behavior and which eventually leads to a more experience cyclists. It is interesting to see experience cyclists (per cycle km's) tend to rate conditions "Risky", whereas lesser experience cyclists (per cycle km's) lead to rate conditions as safe. This confirms with the findings of Heinen et al. (2011) that longer distance bicycle commute plays a significant role, explanatory power increases and user enjoys better attitudes, habits and norms in a more effective manner. This study confirms that longer distance ultimately results into better user experience, more exposure to conditions and better understanding of risk. Whereas notably this study also differs with the finding by (Heinen et al., 2011) that higher cycling distance is not a significant predictor for safety perception.

It can be inferred among all age groups unanimously perceive risk (related infrastructure) in Flanders as critical and important factor for modal shift. Risk perception is considered high and overall cyclist pupils tend not to be comfortable with current infrastructural measures. Infrastructural features need to be addressed cumulatively by governments. Since the mobility regulations were recently introduced this may have influenced the responses (reduced) among cyclists. Moreover, weathering conditions (especially for younger category) are also citied critical but may be individually addressed and cannot be addressed through cumulative policy.

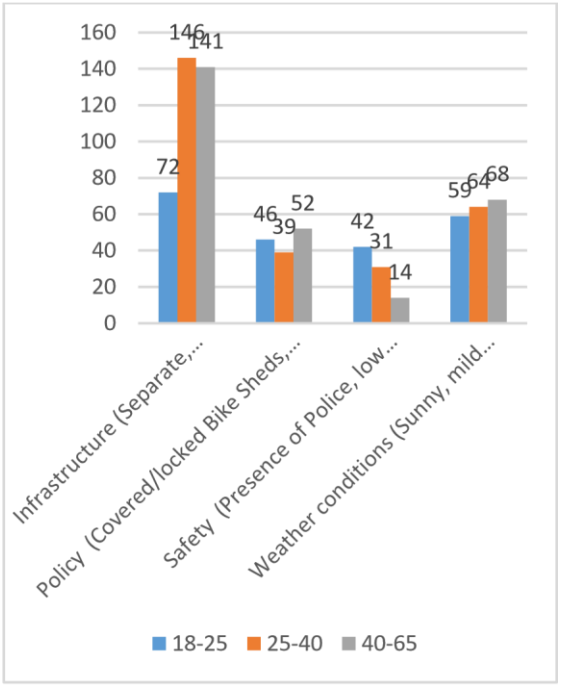
4.5. Infrastructural attributes

4.5.1. Suggestions for improving safety at intersections

Respondents were asked for possible suggestions for improving safety at intersections. No significant association was found between age and response $\chi 2$ (6) = 8.8, p = 0.19. Neither any significant association was found among medians since Kruskal Wallis test reveals, test value (2) = 3.49, p= 0.174. Figure 7(a) show respondents Presence of car users in traffic and removing them was a suggestion for working class (N= 84, 38.35%). While younger and ageing category perceived infrastructural features (Separate bicycle paths) as important for suggestion. To be noted both relates into separation of traffic indirectly, which is in conjunction with the findings of (Hamilton-Baillie and Jones 2005).



(a)



(b)

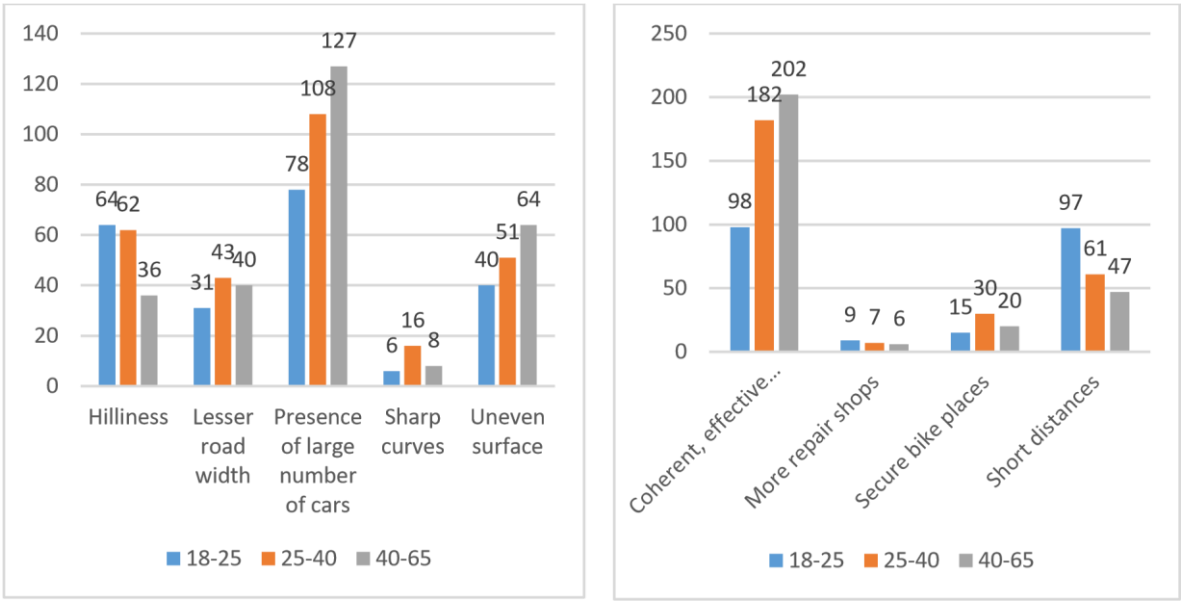
Fig 7. Responses towards stimulants "Suggestions for Improving safety at intersections" and "Important factor for modal shift to bicycle use" (a) Suggestions for Improving safety at intersections (b) Important factor for modal shift to bicycle use.

4.5.2. Important factor for modal shift to bicycle use

Respondents were investigated for critical factor for modal shift. Significant association was found between age and response $\chi 2$ (6) = 38.22, $p < 0.05$. Significant association was found among medians since Kruskal Wallis test reveals, test value (2) = 16.073, $p < 0.05$. Figure 7(b) show respondents Infrastructure (N=359, 46.38%) and weather conditions (N=191, 26.67%) were considered most important for a possible modal shift. This aligns with the findings of R.Nieuwkamp, 2018 that infrastructure and weather play a critical role in safety perception of weak road users and may led to accidents (R. Nieuwkamp 2018).

4.5.3. Infrastructural Factors Effecting Bicycling

Respondents were investigated for exogenous factors effecting bicyclist not to cycle. Significant association was found between age and response $\chi 2$ (8) = 25.422, $p < 0.001$. Significant association was found among medians since Kruskal Wallis test reveals, test value (2) = 13.357, $p < 0.05$. Figure 8(b) show respondents rated presence of cars (N=313, 40.43%), hilliness (N=162, 20.93%) and uneven surfaces (N=155, 20.25%) for possible exogenous factors not to cycle.



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

Fig 8. Responses towards infrastructural features "Infrastructural Factors Effecting Bicycling" and "Perceived Behavioral Factors for Cycling" (a) Infrastructural Factors Effecting Bicycling according to different age categories. (b) Perceived Behavioral Factors for Cycling.

4.5.4. Perceived Behavioral Factors for Cycling

Respondents were asked for most pleasant features which appeal to cycle. Significant association was found between age and response $\chi 2$ (6) = 58.976, $p < 0.05$. Significant association was found among medians since Kruskal Wallis test reveals, test value (2) = 50.477, $p< 0.05$. Figure 8(b) show respondents rated coherent and effective infrastructure (N= 482, 62.27%), Short Distance (N=205, 26.48%) as important. Whereas younger age category majorly chooses for short distance (N=97, 47.31%).

5. Conclusions

This manuscript takes into account various TDMs, critical features for choice adoption, and perceived factors influencing risk perception. The investigation is done by classifying bicycle riders according to their age categories. The investigation was based on multiple cross questioning for risk perception, perception of infrastructure, influence of TDMs and their relevance to behavior. The critical features which differentiates this manuscript from previous studies is that special attention is sought regarding features effecting modal choice and further investigation is lied according to motivators, barriers and stimulants accordingly. Heterogeneity among cyclists were taken into account while segregating population segments according to their age categories. The calculated results may be treated as a guideline for decision makers to design programs implicating safety perception, reduce determinants which effect cycling and ultimately elevating cycling levels. The results reveal mix effect, yielding varied responses and unanimous responses against specific measures according to age classification. Age categories were noted as critical indictor for choice prediction due to the fact that variation in responses were seen as comparing to younger and working pupils. The variation in responses were recorded due to experience, barriers regarding cycling, lifestyle and proximity of home to activity (urban/suburban periphery). Aged individual perceived risk better, due to their cycling experience, longer distance, cycling preference, attitudes towards TDMs and infrastructural features. Unanimously among all age segments infrastructural features were termed as critical. Whereas "Presence of strong road users" also raised concerns for cycling attitude. Interesting finding is that Cyclists in Flanders had a different perception, attitude towards pyramid (Scheltema, 2012) and the responses varied accordingly. Ageing segments rated "Safety" i.e. As the most critical features. While youngest age group rated "Comfort" i.e. Hilliness as a significant feature. While working class had a mixed preference and attitudes towards the pyramid.

Important demographic feature reveals that participants had higher education (above bachelor's education 77.51%) and were pro-cycling (62%). According to Peck (2011) education programs help reduce traffic violations. Educated individuals have tendency to abide by traffic laws due to knowledge acknowledgment. They tend not to engage in risky behavior leading to conflict.

The segregation of results among different behavioural classes reveal that it was useful for reflection for individual attributes towards various situations. TDMs measures only attracts certain behavioural classes/age categories does not attract all of them. Traffic calming measures which result in lesser exposure between weak and strong road users were helpful while other measures such as 20 km/h and added benefits of cycling at work/school were not effective. Hence addressing perceived risk for traffic participation is a multifaceted problem.

Unfortunately, none of the above features address the effect of behavioural perception of cycling for nonbicyclists. Hence through this research, the authors only could address behavioural aspects for active or passive cycling users and *not for non-cycling users i.e. car and public transport.* The research may be considered prominent especially in Flemish context because it helps creates guidelines for effective interventions and mitigation of risk perception.

To understand critical factors related to adoption of cycling, a clear distinction shall be made according to different behavioural classes. In this study those behavioural classes were distinguished as age categories. In the age categories the behaviour tends to differ due to multiple reasons i.e. experience, perception, need, purpose, cost, proximity, available facility and incentives. Thus, to understand behavioural differences among young, working and aging commuters is considered very critical. The findings of this study suggest that for aging commuters' safety features such as *separate trails, risk associated with motorised traffic, blind spots are considered critical*. However, for young commuters, environmental factors such as *distance, hilliness, terrain* and also stimulants such as tax reduction, paid per km policy and *first free electric bicycle* were considered important. Yet this has to be relatively validated since for Flemish context those stimulants are not yet available widely throughout mentioned age category.

For *working class* users *appeal of nature, coherency/effectiveness of infrastructure and stimulants i.e. tax reduction, free electric bicycle are considered important*. To be noted working class category had the both mixed attributes associated with young and aging group. This can be explained since this age stage is a delicate transition from youth to aging category with evolution of social economic circumstances. The results imply that aging category is more concerned about safety and infrastructure, while younger age groups are more inclined towards measures i.e. stimulants, environment and social outlook.

Older age individuals also rely more on peer support, while relative younger people like more of an individualist approach. Aging group considers infrastructure as "Risky", while younger and working class consider is "Safe".

Table 5 . Factors associated with cycling behaviour

Age category	Motivations	Barriers	Factors influencing choice adoption
18-25	More individualists, Accessibility & Parking, Shorter distance.	Long Distance, Hilliness	Tax Reduction, Paid km policy and first electric bicycle, separate elevated trail, Infrastructure
25-40	More individualists, Appeal of Nature, Accessibility and Parking	Motorized traffic, More Freedom from traffic, Blind spots	Coherency of infrastructure, Tax reduction and free electric bicycle separate elevated trail, Infrastructure (Separation, Prioritization, Elevation of trails)
40-65	Accessibility, Parking & other	Rely on peers, Motorize traffic, blind spots, and perceived infrastructure as risky, separate trails. Blind spots	Coherency of infrastructure, Motorized traffic, attracts longer distance, Infrastructure (Separation, Prioritization, Elevation of trails)

Transportation programs which aims at reducing traffic interaction, exposure between weak and strong road users help in reducing risk perception especially among cyclists. Most effective among them are reducing accessibility for strong road users for Central Business District (CBDs) and redesigning bicycle paths to prioritized, elevated and reflective manner. The discussed interventions will induce perception of liberty, safety, risk reduction and will certainly encourage people to use bicycles for utilitarian needs. Future policy makers shall ponder their focus on how to reduce risk perception of going through vulnerable intersection for cyclists? It is considered the most significant obstacle preventing users from cycling, but yet needs detailed investigation of how this may be treated effectively.

Providing a safe and separate cycling infrastructure helps improve safety perceptions not only for experienced cycling users but potential future cyclist. This research helps identify that multiple factors contribute to cycle or not. This include *perceived safety* among users according to their virtue of experience identified through age influenced by factors such as *presence of strong road users* (Cars), vulnerable intersections (*blinds pots*), *separation and priority* over normal traffic and other non-safety related issues i.e. congestion, parking and relative time consumption in trip.

In future studies special focus shall be shed for car users and their behaviour related to cycling, towards factors related to cycle or not cycle. Moreover, attitudinal behaviour of car users towards cyclists is also important and its nature shall be investigated as *aggressive or passive*. This is critical since cars users contribute as the major proportion of traffic situation in Flanders.

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