A BEHAVIOURAL VIEW: BICYCLE LIGHTS

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24-6-2016

RADBOUD UNIVERSITY Master thesis for Economics and Policy

1. Abstract

This study is an attempt to find the underlying factors that cause people to ignore the bicycle light regulation, which would explain the high rate of offenders. With two different revealed behavioural dummies, (1) having bicycle lights and (2) buying bicycle lights, we test the behaviour towards bicycle lights. Our survey was fulfilled by 144 cyclists, 59 of them did not have bicycle lights ('offenders'). We included questions regarding the theory of planned behaviour, the health belief model, the deterrence theory and an intention action gap model, complemented with 2 context variables for buying bicycle lights. We found that a higher willingness to buy was only explained by the context with the highest need, when leaving the bicycle shed during darkness. We find that both the subjective norm and the behavioural control are relevant for the use of bicycle lights. Individuality barriers were also more likely to be experienced by offenders. Therefore we can state that the offending behaviour of cyclists without lights is explained by the difficulties to actively commit to intentions due to practicality and individuality barriers and planning difficulties.

Key words: Bicycle lights, willingness to buy, deterrence theory, health belief model, theory of planned behaviour, intention action gap.

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2. Introduction

This study reveals that the behaviour of purchasing bicycle lights is only effected by the context of direct need. The revealed behaviour of the willingness to buy bicycle lights is higher when it is dark and especially when the cyclist is leaving during darkness. Other aspects do appear to be irrelevant for the willingness to buy, including the perception of police enforcement and health belief. The fact that a cyclist directly shows offending behaviour when he refuses this offer does increase his willingness to buy. This reveals that the cyclist has the intention to have bicycle lights when cycling in darkness, but lacks in anticipating on this intention.

Bicycle lights do improve traffic safety in darkness, when traffic is most dangerous (Reurings, 2010). Together with retro-reflecting material and street lighting, bicycle lights improve visibility and decreases the risk of an accident. Additionally they are assumed to decrease severity due to reduced reaction time and the ability to take evasive action for the vehicle driver involved in the accident (Kim, Kim, Ulfarson, & Poretto, 2007; Kwan, & Mapstone, 2006). In several countries it is therefore mandatory to use lights during night-time, including the Netherlands. By cycling without bicycle lights, you risk a fine of more than 60 euro. Meanwhile, the observations of Rijkswaterstaat (2013) record a fluctuation of around 60% of the total cyclists to have bicycle lights over the last decade. This low level does show the failure of both public campaigns and police enforcement to put cyclists up to the bicycle lights.

This study attempts to find the underlying factors that cause people to ignore the regulation, which would explain the high rate of offenders. The relevant question is: Why do cyclists have no light on their bicycle? With the behavioural economic view, our focus is on the psychological determinants of behaviour concerning bicycle lights. We study these factors with a questionnaire about particular perceptions of police enforcement, the danger in traffic and the barriers regarding the consumption or maintenance of bicycle lights. We can test the behaviour towards bicycle lights by the observation of having bicycle lights or not. Additionally, we offer the offenders to buy bicycle lights during the questionnaire, which is considered a revealed behaviour for the willingness to buy bicycle lights. This enables us to compare the indicated values from the questionnaire with the two different revealed behaviours.

We expected that cyclists are affected by planning difficulties which restrain them from buying bicycle lights. We confirm this assumption by performing the questionnaire in different settings. Because cyclists are required to have bicycle lights during darkness, we assume that the bicycle lights are present irrespective of time or sunlight. Therefore, the possession of light should not differ during daylight or darkness. But during darkness, we confirmed that cyclists are more eager to buy lights

compared to during daylight. The higher willingness to buy during darkness is because of the obligation on account of regulations and the added value in terms of visibility compared to during dusk. Likewise, we expected higher willingness to buy when the cyclist wants to cycle away instead of when he or she is parking the bicycle, because of the need of bicycle lights when the cyclists is cycling away. Both effects do indicate that the behaviour towards the purchase is characterised by inconsistency in the willingness to buy bicycle lights.

Additional to the contexts, we try to analyse the behaviour towards bicycle lights with four behavioural models. For the case of bicycle lights use, we do expect that neither the health belief model nor the deterrence theory will have very strong predicting power. It is therefore assumed that the offending cyclists do not perceive these risks less likely. A stronger impact is assigned to the lack of cyclists to foresee their need in bicycle lights or their ability to fulfil their intention, which was also evident in the willingness to buy. Both the models we use based on the theory of planned behaviour and the intention action gap should therefore have components that do explain behaviour towards bicycle lights. In line with the inconsistent behaviour we observe in the willingness to buy, we assume that offending behaviour is explained by the failure to commit to the intention to have bicycle lights.

3. Theory and measures used

A specific behavioural tool to encourage desirable behaviour is called 'nudging' or 'libertarian paternalism'. It can be described as a way to steer people's behaviour by changing the context without any form of enforcement. Thaler and Sunstein (2003, p. 5) described it as a "self- consciously attempt" to help people make more healthy, sustainable or social decisions. Such an approach towards bicycle lights is more or less absent in academic literature. This behavioural experiment will try to find the determinants that might change the behaviour of cyclists to help them cycle more safely in traffic.

How can we influence cyclists to use bicycle lights? Well, there are two distinctive motivators, the intrinsic and the extrinsic determined motivators (Deci, & Ryan, 1985). Both intrinsic and extrinsic motivators depend on a reward or punishment, which will encourage the preferred practise or behaviour. Intrinsic motivators originate from the organic need to be competent and is self-determining. The reward is thereby inherent in the activity itself. For the case of bicycle lights, the obvious intrinsic motivators are the perception of norms and the willingness to cycle safely. Extrinsic motivators are created by a reward which is imposed upon the individual. The current fine for non-provision is a clear example of an extrinsic motivator.

To include relevant aspects for the behaviour towards bicycle lights, we will construct several models to predict the use. These models are based on relevant theories regarding safety behaviour, commitment to intentions and risk aversion. We use the deterrence theory, the health belief, theory of planned behaviour and the intention action gap. We will introduce these theories and the corresponding operationalisation in the upcoming sections.

3.1 Deterrence theory

Fines are assumed to reduce the occurrence of the undesired behaviour, according to the deterrence theory originating from written work from Beccaria (1764/1963), Bentham (1789) and Becker (1968). The theory states that criminals, or offenders in this case, are rational agents that weigh the costs and benefits of their offending activity before deciding to execute it. Offenders are expected to withhold the activity when the net benefits become negative. The particular costs are determined by the perception of severity and the certainty of punishment, together with personal preferences (Polinsky, & Shavel, 1979). In case of the bicycle lights, the fine might be weighed against the price of batteries, led lights or the maintenance of the dynamo, which leaves the cyclist with a cost-benefit analysis. If this is the case, an increase in the level of the fine or of the level of police enforcement would be effective to deter offending behaviour.

Because of the extrinsic motivation of the fine, cyclists could approach the use of bicycle lights strategically. It is possible that such an approach might crowd out other reasons for having bicycle lights, it might crowd out the intrinsic motivation (Gneezy, & Rustichini, 2000). This would be the case when cyclists make the cost-benefit analysis and are merely not persuaded to use bicycle lights by the level of the fine and the severity of the police enforcement. When the cyclist does consider the behaviour strategically, he might be tended to undermine his intrinsic motivation. Evidence for the crowding out effect was for example observable in the experiment of Deci (1975), two groups of college students were paid or not paid to work on an interesting puzzle. The students who did not get paid in the first stage, stayed significantly longer after this first stage to finish the puzzle in the second stage when neither students get paid. In the long run, the monetary incentive might have opposite results, because the intrinsic motivation is disregarded or ‘crowded out’.

3.1.1 Deterrence theory operationalisation

To test the existence of the costs-benefit analysis for the case of bicycle lights, we need to capture all determinants for such an analysis. Therefore we included four questions. We asked the cyclist about their perception regarding the level of the police enforcement, or the frequency of getting caught in a whole year (*Police*). The assumed costs of offending behaviour are the indicated costs of the fine for cycling without both front and rear bicycle lights (*Fine(€)*). As an additional feature, we asked the

cyclists about their experience of being caught and if that has occurred in the past half year (resp. *Fined* and *FinedHY*), this might explain a higher perception of the police enforcement.

For the cost-benefit analysis, we should weigh the costs of offending with the costs for aligning behaviour. The costs of aligning behaviour in this case, are the costs of the bicycle lights. By asking about the price of the cheapest lights available, we make the question unilateral for the sake of comparison (*LED(€)*). We will test the effect of each separate component on the revealed behaviour (squares in figure 1) and the cost-benefit analysis is tested with the constructed variable (*CostBenefit*; circle in figure 1) of the following formula:

$$CostBenefit = (Police/365) * (BicycleUsage * 35) * (Fine(€)) - (LED(€) * 5) \quad (1)$$

The perception of Police enforcement *(Police)* is divided by 365 days to transform the variable in terms of *Police* per day. Then it is multiplied by the indicated days the respondent cycles in a week (*BicycleUsage*) and the average working weeks a year (45 minus 10 to control for summer days cycling). In this way, the experienced police enforcement is transformed to the indicated frequency of cycling in a year. This is multiplied with the indication of the costs of the fine. On the right end of the equation are the costs for bicycle lights, which are multiplied with 5. We assume that the cyclists will have to buy bicycle lights around 5 times per year. Since we asked for the cheapest ones available, it is likely that these do not work very long or that other, more expensive lights are purchased instead. That would lead to higher costs. We simply weigh the overall costs for bicycle lights by subtracting that from the costs of getting caught. We assume that a rational, money maximizing individual will use a comparable trade-off to determine its behaviour regarding the use of bicycle lights.

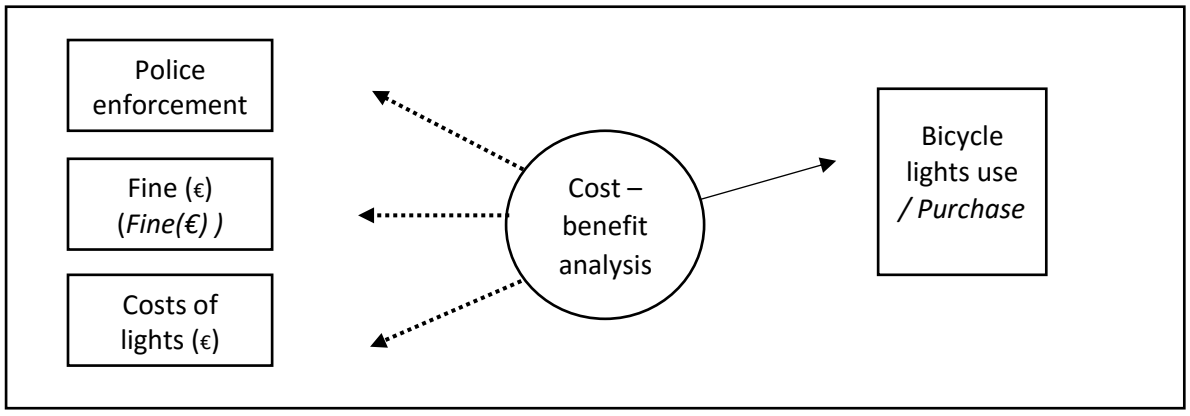

Fig 1: *Deterrence theory model to predict the behaviour towards bicycle lights. The circle does represent the predicted values of the CostBenefit formula (1), rectangles are indicated components and arrows represent logistic regression estimators for the according revealed behaviour.*

Table 1: Deterence model components and factors

Variable	Description
Fine(€)	How expensive is the fine? (€)
Police	In 365 days cycling, how many days would you expect to get fined?
LED(€)	How expensive are the cheapest lights?(€)
CostBenefit	(Police/365)*(BicycleUsage*35)* (Fine(€)) - (LED(€) *5)
BCostBenefit	=1 if CostBenefit is positive
RelFined	=1 if ever been fined for not having bicycle lights
Fined	=1 if received a fine during the past half year
FinedHY	=1 if knows family or friends who are fined during past half year

3.2 Health belief

Safety equipment is meant to contribute to traffic safety and health. Whether the use of bicycle lights is explained by the differences in the perception of traffic safety during darkness is tested with the health belief model. This health belief model (HBM) constructed by Rosenstock (1966, 1974) distinguishes two aspects of health belief: threat perception and behavioural evaluation. For threat perception there are two components, which are perceived susceptibility and anticipated severity. The first refers to the perception of susceptibility to a cycling accident and the latter to the severity felt by the consequences of this accident. With these two components we assume to capture the risks in terms of the traffic safety and health consequences. The behavioural evaluation has also two sets of beliefs, namely the perceived benefits and perceived barriers regarding the performance of health behaviour. Perceived benefits are indirect gains from behaving safely, the image of being 'cool' when you have a motor helmet for example. On the contrary, the perceived barriers refer to the barriers to enact the health behaviour. For a bicycle helmet, someone might for example withhold from using it because he or she beliefs it will cause bullying, because it is 'not cool'.

3.2.1 Health belief operationalisation

The two components of threat perception and behavioural evaluation are determined each by two questions. The susceptibility is approached by an estimation of the number of accidents in a year when cycling at night without bicycle lights (*Susceptibility*). This way of phrasing is intended to be more intuitive than a relative estimation. Additionally, the anticipated severity is approached with an estimate of the number of deadly accidents out of a hundred (Severity). In that way we hope to measure the belief of serious risks in terms of health. For the behavioural evaluation, the framework concerns about two distinct beliefs. The first is related to barriers, which we will determine with the effect of peer pressure (*Friends)*. Teenagers or students might have different perspectives of 'cool' behaviour than adults do, what might influence behaviour as well. The second question concerning belief is about the benefits of bicycle lights, which is captured by the question about the feeling of increased safety (*Safeness*).

Table 2: Components and factors of the HBM

Variable name	Description	Scoring
Susceptibility	In 365 days cycling, how many times would you have an accident in darkness without lights	
Severity	How many accidents are deadly out of hundred?	
Threat	Severity*Susceptibility	
Friends	1= if friends expect you to have lights	0= no 1= yes
Safeness	By using bicycle lights, traffic becomes safer	1= fully disagreed 5= fully agreed

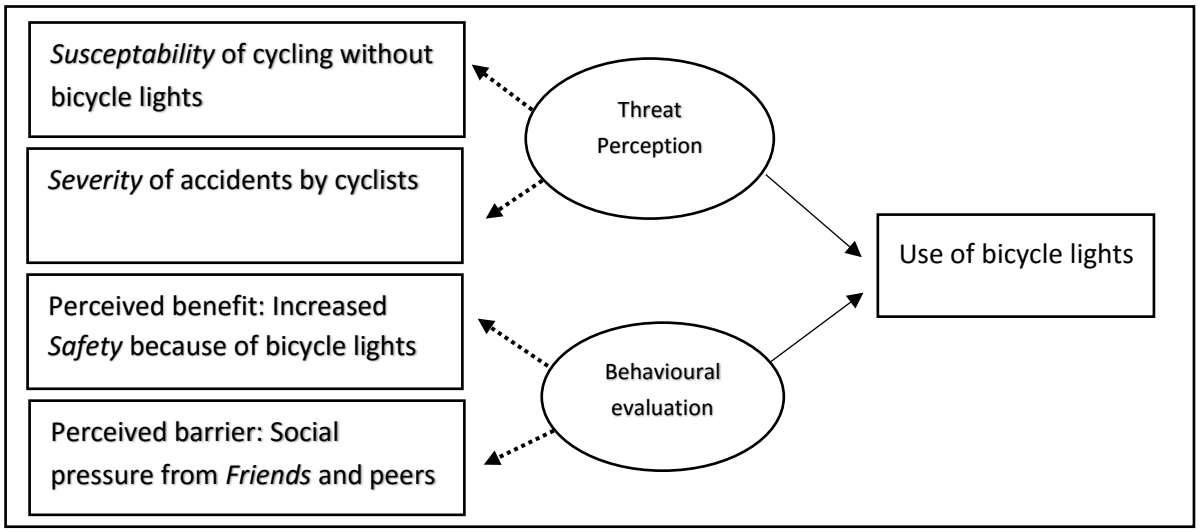

Figure 2: *Health belief model Circles represent latent factors, rectangles indicated components and arrows represent logistic regression estimators for the use of bicycle lights.*

3.3 Planned Behaviour

According to the theory of planned behaviour (TPB), the immediate cause of behaviour is one's intention to engage that behaviour. The intention is determined by a person's attitude toward the behaviour, the person's subjective norm and the behavioural control. Attitudes are based on a person's overall evaluation towards the behaviour and the subjective norm depends on the person's belief of what significant others think about his behaviour (Ajzen, 1985, 1991; Conner, & Sparks 1996). In the case of bicycle lights, it is both important that the cyclist acknowledges the added value of lights in traffic and beliefs that others make him feel that it is important to them as well. For the latter, there might be a contrary opinion in different social groups (Conner, and Sparks). For example, children might think that their parents like to see them with proper lighting, where peers think it is unnecessary or ridiculous. The perceived behavioural control refers to the perception of difficulties for the performance of the behaviour. This third predictor is both a direct factor for the actual behaviour, as for the intention.

The TPB of Ajzen (1985, 1991) has been applied to several health and traffic behaviours. To predict the actual behaviour, Ajzen included non-volitional factors in his model for the (TPB). These factors represent the perception of the difficulty of performing the behaviour and includes for instance past experience, a plan of action and general self-knowledge. This includes also the perception of factors that may hamper the behaviour externally with practical problems. Ajzen's model predicts an individual to succeed in his intention of behaviour when he correctly perceives sufficient internal and external control over the factors.

3.3.1 TPB operationalisation

We included eight questions in total to construct the TPB model. The TPB is ought to predict behaviour with several factors that determine intentions. The intentions are consequently the predictor for actual revealed behaviour. To measure the *intention* of cyclists, we asked the respondents at what extent they always try to use bicycle lights in the dark (*Intention*). The respondent was able to answer with the five-point Likert scales (ranging from totally disagree to totally agree) which is the case for the other questions as well, if not mentioned otherwise (Likert, 1932). Individuality is captured with the subjective level of importance (*Importance*). The level of belief concerning the use of bicycle lights is consequently measured with the contextual question about the added value of bicycle lights for traffic safety (*Safeness*). Similar to De Lange (2010) we measure the social pressure by asking if family members expect that the respondent has bicycle lights, which is a yes or no question (*Family*). In addition to the study of De Lange (2010), we included social pressure from peers or friends (Friends). It is interesting to see the impact of the different groups, since they might have counteracting beliefs. We included four relevant obstacles for the behavioural control. The lack of money (*LMoney*) and the lack of time (*LTime*) to buy bicycle lights and the experience of fast-breaking and stolen bicycle lights, which are all yes or no questions as well (resp. *Broken* and *Stolen*).

Table 3: Components and factors of the TPB

variable name	variable label	Scoring
Intention	When it is dark I will always try to have bicycle lights	1= fully disagreed 5= fully agreed
Importance	Cycling with lights is important	1= fully disagreed 5= fully agreed
Safeness	By using bicycle lights, traffic becomes safer	1= fully disagreed 5= fully agreed
Family	=1 if family expects you to have lights	1= yes 0= no
Friends	=1 if friends expect you to have lights	1= yes 0= no
Laziness	=1 if experienced laziness or forgot to buy lights	1= yes 0= no
LMoney	=1 if experienced lack of money	1= yes 0= no
LTime	=1 if experienced lack of time to buy bicycle lights	1= yes 0= no
Broken	=1 if experienced broken lights	1= yes 0= no
Stolen	=1 if experienced stolen lights	1= yes 0= no

3.4 Intention action gap

Microeconomic theory (consumer theory) states that humans make decisions that maximize their utility. Making decisions requires a comparison of the costs and benefits of alternative actions within a specific budget, rather than about certain values or attitudes (Sammer, & Wüstenhagen, 2006). Young, Hwang, McDonald & Oates (2010) argue that the gap of stated values and purchases can be due to "brand strength; culture, finance; habit; lack of information; lifestyles; personalities; or, trading off between different ethical factors" (p 22). Moreover, time or convenience can often be the major determinant of consumer behaviour. The intention- action gap is also expected in the case of bicycle lights purchases, which might be easily postponed or forgotten.

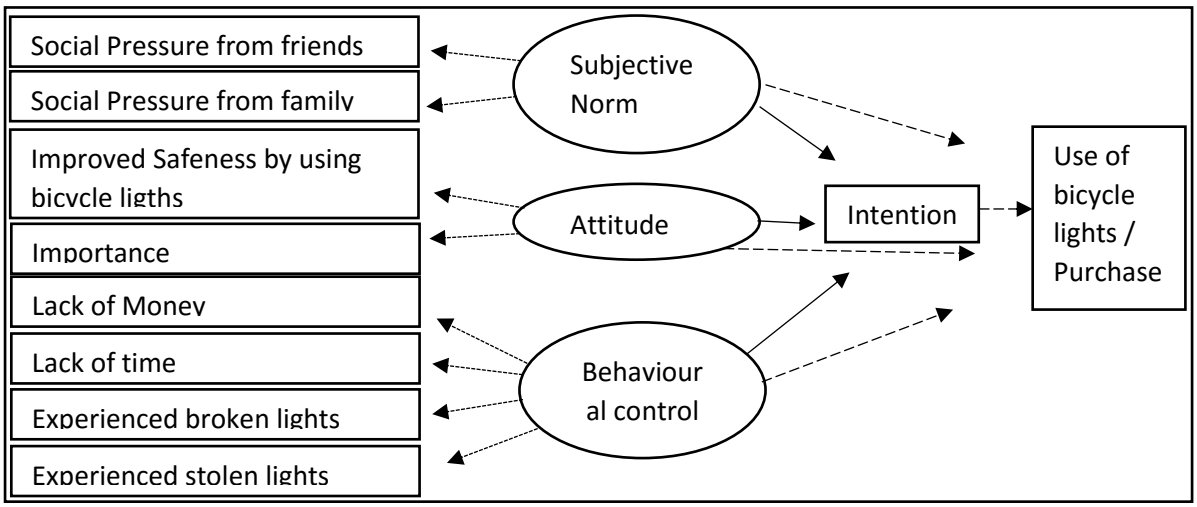

Figure 3: *Planned behaviour model Circles represent latent factors, rectangles observed variables and arrows represent logistic regression estimators or linear probability estimation in the case of intention.*

Vermeir and Verbeke (2006) argue that consumers are passive with regard to their attitude or values, and work within their budget rather than following their values. Furthermore, behaviour is often based on habit and therefore the values are usually not taken into consideration (Vermeir, & Verbeke). People act impulsively and in ways that do not correspond to their declared evaluations and goals. Moreover, Chatzidakis, Hibbert and Smith (2007) argue that consumers use neutralization techniques to justify pursuing their more selfish goals instead of purchasing environmental friendly products. Thus, the prevailing motivation for actions is self-interest rather than altruism.

3.4.1 Intention action gap operationalisation

Especially for environmental responsibility studies, there is a lot of research about cognitive theories that assume individuals to form their attitudes and plan their behaviour in a rational and unproblematic way (Blake, 1999). We include this model to complement the TPB, which is assumed to fail to incorporate structural and institutional arrangements that affect individual action. One important aspect of one's environmental behaviour is for example his perception of power to make a

difference. In the intention action gap we construct the gap between intention (value) and the actual action (*Gap* = *Lights* – *Intention*/5), divided by five to get two equivalent values. To identify the barriers and reasons for the observed actions that were not in line with the stated values or intention, we follow the framework of Blake (1999). His framework consists of three different types of obstacles that stand between the sphere of 'concern' and that of 'action': individuality; responsibility and practicality.

The individuality barrier refers to personal attitudes or the cognitive structure to engage in some kind of action. These internal barriers are especially influential for people whose attitudes are 'peripheral' within their wider attitudinal structure. Meaning that the concerns about bicycle lights are outweighed by other conflicting attitudes: extend of their budget, laziness or lack of interest for example. Two questions were included in our survey to capture the personal attitude and cognitive structure. We asked about experience of laziness and forgetful behaviour concerning the purchase of bicycle lights (*Laziness*) and an indication whether somebody thinks of him- or herself to be the type of person to have bicycle lights (*Type*). The factor constructed for the individuality was created by the indication of *Type* divided by five (for two equivalent scores) minus the indication for *Laziness*.

Factors that influence people's evaluation of the consequences of behaviour are responsibility barriers. For example, a very important aspect for environmental issues is the assumption that acting environmental friendly would not make a difference, because it lacks efficacy. For the case of using bicycle lights we assume that a cyclist might withhold from self-sufficing because of the assumption that it is not his or her responsibility to provide traffic safety (*SafeResp*). People that cycle without lights might feel that they cannot reduce the risks or that they are not responsibility for it. The responsibility barrier is therefore the combination of the indicated increase in traffic safety by using bicycle lights (*Safeness*) and the responsibly for it (*SafeResp*). The third barrier, the practicality barrier, is about the ability to comply with behaviour. Possible obstacles for using bicycle lights in this sense include lack of time or money and the experience of broken or stolen bicycle lights (resp. *LTime, LMoney, Broken and Stolen*). Exactly the same as the components of the behavioural control in the TPB model. Between the different barriers, some overlap can be expected, the experience of laziness or the lack of time for instance. The different classifications are meant to separate the complex differences in social contexts.

Table 4: Components and factors of the Intention gap model

variable name	Description	Scoring
Laziness	=1 if experienced laziness or forgot to buy lights	1= yes 0= no
Type	I am the type of person that has bicycle lights.	1= fully disagreed 5= fully agreed
SafeResp	A safe traffic is my own responsibility	1= fully disagreed 5= fully agreed
Safeness	Traffic becomes safer with the use of bicycle lights	1= fully disagreed 5= fully agreed
LMoney	=1 if Experienced lack of money	1= yes 0= no
LTime	=1 if Lack of time to buy bicycle lights	1= yes 0= no
Broken	=1 if experienced broken bicycle lights	1= yes 0= no
Stolen	=1 if experienced stolen bicycle lights	1= yes 0= no

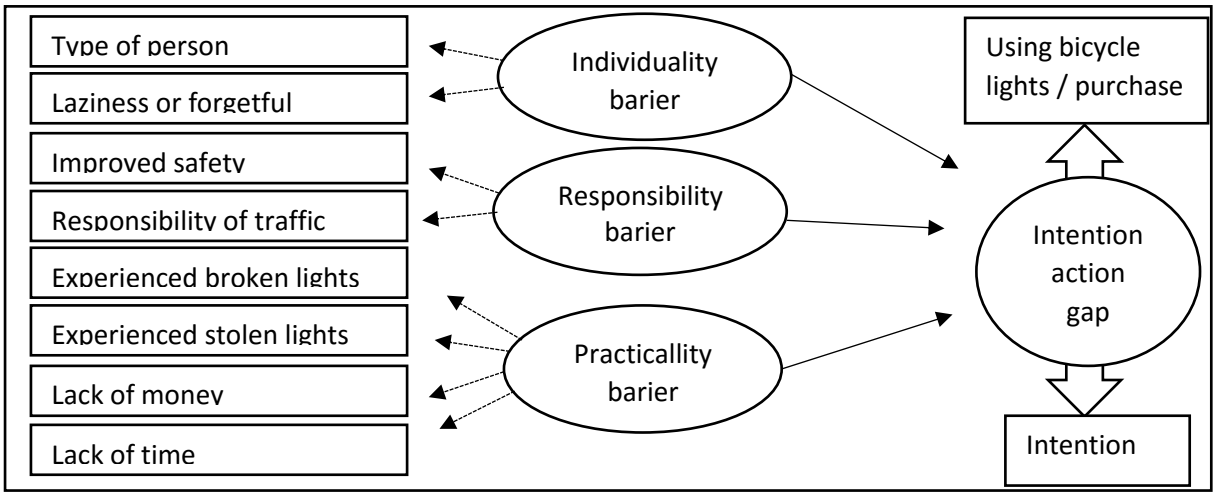

Figure 4: *Intention action gap model: Circles represent latent factors, rectangles observed variables and arrows represent logistic regression estimators for the Intention action gap.*

3.5 Other aspects

For each model we test in this study, we use control variables to remove their effects from the equations. As control variables we included the following personal characteristics (questions 1 - 6). A higher *education* is assumed to increase safety behaviour. The higher educated are supposed to be more efficient at processing information about the risks and benefits of safety equipment, or they experience less influence of time- or risk preference (Blomquist, 1979). *Gender* can be a determinant for behaviour. Women are generally assumed to be more risk averse than men in consumer choices like preventive dental care and in their traffic behaviour like seat belt use and speeding (Jianakoplos, & Bernasek, 1998; Hersch, 1996).

Behaviour is also expected to be more risk averse with increasing *Age*. Adolescents are assumed to reason more poorly than adults do when trading off risks and benefits and they are assumed to have less control to suppress distracting incentives (Reyna, & Farley, 2006). Both TNS NIPO (2015) and Rijkswaterstaat (2013) did find that especially adolescents and young adults are less likely to have lights compared to older age groups. The frequency of the cyclist' use of the bicycle is also included

(*BicycleUsage*), cyclists who use their bicycle more often might take better precautions because they are more frequently exposed to the different risks involved. In accordance with De Lange (2010), the possession of a *driver's license* is included. If somebody has a driver's license, it means that this person might have experienced poorly visible cyclists when driving at a high speed in a car.

Table 5: Other aspects

Variable name	Description	Scoring
Education	level of education	1= high school 2= middle applied education 3= higher education
Male	=1 if male	1=male 0= female
Age	Respondents' age	1= 0-15; 2= 15-29; 3= 30-44; 4= 45-59;5= >60
Driving	=1 if respondent has a driver's license	1= holder 0= No holder
BicycleUsage	The frequency of using bicycle	1=1-2 days; 2= 3-4 days 3= >5 days

3.6 Traffic safety studies

3.6.1 Literature about bicycle lights

On the initiative of several Dutch traffic organisations a public research (TNS NIPO, 2015) was conducted regarding bicycle lights. With a survey, they found that especially adolescents, higher educated and 'frequent cyclers' do not have bicycle lights against their better judgment. More than 95 percent of the cyclists indicated that cycling without lights is dangerous, but still only 4 out of 10 cyclists indicated to replace the empty batteries of the bicycle lights directly. The actual use of bicycle lights and the behaviour regarding the replacement of batteries were also not in line with the intentions of cyclists. We hope to examine this behaviour further and find the reasons for the missing performance or commitment.

The study with the most resemblance with our approach is by De Lange (2010). His questionnaire was constructed to capture the deterrence theory and the TPB. The analysis was based on 90 interviews and 459 observations. De Lange's survey showed that the cyclists with light were sufficiently intrinsically motivated, this was also shown by their stated importance of traffic safety. The cyclists without bicycle lights indicated to be incentivised with a larger fine than the operative 35 euros and they were also found to be sensitive to police inspection. From the components of the TPB, both the attitude towards having bicycle lights and the practical problems influenced the use of bicycle lights.

While the fine is currently increased to 64 euro since January 1st of 2016, it would be interesting to find out if this has led to less offenders without bicycle lights. During the survey of Rijkswaterstaat (2013), the fine was already increased to 45 euro, but compared to the 62% of cyclist with bicycle lights observed by De Lange (2010), there has no significant reduction taken place (61%, 2012/2013). De Lange also recommended the "Parkstad" approach, which was a trial where students received a LED with additional information about the importance of bicycle lights and an increased level of

enforcement by the police (Gemeentes Parkstad Limburg, 2005). This approach was considered successful by De Lange, but is probably because of the expenses not extended, at least not to national level. This example does show the impact of three different approaches: distribution of LED, information about lights and increased police enforcement. Whether the effect is due to the police enforcement or a change in attitude is not clear.

3.6.2 Comparable behavioural studies

Because of the shortage in literature about the behaviour towards bicycle lights, we expand with several studies for other safety equipment. Since all safety equipment is used to diminish fatality risks, the methods are universal. Lajunen and Rasanen (2004) derived a questionnaire for students among secondary comprehensive school and upper secondary school in Sweden to study the use of bicycle helmets. Their framework was constructed with components of the TPB together with the health belief model and locus of control. The locus of control refers to the belief that events are consequences of one's own actions and therefore controllable, or beyond their personal control on the other hand (Lajunen and Rasanen). Especially the TPB components came out as the most important. The subsequent perceived barriers for helmet use were negative peer opinions and inconvenience of wearing helmets.

The valuation of the statistical life is a 'yardstick' for scholars and public agencies to value the abstract risks of fatality with the willingness to pay or accept risks (Viscusi, & Aldi, 2003). Anderson (2013) studied the usage of seatbelts and bicycle helmets by analysing the willingness to pay for traffic safety, examined by a questionnaire. For bicycle helmets, the value of statistical life estimated for usage did not correspond with the stated willingness to pay, while it did correspond for the usage of seatbelts. Hence there was no relationship between the perception of risk and usage of bicycle helmets. Svensson (2009) examined six different precautionary behaviours with a mail survey, (front and rear seatbelt, bicycle helmet, bicycle light, reflector, and withhold from speeding) and compared that with the stated willingness to pay for a mortality risk reduction. He did not find a significant relation for any of the safety equipment.

The consumer's behaviour towards the consumption of sustainable food was investigated by Vermeir and Verbeke (2004) with a model for the intention action gap. This consumer behaviour is characterised by deviation between values or attitudes and the actual purchased goods. Perceived availability of sustainable food, the effectiveness of buying these goods and experiencing social pressure from peers (social norm) did increase the consumer's intentions to buy, despite rather negative attitudes (Vermeir, & Verbeke). The intention action gap is referred to in several traffic safety studies, but it is mainly examined with the TPB, instead of a model for the intention action gap.

4. Method and Procedure

4.1 Revealed behaviour

Our questionnaire (appendix 1 and 2) is constructed according to the literature concerning the deterrence theory, the health belief model, the planned behaviour model and the intention action gap model. Both the cyclists with and without lights are questioned to find the determinants for their behaviour. The first is the presence of working bicycle lights on the bicycle or cyclist, since it is allowed to attach the light to the body as well. The interviewer determines the compliance of the required bicycle lights himself, to avoid cheating or difference in the norm. The requirement for complying behaviour is having two bicycle lights, one for the rear and one for the front.

The second form of revealed behaviour is constructed by offering the offenders to buy a set of LED lights. The cyclist is subsequently showing his willingness to buy bicycle lights. Having bicycle lights shows aligning behaviour by their own initiative and action, the willingness to buy is aligning behaviour as well, but the failure of providing oneself with lights. We can treat these purchases as evidence for the difficulty to provide oneself with bicycle lights, because he or she does show the willingness to buy and to cycle with lights. We interpret the repelling of the offer as the revealing ignorance of having bicycle lights, because the cyclist does not actively commit. These two observations of revealed behaviour refer to methods where actual market behaviour is used to reveal individual behaviour (Anderson, 2013; Atkinson, & Halvorsen, 1990).

The two forms of revealed behaviour complement each other. Were the observation of bicycle lights is ought to find differences between offenders and cyclists with lights, the observed willingness to buy enables to examine the factors that affect the offenders' behaviour with respect to the purchase of bicycle lights. We fully neglect the role of reflectors, which are basically added to the bicycle by the producer and cannot be removed so easily as well. In the case of flashing bicycle lights we will also list the cyclist as complying. Although flashing lights are against the regulation, the cyclists show self-sufficing motivation to have bicycle lights. Especially during dusk, we will ask the cyclist to activate their bicycle lights so it can be verified. For the offered bicycle lights, we ask the price of the originating store (Action). We give the cyclist two options, either a set of small LED lights for 1 euro or two bigger lights, with more visibility, for 1.30 euro per light (either front or rear). For the cyclists without cash on them, we gave the cyclist the option to pay us later, by giving them a note with our bank account number to send the money to.

4.2 The two contexts

To capture the time inconsistency problem and planning difficulties which restrain cyclists from buying a bicycle light, we performed the experiment in four different contexts: 1. during darkness versus (2)

dusk and 3. when the cyclist wants to leave versus (4) when he wants to park his bicycle. We will conduct this experiment in the four different contexts, to capture the inconsistency of the willingness to buy. The context variables are constructed to compare a situation where the cyclist is directly in need of lights and a situation where the purchase can still be postponed. Consequently, this tendency to postpone the purchase might cause difficulties for cyclists to provide oneself with lights. To test the strength of this effect, we include the indicated intention to use bicycle lights in this model. This relation would suggest that the intended behaviour does explain the willingness to buy, what might weaken the claim of inconsistency.

The first two contexts differ with respect to the darkness outside, either the survey was conducted during darkness or during dusk. We will compare the willingness to buy of the respondents we question during dusk at 8:00 and 9:00 PM with those we question during darkness at 9:30 to 10:30 PM (Zonsondergang.info). In dusk, the visibility of cyclists is higher and there is no legal enforcement to have bicycle lights. Although the cyclists without bicycle lights do not break the rules while they are cycling during dusk, we take them for 'offenders' in this study as well. The corresponding *hypothesis 1*: *During darkness, the willingness to buy bicycle lights is higher, compared to during dusk.*

The second context difference does concern the activity of the cyclist. We will compare the differences between cyclists who are about to cycle away with cyclists who just parked their bicycle. The cyclist who is about to cycle away has the need for bicycle lights right away, while the cyclist who is parking his bicycle is able to postpone the purchase. Because of this need for lights, we expect a higher willingness to buy. The corresponding *hypothesis 2: When the cyclist is planning to cycle away, the willingness to buy bicycle lights is higher, compared to when he or she is parking the bicycle.* We will also test the effect of the interaction term of both in darkness and leaving (*Interaction).* This interaction term represents the situation of direct need, as the cyclist will have offending behaviour when he or she will reject the offer. Therefore, the third hypothesis is: *When the cyclist is planning to cycle away during darkness, the willingness to buy bicycle lights is higher, compared to when he or she is not parking his bicycle.*

4.3 Treatment effects

Because of a possible treatment effect in the purchase estimation caused by the survey, we constructed two different surveys for the offenders. In one we offered the bicycle lights in the end of the survey, in the other it was at the beginning. We aimed to give 75 percent of the offenders the survey which offered the bicycle lights in the end, the remaining 25 percent were offered the bicycle lights at the start. Considering our hypothesis of revealed behaviour affected by context, the order of the experiment might show the effect of contexts in the decision to purchase as well. A possible

treatment effect might suggest that the willingness to buy is affected by inciting the cyclist to assess and think about the risks of cycling without lights.

4.4 Location

Because we would like to generalize in some respect for the Netherlands, we performed the experiment in ten different places, both in municipalities and in cities. The locations have been chosen due to their level of fines given for the absence of bicycle lights in 2015 (CJIB, 2016). The highest score was in Nijmegen with 5.1 fines given per 1000 inhabitants, the lowest score was in Brummen with just 0.1 (CJIB). The surveys were completed by cyclists in bicycle sheds with and without surveillance. A large part of the sample was collected near train stations because of the abundancy of bicycles and the frequency of cyclists leaving and parking their bicycle. Four experiments in the city centre (of Nijmegen 2x, Arnhem and Utrecht) were conducted to complement the location of train stations. To avoid any influence of bystanders, we did not examine groups of people. All locations, the corresponding dates and the fines issued in 2015 are included in the appendix (4).

5. Data analysis

We will test if we can find explanations for the behaviour towards bicycle lights in the context during the survey and with the four behavioural models. We will not treat the shortly mentioned locus of control due to its overlap with the TPB model and a preferred limited survey. Since both dependent variables are binary- coded, we will use a logit model. The logit coefficients are explained by the logarithm of the odds, which is the probability that something happens divided by the probability that it does not happen (Demaris, 1995). Additionally, we provide the marginal effects (mfx) of these estimations in the appendix.

The personal characteristics are considered control variables for our analysis. Because of our relatively small sample (144 observations), we need to be careful with the number of variables in each model. Possible biases can occur because of low ‘events per variable’: the variables used relative to the observations. Several studies suggest a minimum number of events per variable to have a proper coverage, but different limits are proposed (Peduzzi, Concato, Kemper, Holford, & Feinstein, 1996; Vittinghof & McCulloch 2007). For the models to predict the purchase of bicycle lights we will not use control variables at all due to the sample of 59 respondents. The rule of thumb of 10 events per variable is still not reached for two estimations for the willingness to buy (7.5 events per predictor), but we cannot remove components of the behavioural models. Considering that a lower number per event does not lead to major problems, this will have to suffice for this study (Vittinghof & McCulloch 2007).

We represent our results in constructed figures for the four models, which were also used in the operationalisation sections. In these figures, the squares represent the variables indicated by the respondents. We included circles to represent latent factors, constructed by multiple components, included to test for corresponding assumptions. These latent factors are interaction terms, cumulative combinations or the outcomes of a formula. We will clearly introduce the specific constructs used for the latent variables in each models. The corresponding components are linked with arrows to the latent variables as well. These arrows also represent the logistic estimations for the dependent variable (by exception of figure (?) which has mainly regression coefficients). In the appendix we included the logistic estimation model with the included control variables, which are not shown in the figures.

6. Results

Of the 144 cyclists in our sample, 59 cyclists did not have bicycle lights. This is a percentage of 59 with bicycle lights, almost similar to the 61% recorded by Rijkswaterstaat (2013). In line with our assumption, this percentage does show that there is a very large group of offenders. These 59 respondents or offenders are used for the estimations for the purchase decision. This sample is unfortunately low, perhaps the findings of this experiment will lead to a larger setup for future research. Of these 59 cyclists, 21 accepted the offer and were willing to buy bicycle lights. We start by testing our control variables to see the influence of personal characteristics upon the two revealed behaviours. Before we test the four models concerning behaviour, we will test the context variables for the willingness to buy lights.

6.1 Control variables

6.1.1 Control variables for the use of bicycle lights

Several personal characteristics show to affect the behaviour towards bicycle lights. In line with De Lange (2010), we find that the respondents with experience as a car driver *(Driving)* are more inclined to have bicycle lights than the ones without. Their experience of the combination of driving at high speed and poorly visible cyclists in darkness might explain that. The frequency of cycling (*BicycleUsage)* turned out significant as well, but with an opposite effect than expected. Cycling more frequently is negatively related with bicycle lights use, which was also found by TNS NIPO (2015). The explanation might be very obvious, as it is easier for cyclists who do not cycle as much to keep batteries from running down as fast.

Table 6: Control variables statistics: percentages of cyclists with lights

Demographic group	Observations	Mean of cyclists with bicycle lights
All Respondents	144	59
Education level achieved or currently doing		
High School	16	62.5
Mid Applied Science	20	65
Higher Education	108	57.4
Gender		
Male	79	56.9
Female	65	61.5
Age		
0-14	0	-
15-29	95	48.4
30-44	30	73.3
45-59	17	86.2
>60	2	100
In possession of driver's License		
No Driver's License	44	41
Driver's license holder	100	67
Frequency cycling		
1-2 days	13	92.3
3-4 days	20	55
>5 days	111	55.9

Also in accordance with TNS NIPO, we find that the level of education does have a negative relation with usage. This is remarkable, especially because the higher educated were found to be better informed about the regulation (TNS NIPO, 2015). A good explanation for this pattern is hard to think of. In line with both TNS NIPO and Rijkswaterstaat (2013), we find that especially the youngest age group (15-29 years old) are likely to cycle without bicycle lights. The very small differences between male and female suggest that there is no influence of gender.

6.1.2 Control variables for the willingness to buy

In the second column of table 7, we show the logit estimations of the control variables for the willingness to buy. The effects of *Driving, Age* and *BicycleUsage*, which were relevant for having bicycle lights, are not evident in the estimations for the purchase decision. We should mention that the relatively older age groups are fairly underrepresented (only 10 out of 59 are older than 30) in this sample. The small group is likely to lead to a bias for *Age* in the estimation for the willingness to buy.

6.2 Treatment test

Before we will start looking at the results for the purchase decision, we will first test for a possible treatment effect. To check for treatment effects, we constructed a dummy-variable (*Treatment*) that was coded 1 for the respondents that received the question in the end of the survey instead of at the start. Fourteen respondents received the offer at the start, against 45 who received it at the end. Because of the low number of this 'treatment' group, it might be unwise to make hard statements

from it. In both the third and fourth column of table 7 we included the treatment variable. The significant and positive coefficient indicates that the treatment effect is present in the estimations for the willingness to buy. The willingness to buy is consequently higher when the offer to buy bicycle lights was in the end of the survey.

Cyclists are therefore assumed to have a higher willing to buy bicycle lights because we put them to determine several risks and make them state their intention. In both the sixth and seventh column in table 7, the treatment effect weakened because of the included interaction term. But the marginal effect of the treatment in this logistic model was still found significant (appendix 3, table a colum 5 and 6). It suggested an average 21 percent higher probability to purchase for the respondents who received the offer in the end, compared to the respondents who received it at the start (appendix 3, table i). Consequently, we do find sufficient evidence that the treatment effect is present. This effect of the fulfilment of the survey can be considered as another context which affects the cyclists in their behaviour towards bicycle lights. The context therefore makes them more likely to actively commit.

Table 7: Logistic estimations for control and context variables

	(1) Lights	(2) Purchase	(3) Purchase	(4) Purchase	(5) Purchase	(6) Purchase
Male	-0.235	-0.294	-0.516			
	(0.386)	(0.566)	(0.615)			
Education	-0.634*	0.508	0.463			
	(0.314)	(0.518)	(0.519)			
Age	0.981**	-0.309	-0.252			
	(0.332)	(0.626)	(0.635)			
Driving	1.004*	0.324	0.472			
	(0.463)	(0.606)	(0.633)			
Bicycle usage	-0.596+	0.0293	0.366			
	(0.343)	(0.657)	(0.692)			
Treatment			1.797*	1.563+	1.419	1.431
			(0.856)	(0.862)	(0.907)	(0.927)
Leaving				0.663	-1.638	-1.571
				(0.717)	(1.022)	(1.078)
Darkness				1.389*	-1.752	-1.696
				(0.618)	(1.337)	(1.378)
Interaction					4.239**	4.136*
					(1.554)	(1.607)
Intention						-0.236
						(0.423)
Importance						0.793
						(0.637)
N	144	59	59	59	59	59
pseudo R-sq	0.139	0.028	0.101	0.144	0.255	0.277

Marginal effects; Standard errors in parentheses
(d) for discrete change of dummy variable from 0 to 1
+ p<0.1, * p<0.05, ** p<0.01
* marginal effect estimated in table a in the appendix(3)

6.3 Context variables

With two context variables *Darkness* and *Leaving,* we test for the willingness to buy in different contexts which represent situations in terms of need. In the fourth column of table 7 we included both *Darkness* and *Leaving*. During darkness the willingness to buy increased significantly, revealing the influence of the bad visibility or the higher need, compared to during dusk. The subsequent context of leaving is not significant in this estimation. Subsequently we constructed an interaction term for the one context with direct need for bicycle lights, when cyclists are leaving during darkness. If the offer is rejected in that context, the cyclist will directly show offending behaviour. Consequently, the rejection leaves the respondent cycling without lights during darkness. Both against regulation and with increased risk in traffic. This interaction term (*Interaction*) is included in column 5 of table 7, together with both the separate context variables *Leaving* and *Darkness*. The separate context variables do capture the remaining unique effect of *Leaving* or *Darkness,* meaning that the other is zero.

Table 8: Context variables statistics

Variable	Description	Obs	Mean(SE of the mean)
Purchase	=1 if bicycle lights were purchased	59	.356 (.483)
Darkness	=1 during darkness	59	.507 (.502)
Leaving	=1 if cyclist is leaving with bicycle	59	.681 (.468)
Treatment	=1 if offer to purchase bicycle lights was in the end of survey	59	.746 (.439)
Interaction	=1 if cyclist is leaving with bicycle during darkness	59	.356 (.483)

Offenders were more than 75 percent more likely to buy bicycle lights when the bicycle lights were offered in the context of leaving during darkness (Appendix 3, table h and figure a). This relation was even with the included variables of intention and Importance still significant (table 7, column 6). Both these indications are not even significant, thus instead of the stated willingness to have bicycle lights, the context is important. The effect of *Darkness* is now absent due to the inclusion of the interaction term. The context of leaving compared to arriving even has a marginal negative effect now the interaction with darkness is captured in the interaction term. Due to the significant effect of the interaction term, we can assume that the corresponding direct need causes a higher willingness to buy among cyclists. This pattern confirms that the behaviour towards the willingness to buy is characterized by inconsistency.

6.4 Deterrence theory

In this section we examine the models for the deterrence theory and the corresponding cost-benefit analysis. To test the effect of police enforcement, the respondents indicated their perception of the risk of getting caught by police (*Police*) and their indication of both the height of the fine (*Fine*) and the

costs of the cheapest bicycle lights available (*LED(€)*). The natural logarithm of each component was used because of the positive skew of the distributions. These components were unfit to predict the willingness to buy, for which the corresponding model is included in the appendix (Appendix 3, table b, column 1 and 2). In figure 5, we show the logit estimators for each component to predict the use of bicycle lights. None was actually found to have a significant effect on the use of bicycle lights as well.

Table 8: Statistics of components and factors of the deterrence theory

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
Fine(€)	How expensive is the fine? (€)	144	58.6	25.9	10	180
Police	In 365 days cycling, how many days would you expect to get fined?	142	4.90	9.10	0	50
LED(€)	How expensive are the cheapest lights?(€)	142	3.41	2.31	.5	15
CostBenefit	Police/365*BicycleUsage*35* Fine(€) - LED(€) *5	140	159.2	379.6	-60	2132.5
BCostBenefit	=1 if CostBenefit is positive	144	.660	.476	0	1

Because we had some additional questions about fines, we are able to examine the impact of several aspect on the indication of the police enforcement and the use of bicycle lights (appendix: table b, column 1 and 2). 29 Percent of the respondents had received at least once a fine for cycling without bicycle lights and only 5 percent received one in the past six months. Having received a fine did not lead to higher indications of police enforcement, not even for the cyclists that were fined during the past six months. Neither can we observe that these respondents learned from this fine, because this group was not relatively more likely to have bicycle lights. Of course we should keep in mind that we do have a small group of respondents that received a fine. Strangely, we do find a positive relation between the indicated *Police* and the knowledge of at least one acquaintance that received a fine (respectively 6.2 against 4.2), it seems as if this affects cyclists more than being fined themselves.

$$CostBenefit = (Police/365) * (BicycleUsage * 35) * (Fine(€)) - (LED(€) * 5) \quad (1)$$

If cyclists are indeed rational agents, we should find evidence for the effect of the cost-benefit analysis for the use of bicycle lights. With the formula for *CostBenefit* shown above (controlled for the average working weeks and average days of cycling) we constructed an analysis of all relevant costs for the use of bicycle lights. Our simulation of the cost-benefit analysis did not predict the use of bicycle lights, the outcomes were unrelated with usage (figure 5). We tried to control for the wide range (-60 to 2132.5) with a binary-coded formulation (*BCostBenefit*), which was 0 for negative outcomes and 1 for the positive outcomes. This variable turned out to be insignificant as well. That brings us to reject the evidence for the presence of the cost-benefit analysis and the deterrence theory in the case of bicycle lights.

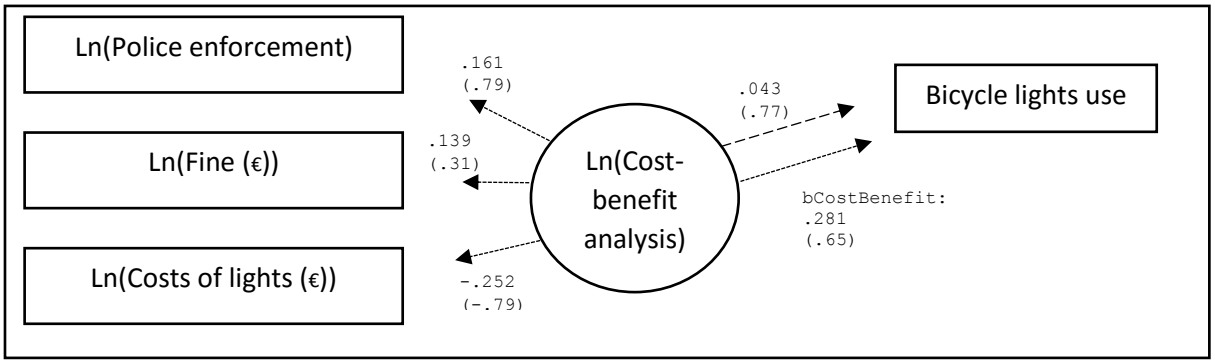

Fig 5: *Deterrence theory model to predict the use of bicycle lights, controlled for age, education, gender, having driver's licence and bicycle usage. The circle does represent the predicted values of the CostBenefit formula (1), rectangles are indicated components and arrows represent logistic regression estimators for the use of bicycle lights. Standard errors in parentheses. + p<0.1, * p<0.05, ** p<0.01. The corresponding complete model of logistic estimations in table b of appendix*

6.5 Health belief model

We proceed with the health belief model, where the differences in the perception of risks in traffic and the efficacy of bicycle lights are used as possible explanation for using bicycle lights. If behaviour is explained by the health belief, we should observe higher indicated risks in traffic among the cyclists with lights. The components of the HBM try to capture the 'threat perception' with an indication of the perceived *Susceptibility* and anticipated *Severity* (table 9 shows question and statistics). For both aspects we use the natural logarithm, because of the positive skew in their distributions. Besides threat perception, behavioural evaluation is supposed to affect the use of safety equipment. The two variables *Friends* and *Safeness* are used, respectively for the influence of peers or friends and the evaluation of the actual efficacy of bicycle lights in terms of traffic safety. As we already gave away, the health belief model lacks to explain the willingness to buy bicycle lights (appendix 3, table c).

Table 9: Statistics for components and factors of the HBM

variable name	variable label	Obs	Mean	Std. Dev.	Min	Max
Susceptibility	In 365 days cycling, how many times would you have an accident in darkness without lights	141	5.397	10.473	0	50
Severity	How many accidents are deadly out of hundred?	143	25.413	25.713	0	100
Friends	Friends expect you to have lights	144	.667	.473	0	1
Safeness	By using bicycle lights, traffic becomes safer	144	4.764	.458	3	5
Threat	Ln(Susceptibility*Severity)	144	2.666	2.405	-4.605	8.086
Evaluation	Safeness/5 + Friends	144	1.619	.501	.6	2

As shown in figure 6, the relation between the behavioural evaluation and usage is completely insignificant. This factor consisting of the aspect of social pressure of friends and the perceived increased safety does not explain the usage and neither do these components separately. Only the indicated *Severity* has a significant relation with the bicycle lights use. Cyclists that do have lights do assume that the severity of accidents is therefore higher than the offenders. The perception of the susceptibility are not significantly different, cyclists without lights share the comparable perceptions. The interaction of both components (Susceptibility * Severity) is considered to be the indication of the overall threat perception of accidents. A higher score for the threat perception stands for the assumed more danger in traffic for cyclists in the dark. This factor does not relate to usage, therefore the perception of direct consequences of cycling without lights are again irrelevant, since the risk of getting a fine was irrelevant as well.

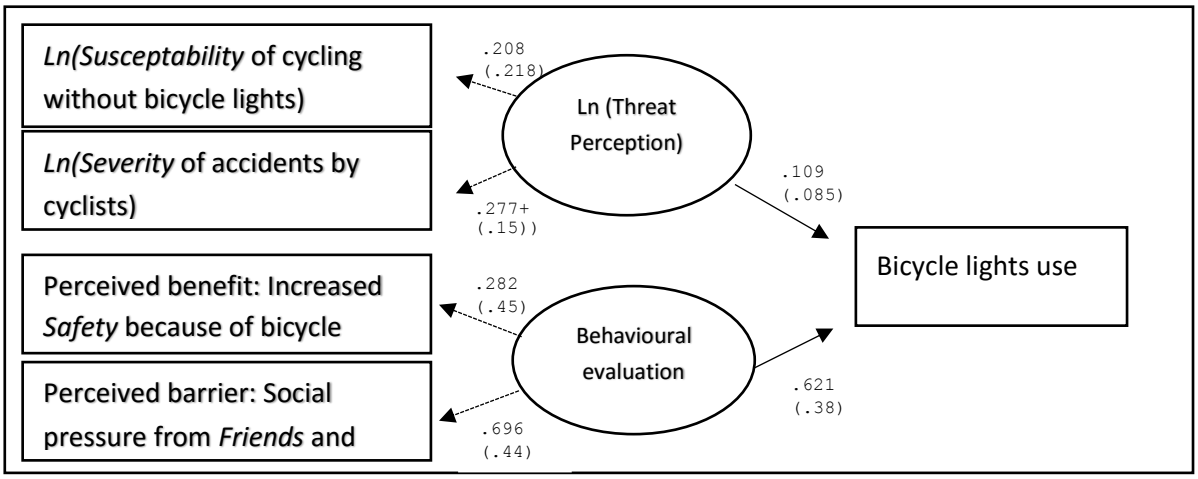

Fig 6: *Health belief model to predict the use of bicycle lights, controlled for Age, Education, gender, having Driver's licence and BicycleUsage. The circles represent latent factors, the according formula in table 9. Rectangles represent indicated components and arrows represent logistic regression estimators for the use of bicycle lights, standard errors in parentheses. Corresponding logistic estimations in table c in the appendix (3).*

6.6 TPB

The TPB does assume that the intention to behave in a certain way does actually predict the revealed behaviour. Because of that, the factors that influence the respondents' intention are considered to affect the revealed behaviour as well. A positive logit coefficient of the *Intention* is strongly significant (figure 7), which makes the assumption valid. People seem to acknowledge the shortage of their intention when they are cycling without bicycle lights. Some cyclists did respond in the following way when they were asked to indicate their intention: *actually I have a strong intention, but apparently it is lower, since I do not have bicycle lights right now*. Such a remark does question if the stated level is the actual intention of the respondents. It does suggest that these cyclists experience some difficulties to behave according to their intention, which is exactly what we try to examine with the TPB model and the following Intention-action gap model.

Table 10: Statistics components and factors of the TPB

variable name	variable label	Obs	Mean	Std. Dev.	Min	Max
Intention	When it is dark I will always try to have bicycle lights	144	4.257	.922	1	5
Importance	Cycling with lights is important	144	4.660	.544	3	5
Safeness	By using bicycle lights, traffic becomes safer	144	4.764	.458	3	5
Attitude	*Importance + Safeness*	144	9.424	.833	7	10
Family	Your family expects you to have lights	144	.944	.230	0	1
Friends	Friends expect you to have lights	144	.667	.473	0	1
Norm	Friends + Family	144	1.611	.556	0	2
LMoney	Experienced lack of money	144	.285	.453	0	1
LTime	Lack of time to buy bicycle lights	144	.139	.347	0	1
Broken	Experienced broken lights	144	.667	.473	0	1
Stolen	Experienced stolen lightsSafeResp	144	.576	.496	0	1
Control	*LMoney + LTime + Broken + Stolen*	144	1.667	1.140	0	4

Now, we will proceed with the variables that ought to have an effect on the indicated *Intention*. Only for the *Attitude* we found evidence for the assumed relation with *Intention.* It sounds very obvious that respondents with a higher indicated importance for bicycle lights also have a higher *Intention*. This result is in line with De Lange's study (2010). The factor of the subjective norm (*Norm)* does not turn out to effect the intention, we might therefore assume that it is more likely that cyclists intend to have lights to enhance their own feelings of safety, instead of the worries of someone else. The barriers regarding the behavioural control do also not appear to influence the cyclists' indication of intended behaviour. These barriers are presumably more likely to influence the use of lights instead of the indicated intention.

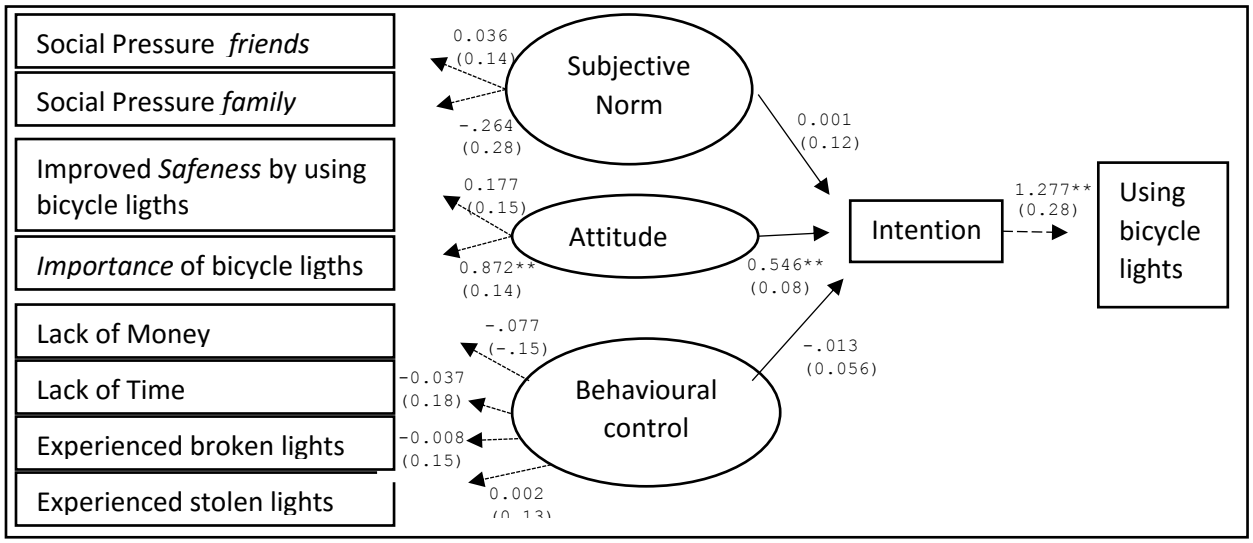

Fig 7: *Planned Behaviour model to predict the intention to use bicycle lights, 3 models, controlled for age, education, gender, driver's license and frequency of cycling. Circles represent latent factors, a combination of components (exact formula in table 9). Rectangles represent indicated components and arrows represent logistic regression or linear probability estimators (for the uso of bicycle lights only), standard errors in parentheses.*

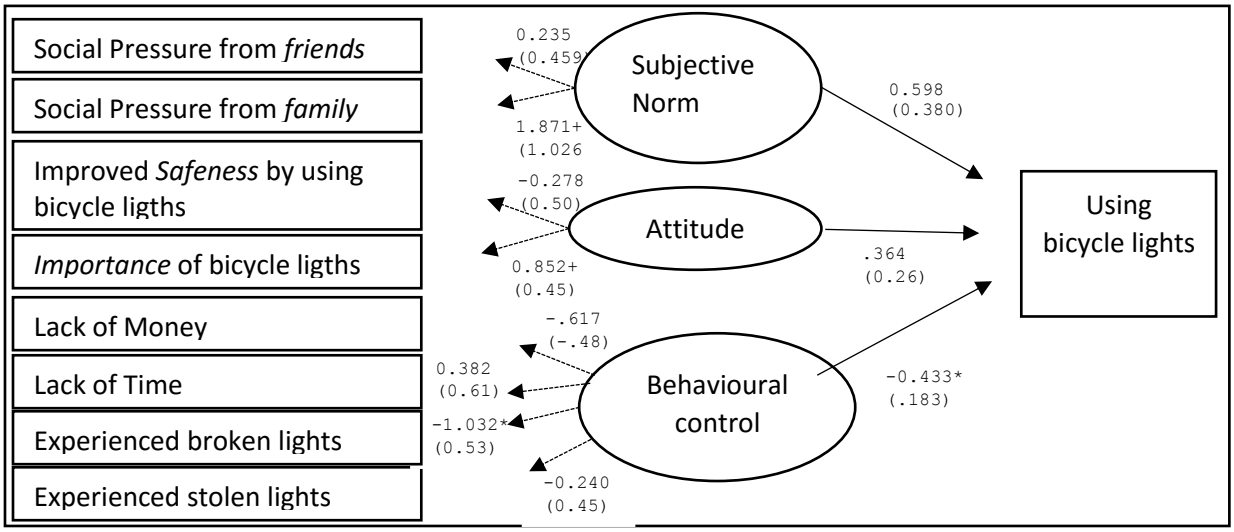

Fig 8: *Planned Behaviour model to predict the use of bicycle lights. Logistic model, controlled for the control variables. Circles represent latent factors, rectangles observed variables and arrows represent logistic regression estimations, standard errors in parentheses.*

The subsequent effects of the components on the use of bicycle lights are presented in figure 8. Both the subjective norm and behavioural control appear to have a significant effect. It is remarkable that the *Attitude* is not relevant since it was the only related factor with the *Intention*. The cyclists without lights therefore do not indicate a significant lower attitude compared to the cyclists with lights. While the intention was not affected by the subjective norm of family members or friends, we do find that especially the social pressure from family members leads to a higher probability of usage. With the indication to experience social pressure from family, the probability of having bicycle lights increased with 43 percent (appendix 3, table d, column 6).

Also do we observe the impact of multiple aspects of the behavioural control (*Control)*. The lack of behavioural control or the experience of multiple barriers keeps cyclists from having lights, according to their indications. With the increased indication of an additional barrier, the probability of having bicycle lights decreased with an average of 10 percent (Appendix 3, table d, column 8). Only the experience of broken lights was separately related with usage, what suggests that this is especially a relevant barrier. Perhaps an explanation lies in the refusal to buy the same or comparable fragile LED lights.

6.7 Intention – action gap

The intention- action gap model is particularly constructed to examine the reasons for the deviation between the stated values or intentions and the revealed behaviour. Three different types of obstacles or factors are assumed to be underlying to this deviation, consisting of the individuality-, responsibility- and practicality barriers. These factors are assumed to affect offenders in such a way that they do not actively commit to their intention or anticipate to their need of bicycle lights. Because these aspects are considered to withhold cyclists from actively committing and take action to buy bicycle lights, it is likely that they do not affect cyclist when we actively offer them the lights. Together with the models for the deterrence theory, the health belief and the TPB, the intention action gap indeed did also not fit our data for the purchase decision (Appendix 3, table f).

Table 11: New components and factors for the Intention Action Gap

variable name	Description	Obs	Mean	Std. Dev	Min	Max
Laziness	Experienced laziness or forgot to buy lights	144	.542	.5	0	1
Type	I am the type of person that uses bicycle lights	144	3.924	1.058	1	5
Individuality	Type/5 - Laziness	144	.243	.573	-.8	1
SafeResp	A safe traffic is my own responsibility	144	4.160	.890	1	5
Responsibility	Safeness * SafeResp	144	8.923	1.116	4	10
Practicality	LMoney + LTime + Broken + Stolen	144	1.667	1.140	0	4
Gap	Intention Action Gap (use) = Lights – Intention/5	144	-.301	.384	-1	0
Gap2	Intention Action gap (Purchase = Purchase – Intention/5	59	-.475	.391	-1	0

The individuality barrier captures the impact of conflicting attitudes that outweigh the concerns about traffic risks. *Individuality* is formulated by the indication of *Type* divided by five to make the scores equivalent, minus Laziness. Both components separately are significantly related with bicycle lights use, shown in figure 9. We already mentioned that the cognitive ability is an issue, which was evident

in the increased likeliness of purchasing bicycle lights in the context of direct need. Now we observe that offenders indicate this aspect to affect their use themselves as well, at least more than the users do. Consequently the aspect of *Individuality* do keep cyclists from cycling with bicycle lights. Unfortunately for these people we only come and offer bicycle lights once, considering that they are likely to regret their laziness in the context of direct need.

The responsibility barrier was constructed with the interaction term of the indicated feelings of responsibility of traffic safety (SafeResp) and the assumed efficacy of using bicycle lights (Safety). This combination does capture the effectivity of using bicycle lights for the purpose to actively create a more safe traffic. In the case of bicycle lights we cannot find evidence that cyclists are encouraged to use bicycle lights because of their perception of efficacy or the feeling of responsibility for traffic safety. The remaining practicality barrier does concern the ability to comply with behaviour. We tested four obstacles, which are identical to the behavioural control elements of the TPB model. Again, we observe the impact of the practicality barrier as a relevant obstacle to use bicycle lights.

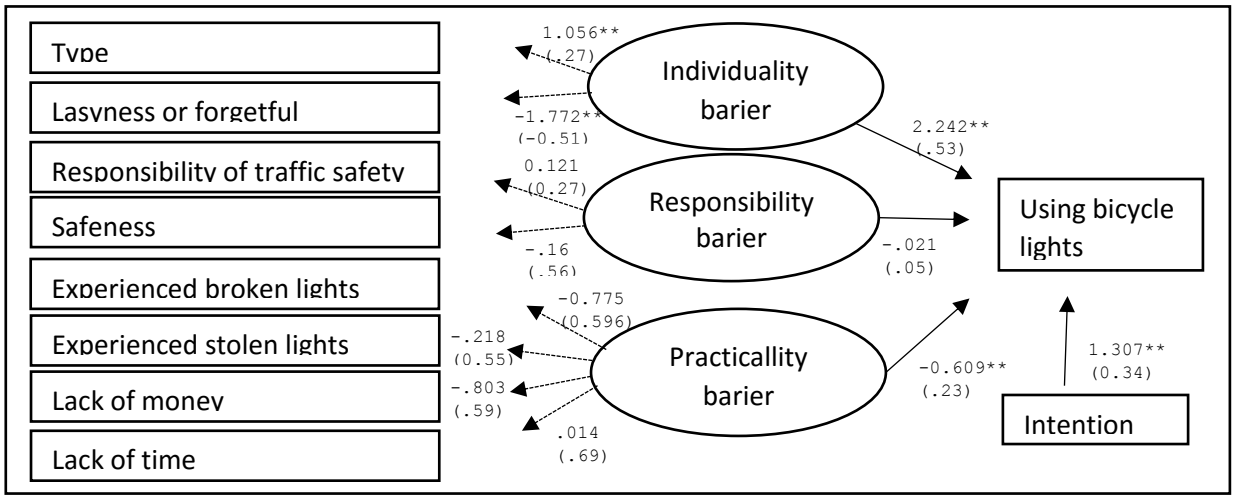

Fig 9: *Intention – action gap model to predict the use of bicycle lights, controlled for Age, education, gender, having a driver's license and Bicycle usage. Circles represent latent factors, the according formula's are shown in table 11, rectangles are indicated components and arrows represent logistic regression, standard errors in parentheses. The corresponding logit model is included in the appendix (3, table f)*

Because of the significant positive effect of the *Intention*, we do observe that cyclists behave for some extent according to their indicated *Intention*. Cyclists without lights indicated to have an average *Intention* of 3.7 out of five (between 'both agree and disagree' and 'strongly agree'). Although this is lower than the indication of the cyclists with lights (4.7), they still show to be unable to act according to their (at least moderate) Intention. We examine this 'intention action gap' (*Gap*) further with the difference between the observed behaviour of having *lights* and the indicated *Intention* (divided by five to get two equivalent values). Using this variable enables us to find out which factors hamper cyclists to act according to their intention.

The estimations for this intention action gap are shown in figure 10. This model shows that the *Gap* is explained by the same factors as the revealed behaviour of having *lights*. This additional estimation model does therefore strengthen our findings. Again we find evidence that offenders acknowledge the lack of cognitive ability to act according to their intention, considering the significant Individuality barrier. Also is the sum of practicality barriers related with this behavioural gap. With the experience of more obstacles for the use of bicycle lights, the gap with intention widens.

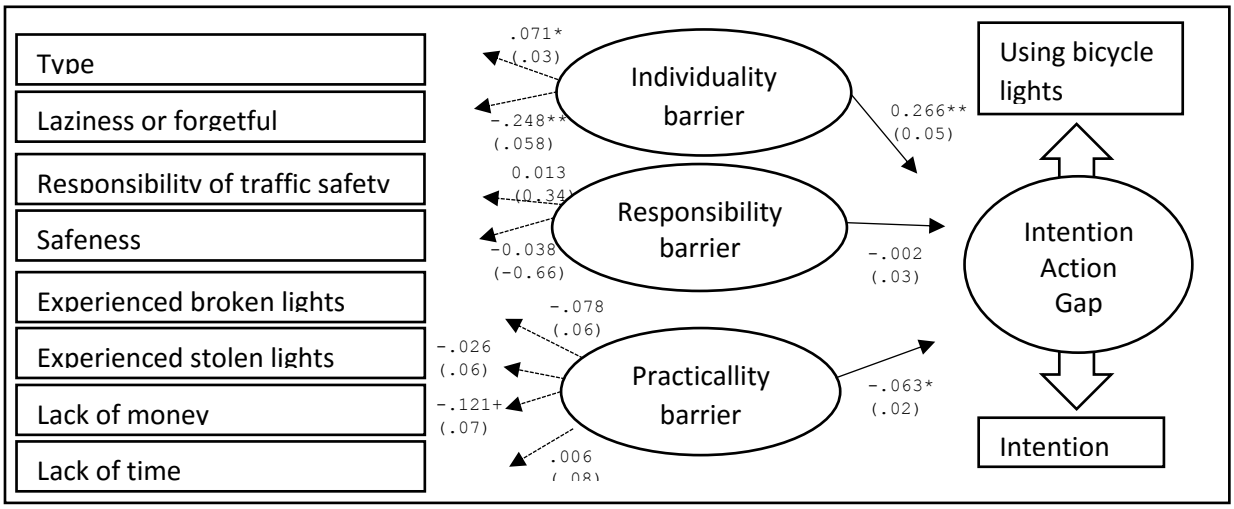

Fig 10: *Intention – action gap model to predict the gap between intention and usage, controlled for Age, education, gender, having a driver's license and Bicycle usage. Circles represent latent factors, the according formula's are shown in table 11, rectangles are indicated components and arrows represent logistic regression, standard errors in parentheses. The corresponding logit model is included in the appendix (3, table f)*

7. Discussion

The aim of the present study was to compare the ability of four social and economic models or theories (health belief model, deterrence theory, theory of planned behaviour and the intention action gap model) to predict the intention to use lights and the use itself. Additionally, we constructed the context variables for leaving versus arriving and darkness versus dusk to capture different situations of the need for bicycle lights. Earlier studies show that the rate of cyclists with bicycle lights is fluctuating around 60 percent. In the present data, 59 percent of the respondents (n=144) had both front and rear bicycle lights. Adolescents were considered to have the highest rate of offenders, something we also find in our sample. Also was the result of De Lange (2010) supported concerning the higher rate of cyclists with bicycle lights among driver's licence holders.

7.1 The willingness to buy

With the dependent variable of purchasing bicycle lights we tried to test the stated intention with the willingness to buy. First, we performed a test for the possible treatment effect, for which was found

evidence. The exposure to the questions about risks might therefore increase the willingness to buy. In the willingness to buy bicycle lights, the behaviour of cyclists was characterized as inconsistent. We found a very strong effect on the willingness to buy in the context of leaving during darkness. This can be interpreted as inconsistent behaviour, because the need to have bicycle lights is immediate. If the cyclist rejects the offer, he will directly show offending behaviour. Due to this inconsistent behaviour, the offenders show to have difficulties to commit to their own intention and to anticipate on future need of bicycle lights

None of the four models used showed fit to explain the revealed behaviour of accepting the offer. Both the perception of the police enforcement and the health belief concerning the risks in traffic were not found to play a role. Some of the other aspects were likely to be irrelevant for this revealed behaviour, because we actively offered the bicycle lights. By offering the lights, the difficulties to anticipate in the need of bicycle lights was removed and so was for example the behavioural barrier of the lack of time. Other aspects from the TPB and the intention action gap, concerning the behavioural norm and three other behavioural barriers, did not appear to be relevant as well.

7.2 The use of bicycle lights

For the revealed behaviour, recorded by the observation of having bicycle lights, we did not find any evidence for the fit of both the health belief model and the deterrence theory. Cyclists were not motivated by their perception of traffic risks, neither was the perception of the risk of getting a fine or the use of the cost-benefit analysis evident in the usage of bicycle lights. We do therefore not agree with De Lange (2010) who claimed that an increase of the fine would be effective. Considering the increased height of the fine since his study (from 35 to 65), the failure of the adjustment is evident in the unaltered high rate of offenders over the followed years (Rijkswaterstaat, 2013). Consequently we found that the effect of both the higher perceived police enforcement and fine were absent.

The TPB has some ability in predicting bicycle light use. Its most important assumption holds, the actual use of lights stems from the intention. In accordance with De Lange (2010) we only find the significant relation for the factor of attitude on intention. The favourable attitude towards having lights enhances the intention to use lights. In this order, the attitude supports the use of bicycle lights, but within the direct estimation of this relation, the support is absent. Both the practical problems and the subjective norm actually do have a direct relation. Our result of the negative effect of the factor of practical problems on having bicycle lights are in line with De Lange, but additionally we find that the subjective norm does encourage the use as well. The experience of constraints to perform are therefore relevant, and so are the opinions of peers and family effective.

Although we do not find complete irrelevance of the indicated intention for the use of bicycle lights, several of the offenders showed to have a considerable intention action gap. Overall, the cyclists are convinced of the importance and indicate to have a high intention, what was also evident in the study of TNS NIPO (2015), but that did not lead to having or buying bicycle lights. This ability to commit to the intention was found to be related with the individuality and practicality barrier. The individuality barrier predicts that respondents indicate lack of cognitive ability to act. Again the practicality barrier was relevant as well, which consisted of several operational problems for bicycle lights or the inability to buy them.

7.3 Practical implications

Following the results of the TPB and the intention action gap, three barriers have been indicated. Especially the social pressure from parents turned out to be important. This effectiveness should motivate parents to encourage their children to have bicycle lights. To tackle the inconsistency problem and for some extent the lack of cognitive ability it can be effective to offer bicycle lights in bicycle sheds. In the bicycle shed it is more likely that cyclists are in direct need of bicycle lights, therefore they should be more likely to buy bicycle lights. This possibility might reduce the effect of the lack of cognitive ability, because the lights are more easily acquired. The effect of the survey itself, which we captured with the treatment effect, might be used in campaigns to stimulate bicycle light use. Asking cyclists about their intention could make them realize about the consequences of their behaviour.

7.4 Limitations

We mentioned for several aspects that our sample size is not large enough to make hard statements. Especially for the models of the willingness to buy, the sample size was very small, therefore we had to consider our findings with caution. We should consider this study as a starting point for the analysis of the behaviour towards bicycle lights. Another limitation of our study is the absent correction for priming, there are possible concerns about the perception of the questions asked. Other studies use multiple questions to capture one component, which removes the effect of priming.

8. Conclusion

The high rate of people cycling without bicycle lights in the Netherlands is showing the failure of both public campaigns and police enforcement. This study attempts to find the underlying factors that cause people to ignore the regulation, which would explain the high rate of offenders. With two different revealed behavioural dummies, (1) having bicycle lights and (2) the willingness to buy bicycle lights, we examined this behaviour with several behavioural theories: the deterrence theory, health belief, TPB

and the intention action gap. Additionally, we constructed two context variables for leaving versus arriving and darkness versus dusk to capture different situations of need for bicycle lights.

Since we combined a survey with an offer to buy bicycle lights, we started with a treatment test. Our test for possible treatment effects did find a weak significance. The fulfilment of the survey seems therefore to increase the willingness to buy, probably because the respondents were incited to think about the risks involved. The interaction term of the two context variables represent the situation of leaving in the dark, which is consequently the context of direct need for bicycle lights. The strong relation between this interaction term and the willingness to buy suggests that the behaviour towards bicycle lights is characterised by inconsistency. It is therefore a matter of direct need that encourages cyclists to buy bicycle lights. This tendency might explain the inability to provide oneself with bicycle lights, as the cyclists probably do not experience this direct need when they are able to buy bicycle lights in the store.

With the absence of any significant effects found in the estimations for the deterrence theory, we cannot observe a possible cost-benefit analysis being operative for the case of bicycle lights. Therefore we might question the actual effectivity of an increased fine or severity. Neither were the components of the health belief model related with having bicycle lights. The differences in perception of danger in traffic does therefore not explain the behaviour towards bicycle lights.

Our respondents indicated to have a very high intention and indicated that having bicycle lights is important. The intention was relatively lower among the offenders, which was explained by a higher indicated importance ascribed to bicycle lights use. Surprisingly, the intention was not related to the willingness to buy, which denoted a lack of commitment of the intention. Both the subjective norm and the behavioural control were related to the usage, therefore the cyclists show to comply with social pressure and experience constrains that keep them from having bicycle lights. With the model for the intention action gap, we found out that the 'gap' is related to the lack of cognitive ability to enforce the intentions. Again the experience of multiple practical barriers were found relevant for the inability to commit to the intention.

Considering the multiple aspects that influence the behaviour towards bicycle lights, this study reveals that the high rate of offenders is merely explained by the lack of cyclists to commit to their intention. The experience of practical barriers of using bicycle lights and the cognitive ability to act are reasons for this intention action gap. Additionally, we find that only the direct need for bicycle lights persuaded the offenders to buy lights, a pattern that we assign to inconsistency or planning difficulties.

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10. Appendix

1. Questionnaire

Observation: (revealed behaviour, listed by interviewer)

- Does the cyclist have proper lights? (red in the rear, white in the front)
- Time
- Is the cyclist parking his bicycle or leaving with his bicycle?
- At what kind of venue is the experiment performed? (train station, city center, university)

English version:

Hello, thank you for participating in my experiment. The following questions are about your use of bicycle lights, it will take about 5 minutes. Your answers are strictly confidential. If you have any questionsabout the content, please ask the interviewer.

1. Highest education (finished or still doing)
    1. High school
    2. Middle- level applied education
    3. Higher education

2. Work status
    1. No paid job
    2. Parttime job (less than 30 hours)
    3. Fulltime (more than 30 hours)

3. How old are you?
    1. Younger than 15
    2. 15 - 29
    3. 30 - 44
    4. 45 - 59
    5. Older than 60

4. Gender
    1. Male
    2. Female

4. How many days a week do you use your bicycle?
    1. 1 or 2 days
    2. 3 or 4 days
    3. At least 5 days

Answer the following yes or no questions:

	Yes	No

5. Do you have a driver's license?	❑	❑
6. Do you do any study?	❑	❑
7. Does your family expect you to have proper bicycle lights?	❑	❑
8. Do your friends expect you to have proper bicycle lights?	❑	❑
9. Have you ever been fined for not having bicycle lights?	❑	❑
10. If you have? Was this during the last half year?	❑	❑
11. Do you know a friend or family member who is fined for cycling without bicycle lights?	❑	❑
12. Do you know somebody who had an accident while cycling during night?	❑	❑

Do you agree with the following statements?

	Fully agree	Strongly agree	Both agree and disagree	Strongly disagree	Fully disagree
13. When It is dark I will Always try to use bicycle lights	❑	❑	❑	❑	❑
14. cycling with bicycle lights I think is important	❑	❑	❑	❑	❑
15. Traffic becomes safer when you use bicycle lights	❑	❑	❑	❑	❑
16. A safe traffic is my own responsibility	❑	❑	❑	❑	❑
17. It is fair to be fined for not having bicycle lights	❑	❑	❑	❑	❑
18. I am the type of person to have bicycle lights	❑	❑	❑	❑	❑

Indicate if you have experienced any of the following aspects:

	Yes	No
19. Lack of money to buy bicycle lights?	❑	❑
20. Lack of time to buy bicycle lights?	❑	❑
21. Stolen bicycle lights?	❑	❑
22. Bicycle lights being broken?	❑	❑
23. No bicycle lights bought because of laziness or simply forgot about it	❑	❑

24. How much do you have to pay for the fine, if you do not have front nor rear lights (--euro)

25. What is the lowest price for a pair (front and rear) of bicycle lights? (--euro)

26. Imagine yourself cycling for 365 days the same route you did/ do just now without bicycle lights in the dark, how many times do you expect to have an accident? (-- times)

27. Imagine yourself again cycling for 365 days the same route you did/ do just now without bicycle lights in the dark, how many times do you expect to get a fine? (--times)

28. Imagine that there are exactly a hundred cyclists who have an accident at night, how many do you expect to be deadly (-- accidents)

29. If you do not have bicycle lights on your bicycle, you can buy them from the interviewer. Do you want to by bicycle lights?

1. Yes
2. No

2. Questionnaire (in Dutch)

Hallo, bedankt dat u mee wilt helpen aan dit onderzoek. De komende vragen gaan over uw gebruik van fietsverlichting, het duurt ongeveer 5 minuten om in te vullen. Uw antwoorden zijn volledig vertrouwelijk. Als u een vraag heeft over de gestelde vragen, kunt u om hulp vragen bij de interviewer.

1. Hoogst genote opleiding (afgerond of mee bezig)

1. Middelbare school
2. MBO
3. HBO of wetenschappelijk onderwijs

2. Werkstatus

1. Zonder werk
2. Part time werk (<30 uur)
3. Full time werk (>30 uur)

3. Wat is uw Leeftijd?

1. Jonger dan 15
2. 15 - 29
3. 30 - 44
4. 45 - 59
5. Ouder dan 60

4. Hoeveel dagen fietst u per week ongeveer?

1. 1 a 2 dagen
2. 3 a 4 dagen
3. Tenminste 5 dagen

Geef antwoord op de volgende ja/nee vragen:

	Ja	Nee
5. Heeft u een rijbewijs?	❑	❑
6. Studeert u?	❑	❑
7. Vindt uw familie dat u met fietsverlichting moet fietsen?	❑	❑
8. Vinden uw vrienden dat u met fietsverlichting moet fietsen?	❑	❑
9. Bent u ooit beboet voor het fietsen zonder fietsverlichting?	❑	❑

10. Zo ja? Was dit in het afgelopen half jaar?	❑	❑
11. Kent u vrienden of familie die in het afgelopen half jaar is beboet omdat ze geen fietsverlichting hadden?	❑	❑
12. Kent u iemand die 's nachts is aangereden?	❑	❑

Bent u het eens met de volgende stelling?

	Volledig mee eens	Zeer mee eens	Gedeeltelijk eens en oneens	Zeer mee oneens	Volledig mee oneens
13. Als het donker is zal ik altijd proberen fietsverlichting te dragen op de fiets	❑	❑	❑	❑	❑
14. Fietsen met fietsverlichting is belangrijk	❑	❑	❑	❑	❑
15. Door fietsen met fietsverlichting wordt het verkeer veiliger	❑	❑	❑	❑	❑
16. Een veilig verkeer is mijn eigen verantwoordelijkheid	❑	❑	❑	❑	❑
17. Ik ben het type persoon dat fietsverlichting heeft	❑	❑	❑	❑	❑
18. Het is eerlijk dat er een boete wordt uitgedeeld indien men geen fietsverlichting heeft	❑	❑	❑	❑	❑

Geef aan of u de volgende zaken ervaart of heeft ervaren:

	Ja	Nee
19. Tekort aan geld om fietslampjes te kopen?	❑	❑
20. Tekort aan tijd om fietslampjes te kopen?	❑	❑
21. Snel brekende lampjes?	❑	❑
22. Gestolen lampjes?	❑	❑
23. Geen lampjes gekocht vanwege luiheid of simpelweg vergeten	❑	❑

24. Hoe hoog is de boete voor fietsen zonder fietsverlichting? Zowel geen verlichting voor als achter (--euro)

25. Hoe duur zijn een paar (voor en achterlicht) van de goedkoopste lampjes? (--euro)

26. Stel uzelf voor dat u voor 365 dagen dezelfde route als nu gaat afleggen zonder fietsverlichting in het donker, hoe vaak verwacht u een boete te hebben? (-- boetes)

27. Stel uzelf weer voor dat u 365 dagen dezelfde route als nu moet afleggen zonder fietsverlichting in het donker, hoe vaak verwacht u een botsing te hebben? (--botsingen)

28. Stel uzelf voor dat in heel Nederland honderd fietsers worden geraakt door een auto in de nacht, hoeveel van deze botsingen zijn dodelijk denkt u? (--botsingen)

29. Voor diegene die geen verlichting hebben heeft de interviewer lampjes ingekocht. Wilt u fietsverlichting kopen? (een set van voor en achterlicht is 1 euro)

1. Ja
2. Nee

3. Tables

Table a: Marginal effects of control and context variables

	(1) Mfx Lights	(2) mfx Purchase	(3) mfx Purchase	(4) mfx Purchase	(5) mfx Purchase	(6) mfx Purchase
Male (d)	-0.0552	-0.0672	-0.115			
	(0.0901)	(0.130)	(0.138)			
Education	-0.149*	0.115	0.102			
	(0.0738)	(0.117)	(0.114)			
Age	0.231**	-0.0702	-0.0558			
	(0.0757)	(0.142)	(0.140)			
Driving (d)	0.241*	0.0731	0.103			
	(0.110)	(0.135)	(0.136)			
BicycleUsage	-0.140+	0.00666	0.0809			
	(0.0802)	(0.149)	(0.153)			
Treatment (d)			0.323**	0.284*	0.249*	0.248*
			(0.113)	(0.120)	(0.126)	(0.126)
Leaving (d)				0.136	-0.366+	-0.350
				(0.137)	(0.222)	(0.236)
Darkness (d)				0.292*	-0.358	-0.345
				(0.121)	(0.251)	(0.260)
Interaction (d)					0.781**	0.769**
					(0.156)	(0.169)
Intention						-0.0487
						(0.0877)
Importance						0.163
						(0.131)
N	144	59	59	59	59	59
pseudo R-sq	0.139	0.028	0.101	0.144	0.255	0.277

Marginal effects; Standard errors in parentheses
(d) for discrete change of dummy variable from 0 to 1
+ p<0.1, * p<0.05, ** p<0.01

Table b: Cost-benefit analysis

	(1) Lights	(2) logPolC~r	(3) Lights	(4) Lights	(5) Purchase	(6) Purchase	(7) Purchase
main							
Male	-0.117	-0.389*	-0.137	-0.178			
	(-0.29)	(-2.21)	(-0.34)	(-0.45)			
Education	-0.614+	0.123	-0.598+	-0.670*			
	(-1.88)	(0.88)	(-1.85)	(-2.11)			
Age	1.013**	0.0723	0.971**	0.980**			
	(2.96)	(0.61)	(2.90)	(2.95)			
Driving	1.099*	-0.148	1.045*	0.963*			
	(2.33)	(-0.68)	(2.24)	(2.07)			
BicycleUsage	-0.620+	0.124	-0.674+	-0.678+			
	(-1.80)	(0.90)	(-1.89)	(-1.89)			
lnPolice	0.161				0.0765		
	(0.79)				(0.26)		
lnFine(€)	0.139				-0.873		
	(0.31)				(-1.26)		
lnLED(€)	-0.252				0.0747		
	(-0.79)				(0.17)		
Fined		0.140					
		(0.71)					
FinedHY		0.0343					
		(0.08)					
RelFined		0.460*					

		(2.48)					
Fines(CJIB)		-0.00494					
		(-0.11)					
lnCostBenefit			0.0434				-0.00306
			(0.77)				(-0.04)
BCostBenefit				0.344		-0.0535	
				(0.81)		(-0.10)	
_cons	0.0618	0.290	0.685	0.849	2.704	-0.560	-0.588+
	(0.03)	(0.47)	(0.47)	(0.59)	(0.98)	(-1.26)	(-1.94)
N	140	142	140	144	59	59	59
pseudo R-sq	0.145		0.141	0.142	0.023	0.000	0.000

t statistics in parentheses
+ p<0.1, * p<0.05, ** p<0.01

Table c: logistic estimations of HBM model

	(1) Lights	(2) Lights	(3) Lights	(4) Purchase	(5) Purchase
main					
Male	-0.162	-0.0201	-0.152		
	(0.425)	(0.433)	(0.400)		
Educ	-0.533	-0.660+	-0.632+		
	(0.337)	(0.340)	(0.323)		
Age	0.904**	1.090**	0.840*		
	(0.343)	(0.383)	(0.339)		
Driving	1.111*	1.013*	0.887+		
	(0.511)	(0.512)	(0.478)		
BicycleUsage	-0.782*	-1.063**	-0.633+		
	(0.365)	(0.403)	(0.348)		
Susceptibility	-0.0104				
	(0.0214)				
Severity	0.0258**				
	(0.00899)				
Friends	0.628	0.696		-0.112	
	(0.433)	(0.435)		(0.558)	
Safeness	0.299	0.282		0.0665	
	(0.436)	(0.449)		(0.572)	
LnSusceptibility		0.208		-0.0199	
		(0.218)		(0.305)	
lnSeverity		0.277+		-0.185	
		(0.150)		(0.232)	
lnThreat			0.109		-0.0238
			(0.0845)		(0.138)
Evaluation			0.621		-0.0781
			(0.384)		(0.524)
_constant	-1.397	-1.005	-0.0529	-0.349	-0.428
	(2.366)	(2.489)	(1.513)	(2.766)	(0.849)
N	141	138	144	57	59
pseudo R-sq	0.221	0.231	0.165	0.010	0.001

Standard errors in parentheses
+ p<0.1, * p<0.05, ** p<0.01

Table d: several estimation models of the TPB model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Est. model:	Lin. Regr.	Lin. Regr	Logistic	mfx	Logistic	mfx	Logistic	mfx
Dep. Var:	Intention	Intention	Lights	Lights	Lights	Lights	Lights	Lights
Male (d)	0.0478	-0.000871	-0.166	-0.0392	-0.0458	-0.0106	-0.228	-0.0530
	(0.129)	(0.129)	(0.436)	(0.103)	(0.445)	(0.103)	(0.417)	(0.0965)
Education	-0.0631	-0.0925	-0.709*	-0.168*	-0.679+	-0.157+	-0.691*	-0.161*
	(0.101)	(0.102)	(0.357)	(0.0843)	(0.353)	(0.0816)	(0.339)	(0.0790)
Age	0.213*	0.266**	0.432	0.102	0.824*	0.191*	0.767*	0.179*
	(0.0915)	(0.0905)	(0.355)	(0.0833)	(0.372)	(0.0840)	(0.336)	(0.0768)
Driving (d)	0.0861	0.101	1.017+	0.245*	1.011+	0.240+	1.083*	0.258*
	(0.157)	(0.157)	(0.520)	(0.123)	(0.522)	(0.123)	(0.503)	(0.118)
Bicycle Usage	-0.156	-0.142	-0.562	-0.133	-0.670+	-0.155+	-0.647+	-0.151+
	(0.101)	(0.101)	(0.396)	(0.0930)	(0.392)	(0.0899)	(0.367)	(0.0849)
Importance	0.872**				0.852+	0.197+		
	(0.136)				(0.451)	(0.105)		
Safeness	0.177				-0.129	-0.0299		
	(0.150)				(0.489)	(0.113)		
Family (d)	-0.264				1.871+	0.430*		
	(0.278)				(1.026)	(0.185)		
Friends (d)	0.0359				0.235	0.0549		
	(0.143)				(0.459)	(0.108)		
LMoney (d)	-0.0773				-0.617	-0.147		
	(0.147)				(0.478)	(0.115)		
LTime (d)	-0.0365				0.382	0.0847		
	(0.183)				(0.608)	(0.128)		
Broken (d)	-0.00818				-1.032*	-0.223*		
	(0.148)				(0.526)	(0.103)		
Stolen (d)	0.00221				-0.240	-0.0552		
	(0.135)				(0.452)	(0.103)		
Norm		-0.000495					0.598	0.140
		(0.121)					(0.380)	(0.0889)
Attitude		0.546**					0.364	0.0849
		(0.0841)					(0.258)	(0.0605)
Control		-0.0132					-0.433*	-0.101*
		(0.0561)					(0.183)	(0.0426)
Intention			1.277**	0.303**				
			(0.276)	(0.0677)				
N	144	144	144	144	144	144	144	144
pseudo R~q			0.280	0.280	0.252	0.252	0.213	0.213

Marginal effects; Standard errors in parentheses
(d) for discrete change of dummy variable from 0 to 1
+ p<0.1, * p<0.05, ** p<0.01

Table e: Logistic estimations of the TPB model for the willingness to buy

	(1)	(2)	(3)	(4)	(5)
Est. Mod:	Lin. Regr	Lin. Regr.	logistic	Logistic	Logistic
Dep. Var.	Intention	Intention	Purchase	Purchase	Purchase
Importance	0.834**			0.828	
	(0.195)			(0.579)	
Safeness	0.145			0.0871	
	(0.245)			(0.638)	
Family	-0.728+			-0.489	

	(0.382)			(0.963)		
Friends	-0.0762			-0.269		
	(0.239)			(0.626)		
LMoney	0.0399			-0.268		
	(0.246)			(0.631)		
LTime	0.128			-0.270		
	(0.333)			(0.833)		
Broken	-0.388			1.380		
	(0.341)			(1.008)		
Stolen	0.187			-0.517		
	(0.257)			(0.666)		
Norm		-0.239			-0.361	
		(0.179)			(0.441)	
Attitude		0.582**			0.400	
		(0.123)			(0.318)	
Control		0.0123			0.0672	
		(0.109)			(0.270)	
Intention			-0.0182			
			(0.277)			
_constant	0.142	-1.331	-0.526	-4.853	-3.890	
	(1.252)	(1.120)	(1.052)	(3.545)	(2.926)	
N	59	59	59	59	59	
pseudo R~q			0.000	0.071	0.026	

Standard errors in parentheses
+ p<0.1, * p<0.05, ** p<0.01

Table f: several estimation models of the Intention action gap (Use of bicycle lights)

	(1)	(2)	(3)	(4)	(5)	(6)
Est. Mod:	logistic	mfx	Logistic	mfx	Lin. Regr	Lin. Regr.
Dep. Var.	Lights	Lights	Lights	Lights	Gap	Gap
Education	-0.535	-0.120	-0.452	-0.102	-0.0546	-0.0516
	(0.392)	(0.0877)	(0.409)	(0.0926)	(0.0457)	(0.0447)
Age	0.653	0.146	0.557	0.126	0.0579	0.0690+
	(0.406)	(0.0891)	(0.399)	(0.0884)	(0.0428)	(0.0392)
Driving (d)	0.752	0.174	0.701	0.163	0.118+	0.115+
	(0.566)	(0.133)	(0.583)	(0.138)	(0.0701)	(0.0687)
BicycleUsage	-0.764+	-0.171+	-0.615	-0.139	-0.0711	-0.0746+
	(0.434)	(0.0961)	(0.426)	(0.0958)	(0.0458)	(0.0445)
Laziness (d)	-1.772**	-0.372**			-0.248**	
	(0.507)	(0.0941)			(0.0578)	
Type	1.056**	0.236**			0.0709*	
	(0.272)	(0.0621)			(0.0313)	
SafeResp	0.121	0.0271			0.0134	
	(0.274)	(0.0611)			(0.0337)	
Safeness	-0.162	-0.0363			-0.0380	
	(0.556)	(0.124)			(0.0664)	
LTime (d)	0.0145	0.00324			0.00606	
	(0.685)	(0.153)			(0.0833)	
LMoney (d)	-0.803	-0.187			-0.121+	
	(0.587)	(0.139)			(0.0675)	
Broken (d)	-0.775	-0.165			-0.0779	
	(0.596)	(0.119)			(0.0671)	
Stolen (d)	-0.218	-0.0486			-0.0262	
	(0.554)	(0.123)			(0.0611)	
Individuality			2.242**	0.508**		0.266**
			(0.527)	(0.117)		(0.0492)

Responsibility			-0.0206	-0.00466		-0.00204
			(0.0484)	(0.0110)		(0.0258)
Practicality			-0.609**	-0.138**		-0.0633*
			(0.228)	(0.0507)		(0.0246)
Intention			1.307**	0.296**		
			(0.347)	(0.0826)		
N	144	144	144	144	144	144
pseudo R~q	0.393	0.393	0.438	0.438		

Marginal effects; Standard errors in parentheses
(d) for discrete change of dummy variable from 0 to 1
+ p<0.1, * p<0.05, ** p<0.01

Table g: Intention action gap model for the willingness to buy

	(1)	(2)	(3)	(4)
Est. Mod:	Logistic	logistic	Lin. Regr	Lin. Regr>
Dep. Var.	Lights	Lights	Gap2	Gap2
Laziness	-0.398		-0.0732	
	(0.656)		(0.122)	
Type	-0.113		-0.0962+	
	(0.303)		(0.0526)	
SafeResp	0.500		0.0631	
	(0.372)		(0.0621)	
Safeness	0.130		0.00783	
	(0.661)		(0.114)	
LTime	-0.105		-0.0241	
	(0.892)		(0.157)	
LMoney	-0.392		-0.107	
	(0.634)		(0.115)	
Broken	1.512		0.221	
	(1.041)		(0.158)	
Stolen	-0.707		-0.0498	
	(0.687)		(0.118)	
Individuality		0.209		-0.0176
		(0.611)		(0.118)
Responsibility		0.293		0.0317
		(0.270)		(0.0449)
Practicality		0.0551		0.0195
		(0.271)		(0.0513)
Intention		-0.0871		
		(0.289)		
_cons	-3.252	-2.942	-0.504	-0.791+
	(3.410)	(2.518)	(0.558)	(0.411)
N	59	59	59	59
pseudo R~q	0.077	0.022		

Standard errors in parentheses
+ p<0.1, * p<0.05, ** p<0.01

Table h: predictive margins (Treatment and context variables)

```
Predictive margins                              Number of obs   =         59
Model VCE    : OIM

Expression   : Pr(Purchase), predict()
------------------------------------------------------------------------------
                 |            Delta-method
                 |     Margin   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------+------------------------------------------------------------
       Treatment |
               0 |   .1879064   .1047218     1.79   0.073    -.0173446    .3931574
               1 |   .4019076   .0621508     6.47   0.000     .2800942    .5237209
                 |
Leaving#Darkness |
             0 0 |   .4278012   .1824587     2.34   0.019     .0701887    .7854136
             0 1 |   .1353551   .1223135     1.11   0.268    -.1043749    .3750851
             1 0 |   .1499489    .078456     1.91   0.056     -.003822    .3037198
             1 1 |   .6153258   .1030786     5.97   0.000     .4132955    .8173561
------------------------------------------------------------------------------
```

Table i: marginal effects of contrasts (Treatment and context variables)

```
Model VCE    : OIM

Expression   : Pr(Purchase), predict()

-----------------------------------------------------
                 |         df        chi2     P>chi2
-----------------+-----------------------------------
       Treatment |          1        3.02     0.0822
                 |
Leaving#Darkness |          1        8.48     0.0036
-----------------------------------------------------

------------------------------------------------------------------
                   |            Delta-method
                   |   Contrast   Std. Err.     [95% Conf. Interval]
-------------------+----------------------------------------------
         Treatment |
         (1 vs 0)  |   .2140012   .1231425    -.0273537     .455356
                   |
  Leaving#Darkness |
(1 vs 0) (1 vs 0)  |    .757823    .260185     .2478699    1.267776
------------------------------------------------------------------
```

4. locations

Location	Date	Train station / city center	Guarded or unguarded bicycle shed	Fines in 2015 (LYFine) per 1000 inhabitants*
Nijmegen, Bisschop Hamer plein	13-04	City Center	Guarded	5.1
Nijmegen CS	29-04	Train station	Unguarded	5.1
Nijmegen, Plein 1944	25-04	City Center	Guarded	5.1
Ede Wageningen, CS	15-04	Train station	Unguarded	2.3
Amsterdam, South station	28-04	Train station	Guarded	1.3
Utrecht, UU	02-05	City Center	Unguarded	1.2
Pijnacker, MS (centrum)	22-04	Train station	Unguarded	0.9
Arnhem, CS	03-05	Train station	Guarded	0.2
Arnhem, Gele Rijdersplein	04-05	City Center	Unguarded	0.2
Brummen	09-05	Train station	Unguarded	0.1

* retrieved from CJIB (2016)