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Nudging in bicycle parking

Influencing the self-organising processes of bicycle parking in public spaces

Master Thesis

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Preface

Here I present my Master thesis entitled “Nudging in bicycle parking: influencing the self-organising processes of bicycle parking in public spaces”, which is the final part of the Master Environmental and Infrastructure Planning at the Faculty of Spatial Sciences at the University of Groningen.

Whilst living in the inner-city of Groningen it became more and more evident to me how much I came to dislike and develop an aversion to the manner in which many people would haphazardly park their bicycles in public spaces. The disorganisation and hindrance thereby created, prompted me to attempt to come up with a viable solution. The concept of “nudging” captured my attention as this appeared to me to be an intriguing possibility as a means to influence the behaviour of cyclists when parking their vehicles. The whole notion in attempting to nudge people and guiding them unawares sounded like a perfect idea to me. In order to become scientifically convinced of the possibilities in nudging, I commenced on an investigation into how one can effectively nudge people into parking their bicycles appropriately.

I would like to thank my supervisor for guiding me through this challenging process with enthusiasm, motivation and always helpful feedback. Secondly, I want to thank my friends and family for supporting, inspiring and being there for me throughout the thesis period, without them this thesis would not have been possible.

I hope you enjoy reading this thesis.

Lara Baxter

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Abstract

The inner-city of Groningen is dealing with inappropriate bicycle parking in public spaces. Current interventions, such as developing bicycle racks or placing 'no parking' signs, do not always seem to decrease the amount of inappropriate bicycle parking effectively. This is problematic since inappropriately parked bicycles create several undesirable effects, it reduces the accessibility of public spaces, prevents the smooth flow of transportations and has a negative impact on the image of the city. Current interventions often fail since they do not recognise that the behaviour of cyclists who park their bicycle is guided through processes of self-organisation and is not always rational. A way of tackling inappropriate bicycle parking is though nudging. This study explores to what extent self-organising processes can be guided through nudging to provide insights for urban planners to determine when nudging could be effective or not in order to prevent ineffective nudges. A field experiment has been conducted in the public space of Westerhaven with a nudge, which consisted of two bicycle squares with two yellow bicycles. The nudge had the ability to steer people into parking their bicycle more appropriately and was thus able to influence people's bicycle parking behaviour. This study concludes that nudging can be a useful instrument for urban planners to influence the self-organisation of bicycle parking in public spaces when used to complement other interventions. It is necessary to combine various interventions to reduce the number of inappropriately parked bicycles, since inappropriate bicycle parking cannot be solved solely through nudging. Finally, it is necessary to acknowledge that the effectiveness of nudging is context-dependent and relies on the interpretation of what is considered as inappropriate bicycle parking.

Keywords: *Nudging, Guided Self-organisation, Self-organising Systems, Bicycle Parking, Descriptive norms*

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1 Introduction

1.1 Influencing bicycle parking through nudging

Bicycles are used as a transportation mode to travel from one destination to another. People have a tendency to park their bicycle as close as possible to their destination since that is most time-efficient (Larsen, 2017). Bicycle racks and garages are not available on every location and are sometimes too far away. Therefore, parking bicycles on pavements in public spaces becomes highly tempting, resulting in a great amount of clogged up bicycles parked in public spaces (Aluvihare et al., 2014).

Inappropriate bicycle parking creates several undesirable effects. Firstly, chaotically parked bicycles reduce the accessibility of public spaces, which is especially troublesome for disabled or immobile people (Fujii, 2005). Secondly, inappropriately parked bicycles may prevent the smooth flow of transportation and may cause problems for logistics. Furthermore, the problem of inappropriately parked bicycles not only brings inconvenience to other people but also has a negative impact on the image of the city since they make public spaces look messy and less organised (Wang et al., 2016). Finally, badly parked bicycles are often negatively perceived, as threatening or risky, affected by theft, vandalism or the weather (Aldred & Jungnickel, 2013). This negative perception is especially problematic since bicycles spend most of their time parked (Larsen, 2017).

A town that is well known for its high-dense bicycle use is Groningen. Groningen is a bicycle-city with more than sixty percent of all its traffic movements occurring by bicycle (Gemeente Groningen, 2015). This is due to the fact that the bicycle is the most efficient mode of transportation in inner-cities compared to the car or public transportation (Aluvihare et al., 2014). Moreover, cycling is more peaceful, cheaper, healthier, sustainable, and people really connect with the city (de Jong & Kolstein, 2015). The ever-increasing usage of bicycles subsequently puts greater pressure on the parking capacity in public spaces (Gemeente Groningen, 2015). It is thus of vital importance that municipalities try to stimulate more appropriate bicycle parking in order to sustain liveability in inner-cities.

The municipality of Groningen is placing more and more emphasis on bicycles in their policies since they want to maintain their reputation as 'Bicycle city' *(Fietsstad)* (Gemeente Groningen, 2015). Firstly, the municipality of Groningen has emphasized the need for more parking spaces by expanding the bicycle garage at the train station and by developing more enclosed bicycle racks in the inner-city of Groningen (Gemeente Groningen, 2015). Furthermore, the municipality of Groningen tries to stimulate appropriate bicycle parking through law enforcement by placing 'no parking' signs or removing wrongly parked bicycles (Gemeente Groningen, 2015).

However, these kinds of interventions do not always seem to be effective in decreasing the amount of inappropriate bicycle parking (Fujii, 2005). Current interventions often fail since they do not recognise that the behaviour of cyclists who park their bicycle is guided through processes of self-organisation. Furthermore, traditional interventions generally assume that when people park

their bicycle they do this by making deliberate choices and that people are consciously aware of their actions (Lehner et al., 2015). However, cyclists are imperfect decision-makers shaped by routine behaviour and social influence (Fukuda & Morichi, 2007). Therefore, the self-organising processes and the behaviour of cyclists need to be considered when wanting to reduce inappropriate bicycle parking.

A way of tackling inappropriate bicycle parking is through nudging. A nudge is an instrument that guides people's behaviour in a subtle manner without taking away their freedom of choice (Thaler & Sunstein, 2009). More appropriate bicycle parking can, for example, be stimulated by marking bicycle parking squares on pavements, rewarding cyclists for parking their bicycle correctly by distributing free saddle covers or discouraging people to park their bicycle on pavements by placing red carpets (Gemeente Groningen, 2015). These nudges ensure that people are still free to choose where they want to park their bicycle. However, they are subconsciously nudged towards parking their bicycle at more preferable locations.

Nudging fits within the changing approaches within urban planning. Increased complexities and uncertainties led to a request for different kind of planning interventions which are more adaptive, flexible and bottom-up (Brand & Gaffikin, 2007; Rauws et al., 2014). Nudging is an instrument that is cheap, flexible and adaptable compared to bicycle racks (Wilkinson, 2013). Therefore, nudging could be an additional instrument to the toolbox of planners, who want to ensure more flexible and bottom-up interventions when planning for bicycle parking.

1.2 Problem definition

The municipality of Groningen has been experimenting with various nudges at different locations in public spaces, aiming to reduce disorderly parked bicycles (Gemeente Groningen, 2015). These experiments merely give an indication of which nudges work and which do not, instead of illuminating why the nudges work or why not. There is thus a lack of clarity regarding the effectiveness of nudging for reducing inappropriate bicycle parking. Besides, it is unclear whether nudging has the ability to influence the self-organising processes of bicycle parking.

Therefore, this study explores to what extent self-organising processes can be guided through nudging. Thus, providing insights for urban planners to determine when nudging could be effective or not. A better understanding of the effectiveness of nudging regarding bicycle parking is necessary in order to prevent urban planners from implementing ineffective nudges.

1.3 Research objective

This study explores whether nudging can be a useful instrument to influence the self-organisation of bicycle parking in public spaces. This will provide insights into the effectiveness of nudging for stimulating appropriate bicycle parking.

The research question which this study attempts to answer is:

"When can nudging be a useful instrument for urban planners to influence the self-organisation of bicycle parking in public spaces?".

A set of sub-questions have been formulated to answer and support the main research question:

1. *"Why can bicycle parking in public spaces be seen as self-organising?"*

The first sub-question discusses why bicycle parking in public spaces can be seen as self-organising. Considering bicycle parking as self-organising provides insights into how inappropriate bicycle parking occurs.

2. *"How can nudging influence the self-organisation of bicycle parking?"*

This study explores whether nudging is able to influence people's bicycle parking behaviour to reduce inappropriate bicycle parking. Therefore, the second sub-question investigates how the self-organising processes of bicycle parking behaviour can be influenced, and whether this can be done through nudging.

3. *"Is nudging an effective instrument to influence bicycle parking?"*

The last sub-question investigates whether bicycle parking can be effectively influenced through nudging. The effectiveness of nudging will be tested by conducting an experiment in a public space in the inner-city of Groningen.

1.4 Thesis outline

This research starts with a literature review on the theory behind self-organisation, nudging and guided self-organisation in chapter 2. Chapter 3 discusses the chosen research strategy, research methods, data collection, and the analysis. The results of this research are elaborated on in chapter 4, which presents the main findings of the research. The conclusion can be found in chapter 5, which answers the sub-questions and research question. Finally, chapter 6 discusses the conclusion and critically reflects on the research gaps by giving suggestions for further research.

2 Theoretical framework

This chapter presents the relevant theories that are necessary to answer the first two sub-questions - underpinning the research question formulated in chapter 1. Firstly, the processes of self-organisation will be discussed and applied to bicycle parking in section 2.1. Considering bicycle parking as self-organising could gain insights on how to try and change the way bicycles are being parked. Secondly, section 2.2 will explain why current interventions often fail in reducing inappropriate bicycle parking. The third section discusses nudging as a possible instrument that could influence the self-organising processes of bicycle parking. However, there is a lack of clarity regarding the effectiveness of nudging. Therefore, section 2.4 explores to what extent self-organising processes can be guided by examining the theory of guided self-organisation. This theory could provide insights for urban planners to determine whether nudging could effectively reduce inappropriately parked bicycles. Finally, the conceptual model which visualises the relations between the concepts and theories discussed in this chapter will be presented in section 2.5.

2.1 Inappropriate bicycle parking as a result of self-organisation

Public spaces with its actors can be considered as self-organising systems, in which cyclists take part. Considering this provides insights for urban planners as to how inappropriate bicycle parking occurs and how this can possibly be influenced. Firstly, the system where bicycle parking takes place will be defined. Secondly, an explanation will be given of what self-organisation is, and how these processes often result in a pattern of inappropriate bicycle parking. Finally, the relevant insights of considering bicycle parking as a result of self-organisation will be summarised.

2.1.1 Defining the system

The pattern of bicycle parking can be seen is a result of the self-organising processes in public spaces. A public space with its self-organising processes can be considered as a distinctive system by defining its boundaries. Defining the boundaries of a self-organising system is not that simple since all systems are intertwined with other systems (Rauws et al., 2016). However, it is not practical to include all the affectable elements of different systems, since this would not give this study a research focus.

Ozaki & Lewis (2006) provide a guideline to define the boundaries of a system. They state that boundaries function at three distinct but related levels: physical, sociocultural and psychological. The physical boundaries are referred to as concrete manifestations of social classifications, i.e. buildings, roads, signs etc. People recognise and understand the meaning of the physical boundaries which then creates boundaries on the sociocultural level. The sociocultural boundaries are shared among people which mark the social classification of space. Finally, these sociocultural boundaries generate cognitive and affective experiences, i.e. excitement, nervousness, fear etc., referred to as psychological boundaries.

These three boundaries can be illustrated with an example of a public space in Groningen, namely the Westerhaven. The physical boundaries of the Westerhaven are, for example, the buildings surrounding the area, the area itself with distinctive red stones, signs which label the area with 'Westerhaven' etc. The meaning of these physical boundaries creates sociocultural boundaries, namely the understanding that it is commonly disapproved to park a bicycle in the area with red stones. The psychological boundaries can for example be the negative feeling a cyclist can get when parking their bicycle inappropriately.

2.1.2 Self-organisation of bicycle parking

Public spaces with its actors can be seen as self-organising systems, in which cyclists partake. Heylighen defines self-organisation as "*the spontaneous creation of a globally coherent pattern out of local interactions*" (2001, p. 1). Self-organising systems are not controlled by single internal or external agents. Instead, they are organised through local interactions between agents (Heylighen, 2008). Changes that occur due to these local interactions between cyclists themselves and between cyclists and other actors eventually propagate through the entire system, resulting in a globally coherent pattern.

This study considers the resulting pattern to be the physical pattern of how bicycles are being parked. This pattern often exhibits inappropriate bicycle parking, e.g., bicycles parked on pavements in front of entrances. This is demonstrated by the influence an individual cyclist has on the bicycle parking behaviour of other cyclists. If someone decides to park a bicycle on the pavement, others will probably do likewise, which often results in a pattern of inappropriate bicycle parking (Fukuda & Morichi, 2007).

This pattern of inappropriate bicycle parking is very difficult to control and predict, since self-organising processes are often non-linear. Non-linearity means that cause-effect relationships are likely to be disproportionate (Rauws et al., 2014). Small changes in the way bicycles are being parked, which are considered by planners insignificant at the time, can unexpectedly escalate leading to an excessive amount of inappropriately parked bicycles.

Moreover, the dynamics of self-organising systems are often circular (Heylighen, 2001). The local interactions of the self-organisation of bicycle parking, which can be referred to as 'bottom-up processes', result in a pattern. This pattern then influences the behaviour of the cyclists by enslaving them. The cyclists will thus conform their behaviour to the established pattern. The established pattern will subsequently be reproduced by local interactions, resulting in a circular causality (see figure 1) (Haken, 1984). The influences between bottom-up and top-down forces will repeat themselves.

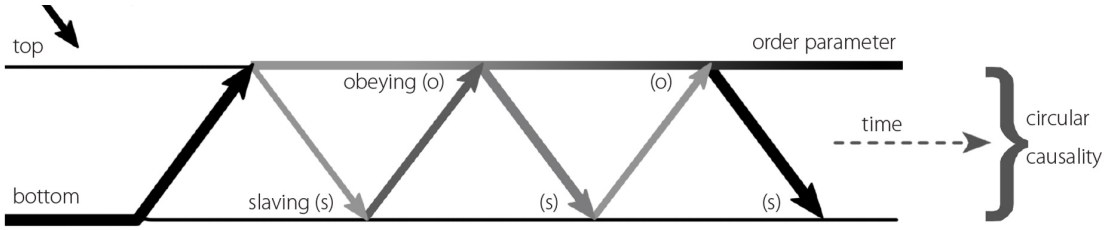

Figure 1 | Circular causality of self-organisation (Haken, 1984)

2.1.3 Conclusion

Acknowledging that bicycle parking in public spaces is a resulting pattern of self-organisation, provides a better understanding for urban planners on how to deal with inappropriate bicycle parking. Bicycle parking in public spaces is shaped by the interactions between cyclists and between cyclists and other people involved, which results in a pattern of parked bicycles. This resulting pattern often exhibits inappropriate bicycle parking.

Since the self-organising processes are circular, this study assumes that the current pattern of inappropriate bicycle parking can, on the one hand, be changed through changes in local interactions. On the other hand, local interactions can also be changed by changing the pattern of inappropriate bicycle parking. Acknowledging these possibilities offers opportunities for urban planners to influence bicycle parking behaviour.

2.2 Failure of current interventions

Urban planners have employed different kinds of planning interventions that attempt to decrease the amount of disorderly parked bicycles in public spaces (Gemeente Groningen, 2015). An obvious intervention is increasing the amount of bicycle parking spaces by creating more bicycle racks, facilities and so on. More bicycle facilities would increase the parking capacity of a city, which presumably would lead to a reduction in inappropriate bicycle parking. Another alternative to stimulate appropriate bicycle parking in public spaces is through law enforcement by placing 'no parking' signs, imposing fines for parking inappropriately or removing wrongly parked bicycles.

These 'traditional' interventions are mainly based on the assumption that people, and in this case 'cyclists', are rational beings, namely people that always make well-considered choices by applying reason and logic to their decisions and choices (Moseley & Stoker, 2013). This thought is derived from classical economics which perceives humans as utility maximisers with perfect information processing capacity (Lehner et al., 2015). Therefore, traditional interventions generally assume that when people park their bicycle, they do so by making deliberate choices and by being consciously aware of their actions (Lehner et al., 2015). However, interventions that consider people to be rational beings, do not always seem to effectively influence the way bicycles are being parked.

This study argues that the failure of 'traditional' interventions can be explained by recognising the bounded rationality of individuals. There is a limit to people's rationality because they do not

always have enough time, information, and resources to make the 'right' choices (Lodge & Wegrich, 2016). This does not mean that people behave in an irrational way, such as making decisions solely based on emotions without any logic or reason. Nevertheless, there is a limit to the ability to process all the information and knowledge that people are confronted with (Moseley & Stoker, 2013). People thus do not always act rationally and are therefore imperfect decision-makers (Thaler & Sunstein, 2009). Furthermore, large parts of people's daily activities, including bicycle parking, are mostly guided by routine behaviour. This kind of behaviour is usually led by subconscious and automatic thinking (Thaler & Sunstein, 2009).

People thus do not always act rationally and make deliberate choices while parking their bicycle. Therefore, urban planners need to be aware of people's behaviour that is characterised by bounded rationality and automatic thinking. An instrument that does acknowledges this is nudging, which will be discussed in the following paragraph.

2.3 Nudging in bicycle parking

An instrument that could influence people's bicycle parking behaviour is nudging. First, the emergence of nudging will be discussed. Then the definition of nudging will be explained. The third part will give some insights on how people *think*, which serves as a base for how nudging works. Followed by a summary of the heuristics that may affect people's decisions. There are, however, also some critiques to nudging, which will be discussed in the fifth part. Finally, the last part will summarise the relevant insights regarding nudging, and also touches upon the effectiveness of nudging.

2.3.1 Emergence of nudging

The theory behind nudging is not new and dates back over a century explaining how environments shape behaviour (Goodwin, 2012). Nowadays it is gaining more attention since Thaler and Sunstein (2009) started using the term 'nudging' in their book about altering people's behaviour in a subtle way.

This growing interest can be explained by the acknowledgement that bounded rationality affects people's daily decision making (Baldwin, 2014). Trying to influence people's behaviour through interventions that require rational and deliberate thinking is often not sufficient (Lehner et al., 2015). Nudges, on the other hand, consider people as imperfect decision-makers in attempting to influence their behaviour. Making it, therefore, a useful instrument that complements other forms of interventions.

2.3.2 Definition of nudging

Nudging refers to the method of influencing the decision making of people through positive reinforcement and indirect suggestions (Thaler & Sunstein, 2009). A nudge, defined by Thaler and Sunstein (2009), is *'an aspect of choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives'.* Nudges try to steer people's choices in directions that will improve their own welfare and that of others while preserving their freedom of choice. How people think and decide is strongly influenced by how

the environment is constructed. Nudges, therefore, focus on changing the informational or physical structure of the environment, referred to as 'choice architecture' (Lehner et al., 2015). Urban planners also deal with how the environment is shaped and could, therefore, make use of nudges in order to provide behavioural change.

In order for urban planners to stimulate more appropriate bicycle parking behaviour, changes can be made in the public space. To illustrate this, red carpets can be placed on pavements to ensure that walking-routes are kept free from bicycles (see photo 1). Cyclists are nudged into parking their bicycle at other locations rather than on the red carpet. The context has thus been changed by placing a red carpet on pavements and thereby influencing people's behaviour. It is evident that this nudge does not remove people's freedom of choice, because they are still at liberty to place their bicycle on the pavement covered with a red carpet.

Photo 1 | Nudging with a red carpet

Thus, nudging has the ability to change human behaviour without them being aware of it (Thaler & Sunstein, 2009). Nudging influences people's behaviour by responding to the thought processes of how people think, which will be explained below.

2.3.3 Two systems of thinking

The thought processes of people can be understood by describing two systems of decision-making namely, the automatic system (system 1) and the reflective system (system 2) (Lehner et al., 2015). The automatic system guides large parts of people's daily routines. This way of thinking is fast, feels instinctive, costs little energy and does not involve what people usually associate with *thinking* because it is mostly unconscious and automatic (Thaler & Sunstein, 2009). This can be illustrated by routine activities, such as cycling the same route every day, which can largely be carried out on auto-pilot. The reflective system is slower and more deliberate, and people use it for making decisions about important choices in life. For example, deciding whether to buy a bicycle or not. Both thought processes are used interchangeably depending on the situation.

Bicycle parking is an activity that for most people comes as a daily routine (Larsen & Funk, 2015). This routine behaviour often results in people relying on the automatic system while parking their

bicycle, making them susceptible to errors in judgement. Therefore, it is necessary that nudging focuses on the automatic system when trying to stimulate more appropriate bicycle parking.

2.3.4 Heuristics and biases

Decisions made by the automatic system rely mostly on heuristics, mental shortcuts and biases (Lehner et al., 2015). When people are required to make quick decisions and the brain gets overwhelmed by information, people tend to focus on a selection of things and ignore others (Moseley & Stoker, 2013). People do this because there is not much time to evaluate all possible options and outcomes. Nevertheless, the automatic system often causes predictable and systematic errors in judgement, which could lead to 'bad' decisions (Quigley, 2013). This is why people could use a helping hand, that helps them make better decisions by giving them a nudge in the 'right' direction (Thaler & Sunstein, 2009).

There are a number of heuristics and biases that could affect people's decisions, which are summarised in table 1. The heuristic that is based on social influence through social norms will be explained in more detail since this one is most relevant when wanting to influence bicycle parking behaviour (Fukuda & Morichi, 2007).

HEURISTICS / BIASES	DESCRIPTION
Anchoring / priming / adjustment	People's estimations are often influenced by reference and starting points.
Availability	People base their estimation of the frequency or probability of an event on the occurrence of a similar and recent example.
Representativeness	People use stereo-types and similarities to categorise persons and objects.
Optimism / overconfidence	People tend to be unrealistically optimistic.
Loss aversion / prospect theory	People do not like to lose things and tend to value good already in their possession more highly than those that they do not yet possess.
Status quo bias	If people can choose out of multiple options, they are likely to stick with the default one.
Framing effects	People make decisions based on the way information is presented to them.
Psychological discounting	People are more focussed on the short-term than on the long-term effects of either threats or opportunities.
Social influence	People highly value the way other see them, especially people in their immediate social network.
Moral convictions	Human behaviour is highly influenced by morals and beliefs.

Table 1 | Heuristics (Moseley & Stoker, 2013; Thaler & Sunstein, 2009)

Social influence through social norms

There are two kinds of social norms, namely injunctive and descriptive norms. Injunctive norms refer to the perception of what is approved or disapproved by others (Cialdini et al., 1990). Injunctive norms that influence people's bicycle parking behaviour reside in the perception of what is inappropriate or appropriate bicycle parking. For example, it is generally recognised that cyclists are not supposed to park their bicycle in front of shops, obstructing entrances. These norms ensure that cyclists are less inclined to park their bicycle inappropriately.

Descriptive norms refer to the perception about how people actually behave, despite this being approved or not (Schubert, 2017). People's bicycle parking behaviour is very much guided by the way other people behave (Fukuda & Morichi, 2007). People often conform their behaviour to the majority since this gives the individual a positive feeling (Brock & Durlauf, 2010; Schultz et al., 2007). For example, if a cyclist parks their bicycle inappropriately, other people will probably follow. Furthermore, since bicycle parking is an activity that for most people is guided by the automatic system, people are more susceptible to unconsciously follow the behaviour of others (Larsen & Funk, 2015).

Knowledge of what other people are actually doing or are perceived to be doing is more powerful than merely telling people what they ought to do (Quigley, 2013). Therefore, it is most relevant to focus on the descriptive norms when wanting to stimulate more appropriate bicycle parking, since people's bicycle parking behaviour is mostly influenced by descriptive norms.

2.3.5 Critique on nudging

There are some critiques on the use of nudging. Firstly, nudging could be seen as a manipulative instrument, since it influences people's decisions (Wilkinson, 2013). The second critique regards the ability of nudging to decide for people what a 'right' decision is (Goodwin, 2012). Thirdly, there is a risk that people could become infantilised citizens, which would decrease an individual's responsibility (Selinger & Whyte, 2012). Finally, there is some ambiguity about the ability of nudging to solve complex problems (Goodwin, 2012). Discussing these critiques is relevant in order to establish the legitimacy and effectivity of urban planners of the use of nudging as a planning instrument. When urban planners use instruments to make changes in the environment, they are supposed to safeguard the interests of the citizens that are involved (Healey, 1996). How nudges are designed should, therefore, be legitimate in order for urban planners to implement them.

Manipulating

First of all, it is argued that nudging could be seen as a manipulative instrument (Wilkinson, 2013). This is because nudging influences people's behaviour by taking advantage of the weaknesses of people's thinking capabilities (Wilkinson, 2013). Besides, people are often unaware that their decisions have been affected by a nudge (Selinger & Whyte, 2012). Since nudging could be seen as manipulating, it can be argued that people are not entirely autonomous in making their own decisions and could take away an individual's freedom of choice (Goodwin, 2012).

This study argues that individuals are always being influenced, with or without the existence of nudging (Lepenies & Małecka, 2015). People are being affected by innumerable physical, social, environmental and informational influences. People do not live in a context-free environment, which makes autonomous decision-making a philosophical fiction. Furthermore, Wilkinson (2013) states that when nudges try to steer people into making decisions that benefit themselves, they would not manipulate and infringe upon the target's autonomy. Thus, even though people have been unconsciously nudged, they are pushed into directions that are beneficial for themselves.

This is also the case for people's bicycle parking behaviour. When people park their bicycle, they are constantly being steered by the present choice architecture of public spaces and the behaviour of other people, resulting often in chaotic parking. This is because the way public spaces are designed does not always stimulate appropriate bicycle parking behaviour. People often park their bicycle next to street furniture, i.e. railings, lamp-posts, parking meters, benches and so on (Gamman et al., 2004). Since street furniture is not meant for parking bicycles, nudges should be designed that stimulate people to park their bicycle in more appropriate places.

What is right?

Secondly, nudges try to influence people into making 'right' or 'better' decisions (Goodwin, 2012). However, what exactly is the desired behaviour a nudge tries to alter and who decides what this is? Someone, in most cases the government, seems to have the power to decide for other people which kind of behaviour is right and which is wrong (Quigley, 2013). Deciding what is 'right' for other people is rather rational and technocratic (Selinger & Whyte, 2012). Simplifying decisions to merely 'right' or 'wrong' is not possible in a world which consist of people with various opinions and values. This suggests that nudges need to be designed with a more communicative approach in mind by involving relevant stakeholders (Healey, 1996).

An argument that supports this technocratic way of deciding what's 'right' is that these desired directions often reflect society's norms and values (Quigley, 2013). These desired directions serve the 'greater good' and stimulate behaviour that is desirable for society as a whole (Selinger & Whyte, 2012). Nudges that try to influence people's parking behaviour are meant to decrease inappropriate bicycle behaviour, which is something that is commonly desired within society (Aldred & Jungnickel, 2013).

Infantilised citizens

Thirdly, by deciding what is right and wrong for citizens, people could become infantilised (Selinger & Whyte, 2012). An argument for this is that nudging attempts to influence people into directions without teaching them anything or improving their skills. This means that they are being treated like children who are controlled by others and which could consequently lead to a decrease in individual responsibility (Selinger & Whyte, 2012).

This study argues that by nudging people into making better decisions, it would free up 'cognitive space' for making perhaps more important decisions (Lepenies & Małecka, 2015). So, instead of infantilising citizens, people have actually more opportunities to become more sophisticated and autonomous moral thinkers. Therefore, nudging people to stimulate appropriate bicycle parking

can enable them to use system 2 less, which would free up cognitive space for making more difficult decisions when needed (Quigley, 2013).

Solve complex problems

Finally, there is some ambiguity about the ability of nudging to solve complex problems (Goodwin, 2012). Goodwin (2012) argues that if it is easy to nudge people into desired directions, it is assumed that people are vulnerable to being nudged in return. This is because nudging does not have the ability to change people's intrinsic behaviour. Changing people's intrinsic behaviour requires large-scale recognition of citizens that major shifts in lifestyle are probably necessary. Furthermore, Goodwin (2012) argues that because nudges emphasise individual preferences and automatic ways of thinking, they are unable to solve complex problems. Solving such complex problems requires collaboration between people to think and deliberate together, rather than tackling problems in isolation. It thus seems that nudges are not that suitable for changing the social and cultural norms of society (Quigley, 2013).

However, since inappropriate bicycle parking occurs locally, it is not necessary to change the social and cultural norms of society at large. Nudges are intended to tackle local problems and are able to make small changes in society (Lehner et al., 2015). Therefore, nudging could still be a useful instrument to stimulate appropriate bicycle parking.

2.3.6 Conclusion

Nudging could influence people's bicycle parking behaviour in a very subtle way by giving them a nudge into a more preferred direction (Thaler & Sunstein, 2009). Since bicycle parking is an activity that for most people comes as a daily routine, cyclists mostly rely on their automatic system (Larsen & Funk, 2015). Furthermore, bicycle parking behaviour is highly influenced by the behaviour of other people, and thus highly influenced by the descriptive norms (Fukuda & Morichi, 2007). Therefore, it is necessary that urban planners focus on nudges that respond to the automatic system by influencing the descriptive norms when trying to stimulate more appropriate bicycle parking.

After discussing the criticisms of nudging, this study argues that nudging could still be an effective instrument for urban planners to influence bicycle parking behaviour. Nudging for bicycle parking is not a panacea for solving inappropriate bicycle parking behaviour. It is an instrument that complements other forms of interventions i.e. regulation, planning of bicycle parking facilities, and so on (Lehner et al., 2015).

Additionally, the question is whether nudging has the ability to influence the self-organising processes of bicycle parking. Determining when nudging could be effective or not is necessary in order for it to become an effective tool for reducing disorderly parked bicycles in public spaces. Besides, a more thorough understanding of the effectiveness of nudging would help prevent ineffective nudges. A theory that could provide insights for urban planners into the effectiveness of nudging to guide self-organising systems is guided self-organisation (Gershenson, 2012).

2.4 Guiding the self-organisation of bicycle parking

This study argues that inappropriate bicycle parking can be considered as a resulting pattern of self-organisation. It seems to be difficult to influence bicycle parking through current interventions that do not consider bicycle parking as self-organising. This study proposes nudging as a possible instrument to influence people's bicycle parking behaviour. However, the ability of nudging to influence self-organising processes is unclear. The theory of Guided self-organisation could provide insights into how to influence self-organising systems (Gershenson, 2012). This theory is derived from the computational sciences, which has not been applied to the social sciences before. Therefore, this study takes the theory of guided self-organisation as a starting point to explore to what extent self-organising processes can be guided through nudging.

Firstly, an explanation will be given about what guided self-organisation is and how it relates to the social sciences. Secondly, an overview will be given that shows the different conditions that enable guidance of systems. In order to make these conditions applicable to bicycle parking, a translation has been made on how these conditions express themselves in an urban context. Thirdly, an explanation will be given of whether these conditions can be achieved through nudging, which provides insights for which conditions nudging can be used and for which not. Finally, the last part will summarise the main findings of this paragraph and will explain why this study will only focus on one condition of guided self-organisation.

2.4.1 Guided self-organisation in the social sciences

Guided self-organisation is a theory that assumes that it is possible to guide self-organising systems towards more desired directions (Gershenson, 2012). Stimulating more appropriate bicycle parking could possibly be achieved by influencing the self-organising processes of bicycle parking.

Guided self-organisation is a theory derived from the computational sciences (Gershenson, 2012). This theory simplifies systems to artificial and mathematical models, which is only possible when phenomena can be isolated from their context and other influences (Flyvbjerg, 2001). Simplifying systems can be useful since this makes analysing the dynamics of the system easier. This is, however, not possible in the social sciences, since phenomena are known to be context-dependent and thus not able to be simplified and analysed in isolation (Flyvbjerg, 2001).

Since bicycle parking is a human activity, it cannot be reduced to a set of rules, making it impossible to simplify the system to merely nodes and links. Therefore, the theory of guided self-organisation cannot be fully applied to the self-organising processes of bicycle parking, instead, the theory of guided self-organisation will be used as a source of inspiration by comparing and connecting it with theories from the social sciences.

2.4.2 Conditions that enable guidance

The theory of guided self-organisation proposes eight different conditions that enable a system to change, which are summarised in table 2 (Gershenson, 2012). These conditions could serve as a

guideline for the effectiveness of nudging by determining which conditions could be achieved through nudging.

The conditions of guided self-organisation use abstract terms which need to be translated to terms which can be applied to bicycle parking. Firstly, the conditions refer to the term 'agents', which are in this case cyclists. Secondly, the term 'inputs' can be understood as for example the influences of cyclists, the environment, social and cultural norms, and so on. Thirdly, the term 'connections' is interpreted as the interactions between cyclists. At last, the term 'module' is interpreted as a group of people, for example, a group of cyclists who own mountain bikes.

	CONDITIONS	*DESCRIPTION*	*TRANSLATION TO SOCIAL SYSTEMS*
NUDGING	Probability	The sensibility of an agent to change its behaviour	Changing people's sensibility that allows for behavioural change
NUDGING	Connectivity	The number of connections between agents	Changing the number connections between bicycle users in public space by concentrating or spreading people.
NUDGING	Canalizing functions	At least one of the inputs has a value that is able to determine the value of the output of the function, regardless of other inputs	Making some stimuli more intrinsically conspicuous to attract the attention of bicycle users
	Silencing	Silencing some agents will make them not responsive or contributing to the self-organisation process	(Re)moving wrongly parked bicycles
	Topology	Changing the landscape of interactions between agents	Changing the degree to which agents interact with direct neighbours or with others over distance
	Modularity	The interactions within the module are more important than those between modules	Changing the interactions of social groups that inhabit public space
	Redundancy	Having more than one copy of an agent	Changing the degree of homogeneity between bicycle users
NUDGING	Degeneracy	Ensuring that different agents of a system perform the same function	Framing information differently, which ensures for more appropriate bicycle parking

Table 2 | Conditions of guided self-organisation (Gershenson, 2012)

2.4.3 Nudging to guide self-organisation

In order to determine when nudging could guide the self-organising processes of bicycle parking, it is necessary to investigate which conditions of guided self-organisation could be achieved through nudging. This study argues that nudging does not have the ability to fulfil the following conditions: 'probability', 'silencing', 'topology, 'modularity' and 'redundancy', which will be explained first. Then the conditions that could be achieved through nudging will be explained, which are: 'connectivity', 'canalizing functions' and degeneracy'.

Conditions that cannot be achieved through nudging

The first condition referred to as 'probability', is about changing the sensibility of a cyclist to change its behaviour (Gershenson, 2012). In order to change people's sensibility, fundamental behavioural changes are needed. Nudging cannot change the probability since nudging does not have the ability to change people's deeply ingrained behaviour (Goodwin, 2012).

Secondly, a system can also be guided by silencing the influence of cyclists by ensuring that their behaviour does not influence others (Gershenson, 2012). A method of achieving this could be by removing wrongly parked bicycles. Removing wrongly parked bicycles is a rigid intervention that punishes people for parking their bicycle inappropriately. This kind of intervention is not a nudge since it does not preserve people's freedom of choice (Thaler & Sunstein, 2009). People should still be free to decide where to park their bicycle, despite it being done inappropriately. Silencing can thus also not be done through nudging.

Thirdly, 'topology' deals with the landscape of connections between cyclists. Promoting a different kind of topology could enhance a system's robustness or flexibility by ensuring that some cyclists have more interactions than others or by stimulating more long-distance interactions (Gershenson, 2012). The degree to which cyclists interact with each other can differ, which can also vary across distance. The topology can be promoted by increasing the infrastructural connectivity of the system's area. For example, creating more space and openness in public space will influence the number of connections. Changing the infrastructure goes far beyond the ability of nudging since these interventions are far more up-scale and rigorous (Thaler & Sunstein, 2009).

Fourthly, promoting modularity of a system can be done by strengthening the interactions within modules rather than those between modules (Gershenson, 2012). Strengthening the interactions within modules improves a system's robustness and evolvability. Promoting the modularity of the system of bicycle parking would suggest that the interactions within social groups need to be strengthened. Strengthening the interactions specifically within social groups is not something that can be done directly through nudging since nudging does not specifically differentiate between people from different social groups. Nudging merely targets particular activities, such as demotivating people from smoking and can thus only differentiate between social activities (Quigley, 2013). Social groups can thus only be indirectly targeted through influencing social activities.

Finally, a system can be guided by promoting redundancy, which refers to the degree of homogeneity between actors. Promoting redundancy improves a system's robustness and evolvability (Gershenson, 2012). Applying this to bicycle parking would mean that bicycle users need to become socially and economically similar. This, again, asks for a transformation of people's deeply ingrained behaviour, which cannot be done through nudging (Goodwin, 2012).

These five conditions cannot be achieved through nudging. Nudging would, therefore, not be effective to change these conditions. However, the following three conditions that could possibly be fulfilled through nudging are: 'connectivity', 'canalizing functions' and 'degeneracy'.

Conditions that can be achieved through nudging

Firstly, the condition referred to as 'connectivity', is about changing the number of connections in a system (Gershenson, 2012). The number of connections in a system can be changed by changing the density of cyclists who will park their bicycle. Nudging has the ability to change the density of where cyclists park their bicycle by concentrating or spreading cyclists across public space (Jacobs, 1992). A higher density of cyclists makes it more likely that the number of connections will increase. Nudges that concentrate parked bicycles are, for example, parking squares on pavements which will possibly enhance the number of connections in that particular area (see photo 2). Nudges can also spread bicycles across public space in order to enhance the number of connections in other areas by creating no-parking squares.

Photo 2 | Nudging with bicycle squares

Photo 3 | Nudging with a red carpet

Secondly, the canalizing functions of a system refers to the ability that one input is able to influence the behaviour of cyclists (Gershenson, 2012). Nudging can influence the canalizing functions by making an input more intrinsically conspicuous than others (Russell et al., 2014). Nudging can do this by altering both properties and placement of objects or stimuli which influences people's behaviour (Hollands et al., 2013). This can be illustrated by placing red carpets on unpreferable parking areas to influence people to park their bicycle somewhere else (see photo 3). The red carpet can be seen as an input that is more noticeable than other inputs, which affects how people park their bicycle.

Finally, the degeneracy of a system refers to the ability of different agents to perform the same function (Gershenson, 2012). The degeneracy can be changed by influencing cyclist's behaviour in such a way that they will behave similarly. Nudging can influence people's behaviour by framing information differently since people make decisions based on the way information is presented to them (Thaler & Sunstein, 2009). Nudging can frame information differently by highlighting one or more aspects (Moseley & Stoker, 2013). An example that illustrates this are signs that show when people are parking their bicycle appropriately or inappropriately (see photo 4). People are then informed about their behaviour. Another way of doing this is by placing saddle covers or pamphlets on people's bicycle, which stresses their behaviour (see photo 5). Information can also be given about the negative consequences inappropriate bicycle parking has on other people

(Fujii, 2005). By doing this, people could become more aware of their behaviour and will hopefully change the way they behave.

Photo 4 | Sign pointing to a wrongly parked bicycle

Photo 5 | Saddle cover with "Bicycle hero"

2.4.4 Conclusion

The self-organising processes of bicycle parking could possibly be influenced through nudging. This is because of the possibility of nudging to fulfil three conditions proposed by the theory of guided self-organisation, namely 'connectivity', 'canalizing functions' and 'degeneracy'. Exploring whether nudging could achieve these conditions would provide insights into whether nudging could be an effective instrument to influence the self-organising processes of bicycle parking.

Nevertheless, this study will not focus on the 'connectivity' and 'degeneracy' of the system. Firstly, determining whether nudging could influence the connectivity of the system is extremely difficult. The connectivity of the system of bicycle parking can be operationalised by measuring the number of interactions between bicycle users and their environment. However, these interactions are difficult to measure since they are often non-verbal, namely through eye contact. Therefore, this study will not research how nudging could influence the connectivity of the system.

Secondly, this study will also not focus on the ability of nudging to promote the degeneracy of the system. This is because providing information, which is intended to change people's opinions and norms regarding inappropriate bicycle parking, is a long-term process. Measuring the effect nudging has on the degeneracy of the system thus requires a long-term research, which would not be possible given the limited research time and scope. Furthermore, the effect of the nudge on people's behaviour is not directly visible. The changed behaviour can express itself at different locations and moments in time compared to the experimental location. Therefore, this study will also not include degeneracy in the research.

Thus, this study will only focus on enhancing the canalizing functions of the system in order to stimulate more appropriate bicycle parking. Nudging could influence the canalizing functions by making some stimuli more noticeable than others in order to attract cyclists attention, which will subsequently affect their bicycle parking behaviour (Russell et al., 2014). This change in behaviour can be measured by observing the changes caused by nudging, namely whether bicycles are being parked more appropriately or not.

Exploring whether nudging has the ability to fulfil the canalizing functions of the system, provides urban planners a guideline to determine when nudging can be effectively used or not. It is important to understand the effectiveness of nudging to prevent urban planners from implementing ineffective nudges.

2.5 Conceptual model

The relations between the concepts and theories discussed in this chapter are visualised in the conceptual model (see figure 2). The conceptual model begins with considering bicycle parking as self-organising. The self-organisation of bicycle parking is shaped by the interactions between cyclists themselves and between cyclists and other people. Out of these interactions, patterns of bicycle parking emerge. These self-organising processes often result in patterns of inappropriate bicycle parking.

This study investigates whether the self-organisation of bicycle parking can be guided to a system that exhibits more appropriate bicycle parking through nudging. The hypothesis of this study is that nudging can influence the canalizing functions of the system with more appropriate bicycle parking as a result.

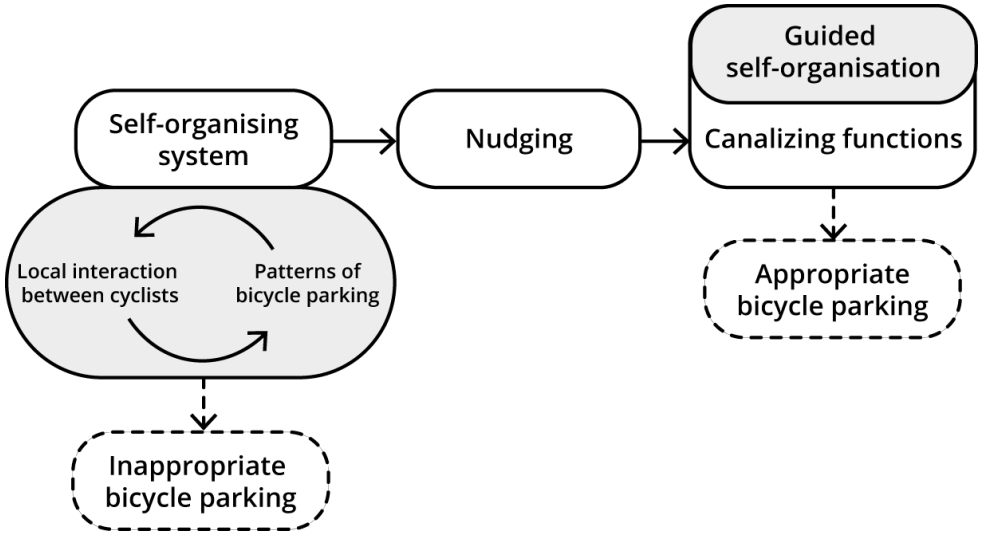

Figure 2 | Conceptual model (Author, 2018)

3 Methodology

This chapter elaborates on the research method used to try and answer the third sub-question formulated in chapter 1. The first section gives a description of the selected research area. The second section elaborates on which areas are inappropriate and which are appropriate for bicycle parking. Thirdly, this study obtained data by conducting a field experiment, which will be explained in section 3.3. The fourth section gives an explanation of how the experimental findings will be analysed. The last section touches upon some ethical issues regarding experimental research.

3.1 Case description

The experiment was conducted in the public space of Westerhaven (see figure 3). This study focussed on the area located within the yellow circle. This area consists of a gym and a few shops, i.e. the HEMA, a café, a tanning salon, the KFC and a shoe outlet store. This study chose this particular area in the Westerhaven since it suffers from a substantial amount of inappropriate bicycle parking by bicycles that not only block the entrances of various shops and the gym but also seem to obstruct the flow of pedestrians, bicycles and logistical transportation.

Westerhaven is a shopping area in the city centre of Groningen. The area is a pedestrian-zone where all automobile traffic is prohibited, including cyclists who in general tend to ignore this rule. The fact that the Westerhaven is a spacious and open area and therefore gives the appearance of being a 'shared space', namely a space that is multifunctional and accessible for all road users with limited signs, is misleading for cyclist and does not discourage them from using it (Kaparias et al., 2015). It has thus become socially accepted among cyclists to cycle through this area, even though this is not permitted.

There are no clear bicycle parking areas in the public space of Westerhaven except from the two parking squares at the entrance from the north and east side, and the bicycle parking square next to the gym (see figure 3). Cyclists are, according to the law, allowed to park their bicycle anywhere in this area as long as the bicycles are not impeding the usage of buildings or blocking entrances (art. 5:12 (1) APVG 2009). People's bicycle parking behaviour is thus not strongly steered through law enforcement (Gemeente Groningen, 2015). Cyclists are, therefore, highly influenced by the bicycle parking behaviour of others (Fukuda & Morichi, 2007). This often leads to inappropriate bicycle parking, which blocks pedestrian flows and entrances.

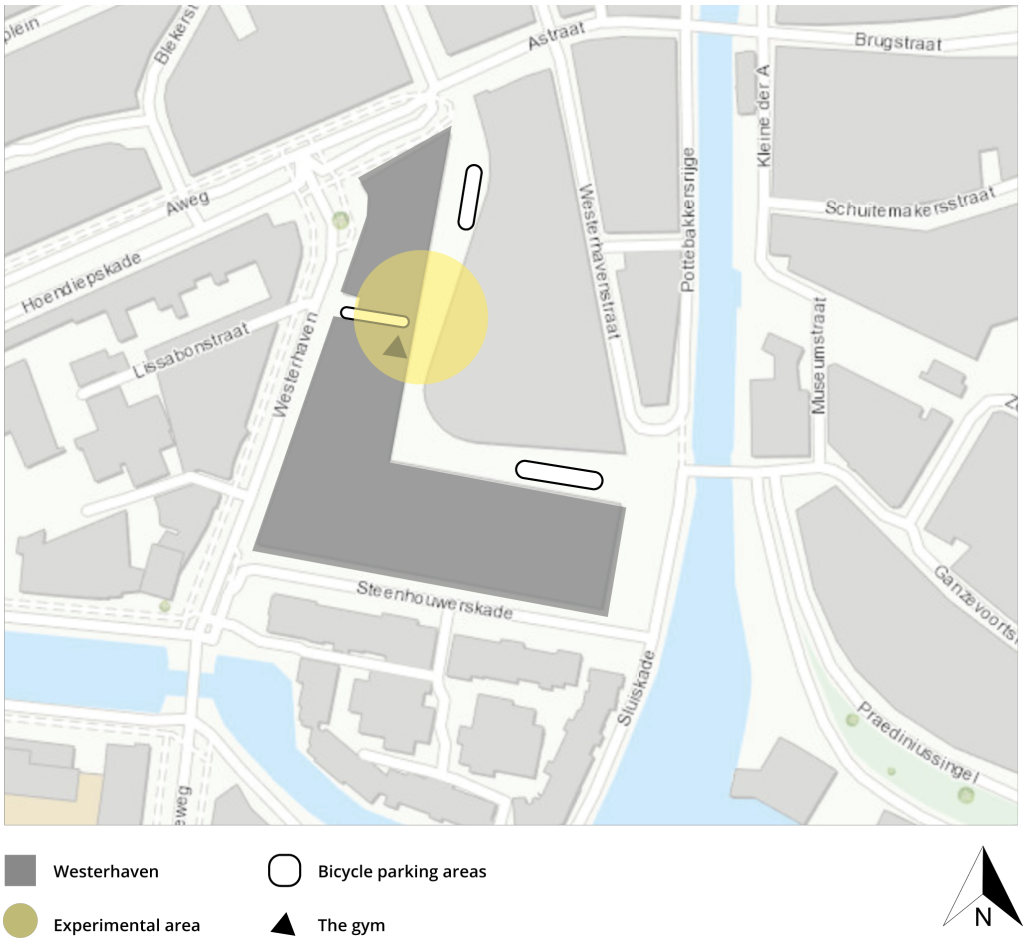

Figure 3 | Map of Westerhaven

3.2 (In)appropriate bicycle parking areas

Bicycle parking is considered inappropriate when it creates socially undesirable effects in the public space of Westerhaven, namely when bicycles are blocking entrances and footpaths, and when bicycles prevent the smooth flow of pedestrians, bicycles and transportation (art. 5:12 (1) APVG 2009; Fujii, 2005).

This study considered bicycles parked inappropriately when they were parked outside of the designated bicycle parking areas. Bicycles parked inside the bicycle parking areas were thus considered appropriately parked. The designated area meant for bicycle parking is visualised with the white area with the black outline (see figure 4 and photo 6). This bicycle parking square was created by the municipality to offer bicycle parking space. Cyclists who visited the gym often parked their bicycle there, since this is an appropriate place which is close to the gym.

Nevertheless, people also parked their bicycle on the pavement in front of the gym or other shops, which often obstruct entrances or footpaths. In order to investigate whether nudging could decrease the number of inappropriate bicycle parking, two bicycle parking squares were created by this study, visualised by the two yellow areas on the map (see figure 4, photo 6 and 7). This study considered these two squares as appropriate areas for bicycle parking since they do not obstruct entrances and footpaths.

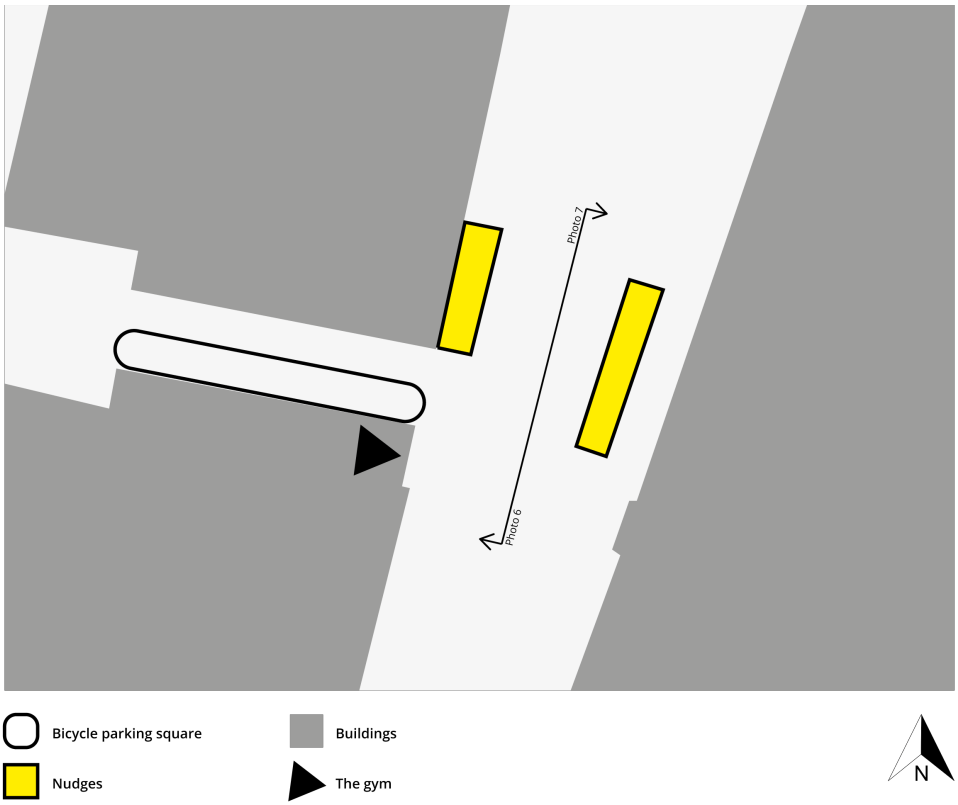

Figure 4 | Experimental area with the bicycle square and nudges

Photo 6 | The bicycle square and the first nudge (square with yellow bicycle)

Photo 7 | The second nudge (square with yellow bicycle)

3.3 Experiment

This study chose to conduct an experiment because answering the research question asked for a practical approach. The research question emphasised the exploration of the effectiveness of nudging in public spaces. In order to gain insights into when nudging could be effective or not, an examination in the practice was required. Therefore, this study experimented with a nudge in the public space of 'Westerhaven' to explore whether nudging could influence the canalizing functions of the system.

The experiment was conducted in a public space, which can be seen as a 'natural environment' for the bicycle user, making this experiment a 'field experiment'. Firstly, an explanation will be given regarding field experiments. Secondly, the experimental group is explained, followed by a description of the nudges. Fourthly, the variables were defined and operationalised in order to measure the effect that one variable had on another. Fifthly, an explanation is given about the pre- and post-test of this experiment. Then, an explanation of the process behind the observations is given. Finally, how the experiment was implemented will be explained.

3.3.1 Field experiments

Experimentation is an approach in which the researcher manipulates one or more variables and controls and measures any change in other variables (Blakstad, 2008). Conducting a lab experiment usually involves the creation of an artificial situation in which events that generally go together are pulled apart in order to establish a cause and effect relationship (Loraine et al., 2010).

However, field experiments are conducted in the natural environment, which makes it impossible to create a situation that is completely controlled without the influence of external variables (Blakstad, 2008; Shuttleworth, 2010). This means that it is harder to establish a cause and effect relationship. Field experiments thus have a lower validity and are more difficult to generalise than

experiments conducted in a lab (McLeod, 2015). Nonetheless, it is still possible to draw valid conclusions from field experiments by minimising the influence of external variables by ensuring that the conditions of the experiment and the 'controlling' group resemble as best as possible (Blakstad, 2008).

Furthermore, experimenting in the field is a more realistic research method when investigating the bicycle parking behaviour of cyclists in public spaces as opposed to lab experiments, since the environment of public spaces where bicycle parking behaviour takes place cannot entirely be moved into a laboratory. Field experiments are thus more realistic, in that they are more likely to reflect real life situations rather than experiments conducted in an artificial situation.

3.3.2 Experimental group

The participants of the experimental group consisted of people that parked their bicycle in the public space of Westerhaven in Groningen. Who these participants were exactly, was not controlled and selected beforehand due to the implications of a field experiment (McLeod, 2015). Instead, the selection of participants was based on the moment of observation, and thus randomly assigned (Alferes, 2012). Furthermore, the participants were not aware that they took part in an experiment since this could alter their parking behaviour. However, this raised some ethical questions, which is discussed in section 3.5.

3.3.3 The nudge

This study investigated whether nudging could influence the canalizing functions of the system. The canalizing functions of the system were influenced by making inputs more intrinsically conspicuous than others (Russell et al., 2014). Firstly, two bicycle squares were created (see figure 4, photo 5 and 6). The squares were made prominent by taping a square on the pavement with white tape. This study considered these bicycle squares as inputs that attracted cyclist's attention.

Furthermore, the nudge also consisted of two bicycles that were painted bright yellow since it's the most attention-grabbing colour (see photo 5 and 6) (Lischer, 2018). Yellow, having a relatively long wavelength and being the most visible colour is for this reason often used for traffic signs, advertisements, and other warning signs used to attract attention. Two inputs were thus made more noticeable than other stimuli in order to influence the canalizing functions of the system.

Moreover, the two bicycles functioned as an example and anchor that attracted people to park their bicycle next to or in line with them. The bicycles basically served as a descriptive norm that tried to encourage cyclists into parking their bicycle appropriately. The hypothesis was that the placement of the yellow bicycles was perceived as socially acceptable for other cyclists, making it more likely that other cyclists would park their bicycle in the same area.

3.3.4 Variables and operationalisation

In order to measure the effect one variable had on another, it was necessary to determine what the independent and the dependent variables were (Blakstad, 2008). Determining the relationship between the variables was important since this indicated which variable needed to be

manipulated and which one needed to be observed. Furthermore, the dependent and independent variables also needed to be operationalised. Operationalisation allowed the variables to be measured, empirically and quantitatively (Blakstad, 2008). For an overview of the variables and their operationalisation see figure 5.

The variable that was being manipulated was called the independent variable, which affected the experimental group. This study explored whether nudging could affect the canalizing functions of the system in order to influence people's bicycle parking behaviour. Nudging is the independent variable that possibly affects the canalizing functions of the system. Nudging was operationalised by describing the nudge (see 3.3.3), namely two bicycle squares with two yellow bicycles.

The dependent variable was the measurable outcome of this manipulation, namely the effect the nudge had on people's bicycle parking behaviour. The change in bicycle parking behaviour was operationalised by determining the change between the number of inappropriately parked bicycles and appropriately parked bicycles.

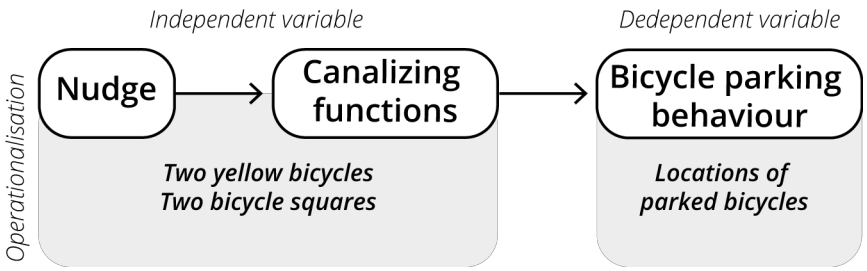

Figure 5 | Overview of the operationalisation of the variables

3.3.5 Pre-test and post-test

In order to determine what the effects of the independent variable were on the dependent variables, it was necessary to execute a pre-test and a post-test (Shuttleworth, 2009a). The pretest measured the situation *without* the manipulation of the independent variable, namely the situation without the creation of the nudge. Measuring the situation *with* the nudge was referred to as the 'post-test'.

Doing a pre-test and post-test was necessary to ascertain whether the observed changes of the experiment were determined by the independent variable or if those changes were caused by other non-experimental factors, i.e. weather, time of day. Therefore, this study tried to resemble the circumstances of the post-test and the pre-test, *with* and *without* nudging, as consistently as possible, namely the day of the week, time of day, weather (temperature/precipitation), location, characteristics of people (age/gender/bicycle) (Blakstad, 2008).

3.3.6 Observations

The data of this experiment were conducted by doing observations, namely five observation *without* the nudge (pre-test) and five observations *with* the nudge (post-test) (see table 4). The pre-tests and post-tests were conducted on the same day of the week with the same time of day. These 10 observations had a duration of two hours each, thus 20 hours in total.

In order to get a natural representation of the distribution of parking of bicycles, observations were done on different days and different times (see table 3) (Baarda, 2012). The first observation of this study took place on Friday and Saturday since those days are often a free day for people, which made it more likely that this area would be busy with people parking their bicycle. This was important since a higher number of cyclists would increase the significance of the bicycle parking problem. Furthermore, observations were also made on two days during the week to get a comprehensive view of the pattern of bicycle parking, namely on Tuesday and Wednesday.

	OBSERVATION	DAY	DATE AND TIME	WEATHER	NUMBER OF PARTICIPANTS
WITHOUT NUDGE	1	Friday	10/8 09:30 – 11:30	Light cloud, 17°	79
	2	Friday	10/8 17:00 – 19:00	Light cloud, 17°	66
	3	Saturday	11/8 10:30 – 12:30	Light cloud, 17°	61
	4	Tuesday	14/8 09:00 – 11:00	Light cloud, 20°	52
	5	Wednesday	15/8 09:00 – 11:00	Light cloud, 22°	62
WITH NUDGE	6	Friday	17/8 09:30 – 11:30	Light cloud, 20°	57
	7	Friday	17/8 17:00 – 19:00	Light cloud, 22°	37
	8	Saturday	18/8 10:30 – 12:30	Sunny, 23°	38
	9	Tuesday	21/8 09:00 – 11:00	Sunny, 22°	48
	10	Wednesday	22/8 09:00 – 11:00	Sunny, 22°	63

Table 3 | Observations

3.3.7 Observation protocol

This study used an observation protocol to ensure that the experiments were conducted systematically, which made the variables comparable to analyse (see figure 5) (Shuttleworth, 2008). Each participant was observed and recorded by filling in the proposed observation protocol. Since this study made observations, it was not possible to exactly determine the characteristics of the participants, i.e. age or the type of bicycle. These characteristics were, therefore, estimated.

Observation protocol

1. Record the exact location, time/date of the experiment
2. Record the weather/temperature
3. Record the exact time of the participants arriving
4. Record the bicycle parking location on the map
5. Record characteristics of the participants:
    1. Gender
        1. Male
        2. Female
    2. Age
        1. 15 years or younger
        2. 16 – 30
        3. 31 - 45
        4. 46 - 60
        5. 61 years or older
    3. Bicycle (De Jong & Kolstein, 2015; Larsen & Christensen, 2015)
        1. Sports bicycle (mountain bike / race bike)
        2. E-bike
        3. Second-hand city-bike (low-value)
        4. City-bike (high-value)
        5. Rental bike (Swapfiets, NS-fiets)
6. Record characteristics of the placement of the bicycle
    1. Appropriately (in the bicycle square)
    2. Inappropriately (outside the bicycle square)
7. Record group composition
    1. Individually
    2. Group of two
    3. Group of two or more

Figure 5 | Observation protocol

The characteristics of the participants that were estimated were their gender, age and type of bicycle. The type of bicycle was categorised into sports bicycles, e-bikes, low-value city bicycles, high-value city bicycles and rental bikes. Larsen & Christensen (2015) argue that people are more attached to their bicycle if they value it highly. This study assumed a behavioural difference between people owning a bicycle that is expensive and those who own a bicycle that is cheap, namely that people with a high-value bicycle parked their bicycle more appropriately in comparison with people with a low-value bicycle. Therefore, the city bicycle has been divided into bicycles with a low financial value and bicycles with a high financial value.

Moreover, the group composition was recorded as it could have affected people's bicycle parking behaviour. People are highly guided by how other people behave, therefore, this study assumed that people that arrive with a group, were influenced by the people they arrived with (Fukuda & Morichi, 2007).

3.3.8 Implementing the experiment

The experiment consisted of two bicycle squares and two yellow bicycles. Firstly, the bicycle squares were created by applying white tape on the pavement. Then, the two bicycles were parked inside the created bicycle squares. Often there were already bicycles parked in the area where the nudge had to be created. Those bicycles were moved inside the created bicycle square. After each experiment of two hours, the nudge was removed by removing the tape and the two bicycles.

The implementation of the experiment was clearly visible for those who were present in the experimental area. Potential participants could thus have been influenced by the creation of the nudge. However, the observations were made 5 min after the implementation, which ensured that the participants coming later were less likely to have seen the creation of the nudge. Furthermore, the experiment was observed from inside the entrance of the gym, thus out of sight. Therefore, the participants were not aware that they were being observed, which ensured that the participants' behaviour was less likely to be influenced by the idea that they were taking part in an experiment.

3.4 Data analyses

The data from the observation protocol were collected via an iPhone by recording the data on a map using the collector app from ArcGIS online. Once the data were collected, they were saved in the ArcGIS online database. The data were processed and mapped out in ArcGIS online to observe spatial patterns (Clifford et al., 2010).

In order to determine if the nudge had a significant effect on people's bicycle parking behaviour, it was necessary to test the results of the data collection statistically with SPSS, which has been tested in chapter 4.

3.5 Ethical issues

This study conducted an experiment in public spaces, which could have led to some ethical issues.

The first issue that needed to be considered is about informed consent. Informed consent refers to the procedure by which an individual may choose whether or not to participate in a study (Drew et al., 2008). The researcher is supposed to make respondents fully aware of the nature of the experiment and of their role within it before they take part in the experiment. However, there are exceptions where informed consent is not always obligated, namely when it refers to naturalistic observations. This experiment had traits of a natural observation since it involved studying the spontaneous behaviour of participants in their natural surroundings (McLeod, 2015). Natural observations do not place participants at risk or damage their financial standing, employability or reputation (Drew et al., 2008). Therefore, it was not obligated to ensure informed consent.

Another element which indicated that consent is not always necessary, is when the observed behaviour is considered public and observable by anyone present in the setting. This study conducted an experiment in public spaces, which was open and observable for everyone. This suggests that it was not necessary to obtain consent. Besides, a reason for not obtaining consent was that it could affect the behaviour or those being observed (McLeod, 2015). The observed behaviour would then not be reliable in order to draw valid conclusions.

Secondly, an experiment should not cause any harm, i.e. extreme psychical pain, psychological stress, personal embarrassment or humiliation (Drew et al., 2008). The experiment conducted by this study only attempts to alter people's parking behaviour by the creation of two bicycle squares with two yellow bicycles. It is not expected that this would be harmful to the participants involved. The participants were not coerced into doing something unwanted, and besides this, they were in their usual environment despite the experiment taking place.

Thirdly, it is important to ensure that participants remained anonymous to safeguard their identity and confidential information (Clifford et al., 2010). This experiment did not obtain people's identity but only made an estimation of the characteristics of the people involved, namely their gender, age and bicycle. The participants, therefore, remained completely anonymous.

3.6 Conclusion

This study experimented with a nudge, consisted of two bicycle squares with two yellow bicycles, in the public space of Westerhaven. The participants that parked their bicycle in the created bicycle squares were considered as appropriately parked. On the other hand, the bicycles that were parked outside the bicycle squares were considered inappropriately parked.

The participants might have not been aware that they took part in the experiment, which could have led to some ethical issues. However, since the experiment was conducted in public space without causing any harm, no informed consent was needed.

The experiment was conducted to investigate whether nudging could influence the canalizing functions in order to influence people's bicycle parking behaviour. The hypothesis was that nudging could influence people's bicycle parking behaviour by influencing the canalizing functions of the system. The results of the experiment will be explained in the following chapter.

4 Results

This chapter presents the results of the experiment. Firstly, the collected data will be described in section 4.1. Secondly, the effect nudging had on people's bicycle parking behaviour will be analysed and tested statistically in section 4.2. Finally, a summary of the relevant results will be given in section 4.3.

4.1 Data collection

This study conducted an experiment by observing the change in the participants' bicycle parking behaviour *with* and *without* nudging. Observations were made to record the characteristics of the participants and the location of where they parked their bicycles. Data were collected of 530 participants. Since this study made observations, it was not possible to exactly determine the characteristics of the participants, which were, therefore, estimated.

Gender

Firstly, the gender of the participants was recorded. Of the participants, 47% were male (n = 247) and 53% were female (n = 283). This ratio between male and female was close to 1:1, which was representative of the population of the Netherlands (CBS, 2018a). A representative sample allowed the collected data to be better generalised to a larger population (Shuttleworth, 2009b).

Age

The age of the participants was recorded, where the majority of the participants were between 16 and 30 years old (see figure 6). The second largest age group was between 31 and 45, which is nearly one-fifth of the largest age group. There was thus an enormous overrepresentation of the participants aged between 16 and 30 years old, which made the sample not entirely representative for the age distribution of the population (CBS, 2018b). It is important to note this since this overrepresentation could influence the outcome of the experiment. There could namely be a difference between the participants' age and their bicycle parking behaviour. Therefore, no statements could be made that explained the populations' behaviour in general (Shuttleworth, 2009b).

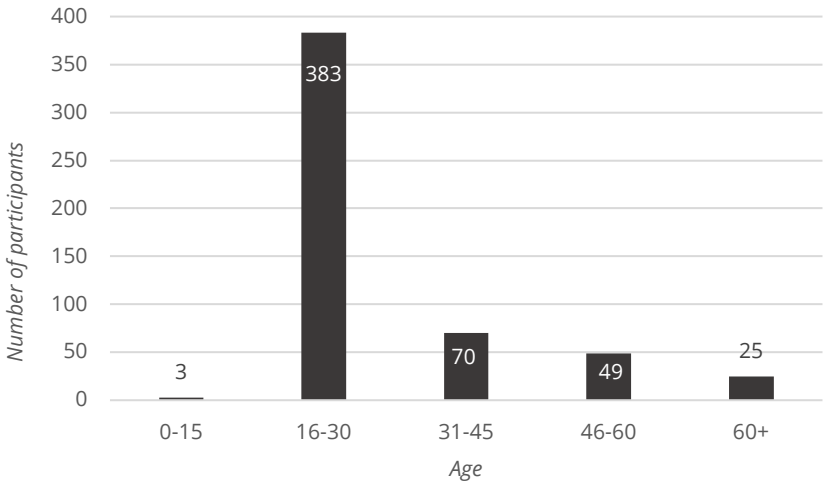

Figure 6 | Age and gender of the participants (n = 530)

Type of bicycle

Most participants had a low-value city-bicycle (n = 288) (see figure 7). A reason for this could be that most participants are young adults (16-30 years old) who often do not have a high income to buy expensive bicycles (Lenting, 2013). The second most owned type of bicycle is the city-bike with a high-value (n = 150). This study assumed that people who owned a low-value bicycle were more likely to park their bicycle more inappropriately (Larsen, 2017). Therefore, there could have been an increase in the number of inappropriately parked bicycles since most participants owned a low-value bicycle.

During the observations, it became apparent that scooters could also have an influence on people's bicycle parking behaviour. Scooters were parked in the same area as the bicycles were being parked, supporting the descriptive norms regarding bicycle parking. Participants with a scooter thus also took part in the self-organising processes. Therefore, this study also observed the participants with a scooter (n = 30).

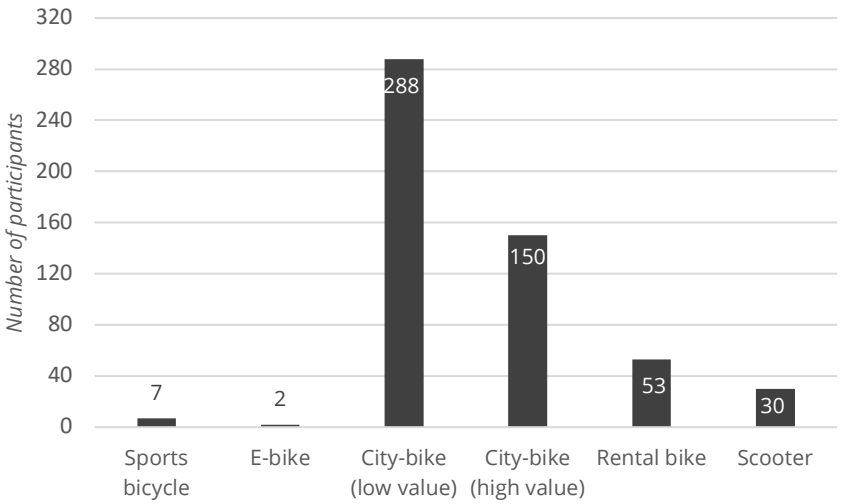

Figure 7 | Type of bicycle (n = 530)

Group composition

Of the participants, 89% (n = 418) arrived alone and 11% (49) arrived together with another participant. People are highly guided by how other people behave, therefore, this study assumed that the group composition could have affected how people parked their bicycle (Fukuda & Morichi, 2007).

4.2 The influence of nudging on inappropriate bicycle parking

To investigate whether nudging had an effect on inappropriate bicycle parking, the location of where the participants parked their bicycle was recorded on a map. This spatial data was used to determine if nudging had the ability to influence people's bicycle parking behaviour. Firstly, the difference between the bicycle parking location *with* the nudge and *without* the nudge was described. Secondly, the influence of nudging on inappropriate bicycle parking was tested statistically. Followed by some field notes that have been made during the observations regarding the influence of nudging on bicycle parking.

4.2.1 Description of the spatial data

The spatial data of the location of the parked bicycles were visualised in GIS with a density map. Density maps were made for the situations *with* and *without* the nudge, where each density map consisted of the collected data of five observations. The density map showed a visual difference between the density of parked bicycles *with* and *without* the nudge (see figure 8). The situation with the nudge showed a higher density of bicycles in the bicycle parking areas than the situation without the nudge. The nudge thus had an effect on people's bicycle parking behaviour.

Furthermore, the number of participants that parked their bicycle inappropriately decreased with the creation of the nudge from 54% to 43% (see figure 9). This relationship between the nudge and the decline of inappropriate bicycle parking was tested significantly in the following section.

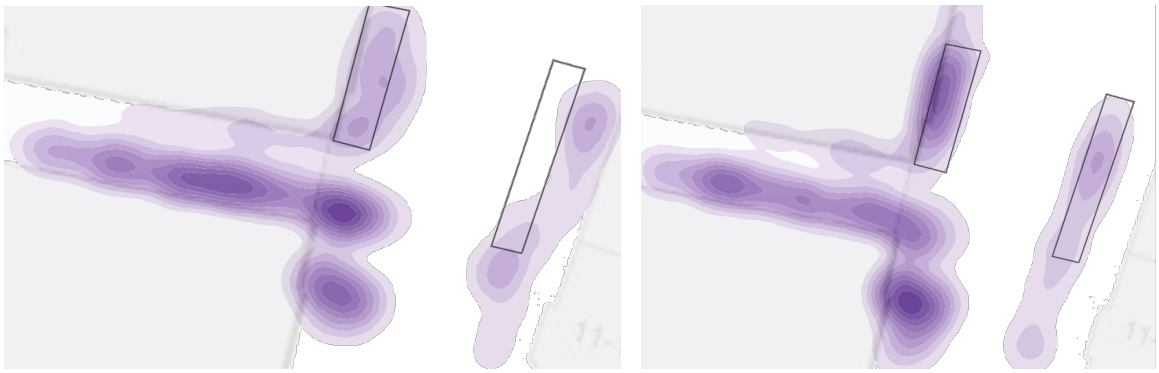

Figure 8 | Density maps (left map is without the nudge, right map is with the nudge)

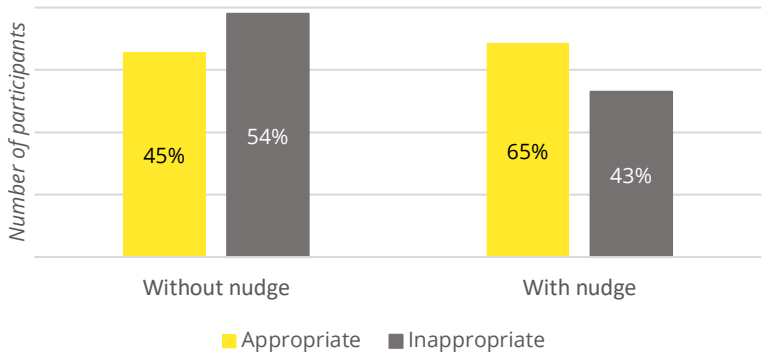

Figure 9 | (In)appropriate bicycle parking (n = 530)

4.2.2 Statistical analysis

The previous paragraph stated that nudging had an effect on people's bicycle parking behaviour. This section tested if the relationship between the nudge and the decline in inappropriate bicycle parking was significant and if this was affected by the participants' gender, group composition, or type of bicycle. The relationships between bicycle parking and the nudge and between bicycle parking and the characteristics of the participants were all tested statistically with the Pearson's Chi-Square test since all the data consisted of nominal variables.

Nudging and bicycle parking behaviour

The hypothesis was that nudging could influence people's bicycle parking behaviour by influencing the canalizing functions of the system. To investigate whether the hypothesis of this study could be rejected or accepted, a statistical analysis was conducted.

The relationship between inappropriate bicycle parking and the creation of the nudge was tested statistically with the Pearson's Chi-Square test. The outcome of this test was p = 0,014 (see appendix, figure 10). This meant that there was a statistically significant association between inappropriate bicycle parking and nudging. People were thus parking their bicycle more appropriately with the nudge. Therefore, the hypothesis of this study could be accepted, namely that nudging had a significant effect on the way bicycles were being parked. However, the strength of this association was low, namely a Phi value of -0,107 and a Cramer's V value of 0,107 (see appendix, table 4 and figure 11). This meant that there was a low relationship between the creation of the nudge and the increase in appropriate bicycle parking. The nudge thus did not have an enormous positive effect on influencing people's bicycle parking behaviour.

Nevertheless, the nudge did have a significant effect on the way people parked their bicycle. The nudge thus influenced people's bicycle parking behaviour in a very subtle way by giving them a nudge into a more preferred direction (Thaler & Sunstein, 2009). Nudging could thus be implemented by urban planners who want to decrease the number of inappropriately parked bicycles.

Type of bicycle and bicycle parking

Bicycle parking behaviour could differ for participants with different types of bicycles. This study assumed that people with a low-value bicycle would park their bicycle more often in inappropriate areas, due to a lack of attachment (Larsen, 2017). The type of bicycle could thus have had an influence on the effectiveness of nudging. Therefore, the relationship between inappropriate bicycle parking and the type of bicycle was also tested statistically with the Pearson's Chi-Square test. In order to perform the statistical test, the data of the participants with an E-bike had to be excluded.

The outcome of this test was p = 0,001 (see figure 12). This meant that there was a statistically significant association between inappropriate bicycle parking and the type of bicycle. However, the strength of association was low with a Phi and Cramer's V value of 0,19 (see appendix, figure 13 and table 4). There was thus a low relationship between the type of bicycle and people's bicycle parking behaviour.

Nevertheless, the type of bicycle still had a significant influence on if people park their bicycle inappropriately or appropriately. Remarkably, people that had a city bike of low value were most likely to park their bicycle appropriately (59%). Participants that were more likely to park their bicycle inappropriately were those with a high-value city bike (57%), a mountain or race bike (57%), a rental bike (64%) or a scooter (63%). These findings contradicted the assumption of this study, which was that people who owned a low-value bicycle were more likely to park their bicycle inappropriately than those with a high-value bicycle (Larsen, 2017). Urban planners need to consider that bicycle squares thus have limitations for cyclists who wanted to secure their bicycle when wanting to effectively decrease the number of inappropriate bicycle parking.

Gender and bicycle parking

The effect of nudging on people's bicycle parking behaviour could have differed per gender, which was also tested statistically with the Pearson's Chi-Square test. The outcome of this test was p = 0,374 (see appendix, figure 14), which shows that there was no significant relationship between the participants' gender and as to whether they parked their bicycle inappropriately or appropriately.

Bicycle parking and group composition

Finally, how people park their bicycle could also have been influenced by the group composition they were in since people are highly influenced by how other people behave. This would suggest that the participants arriving together could have behaved differently than those arriving alone. For example, a participant that was arriving together with another participant could have been influenced by their companion.

Therefore, the relationship between group composition of the participants and how they park their bicycle was tested with the Pearson's Chi-Square test. The outcome of this test was a p-value of 0,202 (see figure 15). This result was not significant, which meant that there was no significant relationship between the group composition and how people parked their bicycle.

However, the statistical test merely showed whether the group composition influenced people into parking their bicycle inappropriately or appropriately. Thus, if the group composition either had a negative or a positive effect on people's bicycle parking behaviour. The findings did not indicate whether people were actually influenced by their companion, either negatively or positively. Unfortunately, this study was not able to test this relationship with the collected data.

4.2.3 Observations of bicycle parking (field notes)

The previous paragraph demonstrated that nudging had a small significant effect on people's bicycle parking behaviour. During the observations, some field notes were made, which provided a more thorough understanding of how the nudge affected the way people parked their bicycle.

During the observations, it became apparent that the nudge created more order in the way bicycles were parked. This was illustrated by the two photos taken before and after the creation of the nudge (see photo 8 and photo 9). The bicycles without the nudge were chaotically parked, where two lines of bicycles emerged (see photo 7). The bicycles that were parked close to the wall were difficult to reach since they are being closed in. The creation of the nudge influenced people into parking their bicycle within the square, which resulted in one single line of parked bicycles (see figure 8). The effect nudging had on bicycle parking was also illustrated in photo 10 and 11. The nudge influenced people to park their bicycle in the square, which created a pattern of neatly parked bicycles.

Photo 8 | Bicycle parking without the nudge (21/8)

Photo 9 | Bicycle parking with the nudge (21/8)


Photo 10 | Bicycle parking without the nudge (17/8) Photo 1 | Bicycle parking with the nudge (17/8)

However, the nudge did not always achieve its goal of ensuring more appropriate bicycle parking. The following five factors were observed during the observations that could affect the effectiveness of nudging. Urban planners need to consider these limitations when wanting to effectively decrease the number of inappropriate bicycle parking.

Firstly, stimulating more appropriate bicycle parking seemed difficult once a pattern of inappropriate bicycle parking had already been established. This was because the behaviour of people was highly guided by how other people behaved (Fukuda & Morichi, 2007). It looked like people followed the bicycle parking behaviour of others and parked their bicycle next to other inappropriately parked bicycles, resulting in a pattern that was difficult to change. It seemed that the nudge did not always work that effectively since people were often still affected by the inappropriate pattern of bicycle parking. The self-organising processes were considered to be too strong to be influenced by nudging once a pattern had been established (Heylighen, 2001). In order for urban planners to be ahead of this emerging pattern, it would be necessary to nudge right at the beginning of the day or the night before.

Secondly, during the observations, it became clear that the type of bicycle may had an effect on the effectiveness of the nudge. It seemed that participants with expensive bicycles preferred securing their bicycle and were, therefore, less drawn to park their bicycle in the bicycle square since the bicycle squares did not provide any opportunities for securing a bicycle. This showed that participants with expensive bicycles often parked their bicycle inappropriately since this offered them more security. The nudge thus may not have been that effective to influence people that wanted more security for their bicycle. Remarkably, these findings contradicted the assumption of this study, which was that people who owned a high-value bicycle were more likely to park their bicycle appropriately (Larsen, 2017). Furthermore, participants that had a bicycle without a bicycle stand were not able to park their bicycle in the square. Those people were parking their bicycle against walls or street furniture, which was considered as inappropriate bicycle parking since this blocked pedestrian flows and entrances. The nudge thus only worked for people that had a bicycle with a bicycle stand and not for those without a bicycle stand. These

limitations show that nudging does not have the ability to influence all cyclists regardless of the type of bicycle they own. Urban planners need to acknowledge this limitation since this shows that a combination of instruments is necessary to effectively decrease the number of inappropriate bicycle parking.

Thirdly, the participants tended to park their bicycle outside the bicycle square once it became too difficult to park the bicycle between other bicycles. Even though there were still some spots left, it was perceived as too crowded. Therefore, participants often parked their bicycle outside the marked line in a continuation as if the line was still present. As soon as this became an impossibility, participants had to park their bicycle somewhere else and therefore were forced to park their bicycle inappropriately. It is thus necessary for urban planners to ensure that there are enough bicycle parking squares available to avoid inappropriate bicycle parking.

Finally, bicycle squares obviously only seemed to work for people that wanted to park their bicycle in that area anyway. People that wanted to visit a shop further away from the bicycle square were drawn into parking their bicycle as close to their destination as possible, namely on the pavement near the shop they wanted to visit. This can be explained because people often park as close as possible to their destination (Larsen, 2017). It thus seemed that the nudge was not able to influence the location of where people parked their bicycle. This finding suggests that it is necessary to provide more bicycle squares which are spread out across public space.

4.3 Summary of the results

The results showed that nudging had a significant effect on how people parked their bicycle, namely that people parked their bicycle more appropriately with the existence of the nudge. Furthermore, people's bicycle parking behaviour was not affected by their gender or group composition. However, the type of bicycle did have an effect on the way people parked their bicycle. Remarkably, people with a low-value bicycle were more likely to park their bicycle in the bicycle square than people with a high-value bicycle.

However, the nudge seemed to have some limitations, which were noticed during the observations. Firstly, the nudge lost its effectiveness once a pattern of inappropriate bicycle parking had emerged. Furthermore, the nudge was not able to influence people that wanted more security for their bicycle or people that had a bicycle without a bicycle stand. Moreover, the effectiveness of the nudge decreased once the bicycle square became too crowded. Finally, the nudge only worked for people that wanted to park their bicycle in that area anyway.

5 Conclusion

This study investigates whether nudging can be a useful instrument for urban planners to influence bicycle parking in public spaces. Firstly, the three sub-questions will be answered, followed by the research question.

5.1 Answering the sub-questions

"Why can bicycle parking in public spaces be seen as self-organising?"

Bicycle parking in public spaces can be seen as self-organising, as bicycle parking is organised through local interactions between cyclists themselves and between cyclists and other actors involved (Heylighen, 2008). Out of these interactions, an unpredictable pattern of bicycle parking emerges, which often exhibits inappropriate bicycle parking. The cyclists will subsequently be influenced by the established pattern, resulting in a circular causality (Haken, 1984).

During the observations, it became clear that the participants' bicycle parking behaviour was influenced by self-organising processes since the interactions between participants influenced the way bicycles were being parked. Once someone decided to park their bicycle inappropriately, it was very likely that others followed suit (Fukuda & Morichi, 2007). On the other hand, participants that exhibited appropriate bicycle parking behaviour also had the ability to affect people into parking their bicycle more appropriately. Out of these interactions a pattern of bicycle parking emerged, which was often difficult to change since the participants subsequently conformed their behaviour to the established pattern (Hermann Haken, 1984).

Changing this pattern is especially difficult through current interventions since they often do not recognise that the behaviour of cyclists who park their bicycle is guided through processes of self-organisation. Furthermore, traditional interventions generally assume that when people park their bicycle they do this by making deliberate choices and that people are consciously aware of their actions (Lehner et al., 2015). However, cyclists are imperfect decision-makers shaped by routine behaviour and social influence (Fukuda & Morichi, 2007). Therefore, the second sub-question will explore how bicycle parking can be influenced.

"How can nudging influence the self-organisation of bicycle parking?"

An instrument that is able to influence people's bicycle parking behaviour is nudging. Nudging alters people's bicycle parking behaviour in a subtle way without taking away their freedom of choice (Thaler & Sunstein, 2009). Firstly, people's bicycle parking behaviour can be nudged by focusing on people's routine behaviour. This is because cyclists mostly rely on their automatic system since bicycle parking is an activity that for most people comes as a daily routine (Larsen & Funk, 2015). Secondly, since bicycle parking behaviour is highly influenced by the behaviour of other people, it is necessary to influence the descriptive norms regarding bicycle parking (Fukuda & Morichi, 2007).

However, since inappropriate bicycle parking behaviour is a result of self-organisation, this study investigates whether nudging can be an effective instrument to influence the self-organising processes of bicycle parking. A theory that helps to gain insights in influencing self-organising processes is guided self-organisation (Gershenson, 2012). Guided self-organisation proposes eight different conditions that enable a system to change, which could serve as a guideline for the effectiveness of nudging by determining which conditions could be achieved through nudging.

This study explores whether nudging has the ability to affect the canalizing functions in order for it to be able to influence the self-organising system of bicycle parking by conducting a field experiment.

"Is nudging an effective instrument to influence bicycle parking?"

A field experiment was conducted to explore the effect nudging had on influencing the canalizing functions of the self-organising system. The nudge affected people's bicycle parking behaviour by making some stimuli more intrinsically conspicuous than others (Hollands et al., 2013; Russell et al., 2014). Firstly, the nudge existed of a bicycle square that had an effect on people's routine behaviour by guiding them to park their bicycle in the bicycle square. Furthermore, the nudge also consisted of two yellow bicycles that served as an example and trigger for people to park their bicycle besides them. The bicycles served as a descriptive norm that encouraged cyclists into parking their bicycle appropriately.

The nudge has the ability to attract people by attracting cyclists towards stimuli that motivated them into parking their bicycle more appropriately. Therefore, the nudge can serve as an input that is able to influence the behaviour of cyclists. This suggests that nudging has the ability to influence the canalizing functions of the system.

5.2 Answering the research question

The research question of this study is: *"When can nudging be a useful instrument for urban planners to influence the self-organisation of bicycle parking in public spaces?".*

This study argues that inappropriate bicycle parking can be considered as a resulting pattern of self-organisation. This pattern of inappropriate bicycle parking can be changed by guiding the self-organising system towards more desirable directions, namely a direction which exhibits more appropriate bicycle parking. The theory of guided self-organisation states that systems can be guided by altering some conditions. Nudging can be an instrument that is able to influence at least one of these conditions, namely the canalizing functions of the system. This study has demonstrated that nudging has the ability to make some stimuli intrinsically conspicuous than others to influence people's bicycle parking behaviour. Therefore, it can be assumed that nudging has the ability to influence the canalizing functions of the system.

Thus, the answer to the research question is: "Nudging can be a useful instrument for urban planners to influence the self-organisation of bicycle parking in public spaces, when it can influence the canalizing functions of the system".

6 Discussion

This chapter will discuss the outcomes and conclusion of this study. Firstly, the conclusion will be interpreted in section 6.1. Secondly, the limitations and recommendations for future research will be given. Section 6.3 will discuss the contribution of this study to planning theory and practice. Finally, a reflection on the research process and outcomes will be given.

6.1 Interpretation of the conclusion

The conclusion of this study is that nudging can be a useful instrument for urban planners to influence the self-organisation of bicycle parking in public spaces since it has the ability to influence the canalizing functions of the system. However, some critical remarks can be made which need to be addressed to fully understand the effectiveness of nudging.

Firstly, this study came to the conclusion that nudging can influence self-organising systems since it has the ability to influence the canalizing functions of the system. Though, as argued in chapter 2, the theory of guided self-organisation cannot be directly copied onto social phenomena such as bicycle parking. Instead, the theory of guided self-organisation can be used as a source of inspiration. Therefore, it cannot be determined with complete certainty that nudging can guide self-organising systems towards more desired directions.

Furthermore, the finding that nudging can positively influence people's bicycle parking behaviour is dependent on the interpretation of what inappropriate and appropriate bicycle parking is. This study considers bicycles parked appropriately if they are parked in a bicycle square. All bicycles that are parked outside of this bicycle square are considered inappropriately parked. However, deciding if bicycles are parked inappropriate or appropriate is a subjective matter, which needs to be considered when interpreting the conclusion of this study. This interpretation thus also led to the remarkable result that low-value bicycles were more likely to be parked appropriately than high-value bicycles. This is because participants with a high-value bicycle preferred double-locking their bicycle, which made them more likely to park their bicycle against street furniture instead of parking their bicycle in the bicycle square.

Moreover, it is difficult to establish a hard cause and effect relationship between nudging and appropriate bicycle parking. This is because this study conducted an experiment in the field, which makes it is hard to rule out all external variables (Blakstad, 2008; Shuttleworth, 2010). Therefore, this study cannot determine with complete certainty that the change in bicycle parking behaviour was solely caused by the nudge.

Finally, it is important to acknowledge that the effectiveness of nudging is context-dependent. The effect nudging had on the way people parked their bicycles in the observed area could be very different on other locations. That nudging did work for the chosen area of this research, does not mean that it will work everywhere. There are numerous varieties of nudges that all differ in effectiveness. Therefore, making general conclusions on the effectiveness of nudging is not possible.

6.2 Limitations and recommendations for future research

There are some limitations to this study that need to be discussed. These limitations subsequently result in recommendations for future research.

Firstly, this study used the ArcGIS Collector Application to record the location of the parked bicycles on a map, which was only represented with a 'point'. This method was not very accurate since there was no ability to indicate the exact position of the bicycle that was being parked. For example, if the bicycle was parked in line with the wall or perpendicular to the wall. This kind of precision could give a better understanding of how people park their bicycle and how this can be influenced. This study, therefore, recommends using a different data collection method that is able to record the placement of bicycles more precisely. Perhaps the spatial patterns of parked bicycles can be captured with a high-quality video camera, which can then be digitised in ArcGIS.

Furthermore, it would perhaps have been better to make observations at busier moments. This is because the number of people parking their bicycle in the observed area would have been higher, with probably more inappropriately parked bicycles. This would have given a more representative image of the problem of inappropriate bicycle parking. It would, therefore, be interesting to investigate whether the findings will differ when conducting the experiments at busier moments.

Moreover, this study concludes that nudging has the ability to influence bicycle parking. Nudging thus has the ability to influence people into parking their bicycle more appropriately. However, it is not completely certain to determine 'how' the nudge was able to influence people's bicycle parking behaviour, namely if the nudge really influenced people by creating a descriptive norm or if that influence was caused by other psychological processes. Further research is necessary to focus more on the psychological processes of people's bicycle parking behaviour. This is important since this will provide better insights into the effectiveness of nudging.

Besides, since this study experimented with two nudges, namely the two yellow bicycles and the bicycle square, it is also not possible to determine if the effect came from one of the two nudges or from both nudges. This is problematic since it limits the understanding of the effectiveness of the nudges. In order to determine the difference in effectiveness between the two nudges, further research is necessary which investigates the effect of the two nudges separately.

Lastly, this study demonstrated that nudging is able to influence people's bicycle parking behaviour on the short-term. However, it is unclear whether these effects will remain on a longer-term (Goodwin, 2012). In order to determine the long-term effects of nudging, a more long-term research is necessary.

6.3 Contribution to planning theory and practice

This study concludes that nudging can be a useful instrument for urban planners to influence bicycle parking. These findings led to a couple of contributions to planning theory and practice.

6.3.1 Practice

Inappropriate bicycle parking can be reduced by applying nudges in the form of bicycle squares. More suitable areas are needed for bicycle parking, which can be provided by creating more nudges in the form of bicycle squares. This study recommends having multiple squares, which are spread across public space. Having multiple bicycle squares provide bicycle parking space for people with different destinations, which is especially necessary since people tend to park their bicycle as close as their destination.

However, since bicycle parking behaviour is self-organising, bicycles that are parked inappropriately highly influence the behaviour of other cyclists. Therefore, it is important to remove wrongly parked bicycles before a pattern of inappropriate bicycle parking emerges.

Furthermore, this study recommends providing more bicycle racks for bicycles that do not have a bicycle stand or need more security. This will reduce the number of bicycles parked inappropriately against walls or street furniture.

A final recommendation for urban planners is to consider nudges to be complementary to other interventions. The problem of inappropriate bicycle parking cannot be solved solely through nudging. It is thus necessary to combine various interventions to effectively reduce the number of inappropriately parked bicycles.

6.3.2 Theory

This study contributes to planning theory by exploring the possibility of applying a theory from the computational sciences to the social sciences. Guided self-organisation is a theory which studies phenomena by simplifying the system to merely nodes and links. This theory has mostly been used to study phenomena that were able to be simplified and isolated from their context. However, guided self-organisation had not been applied to phenomena in the social sciences before. This study, therefore, tries to explore the possibility of applying guided self-organisation to a social phenomenon, namely the self-organisation of bicycle parking, to provide insights for urban planners to determine when nudging could be effective or not.

This study concludes that nudging can be seen as a form of guidance to transform the self-organisation of bicycle parking. However, determining whether nudging can actually influence the canalizing functions of the system has to be researched further.

6.4 Reflection on research process and outcomes

The research process did not go without ups and downs. First of all, it was difficult to decide what the focus of this study was going to be. Many directions came by which were all interesting and difficult to choose from. Therefore, formulating the research question and the sub-questions took quite some time. After a period of struggle, my supervisor suggested using the theory of guided self-organisation, which enabled this study to gain more research focus.

However, it was difficult to grasp and understand the theory of guided self-organisation. This was because it is an abstract theory, and derived from the computational sciences, which is not my field of expertise. Thus, understanding this theory also demanded a lot of time and perseverance. Gradually, it became clearer which direction I wanted to go to and the research process accelerated.

While doing the experiments, I noticed that I should have done more explorative observations beforehand. The research process was mostly characterised by desk-work, namely reading, thinking and writing. More insights on bicycle parking behaviour would have been obtained by going into the field and observe people parking their bicycle in public spaces. This would have contributed to a better understanding of how to conduct the experiments.

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8 Appendix

Level of association	Description
0.00	No relationship
.01 to .09	Negligible relationship
.10 to .29	Low relationship
.30 to .49	Moderate relationship
.50 to .69	Substantial relationship
.70 or higher	Very strong relationship

Table 4 | Measures of association (Davis, 1971)

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.065[a]	1	.014		
Continuity Correction[b]	5.643	1	.018		
Likelihood Ratio	6.078	1	.014		
Fisher's Exact Test				.015	.009
Linear-by-Linear Association	6.054	1	.014		
N of Valid Cases	530				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 120.12.

b. Computed only for a 2x2 table

Figure 10 | Pearson's Chi-Square on the relation between inappropriate bicycle parking and nudging

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	-.107	.014
	Cramer's V	.107	.014
N of Valid Cases		530	

Figure 11 | Strength of association between bicycle parking and nudging

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	19.020[a]	4	.001
Likelihood Ratio	19.164	4	.001
Linear-by-Linear Association	10.355	1	.001
N of Valid Cases	528		

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is 3.45.

Figure 12 | Pearson's Chi-Square on the relation between bicycle parking and type of bicycle

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.190	.001
	Cramer's V	.190	.001
N of Valid Cases		528	

Figure 13 | Strength of association between bicycle parking and type of bicycle

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.790[a]	1	.374		
Continuity Correction[b]	.642	1	.423		
Likelihood Ratio	.790	1	.374		
Fisher's Exact Test				.385	.211
Linear-by-Linear Association	.788	1	.375		
N of Valid Cases	530				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 122.10.

b. Computed only for a 2x2 table

Figure 14 | Pearson's Chi-Square on the relation between gender and inappropriate bicycle parking

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.626[a]	1	.202		
Continuity Correction[b]	1.256	1	.262		
Likelihood Ratio	1.633	1	.201		
Fisher's Exact Test				.220	.131
Linear-by-Linear Association	1.623	1	.203		
N of Valid Cases	527				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 22.87.

b. Computed only for a 2x2 table

Figure 15| Pearson's Chi-Square on the relation between bicycle parking and group composition