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Master Thesis Behavioral Economics

Nudging cyclists and moped users to safe behavior in a pedestrian area

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Abstract:
In this research it is investigated whether poster nudges are an effective tool to increase safe behavior, that is, the amount of cyclists and moped users that dismount or slow down to walking pace in a pedestrian area. Two posters were designed and tested. One poster included a warning nudge and the other a social norms nudge. The posters were tested in the context of a restaurant in Rotterdam where a pedestrian area separates the outdoor seating area from the restaurant. During the day this pedestrian area is used intensively by cyclists and moped users on their travel route, which is potentially dangerous as waiters are crossing the pedestrian area when the outdoor seating area is used. This research shows that the poster nudges are effective tools to increase safe behavior. Compared to the control group, the warning poster increased the probability of safe behavior by 11.9 percentage points and the social norms poster increased this probability by 12.5 percentage points. Also the amount of people at the pedestrian area and the direction of the cyclists/moped user affected the behavior. This research shows that poster nudges are a useful tool to increase safe behavior of cyclists and moped users in a pedestrian area and it is suggested that posters are useful for increasing safe behavior of cyclists and moped users in general.

Keywords: Nudging, poster, social norms, warning, safe behavior, field experiment

Contents

1. Introduction

Nudging is a popular measure to stimulate behavioral change. Nudges are tools that are implemented in a certain environment and that are designed to trigger people to act in the way the designer of the nudge, the choice architect, wants. Nudges steer the behavior of individuals in a predictable direction, but on the other hand they should not take away the freedom of choice of those individuals. Therefore, nudges should be transparent as people should not be manipulated by them (Sunstein, 2014). Selinger and Whyte (2012) show the importance of having a clear definition of nudging at the start of a research, as sometimes interventions in the literature are claimed to be nudges while they are not. Interventions that are not nudges but are claimed to be could give a wrong image of nudging.

After the introduction of nudging by Thaler and Sunstein (2008), it became a more and more popular tool for behavior improvement. For example in the Netherlands the registration system for organ donation recently changed from an opt-in system to an opt-out system, which implies that the default option is that someone is a registered donor instead of not being one. This so called default nudge caused an increase in the amount of people actively giving permission for organ donation by a million (Moeliker, 2022). A couple of years before that the Dutch government used this default nudge to decrease the average student loans, which caused indeed a decrease in the amount of students that loaned the maximum monthly amount (NRC, 2015). These nudges were necessary as the demand for organs was too high compared to the supply and because students loaned too much for their own good.

A context in the Netherlands that also has the necessity of behavioral change is the context of transport. In the Netherlands there is an upward trend of the amount of traffic accidents in which at least one person dies. Data from Smart Traffic Accident Reporting counted 491 of those accidents in 2021, while this increased to 578 in 2022 (NOS, 2023a). One year earlier, research by VeiligheidNL showed that in the last ten years the amount of victims of traffic accidents increased by eighteen percent. The amount of serious injuries of cyclists involved in traffic accidents even increased by twenty nine percent (NOS, 2022).

Also in the field of transportation nudging is used, with mixed impact. For example in the Netherlands in areas nearby schools ‘Dick Bruna’-signs and ‘Victor Veilig’-dolls are placed on the side of the road to stimulate car drivers to slow down, but research shows that the average speed only decreased by four kilometers per hour and that this effect only lasted for

one week (Ten Wolde, 2022). A nudge in Amsterdam had more effect. A device placed next to a traffic light for cyclists showed the amount of cyclists that had stopped that day before the red light. An increase of twenty percent of cyclists that stopped before the red light was caused by this device (NOS, 2023b).

In the scientific literature the field of transportation combined with nudging is upcoming, with for example recent contributions about nudging to take public transport (Franssens, Botchway, De Swart and Dewitte, 2021) and nudging tourists to walk instead of using other forms of transportation (Chen, Lehto, Lehto and Day, 2023), nudges that were both effective. Not all nudges are effective as they are in these examples, but also in the context of transportation nudges seem to be a useful tool to stimulate behavioral change in a positive way.

In this research a field experiment is carried out to contribute to this field of transportation and nudging. In the experiment people will be nudged to dismount from their bicycle or moped or slow down to walking pace to pass the pedestrian area between a restaurant and its outdoor seating area safely. Sunstein (2014) mentioned in his paper the ten most important nudges in scientific literature. In this research the effectiveness of the two nudges from those ten that are applicable in the situation described above are tested. These are the warning nudge and the social norms nudge. Warning nudges are used in cases where dangers are involved to make people aware of this. Social norms are used to emphasize what most people do or what most people should do, by which way people could be stimulated to change their behavior (Sunstein, 2014). Posters will be used to show the nudges. The research question that will be answered in this paper is the following:

> *What is the effect of warning and social norms poster nudges on cyclists and moped users dismounting or slowing down to walking pace in a pedestrian area?*

The contribution of this research is threefold. The first one is given by the trend of traffic accidents that is rising. Traffic accidents are bad for everyone involved and therefore it is important to find solutions to stop this trend. Nudges are a useful tool to stimulate safer behavior of individuals that take part in transportation as it has proven to work in real life and also because they are easy to implement on the short term. The second reason this paper contributes is the large research gap. There is some research in the field of transportation and

nudging, but there is still missing a lot. For example about cyclists and moped users the knowledge is narrow and specifically about dismounting no research was found at all. The third contribution of this paper is its relevance for the restaurant where the field experiment is carried out. For a long period they have been experiencing the problems of cyclists and moped users using the pedestrian area between their restaurant and outdoor seating area as a road to travel. This can be dangerous in case children are playing there or waiters cross the area. The restaurant itself tried multiple solutions of which none worked, so it would be helpful for them if the nudges worked. In the third section of this paper the context of the experiment will be extensively discussed.

From here on this paper is separated into six parts. First an overview will be given of the literature that is relevant for this research (Section 2). This second section will be concluded with two hypotheses that are needed to answer the research question. After that the experiment carried out to collect data will be explained in detail (Section 3). The fourth part includes an explanation of the data collected and how the data will be analyzed. In the fourth part the analysis is described and the two hypotheses are tested (Section 4). The paper finishes with a critical review of the research (Section 5) and a concluding part in which the research question is answered (Section 6).

2. Literature review

In this section an overview of the literature will be given. First the fields of behavior in transportation and nudging will be introduced, after which literature of these two fields combined will be presented. The section will be concluded with literature about warning nudges and social norms nudges and the two hypotheses that result from this literature.

2.1 Behavior in transportation

To analyze behavior at the individual level, Vlek (2000) suggests using the NOA-model. Behavior depends on needs (N), opportunities (O) and abilities (A). Needs and opportunities together form the motivation to perform, while opportunities and abilities give the area that is in behavioral control. Motivation and possibilities form behavior. In transportation human motivation and possibilities play an important role on choices made at individual level as car drivers, cyclists, pedestrians and more. Therefore human behavior affects transport outcomes.

Jackson and Jucker (1982) investigated the effect of travel time on route choice and found a large impact that differed across individuals. There were participants that tried to avoid every possible risk of delay, even accepting longer routes, and there were participants that based their route choice on shortest expected travel time, accepting the risk of delay. Risk behavior therefore impacts route choice of individuals and thus transport outcomes. Koppelman and Pas (1980) investigated travel mode preferences and actual mode choice and found that perception of mode performance and feelings about modes are explanatory variables for this. As perception and feelings are determinants of individual behavior, here also behavior affects transport outcomes. From interviews with cyclists Dill and Gliebe (2008) concluded that main determinants for cycle route choices are distance minimization and vehicle bustle. Also routes with separate bicycle lanes and less traffic lights were used more. Their sample was therefore affected by minimizing cycle time and maximizing travel safety. Jing, Zhao, He and Chen (2018) did a systematic review on the Random Regret-Minimization model, a model predicting traveler's choice behavior by minimizing the value of regret decision criteria. One of the conclusions of their paper is that choice for travel route and mode are connected. All in all human behavior in choices and preferences affects among other

things the travel routes people take and by which mode they travel, and therefore what happens on the road.

People are not fully rational in the sense traditional economists use in research. Kahneman and Tversky (1979) founded the prospect theory as alternative for the expected utility theory (EUT) to more accurately predict people's decision making. Prospect theory predicts among other things loss aversion and diminishing sensitivity, meaning that changes in larger amounts have more impact than the same changes in smaller amounts (Van de Kaa, 2010). Multiple papers investigated the prospect theory in the context of transportation and found evidence for irrational behavior (Avineri and Bovy, 2008). In these papers the improved version of prospect theory by Tversky and Kahneman (1992), the cumulative prospect theory (CPT), is used. In case of route choice behavior CPT gave more accurate predictions than EUT. CPT predicts greater risk aversion for gains than for losses and this also holds for travel time (Gao, Frejinger and Ben-Akiva, 2010; Xu, Zhou and Xu, 2011).

Besides not fully rational, humans also are habitual creatures, which again holds in the context of transportation. When people are used to do something, they likely keep doing the same thing (Schneider, 2013). Habit is a strong predictor of bicycle use (De Bruijn et al., 2009; Willis, Manaugh and El-Geneidy, 2015) and car use (Şimşekoğlu, Nordfjærn and Rundmo, 2015). As car use habit is positively correlated to attitude and emotions about cars, Domarchi, Tudela and González (2008) concluded that it might be difficult to break the circle of habits, but on the other hand research by Fujii and Kitamura (2003) shows through an experiment that by distributing free bus tickets for one month car use habits changed into bus use habits. When conditions are stable, habits in transport have a strong influence on choices made, but when conditions differ, this effect decreases (Schneider, 2013).

2.2 Nudges

In their book *Nudge* Thaler and Sunstein (2009) describe nudges as *"any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic consequences. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates*". By adjusting the environment, people are stimulated to change their behavior. So an advantage of nudges compared to legislation is that there is no compulsion, people keep their freedom of choice. Therefore it is also very important that nudges are transparent, people should not be

manipulated as that would take away their freedom of choice (Sunstein, 2014). Nudges are necessary as the world seems to get more and more complicated. Nudges are meant to serve in helping people making better choices, choices they judge themselves. Sludge, that is nudge that is not in the interest of the choice maker, should be averted (Thaler, 2018).

Since the 'invention' of nudging, randomized control trials have been booming to investigate the effect of nudges in real life. Kroese, Marchiori and De Ridder (2016) tested a nudge where healthy food was placed on a more visible place than unhealthy food in train station snack shops and found that more healthy snacks were sold than before. Pennycook et al. (2020) investigated misinformation during the COVID-19 pandemic and they concluded that showing participants a simple accuracy reminder before sharing information decreased the amount of misinformation spread. As a last example, Castleman and Page (2016) used personalized text messages to get first year students to request again for federal student aid for their second year and they found an increase of almost fourteen percentage points in likeliness of continuing enrollment for the aid. Besides success stories there are also nudges that do not work at all or that work in the wrong direction. A systematic review by Hummel and Maedche (2019) found that 62% of nudges in the literature they investigated had a statistically significant effect. This does not include non-published research, so the percentage might be lower. But in the end still a lot of nudges have proven to be effective and as nudges are cheap to implement in most cases it is a useful tool to improve behavior.

Poster nudges are a specific kind of nudges in which a poster with a nudge on it is placed somewhere meant to draw the attention of the target group and trigger them to behave in the way the choice architect aimed at. As long as the text on the poster does not forbid anything or changes economic consequences significantly and is cheap and easily avoided, it counts as a nudge (Thaler and Sunstein, 2009). Posters are easy to place in toilets to stimulate hygienic behavior. Posters next to dispensers in a hospital increased the use of alcohol-based hand rub by medical staff (Caris et al., 2018) and research in Indonesia during the COVID-19 pandemic found that placing a poster including a rhyming text and visuals of handwashing above the sink increased handwashing by seven percentage points (Prasetyo, Sofyan, Muchtar and Dewi, 2022). Also for promoting pro-environmental behavior posters are a useful nudge. In a between company experiment in India posters were used to nudge employees to reduce paper use for printing. The nudge reduced the paper waste and had still a significant effect one and a half month after the posters were removed. For posters that

were pasted on printers the effect after the nudge remained the same post-treatment and one and a half month after the intervention. For posters placed on office cubicles the paper usage increased back towards the old level, but stayed significantly different from it (Chakravarty and Mishra, 2019). Agha-Hossein et al. (2015) used an interactive poster that could count the amount of people taking the stairs instead of the elevator and another interactive poster to stimulate students to switch of the light when they left a room. Both posters had a positive effect and the authors conclude that combined with a clear message, interactivity can further improve behavior. Van der Meiden, Kok and Van der Velde (2019) nudged employees of an office to use the stairs. In their experiment they used posters and footprints on the floor. The results show that footprints had a significant increasing effect on stair use, while the effect of posters was insignificant. A questionnaire after the experiment revealed that the footprints were noted by almost each respondent, while not even half of the respondents had noted the posters, which shows the importance of saliency for impact.

2.3 Nudges in transportation

As the field of transportation and economics implemented the theories of behavioral economics, also the combination of nudging and transportation is investigated more and more in the last couple of years. In Rotterdam in The Netherlands a large field experiment was carried out to investigate whether a social label typifying participants as sustainable travelers on a free distributed bus card holder had an increasing effect on bus use compared to participants that received a bus card holder without the extra message. The researchers found an increase in bus use in the nudged group relative to the control group (Franssens, Bothway, De Swart and Dewitte, 2021). In a more individual focused experiment, Anagnostopoulou et al. (2020) collected transportation data of thirty participants through their mobile phone use. They also made a profile of the participants to find out what persuades them. With this data personalized nudges were designed for a route planning app to stimulate sustainable transport behavior. From the results the authors concluded that individual nudges have a strong, pro-sustainable effect on transport mode choice. Gravert and Collentine (2021) concluded that sometimes nudges are not enough to stimulate public transport use. In their results they suspect an intention-action gap. By using social norms on a flyer to persuade participants to use public transport, the results show that 16% of the participants wanted to increase their public transport use, while in actual action no change was noticed.

In the context of car use Namazu, Zhao and Dowlatabadi (2018) used a reminder nudge to test whether this affected shared car users to check cars before renting it. The results show a clear positive effect of the nudge, an effect that remained and even further increased after the nudge was removed. Choudhary, Shunko, Netessine and Koo (2022) used feedback nudging to increase safety in car driving behavior. Performance was measured by systems in the cars of participants. Participants received feedback on either their best performance or on their average performance or on their latest performance. Effects were the largest for the average and best performance feedback, in a later part of the research explained by the fact that a low variability in reference points gives more effect.

Research by Liu, Qu and Ge (2022) shows the importance of pedestrian behavior. In their research it was shown that pedestrians following traffic rules are the second motivator for car drivers to change their behavior in safe car driving. In the section about nudging, researches by Agha-Hossein et al. (2015) and Van der Meiden, Kok and Van der Velde (2019) were already mentioned where nudging stimulated people to use stairs instead of elevators. Also colored pavements help to stimulate walking as a mean of transport as it increases salience of the pavement and improves temper of the people using it (Chen, Lehto, Lehto and Day, 2023).

There is not much literature specific on behavior of cyclists and moped users. About dismounting in pedestrian areas there is no literature at all available. There is some research about nudging cyclists to safer behavior. Kumar and Kumaar (2020) investigated the effect of lane marking on cyclists, something that affects car drivers to drive more safely. In their research they did not find an effect on behavior of cyclists or moped users at a T-intersection. Fyhri, Karlsen and Sundfør (2021) showed that there is a positive effect of giving cycle lanes on roads a red color. More cyclists started using the cycle lane instead of the pavement. Visibility and perceived safety were mentioned as reasons. What affects speed of cyclists are visual nudges like lines on the road with decreasing distance to give the illusion of speed, lines that seem to narrow the street and signs on the side of the road showing the actual speed of someone followed by messages about this speed (Wallgrena, Karlssona and Alvergrena, 2020). Nudging also is a useful complement to improve parking behavior of cyclists (Baxter, 2018) and it has a positive effect on bike locking behavior (Sas, Ponnet, Reniers and Hardyns, 2021).

Specific research on mopeds is also not available, but there are two researches about e-scooters and nudging. Ocean and Woodman (2022) investigated vandalism towards shared

e-scooters and the effect of three different nudges on that behavior. For one nudge they found no effect and for the other two that found that the nudge backfired, the behavior after being nudged was even worse than before. Johansen (2022) tested nudges for Bolt to stimulate e-scooter rental. The nudge was to add the option of e-scooter rental in the app menu. Results showed a significant increase of e-scooter renting.

2.4 Warning nudges

According to Sunstein (2014) the best nudge in case of risks is the use of warnings. An example he mentions for this is the use of cigarettes. For example in The Netherlands warnings are added to cigarette packages to discourage smoking. After the default nudge, warning nudges are investigated the most. From a sample of fifty-five effect sizes from eighteen studies about warning nudges, the median effect of the nudges was 20%. The mean was skewed, caused by research by Khern-am-nuai, Yang and Li (2017), who found an increase of 1681% in password generating behavior (Hummel and Maedche, 2019). For warning nudges to work, at least it is important to have clear and notable nudges. In the United Kingdom, where warning gamblers is obligated, gamblers are not nudged well as the nudges have a confusing format, are small or placed at unnoted places (Newall, Walasek, Ludvig and Rockloff, 2022).

Song et al. (2021) conducted a systematic review on 118 studies about color-coded labels and warning labels on food and the effect of that on consumers' behavior. All the different product labels, including the nutrient and health warning labels, directed consumers toward more healthy choices. Of course warning labels do not have a similar effect on everyone. Consumers that already have a greater motivation for healthy behavior are more strongly affected by warning labels (Ares et al., 2018).

Warning people through nudges does not always affect actual behavior. In a context of getting insured for cases where someone is not able anymore to work, information used to increase risk awareness and trigger loss aversion did work to get a larger awareness for insurances, but participants did not continue in searching more about the insurances (Miesler, Scherrer, Seiler and Bearth, 2017). In an online experiment people were nudged to disclose less personal information, but the nudge only worked to attract the attention of the participant towards the privacy policy link and not to let participants disclose less personal information (Rodríguez-Priego, Van Bavel and Monteleone, 2016).

In the context of transportation Al-Ghamdi (2007) investigated the effect of a warning system that was activated in foggy circumstances and that had speed advice as output. The warning system caused an average speed reduction of 6.5 kilometers per hour. As an average reduction of 5 kilometers per hour decreases the amount of accidents by 15%, this is a large effect. Yan, Liu and Xu (2015) used an in-car warning system to warn drivers to stop before a yellow light when the distance was too large to pass it in time. This also had a large impact on the drivers behavior; there was a decrease of more than 80% in times a red light was passed by a car.

Even though there are cases where warning nudges do not have a significant effect, most of the researches mentioned had positive results caused by the nudge. As warning nudges also affect behavior in transportation and an earlier section showed the positive impact of poster nudges, it is expected that for the experiment of this research there is a positive effect on behavior. Therefore the first hypothesis is the following:

[1] Using a warning nudge on a poster has a positive effect on cyclists and moped users dismounting or slowing down to walking pace in a pedestrian area.

2.5 Social norms nudges

Sunstein (2014) thinks of social norms as a very powerful nudge, especially when it is very specific and as local as possible. There are two kinds of social norms. Descriptive norms are about what people are doing, injunctive norms are about what people think what should be done. Descriptive norms are a kind of groupthink, they inform people about what is the likely thing to do. Descriptive norms have a larger impact than injunctive norms (Cialdini, Kallgren and Reno, 1991). From a sample of twelve studies about social norms including forty-nine effect sizes, the average effect size was 29% (Hummel and Maedche, 2019).

A famous research that used social norms to nudge participants is about the reuse of towels in hotel rooms. The social norms, stating for example that 75% of the guests reused their towels, had a larger effect than a standard message on the importance of towel reuse for the environment. It was also found that a larger effect was reached when the social norm was localized (guests that stayed in the same room) than when people could identify themselves through words like men, women or citizens. After the local message almost 50% of the guest reused their towels, while of the guests who only got the standard message less

than 40% reused their towels (Goldstein, Cialdini and Griskevicius, 2008). Social norms also had a positive impact on pro-environmental decisions of farmers, even after subsidies were finished (Kuhfuss et al., 2016). In case of waste separation, social norms had a negative effect on people who already sorted a lot, while moderate social norms had a positive impact on separating behavior for participants that did not separate that much. The latter was probably caused by the fact that the high norms were out of reach and therefore did not stimulate behavior change (Czajkowski, Zagórska and Hanley, 2019).

In an experiment by John (2018) social norms actually backfired the taxes payed, but this is in contrast to a lot of other researches in this context. Reasons mentioned for the backfire are the words used in the message and the heterogeneity of the group. Dur, Fleming, Van Garderen and Van Lent (2021) did not find an actual effect of social norms. They found an increased intention to save money, but not an actual change in saved money. Li and Chapman (2013) investigated health and nudging and mentioned four studies about social norms. For vegetable intake they found a positive result, but for decreasing calorie intake the studies mentioned gave different directions of the outcomes.

The impact of social norms in transportation is for example shown in air travel. Flight shame changes the social norm of air traveling as positive for the social status to something someone should not be proud of. This has an effect on the support for increasing costs of air traveling and forcing airlines to act more sustainable (Gössling, Humpe and Bausch, 2020). Using social norms also decreased car use for commuting purposes in a Canadian experiment, the height of the social norm had a linear relationship with the decrease of car use. The group that was shown the highest social norm reduced car use with a commuting purpose five times more compared to the baseline (Kormos, Gifford and Brown, 2015). This positive effect of social norms on more sustainable mode choice and movement towards greener transport is also shown by other studies (Zhang, Schmöcker, Fujii and Yang, 2016).

This literature section has shown that social norms are especially powerful in pro-social contexts like improving sustainable behavior. For cases where behavior mainly affects personal outcomes, the impact of social norms is more mixed. As this research is about behavior that mainly impacts others and thus improving that behavior is pro-social, combined with the fact that posters are effective nudges when placed correctly and notable, it is expected that a social norms nudge has a pro-social effect in the experiment of this study. Therefore the second hypothesis is the following:

[2] Using a social norms nudge on a poster has a positive effect on cyclists and moped users dismounting or slowing down to walking pace in a pedestrian area.

3. Experimental design

In this section first it will be explained what the problem is that should be solved. After that the interventions that will be tested to solve this problem will be discussed. The section will be finished with a description of how the field experiment will be carried out.

3.1 The problem

Restaurant Prachtig is located below the Erasmusbrug in Rotterdam. Between this restaurant and its outdoor seating area there is a pedestrian area that is used a lot by cyclists and moped users instead of other, official cycling paths. Figure 1 shows the situation from above. On one side a clear sign is showing that there is a pedestrian area. On the other side the sign indicating this is missing, but the sign has been there before. The problem is not that this small pedestrian area is a part of the travel route of cyclists and moped users, the problem is that they do not dismount and sometimes even drive at a fast speed when they are passing the restaurant. During the first meeting one of the managers of the restaurant told that this causes dangerous situations as waiters are crossing the pedestrian area when serving people at the outdoor seating area. Besides, when there are families with children between the customers there is also the danger that something happens to them, as children are less careful when walking around.

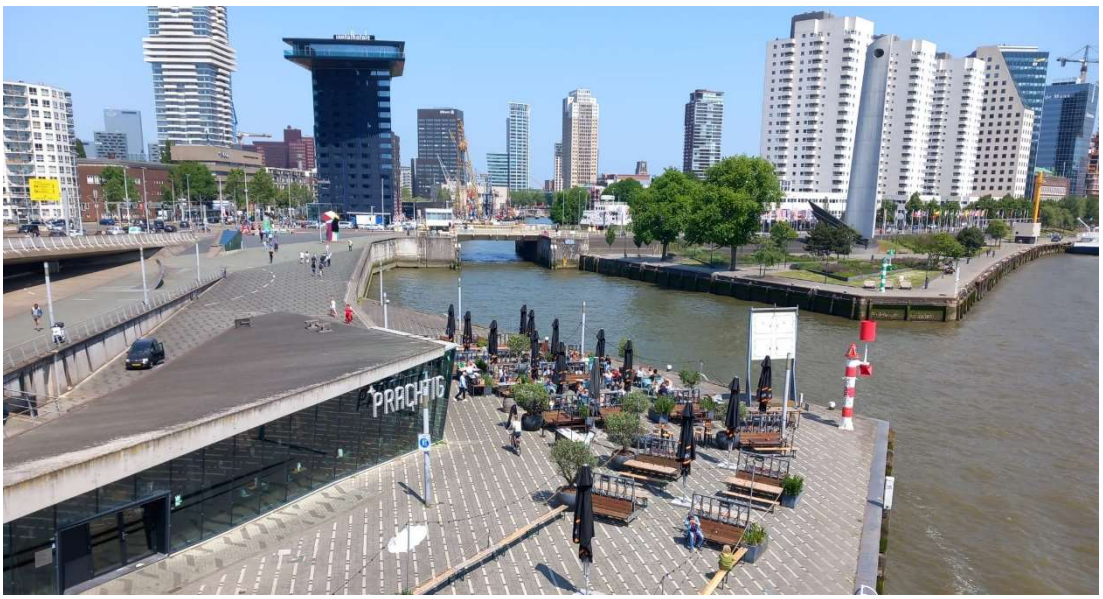

Figure 1 Restaurant Prachtig seen from the Erasmusbrug. From the south a traffic sign is still clearly showing that there is a pedestrian area between the restaurant and the outdoor seating area.

3.2 The interventions

In case the barrier to change behavior is small, only a small incentive, like a simple nudge, is needed to change behavior (Datta and Mullainathan, 2014). As the only barrier here is that people will lose a few seconds on getting from A to B, an assumption made in this research is that the barrier is small, wherefore a simple nudge should help to change behavior. As mentioned in the introduction the effect of a warning nudge and a social norms nudge on posters will be tested to increase the amount of cyclists and moped users that dismount or slow down to walking pace when they are passing the pedestrian area.

The posters designed especially for this experiment are shown in figure 2. On the left there is the warning nudge poster. It says *"Watch out! This is an outdoor seating area! Dismount and avoid accidents".* As Sunstein (2014) says that a risk of warning nudges is that people think that the notion is irrelevant to them because they are careful enough themselves and that this could be solved by adding what steps should be taken to lower the risk, the last part of the text is added to the poster. Below the text a possible situation is shown where a waiter and a cyclist both do not pay attention and will likely collide. The background of the poster is made red to increase the warning effect, as the color red is associated with danger (Pravossoudovitch, Cury, Young and Elliot, 2014).

On the right part of figure 2 the social norms nudge poster is shown. The text of this poster is translated as *"80% of the cyclists and moped users dismount here. You too?"*. Dolan et al. (2012) mentions that social norms can backfire when people already behave in the way the choice architect aims at. A solution they give is to acknowledge the correct behavior. This acknowledgment is done by showing pictures of happy people that dismounted. Also the green background has to give this effect, as the color green is a pleasant color to look at and arouses positive emotions (Valdez and Mehrabian, 1994; Kaya and Epps, 2004). Another reason to use dominant colors for both posters, and also to use short and simple texts, is the reason of salience. What draws people's attention is what influences behavior. As people receive an extreme amount of stimuli, way more than they could handle, the brain automatically filters out a lot of them. What is salient is not filtered out. Things that are new are more salient, but also things that are accessible and simple are more salient. Something is more attracting to pay attention to when it is understandable (Dolan et al., 2012).

Figure 2 On the left the poster with a warning nudge is shown and on the right the poster with a social norms nudge is shown.

3.3 Experiment

In the experiment there are three different groups, one control group and two treatment groups. If an experiment is set up outside of a controlled lab and participants do not know they take part in an experiment, it is a field experiment. This experiment is an unobtrusive observational field experiment because there will be no contact between the experimenter and the participants and the behavior of participants will be observed and counted. Behavior will be categorized as either dismounting or walking pace or no change. Behavior will be seen as slowing down to walking pace when passengers do not dismount, but only move at a pace needed to balance and not to fall.

The experiment will be carried out on six different days, four hours per day, so data will be collected over a total period of 24 hours. The days of measurement are Tuesday May 23, Wednesday May 24 and Tuesday May 30 till Friday June 2. On Mondays the restaurant is closed and as it is expected that the mindset during traveling by bike or moped does not depend on days, no measurements are done in the weekend. As the outdoor seating area is mainly used between 12:00 and 18:00 and therefore not dismounting is the most problematic,

that is the period of measurement. Measurements are also done between 10:00 and 12:00 to see if there also is an effect of the nudges when the outdoor seating area is used less intensively. The period from 10:00-18:00 is separated into four different blocks of two hours (10:00-12:00, pre-lunch; 12:00-14:00, early afternoon; 14:00-16:00, afternoon; 16:00-18:00, late afternoon). Inside these blocks of two hours each nudge and the control group will be observed separately for thirty-five minutes, with in between five minutes to change the setting. This is done to make the comparison between the different groups more reliable, as the different groups are closer together in time and thus the things that are different between the situations are as limited as possible. So over the six measurement days, each day there will be two observation blocks. The order of treatment and control groups will be randomly defined for each block

The posters will be placed on boards on both sides of the pedestrian area. They will be placed at the start of the area, so people know from where it is expected that they walk. By using boards it is easy to take the posters inside or outside and thus switch between the measurement groups. Figure 3 shows the situation from the north with and without the poster nudge.

Every cyclist or moped user that passes will be assigned to either 'dismounting' or 'walking pace' or 'no change'. It will also be notated if someone is a moped user or a cyclist, from which side they came and if at the moment of passing there were four or more people in the pedestrian area. Four is chosen as that is the amount of people that can walk together side by side in the area. Other variables that will be notated are the exact date, the day, the weather type, the block, the exact time period, the amount of people in the outdoor seating area and to which group the observations belong. These other variables will be the same for each observation over a thirty-five minute period, they will not be observed for each observation specifically as they are variables that are (expected to be) constant over this period. The weather types used are sunny, cloudy, and rainy. The amount of people in the outdoor seating area is determined at a seven-point Likert scale, from empty to filled.

During a baseline measurement on Friday the 19th of May from 15:30-17:00 seven mopeds and seventy-five bicycles passed. During the measurement the outdoor seating area was almost filled and the weather was both sunny and cloudy. Six of the moped users and forty-five of the cyclists did not dismount or cross at walking pace, which is equal to sixty-two

percent. To measure a decrease to at least below fifty percent a total sample size of at least 468, or a 156 sample size per group, is needed.

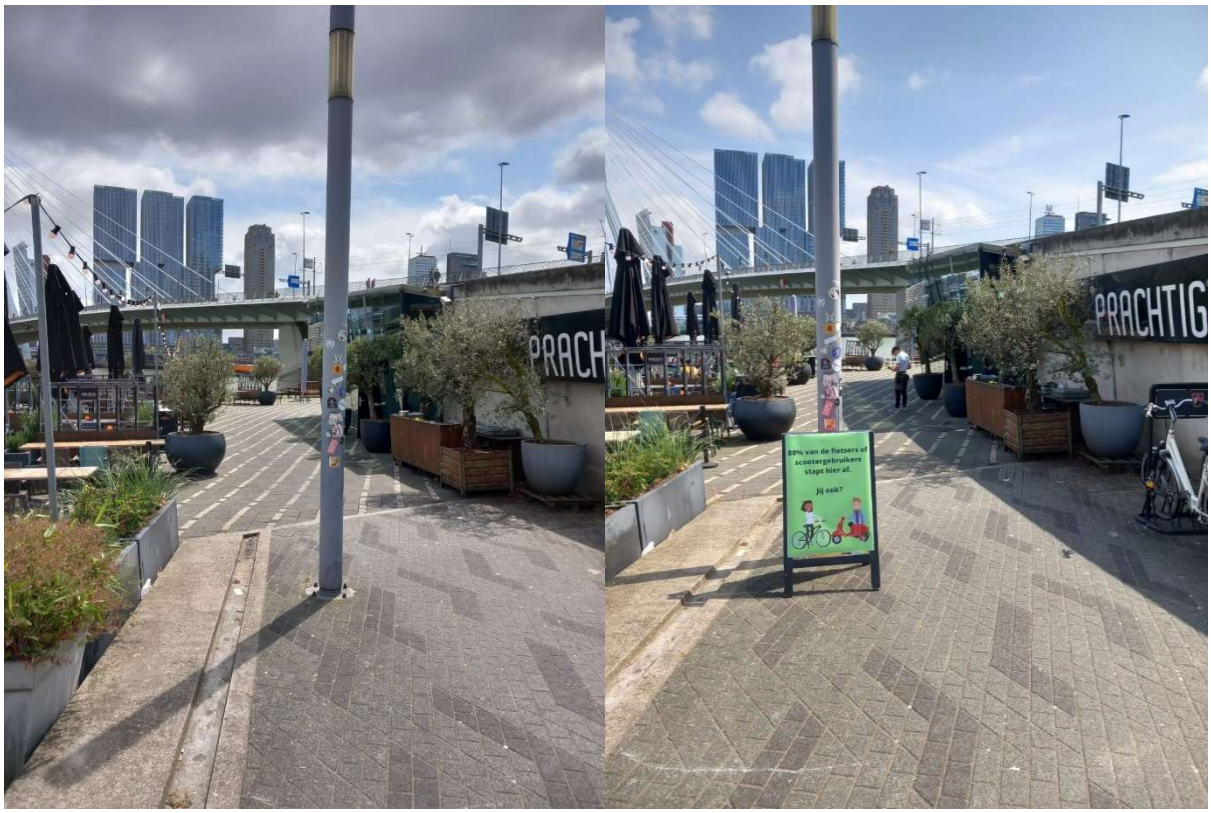

Figure 3 The pedestrian area seen from the north without and with a poster nudge. The poster used here is the social norms nudge.

4. Data and Methodology

In this section first an overview of the collected data will be provided. After that the methods used to analyze the data and to test the hypotheses will be explained.

4.1 Data

During the experiment, over a period of twenty hours spread over five days, 1,054 cyclists and moped users passed the restaurant and therefore entered the dataset. The actual experimental period was one day shorter than the planned period of measurement, because on the last planned day of measurement (Friday June 2) at Willemsplein there were preparations for a festival. This made it impossible to cross that part, wherefore no cyclists and mopeds would cross the pedestrian area between the restaurant and its outdoor seating area. As already enough data was collected, no other measurement moment was planned.

The variables that are part of the dataset are already mentioned in the previous section. On Thursday the first of June already preparations of the festival were ongoing, so a dummy variable indicating this was added. The variable indicating the amount of people at the pedestrian area was not measured on the first day, wherefore that data is missing for 279 observations. From day two onwards this variable was also measured.

Table 1 Descriptive statistics of the three dummy variables measured for each observed individual

Variable	Description	Observations	Mean	Standard deviation
Cycle	Dummy variable indicating if observed individual travelled by bicycle (1) or by moped (0)	1.054	0.969	0.174
South	Dummy variable indicating if observed individual travelled from the south (1) or from the north (0)	1.054	0.558	0.497
Few	Dummy variable indicating if observed individual passed while less than 4 people (1) or at least 4 people (0) were at the pedestrian area	775	0.697	0.460

Table 1 shows the descriptive statistics of the three dummy variables *cycle*, *south* and *few* that were measured for each observation separately. It shows that almost all of the observed individuals traveled by bike, a bit more than half of them came from the south and almost seventy percent passed while there were less than four people at the pedestrian area.

Table 2 Distribution of observed individuals for the main dependent variable 'behavior'

Category	Description	Frequency	Percentage
No change	Not dismounted and the pace of the observed individual was faster than walking pace	675	64.04
Walking pace	Not dismounted, but the observed individual slowed down to walking pace	116	11.01
Dismount	The observed dismounted for passing the pedestrian area	263	24.95

The tables 2 and 3 both show the distribution of the two main (categorical) variables. The variable *behavior* is the main dependent variable and its distribution is shown in table 2. Overall, for almost 65% of the observed individuals there was not observed safe behavior, which is either slowing down to walking pace or dismounting. Approximately, this is in line with the baseline measurement.

Table 3 Distribution of observed individuals for the main independent variable 'nudge'

Category	Description	Frequency	Percentage
Control	No poster placed	363	34.44
Warning	On both sides of the pedestrian area the poster with the warning nudge was placed	382	36.24
Social norms	On both sides of the pedestrian area the poster with the social norms nudge was placed	309	29.32

The variable *nudge* is the main independent variable and the distribution of this variable, indicating the group of the observed individuals, is shown in table 3. The frequency shows that each group is large enough according to the power test to capture a change of at least ten percentage points. The distribution of observed individuals over the different groups is quite equal.

For the other relevant (categorical) variables, *weather*, *block*, *date*, *day*, *time* and *customers* tables 1 to 6 in Appendix A show the distribution of these variables. About fifty percent of the time it was sunny and about fifty percent of the time it was sunny and cloudy. In the first and third block there were about 200 observations each and in the second and fourth block there were about 300 observations each. There are no measurements of periods where the outdoor seating area was (almost) filled. The most observations were done while the outdoor seating area was less than half filled and the least observations while the outdoor seating area was more than half filled.

4.2 Methodology

The analysis for the two hypotheses will be done in multiple steps. First the distributional differences in the different kinds of behavior will be tested. After that the exact effect of the posters will be measured through regressions. This second type of testing will be done for the dependent (categorical) variable *behavior*, with the three different behavior types as mentioned in table 2, but this test will also be done for the dependent (dummy) variable *safer_behavior* for which the behaviors 'walking pace' and 'dismount' from table 2 are taken together and given value one, while the behavior 'no change' is given value zero. This way it is possible to show if there is an effect if the safer behavior categories (dismount and walking pace) separately are statistically insignificant. The effect measured by regressions will be done for models with and without control variables. All these steps together will be taken for both hypotheses separately, so for testing the first hypothesis the data of the observed individuals nudged by a social norm will be left out and for testing the second hypothesis the data of the observed individuals nudged by a warning will be left out.

As the categories of the dependent variable are not ordered naturally it is data at an nominal or categorical scale. Therefore it is possible to use the nonparametric Fisher exact test, which can test if there is a significant difference in the distribution between two samples. The null hypothesis is that the outcome is distributed equally over the different categories and the alternative hypothesis is that the distribution differs for the two samples. This test will show for both hypotheses if there is a significant difference between the control and the nudged group, but it does not yet show the direction of the difference, for which it cannot fully test the hypotheses of this research.

To find the direction of the effect and also the exact effect of the poster nudges on behavior, regressions will be used. For the *safer_behavior* dummy variable the logit model, a non-linear binary model, will be used. The logit model is defined such that it is not possible to get predictions lower than zero or higher than one and can therefore predict the probability of an event occurring. The logistic function is $\sigma(z) = \frac{e^z}{1+e^z}$, where z is the linear combination of the coefficients with the independent variables (for example $\beta_0 + \beta_1 x_1$ in case of one independent variable). The more negative z gets, the more $\sigma(z)$ approaches zero. The more positive z gets, the more $\sigma(z)$ approaches one. This effect is exponential to both sides, wherefore the logistic function produces an S-shaped graph (Garcia-Gomez, 2022). So, in the

specific case of this research, the logistic model is $\sigma(z) = \frac{e^{(\beta_0+\beta_1*nudge \ \sum_{i=2}^{n}\beta_i*c_i)}}{1+e^{(\beta_0+\beta_1*nudge \ \sum_{i=2}^{n}\beta_i*c_i)}}$. In this, n is the total amount of control variables in the complete model and c includes these control variables. The outcomes of the regression of the logit model will be analyzed using marginal effects, which will show the exact effects of the variables.

To find the direction and exact effect for the *behavior* categorical variable, a multinomial logit (MNL) model will be used. As this categorical variable, as mentioned earlier, is nominal, the variable is unordered and therefore the MNL model is the best fit. With three categories, the regression output will be one base outcome that is the reference point and for the other two categories separate coefficients. So, for each variable there will be two coefficients and for each category of the dependent variable there will be a separate function. The basic MNL function is almost the same as the logistic function: $\pi(x) = \frac{e^x}{1+e^y+e^z}$. This is a function for three categories. x here is the linear combination of the coefficients with the independent variables within the category the function is for, which is equal to zero for the base outcome. The y is the regression for the second category and z is the regression for the third category. So, in the MNL function for the second category x and y are equal and in the MNL function for the third category x and z are equal (Bago d'Uva, 2022). In the specific case of this research, the MNL model for example for the second category is $\pi(x) = \frac{e^{\beta_{0,2}+\beta_{1,2}*nud \quad \sum_{i=2}^{n}\beta_{i,2}*c_{i,2}}}{1+e^{\beta_{0,2}+\beta_{1,2}*nudg \quad \sum_{i=2}^{n}\beta_{i,2}*c_{i,2}}+e^{\beta_{0,3}+\beta_{1,3}*nudge+\sum_{i=2}^{n}\beta_{i,3}*c_{i,3}}}$. Here, n again is the total amount of control variables and c includes these control variables. Also here, to get the exact effect of the variables the outcomes of the regressions will be analyzed using marginal effects.

The control variables in the model are the variables *customers*, *weather*, *day*, *cycle*, *south* and *few*. As models in which at least two of the variables *block*, *date*, *day* and *time* are used omit at least one of these variables because of collinearity, these variables cannot be used in the models combined. The variables *date* and *day* are highly correlated (0.7807) and as it is more reasonable that behavior is affected by a certain day and not by a certain date, the variable *date* is left out of the model. As some categories in the variables *block* and *time* are also omitted because of collinearity caused by the variable *customers*, these two variables will also not be added to the complete model. Also the variable *festival* is not part of the models as this dummy variable is one during the whole Thursday and zero in all the other cases, for which it also causes collinearity.

5. Results

In this section the data will be analyzed. This section is separated into three parts, one part for each hypothesis and a last part in which control variables will be analyzed and the inter-rated reliability will be measured. The analysis of the hypotheses will be done in two parts as described in the methodological part.

5.1 Hypothesis 1

The first hypothesis to test was the following: *Using a warning nudge on a poster has a positive effect on cyclists and moped users dismounting or slowing down to walking pace in a pedestrian area.* First it will be proved that there is an effect of the posters on the distribution over the different behavioral categories, after which it will be shown that the effect is indeed positive.

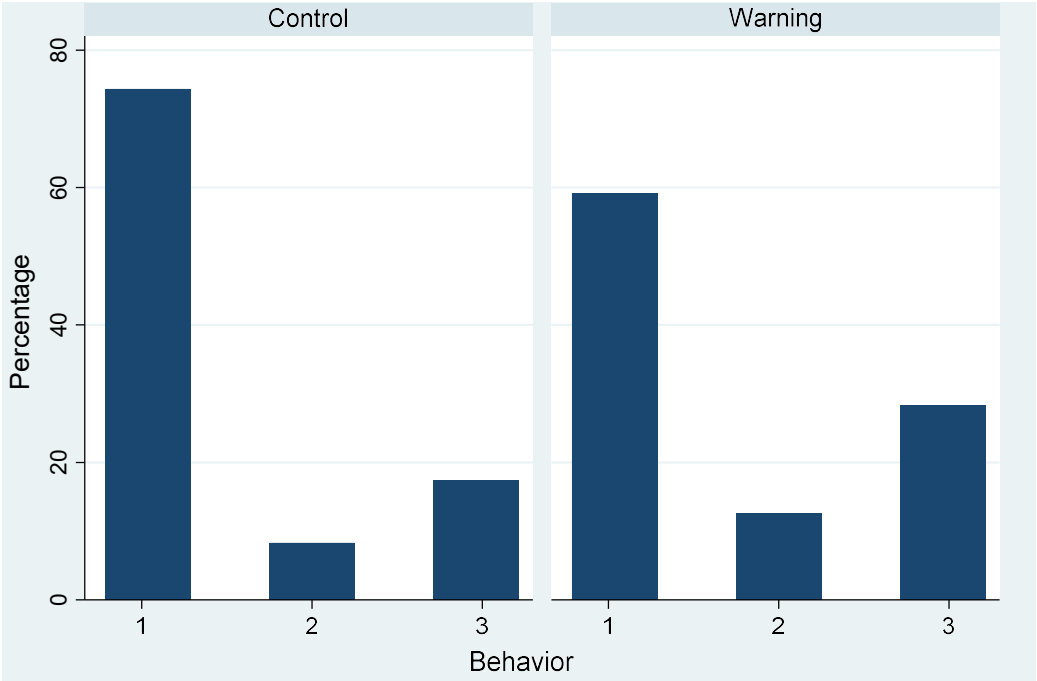

Figure 4 Distribution of behavior within the control group and the warning nudge group. 1 is no change, 2 is walking pace and 3 is dismounting.

Figure 4 gives visual insight in the effects the warning poster had on behavior. In the warning group the amount of people that passed the restaurant without changing pace is about fifteen percentage point lower than in the control group. In the nudged group this resulted in a higher part of the observed individuals that passed at walking pace or dismounted compared to the control group.

Table 4 Distribution of behavior within the control group and the warning nudge group

Group	No change	Walking pace	Dismount	Total
Control	270 (75%)	30 (8%)	63 (17%)	363
Warning	226 (59%)	48 (13%)	108 (28%)	382
Total	496	78	171	745

Table 4 gives the exact numbers and percentages of the visualized distribution in figure 4. The 3x2 Fisher exact test gives a p-value of 0.000, which tells that the distribution of the two groups differs significantly at the 1% significance level and thus the null hypothesis that there is no difference in distribution is rejected. Therefore, the warning nudge has a statistical significant effect on cyclists and moped users dismounting or slowing down to walking pace when passing the restaurant.

Table 5 Regressions of the effect of the warning nudge on behavior

	Model 1	Model 2	Model 3	Model 4
Warning	0.695***	0.557**		
	(0.159)	(0.220)		
	*0.152****	*0.119***		
Warning –			-	-
no change			-	-
			*-0.152****	*-0.121****
Warning –			0.648***	1.115***
walking pace			(0.250)	(0.381)
			*0.043**	*0.079****
Warning –			0.717***	0.384
dismount			(0.182)	(0.238)
			*0.109****	*0.042*
Log likelihood	-464.895	-335.499	-619.663	-442.290
Pseudo R2	0.0206	0.0801	0.0156	0.0853
N	745	551	745	551

*The standard deviation is given in brackets and the marginal effects in italics. Significance levels: ***p<=0.01, **p<=0.05, *p<=0.10. In the logit models 1 and 2 the dummy variable* safer_behavior *is the dependent variable. In the multinomial logit models 3 and 4 the categorical variable* behavior *is the dependent variable. In the models 2 and 4 control variables are added. Complete models can be found in Appendix B, tables 1 to 4.*

In table 5 the regression output of the main independent variable is shown for the *safer_behavior* dependent variable (model 1 and 2) as well as the *behavior* dependent variable (model 3 and 4). The first and third model are without control variables, in the second and fourth model control variables are included. As mentioned in the data section, the models with control variables miss observations because on the first measurement day the amount of people at the pedestrian area was not counted yet. The tables 1 to 4 in Appendix B give the complete regressions for these four models.

The logit Model 1 shows that compared to the control group being nudged by a warning increases the probability of behaving safe. This effect is significant at the 1% level. The exact effect according to this model is on average a 15.2 percentage point increase of safe behavior, which is also significant at the 1% level.

After adding control variables in Model 2 it occurs that this effect is overestimated, but it can still be concluded that the warning nudge causes an increase of safe behavior. Model 2 shows that on average there is an 11.9 percentage point increase of safe behavior when people are nudged by a warning poster compared to not being nudged, keeping everything else fixed. This is significant at the 5% level.

The multinomial logit Model 3 shows specifically the different effects of the poster on dismounting and slowing down to walking pace. This model shows that, compared to being in the control group, being nudged by the warning poster increases the probability of slowing down to walking pace relative to the base outcome of not changing, which is significant at the 1% level. This is also the case for probability of dismounting. For absolute effects, compared to being in the control group, being nudged by the warning poster on average decreases the probability of not changing pace by 15.2 percentage points (significant at the 1% level), the probability of slowing down to walking pace increases on average by 4.3 percentage points (significant at the 10% level) and the probability of dismounting increases on average by 10.9 percentage points (significant at the 1% level).

After adding control variables in Model 4, the exact numbers change as it occurs that the effect for the categories of not changing and dismounting is overestimated, while the exact effect for slowing down to walking pace is underestimated. Keeping everything else fixed, compared to being in the control group, being nudged by the warning poster on average decreases the probability of not changing pace by 12.1 percentage points (significant at the 1% level), increases the probability of slowing down to walking pace on average by 7.9

percentage points (significant at the 1% level) and increases the probability of dismounting on average by 4.2 percentage points (insignificant).

Overall it should be concluded that the first hypothesis, claiming that using a warning nudge on a poster has a positive effect on cyclists and moped users dismounting or slowing down to walking pace in a pedestrian area could not be rejected, as the statistics above taken together show that the warning nudge has a significant positive effect on safe behavior and especially on slowing down to walking pace.

5.2 Hypothesis 2

The second hypothesis is focused on the social norms nudge and formulated as follows: *Using a social norms nudge on a poster has a positive effect on cyclists and moped users dismounting or slowing down to walking pace in a pedestrian area.* The structure of the analysis will be the same as for the first hypothesis.

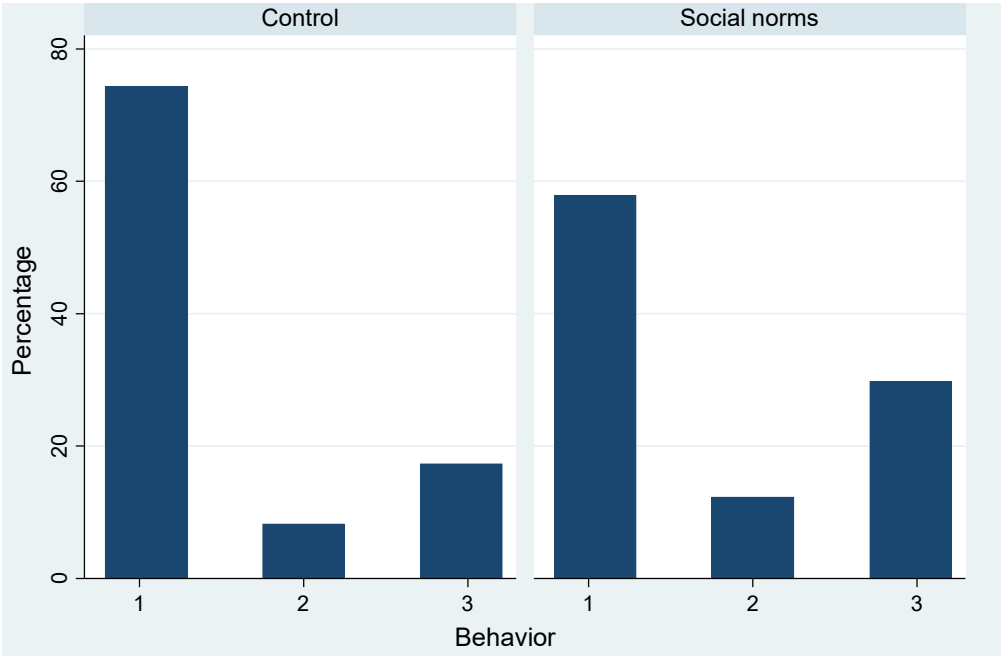

Figure 5 Distribution of behavior within the control group and the social norms nudge group. 1 is no change, 2 is walking pace and 3 is dismounting.

Figure 5 shows visually the behavior in the control group and the group that was nudged by the social norms poster. Also here the amount of observed individuals that did not change their pace is about fifteen percentage points lower in the nudged group, what results in a relative higher amount of observed individuals that either dismounted or slowed down to walking pace in the nudged group.

Table 6 Distribution of behavior within the control group and the social norms nudge group

Group	No change	Walking pace	Dismount	Total
Control	270 (75%)	30 (8%)	63 (17%)	363
Social norms	179 (58%)	38 (12%)	92 (30%)	309
Total	449	68	155	672

Table 6 specifies this picture into exact numbers. The Fisher exact test gives a p-value of 0.000, by which the null hypothesis that the distribution of the control group and the social norms nudge group does not differ is rejected at the 1% significance level. Thus from the data in table 6 it is concluded that there is a statistical significant effect of the social norms poster on the behavior of the cyclists and moped users passing the restaurant.

Table 7 Regressions of the effect of the social norms nudge on behavior

	Model 1	Model 2	Model 3	Model 4
Social norms	0.746***	0.629**		
	(0.167)	(0.262)		
	*0.165****	*0.125***		
Social norms –			-	-
no change			-	-
			*-0.165****	*-0.116***
Social norms –			0.647**	0.760*
walking pace			(0.263)	(0.461)
			*0.040**	*0.043*
Social norms –			0.790***	0.523*
dismount			(0.190)	(0.288)
			*0.124****	*0.073*
Log likelihood	-416.843	-275.112	-553.868	-359.204
Pseudo R2	0.0239	0.1197	0.0183	0.1186
N	672	476	672	476

*The standard deviation is given in brackets and the marginal effects in italics. Significance levels: ***p<=0.01, **p<=0.05, *p<=0.10. In the logit models 1 and 2 the dummy variable* safer_behavior *is the dependent variable. In the multinomial logit models 3 and 4 the categorical variable* behavior *is the dependent variable. In the models 2 and 4 control variables are added. Complete models can be found in Appendix B, tables 5 to 8.*

Table 7 has the same intent as table 5 for the warning nudge. The first two models are for the dependent variable *safer_behavior*, while the last two models are for the dependent variable *behavior*, thus separating safe behavior into walking pace and dismounting. Model 2 and 4 are with control variables, Model 1 and 3 only include the main dependent and independent variable. Also here Model 2 and 4 miss observations because the variable about the amount of people at the pedestrian area was only measured from the second day and further. Table 7 only gives the coefficients for the main independent variable. The tables 5 to 8 in Appendix B give the complete regression output.

Model 1 shows a positive effect on safe behavior of the observed individuals nudged by the social norms poster compared to the control group. This is significant at the 1% level. The exact effect is that on average there is a 16.5 percentage point increase in the probability of safe behavior if someone is nudged by social norms compared to not being nudged, which is also significant at the 1% level.

Model 2 shows this effect is overestimated, but in the correct direction. Compared to the situation of the control group, in case observed individuals were nudged by the social norms poster on average there is a 12.5 percentage point increase in the probability of safe behavior, ceteris paribus. This effect is significant at the 5% level.

That the social norms poster causes safer behavior is also confirmed by the multinomial logit models. Model 3 shows that, compared to being in the control group, being in the social norms nudge group increases the probability of passing the restaurant at walking pace relative to not changing pace. This effect is significant at the 5% level. For the probability of dismounting this is the same, but this effect is significant at the 1% level. Absolute effects are that, compared to being in the control group, being in the social norms group on average decreases the probability of no change by 16.5 percentage points (significant at the 1% level), on average it increases the probability of slowing down the walking pace by 4 percentage points (significant at the 10% level) and it increases on average the probability of dismounting by 12.4 percentage points (significant at the 1% level).

Adding control variables shows that these effects are overestimated, but again in the right direction. When everything else is fixed, compared to being in the control group, being in the social norms nudge group on average decreases the probability of no change by 11.6 percentage points (significant at the 5% level), increases the probability of slowing down to

walking pace on average by 4.3 percentage points (insignificant) and on average increases the probability of dismounting by 7.3 percentage points (insignificant).

Overviewing this comparison of the control group and the social norms nudge group, it should be concluded that the second hypothesis that using a social norms nudge on a poster has a positive effect on cyclists and moped users dismounting or slowing down to walking pace in a pedestrian area could not be rejected. The statistics above show that there is a significant difference between the distribution of behavior between the two groups and also that the social norms posters had a significant effect on safe behavior.

5.3 Extended analysis

As mentioned, in Appendix B the tables 1 to 8 give the complete regression output of the models used in the analysis above. These tables show that overall the amount of customers, the weather, the day or if someone travels by cycle or moped does not have a significant effect on behavior. On the other hand, the amount of people at the pedestrian area and if an observed individual came from the south or from the north affected the behavior. Table 2 in Appendix B shows that for the observed individuals of the control and warning nudge group, keeping everything else constant, compared to someone who traveled from the north, for someone who traveled from the south there is a higher probability of safe behavior (significant at the 10% level) and that for an observed individual that passed the restaurant with few people at the pedestrian area, compared to someone who passed with many people at the pedestrian area, the probability of safe behavior decreases (significant at the 5% level). Table 4 in Appendix B shows that this effect holds for slowing down to walking pace relative to not changing, but not for dismounting. The tables 6 and 8 in Appendix B show the same for the observed individuals from the control and social norms nudge group, with the difference that in this case the effect also holds for dismounting relative to not changing and that the effects have a higher significance.

As the category of slowing down to walking pace is subjective, a second person also counted cycles and mopeds during block four at Wednesday May 31. This way it is possible to check for the objectivity of the measurement. For the variable *behavior* the inter-rater reliability was tested and the outcome was an agreement of 64.78%. According to the ranking Landis and Koch (1977) gave to this score, this is a substantial outcome. The p-value of the test is 0.0000, wherefore the null hypothesis that the counting is done randomly should be

rejected. Also for the variable indicating the amount of people at the pedestrian area the inter-rater reliability was calculated, as it could be seen as subjective who to count as being at the pedestrian area and who not. For this variable there was an agreement of 77.36%, which again is seen as substantial by Landis and Koch (1977). With a p-value of 0.0000 also here the null hypothesis was rejected.

6. Discussion

In this section the research will be finalized by giving a summary of the previous sections. After that the (outcomes of the) research will be discussed in three steps. First the outcomes will be linked to existing literature, after that a discussion of the limitations of this research follows and this section closes of by giving suggestions for follow-up research.

6.1 Summary

The goal of this research was to find an answer on the question *what is the effect of warning and social norms poster nudges on cyclists and moped users dismounting or slowing down to walking pace in a pedestrian area?* Previous literature suggested that poster nudges are a useful tool to stimulate behavioral change. As there is a wide range of literature showing the effectiveness of warning and social norms nudges in changing behavior into the direction the choice architect wants, two hypotheses were formed stating that a warning poster nudge as well as a social norms poster nudge would have a positive effect on cyclists and moped users dismounting or slowing down to walking pace in a pedestrian area.

To test these hypotheses data was collected in a field experiment where behavior of cyclists and moped users was observed. By using poster nudges cyclists and moped users that crossed the pedestrian area between a restaurant and its outdoor seating area on their travel route were stimulated to dismount. Their behavior was counted either as dismounting or as slowing down to walking pace or as no change. The first two behavioral types were seen as safe behavior and an increase in these two behavioral types caused by the poster nudges therefore would be a positive result. Logistic regressions were used to find the exact effect of the poster on safe and non-safe behavior. Multinomial logistic regressions were used to test if there were significant effects on dismounting and slowing down separately.

For the individuals that were in the warning nudge group the probability of behaving safe increased by 11.9 percentage points compared to the control group. Separated into dismounting and walking pace, for individuals nudged by the warning poster compared to the control group, the probability of slowing down increased by 7.9 percentage points and the probability of dismounting increased by 4.2 percentage points. The effect specifically for dismounting was insignificant.

For individuals in the social norms nudge group comparable results were found. Compared to the control group the probability of safe behavior increased by 12.5 percentage points. Specified to dismounting and walking pace, compared to the control group, for individuals nudged by the social norms poster the probability of slowing down increased by 4.3 percentage points and the probability of dismounting increased by 7.3 percentage points. These separated effects were statistically insignificant.

6.2 Link to literature

The results show that there is a significant effect of the poster nudges on safer behavior. This effect is in line with the literature cited in the literature review. Domarchi, Tudela and González (2008) concluded that it is difficult to change habits, while Schneider (2013) stated that habits could change when conditions differ. Both paper show a part of the truth this research has shown. A part of the people changed their behavior because of the small environmental change of the poster, but still a large amount of the people passing the restaurant did not.

Previous research has shown the importance of salience when using poster nudges. Posters have to be noted by the target group to have impact (Van der Meiden, Kok and Van der Velde, 2019). Posters that were placed at salient places like in the research of Caris et al. (2018) and Prasetyo, Sofyan, Muchtar and Dewi (2022) had significant effect on behavior. In this research the posters were made in large format with bright colors and they were placed on the pedestrian area so there was a high chance that people did not miss them. That the posters have been effective is in line with previous research.

In line with literature already mentioned before, warning nudges are effective, though the effect in this research is smaller than the median effect of 20% Hummel and Maedche (2019) found in eighteen studies. For social norms nudges the case is the same, also here the literature shows that it is an effective nudge, but the effect of this research is smaller than the average effect of 29% Hummel and Maedche (2019) found in twelve studies.

6.3 Limitations

This research has several limitations that could either have impacted the results or are related to the relevance of the research. Five limitations of this research will be discussed here.

The first two limitations relate to the design of the poster. One limitation is the language used on the posters. The text on the posters is Dutch. As Rotterdam is an international city and the environment of the restaurant is an attraction for tourists it might be that the effect is smaller because people did not understand the text. Partly this problem is taken away by the images on the posters. This problem could be solved by adding an English translation of the text, but then another problem could be that there is too much text on the poster, wherefore it would take people too much time to oversee the poster and thus it would probably give a smaller effect. Another solution could be to use only images to nudge, in that case there will not be a language problem.

A second limitation is related to colorblindness. For people who are colorblind the posters will be less striking as they do not see the bright colors. In the Netherlands 8% of the men and 0,5% of the women have a form of colorblindness (Oogfonds, 2023), so on average about 5% of the individuals in the dataset has a form of colorblindness. This could therefore have impacted the results. On the other hand, the expectation is that this impact is low as the posters were placed at the pedestrian area and therefore salient enough. Besides, the message of the text and the pictures should be clear enough.

A third limitation of this research is that cyclists and moped users who are at a high speed would have been less able to see the poster. In case the speed was too high they would not have seen the poster and therefore they would not be influenced by it. Even if they would have noticed the poster, for cyclists and moped users at high speed it would be more difficult to read the text. Like for the first limitation, this problem could be partly solved by using images as quickly seeing an image could already make the cyclist or moped user understand the message.

The last two limitations are related to the external validity of the research. First it is not possible to say anything about the effect of the poster nudges outside of the good weather season. During the data collection there was good weather all the time. Of course the period of measurement was the most relevant to the restaurant as good weather increases the attractiveness of the outside seating area of the restaurant. But based on this research it is not possible to make general comments about all sorts of weather circumstances. To relativize this a bit it is important to see that in colder and more rainy periods much less people walk at the street and also less people travel by bike or moped. Good weather increases the amount

of people outside and traveling by foot, bike or moped and therefore it is more important that the posters are effective in good weather periods.

A last limitation to discuss is that of generalizability in general. The experimental setting is very specific and the situation of a restaurant and an outside seating area with in between a pedestrian area that is heavily used by cyclists and moped users is quite unique. As the situation of this experiment is so unique, the relevance of this research is not in the fact that the results and methodology could be used one-to-one in comparable situations. Especially also because the posters are designed specifically for the situation of the restaurant. But what this research has shown is that poster nudging has an effect on the behavior of cyclists and moped users and therefore it is suggested that poster nudges, especially warnings and social norms, are a useful tool to change behavior at places where there is a conflict between cyclists/moped users and other traffic participants.

6.4 Future research

As the field of nudging and transport is still young and there still are a lot of open questions, it is relevant to fill the gaps. As already mentioned in the introduction the amount of traffic accidents increases (NOS, 2023a) as does the amount of cyclists with serious injuries caused in traffic accidents (NOS, 2022). Filling in the research gaps of how to turn this around and increase safe behavior is important. This research has shown the effectiveness of poster nudging on safe behavior of cyclists and moped users. A suggestion for future research based on the limitations is to test the effect of posters without text and only with images or symbols. Another suggestion is to test if poster nudges (warning and social norms) also work in other situations where cyclists/moped users could behave unsafe, like in case of ignoring traffic lights, cycling at the wrong side of the road (which is for example the case at the Erasmusbrug in Rotterdam) or traveling without working lights during the evening and night.

7. Conclusion

The goal of this research was to find out if posters with warning and social norms nudges increase safe behavior of cyclists and moped users in a pedestrian area in the form of dismounting or slowing down to walking pace. A field experiment was carried out to collect data. During five different days the behavior of 1.054 cyclists and moped users crossing the pedestrian area between a restaurant and its outside seating area was observed. These individuals were either part of one of the two treatment groups, and thus nudged by one of the two posters, or they were in the control group. The warning poster nudge as well as the social norms poster nudge were effective tools to increase safe behavior of cyclists and moped users. Individuals from the warning poster nudge group had an 11.9 percentage point higher probability of behaving safely and individuals from the social norms nudge group had a 12.5 percentage point higher probability of safe behavior, both compared to the control group. Specifically for slowing down to walking pace individuals from the warning poster nudge group had a 7.9 percentage point higher probability compared to the control group. For the social norms group this effect was not significant and also specifically for dismounting there was not found a statistically significant effect of the poster nudges. Besides the poster there also was a causal effect of the amount of people at the pedestrian area and the direction of the cyclists or moped users.

What these findings mean is that salient posters with warning and social norms nudges are an effective tool to increase safe behavior, thus dismounting or slowing down to walking pace, of cyclists and moped users in pedestrian areas. More generalized this research shows that warning and social norms poster nudges are an effective tool in case of conflict between cyclists/moped users and other traffic participants. Therefore, based on this research it is suggested that poster nudges should be used to increase the safe behavior of cyclists and moped users and therefore decrease traffic accidents and unsafe situations. This could be in pedestrian areas where cyclists and moped users should dismount or, after research has shown effects, in other situations of conflict, like for ignoring traffic lights. Even though the posters only improved the behavior of a part of the cyclists and moped users, as posters are cheap and easily to implement it is highly recommended to bring this in practice. Changing behavior and habits is a difficult challenge, but as making small changes in the environment is easy and helpful, nudging is what should be done to increase traffic safety.

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Appendix A

Table 1 Distribution of observed individuals for the variable 'weather'

Weather	Frequency	Percentage
Cloudy	12	1.14
Sunny	515	48.86
Sunny & cloudy	527	50.00

Table 2 Distribution of observed individuals for the variable 'block'

Block	Frequency	Percentage
1	211	20.02
2	301	28.56
3	192	18.22
4	350	33.21

Table 3 Distribution of observed individuals for the variable 'date'

Date	Frequency	Percentage
23 May	279	26.47
24 May	150	14.23
30 May	196	18.60
31 May	263	24.95
1 June	166	15.75

Table 4 Distribution of observed individuals for the variable 'day'

Day	Frequency	Percentage
Tuesday	475	45.07
Wednesday	413	39.18
Thursday	166	15.75

Table 5 Distribution of observed individuals for the variable 'time'

Time	Frequency	Percentage
10:00-10:35	96	9.11
10:40-11:15	61	5.79
11:20-11:55	54	5.12
12:00-12:35	94	8.92
12:40-13:15	139	13.19
13:20-13:55	68	6.45
14:00-14:35	58	5.50
14:40-15:15	58	5.50
15:20-15:55	76	7.21
16:00-16:35	96	9.11
16:40-17:15	114	10.82
17:20-17:55	140	13.28

Table 6 Distribution of observed individuals for the variable 'customers'

Customers	Frequency	Percentage
Empty	191	18.12
Almost empty	215	20.40
Less than half filled	303	28.75
Half filled	184	17.46
More than half filled	161	15.28

Appendix B

Table 1 Regression of the warning nudge on safe behavior, Model 1 table 5

Variable	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Warning	0.695	0.159	4.37	0.000	0.383	1.007
Constant	-1.066	0.120	-8.86	0.000	-1.30	-0.830

Table 2 Regression of the warning nudge on safe behavior, Model 2 table 5

Variable	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Warning	0.557	0.220	2.54	0.011	0.127	0.987
Customers						
Empty	0.488	0.912	0.53	0.593	-1.300	2.276
Less than half filled	1.381	0.996	1.39	0.165	-0.571	3.333
Half filled	1.577	0.794	1.99	0.047	0.021	3.133
More than half filled	0.942	0.819	1.15	0.250	-0.664	2.548
Weather						
Sunny	1.207	1.127	1.07	0.284	-1.001	3.416
Sunny & cloudy	1.060	1.142	0.93	0.353	-1.179	3.299
Day						
Tuesday	0.315	0.308	1.02	0.307	-0.290	0.919
Wednesday	0.161	0.653	0.25	0.805	-1.119	1.442
Cycle	0.265	0.662	0.40	0.689	-1.033	1.562
South	0.372	0.194	1.92	0.055	-0.008	0.751
Few	-0.469	0.210	-2.23	0.026	-0.880	-0.0572
Constant	-3.437	1.493	-2.30	0.021	-6.364	-0.509

Table 3 Regression of the warning nudge on behavior, Model 3 table 5

Variable	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
1	(base outcome)					
2						
Warning	0.648	0.250	2.60	0.009	0.159	1.137
Constant	-2.197	0.192	-11.42	0.000	-2.574	-1.820
3						
Warning	0.717	0.182	3.93	0.000	0.359	1.074
Constant	-1.455	0.140	-10.40	0.000	-1.730	-1.181

Table 4 Regression of the warning nudge on behavior, Model 4 table 5

Variable	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
1	(base outcome)					
2						
Warning	1.115	0.382	2.92	0.003	0.367	1.862
Customers						
Empty	-0.433	1.336	-0.32	0.746	-3.052	2.185
Less than half filled	-0.356	1.478	-0.24	0.810	-3.254	2.541
Half filled	0.544	1.116	0.49	0.626	-1.644	2.731
More than half filled	0.019	1.178	0.02	0.987	-2.289	2.327
Weather						
Sunny	13.084	730.246	0.02	0.986	-1418.173	1444.340
Sunny & cloudy	13.025	730.246	0.02	0.986	-1418.232	1444.281
Day						
Tuesday	1.320	0.573	2.30	0.021	0.197	2.442
Wednesday	0.384	1.080	0.36	0.722	-1.734	2.501
Cycle	-0.864	0.763	-1.13	0.257	-2.360	0.631
South	0.650	0.333	1.95	0.051	-0.002	1.302
Few	-0.928	0.343	-2.71	0.007	-1.600	-0.256
Constant	-15.043	730.247	-0.02	0.984	-1446.302	1416.216
3						
Warning	0.384	0.238	1.62	0.106	-0.082	0.850
Customers						

Empty	0.918	1.193	0.77	0.442	-1.421	3.257
Less than half filled	2.181	1.283	1.70	0.089	-0.334	4.696
Half filled	2.100	1.073	1.96	0.050	-0.003	4.202
More than half filled	1.406	1.095	1.28	0.199	-0.741	3.552
Weather						
Sunny	0.650	1.157	0.56	0.574	-1.618	2.918
Sunny & cloudy	0.538	1.173	0.46	0.646	-1.761	2.836
Day						
Tuesday	0.030	0.335	0.09	0.929	-0.627	0.687
Wednesday	0.209	0.755	0.28	0.782	-1.270	1.689
Cycle	1.338	1.090	1.23	0.220	-0.798	3.475
South	0.256	0.212	1.21	0.227	-0.159	0.672
Few	-0.327	0.229	-1.43	0.153	-0.775	0.121
Constant	-4.747	1.885	-2.52	0.012	-8.44	-1.051

Table 5 Regression of the social norms nudge on safe behavior, Model 1 table 7

Variable	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Social norms	0.746	0.167	4.48	0.000	0.420	1.072
Constant	-1.066	0.120	-8.86	0.000	-1.30	-0.830

Table 6 Regression of the social norms nudge on safe behavior, Model 2 table 7

Variable	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Social norms	0.629	0.262	2.40	0.016	0.115	1.142
Customers						
Empty	0.553	0.819	0.68	0.500	-1.052	2.158
Less than half filled	1.325	0.819	1.62	0.106	-0.280	2.931
Half filled	1.213	0.856	1.42	0.157	-0.465	2.891
More than half filled	0.740	0.840	0.88	0.378	-0.907	2.387
Weather						
Sunny & cloudy	-0.539	0.398	-1.36	0.175	-1.318	0.240
Day						
Tuesday	0.167	0.464	0.36	0.719	-0.742	1.076

Wednesday	0.342	0.509	0.67	0.502	-0.656	1.339
Cycle	0.391	0.636	0.61	0.539	-0.857	1.638
South	0.654	0.211	3.10	0.002	0.240	1.068
Few	-0.886	0.243	-3.65	0.000	-1.362	-0.410
Constant	-1.929	1.047	-1.84	0.065	-3.980	0.123

Table 7 Regression of the social norms nudge on behavior, Model 3 table 7

Variable	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
1	(base outcome)					
2						
Social norms	0.647	0.263	2.47	0.014	0.133	1.162
Constant	-2.197	0.192	-11.42	0.000	-2.574	-1.820
3						
Social norms	0.790	0.190	4.16	0.000	0.418	1.162
Constant	-1.455	0.140	-10.40	0.000	-1.730	-1.181

Table 8 Regression of the social norms nudge on behavior, Model 4 table 7

Variable	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
1	(base outcome)					
2						
Social norms	0.760	0.461	1.65	0.099	-0.144	1.665
Customers						
Empty	0.714	1.163	0.61	0.539	-1.564	2.993
Less than half filled	0.865	1.179	0.73	0.463	-1.445	3.175
Half filled	0.431	1.255	0.34	0.731	-2.028	2.889
More than half filled	-0.166	1.237	-0.13	0.893	-2.591	2.258
Weather						
Sunny & cloudy	-0.206	0.689	-0.30	0.765	-1.557	1.144
Day						
Tuesday	0.542	0.789	0.69	0.493	-1.005	2.089
Wednesday	1.047	0.893	1.17	0.241	-0.705	2.798
Cycle	-0.914	0.690	-1.32	0.186	-2.267	0.439
South	0.873	0.375	2.33	0.020	0.138	1.609
Few	-1.137	0.403	-2.82	0.005	-1.926	-0.347
Constant	-2.375	1.381	-1.72	0.085	-5.081	0.331
3						
Social norms	0.523	0.288	1.81	0.070	-0.042	1.088
Customers						
Empty	0.534	1.102	0.48	0.628	-1.625	2.693
Less than half filled	1.559	1.094	1.43	0.154	-0.585	3.703
Half filled	1.528	1.132	1.35	0.177	-0.690	3.747
More than half filled	1.173	1.115	1.05	0.293	-1.013	3.359

Weather						
Sunny & cloudy	-0.711	0.448	-1.59	0.112	-1.588	0.167
Day						
Tuesday	0.095	0.525	0.18	0.857	-0.935	1.124
Wednesday	0.090	0.566	0.16	0.873	-1.019	1.199
Cycle	1.818	1.102	1.65	0.099	-0.343	3.979
South	0.588	0.231	2.55	0.011	0.135	1.040
Few	-0.834	0.260	-3.21	0.001	-1.344	-0.325
Constant	-3.593	1.562	-2.30	0.021	-6.655	-0.531