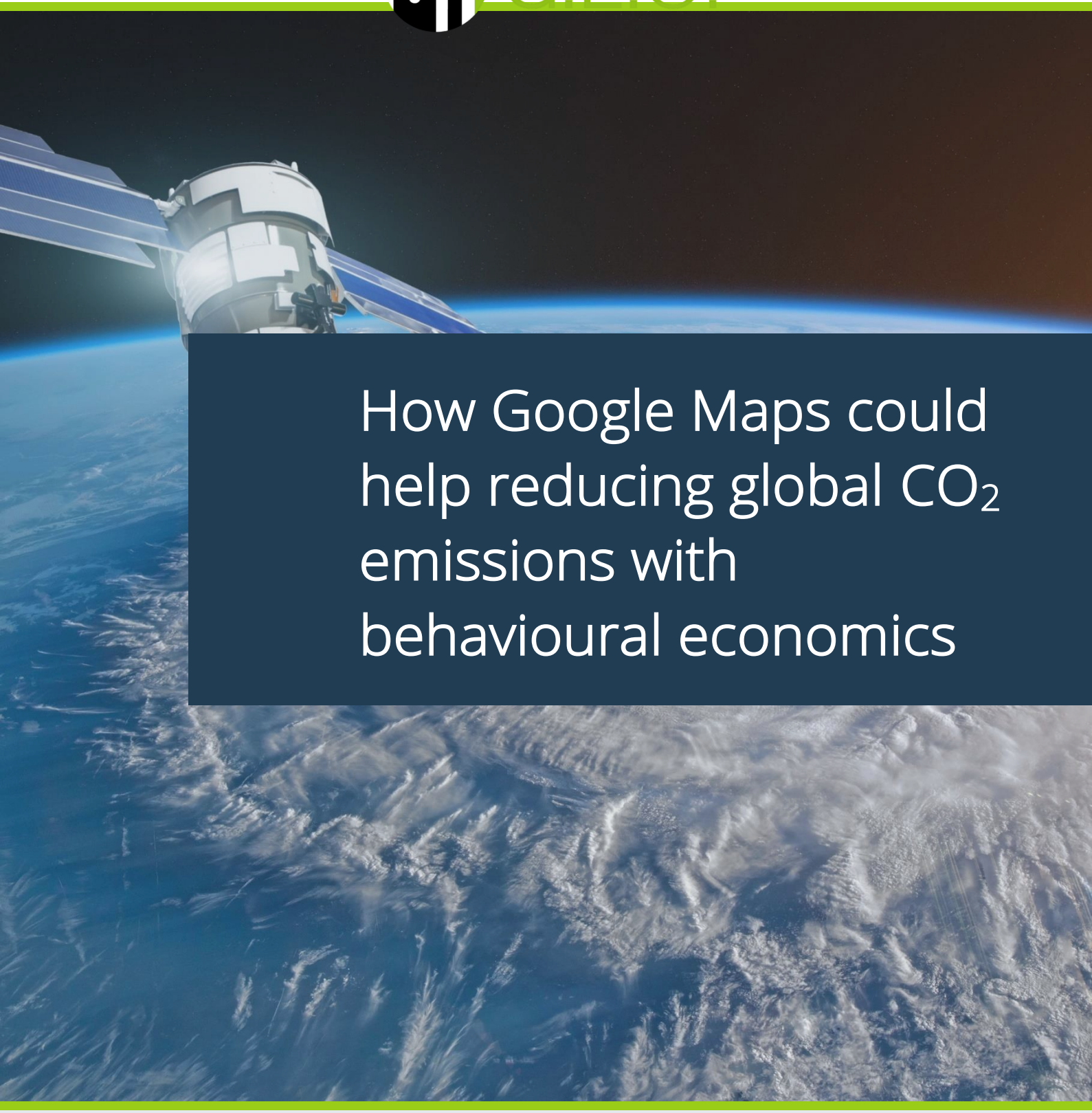
G.E.O.



How Google Maps could help reducing global CO_2 emissions with behavioural economics

REDATTO DA:
Giulio Nicoletti – Junior Researcher

Mondo Internazionale
Associazione culturale
Gallarate, Via Marco Polo 31
21013 - VA, Italia
C.F. 91071700123
P.IVA 03727710125

Mail: segreteria@mondointernazionale.com

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ABSTRACT

This paper intends to shed light on the possible effects of a nudging intervention aimed at reducing urban emissions of CO_2. The nudge works by visually incentivising low-emissions means of transport and disincentivising high-emissions ones: in a satellite navigation application, the transport options are reordered and coloured red, orange and green according to their emissions category, and emissions are made explicit. A pilot phase was run and the results are encouraging and in line with the theoretical expectations, even if more grounded statistical studies are necessary. Finally, some evaluations on the possible impact of the nudge are made.

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Context and objectives

The nudging intervention designed in this paper is based on the idea that it is of a common interest to reduce carbon dioxide emissions. It is useful to sum-up the reasons behind this claim, and the scientific understanding on the issue. There is widespread evidence that the climate warmed-up by 1.18 Celsius degree since the late 19th Century. Moreover, the level of carbon dioxide in the atmosphere skyrocketed in during the last Century due to human activity. As CO_2, together with other greenhouse gases emitted by human activity, has a heat-trapping nature, a great number of studies found climate-warming as human-caused, with a probability greater than 95%.[1] Additionally, nearly 30% of emissions are originated by the transportation sector, and specific studies have shown that traffic congestion enhances emissions by up to 75% at roadway scales.[2] Hence, in urban areas, especially large ones, carbon dioxide is particularly concentrated.

This context clearly calls for policy-interventions and regulations in various economic sectors, while nudging interventions could be useful to tackle the issues in areas in which it is not advisable, or not viable, to enact regulations, or in broader, and more efficient policy packages that include both regulations and nudging interventions. The intervention described in this paper aims at reducing urban carbon dioxide emissions by giving visual incentives for choosing low-emissions means of transport and promoting awareness on individual CO_2 emissions through an update of Google Maps. Other new applications could be designed, but in this paper we will usually refer to Google Maps as it is used by more than one billion users, and thus with a simple update that changes the way it presents options, it could have a potentially large impact on the behaviour of a great number of users.

[1] Benjamin D. Santer (1996)
[2] Conor K. Gately (2017)

Behavioural Biases

The aim of the nudge is to make people more prone to choose sustainable means of transport in urban movements, where the time-differences of the options are usually comparable and traffic congestion is a clear problem. It is therefore important to assess some behavioural biases that lead people using higher-emissions alternatives, especially in the context of navigations app such as Google Maps. First, the application may lead to a default option bias, as it presents "car" as the first option. This may lead users to simply fall into a habit formation in which they move by car in situations in which they could walk or take a bus. Some people also simply make their choice on the basis of the idea that generally moving by car is faster (especially for longer urban movements), and more comfortable, and they may not take into account the fact that using a car in urban movements is also unhealthier than walking or cycling and creates pollution (and eventually traffic congestion); habit formation may then lead people use car even when cycling or walking are actually faster options. Moreover, people may not take into account the economic costs of using car due to a lack of information, while the cost of taking public transport is clearly explicit. However, experiments showed that even when costs are clearly specified and higher for car, a "stickiness" in changing travel choices is observed, not in line with the rational choice model of the most economic option.[3] A possible explanation of the persistent choice of using car could be made through the lenses of the dual system of Kahneman,[4] that described our inner choice architecture through two systems: the reflective cognitive system is rational, analytical, "slow", while the automatic cognitive system is automatic and associative. Thus, even when people are exposed to correct information about the cost, the automatic cognitive system could overrun the reflective one with heuristic and emotional evaluations, such as car perceived as a "symbol of status of freedom"[5] along habit formation. For these reasons, it is important to clarify that regulations may be sometimes more effective than other

[3] Alessandro Innocenti (2013)
[4] Daniel Kahneman (2011)
[5] Alessandro Innocenti (2013)

"soft" choices, but at the same time, nudging interventions may represent a complementary contribution.

Nudge design

The nudge intervention was designed in order to offset some behaviour biases and help reducing CO_2 emissions. It should do so in a dual way: the colours displayed in the application may be useful to tackle some biases of the automatic cognitive system by associating "strong" colours with undesired options, while at the same time the specified emissions could be effective in raising awareness on the effects of our action to the reflective cognitive system.

The nudge would work in the following manner. First of all, the designed application automatically approximates the CO_2 emissions per means of transport. In most urban areas, there are basically four options of movements: walking, driving, cycling or using public transport. Walking and cycling are clearly non-carbon options, while car's (or motorcycle) emissions can be calculated in two way. In the simpler one (used in the pilot phase), an average of CO_2 emissions per kilometre is given, and multiplied by the distance. In a more precise manner, the user could enter in the application the used car model, and the application could find in a database the average emissions per kilometre of that specific vehicle, while taking into account other factor for the calculation, such as traffic congestion. This method would also raise awareness on how eco-friendly and fuel-efficient each car is, especially when the vehicle is electric or hybrid. Then the application automatically assigns a colour for each of the means of transport on the basis of its emissions. By a matter of simplicity, three broad categories were identified, and thresholds were designed to include electric vehicles in the "green domain" (virtually 0 emissions of CO_2 per kilometre) public transport in an intermediate category (including buses and train), and cars and motorcycle in the red category (high polluting means of transport). Further studies on atmospheric pollution could be useful to detect more precise and useful thresholds. Moreover, as fuel efficiency increase in newer cars,

thresholds could be reduced over time, hence making it possible that, for example, old polluting buses fall into the "red category".

Emissions (grams of CO_2 emitted per kilometre)	Colour	Means of transport
Virtually 0g or very low emissions	Green	Walking, bicycle, electric bus, electric car, metro, electric scooter
30g – 90g	Orange	Bus, train, hybrid car
90g+	Red	Car, motorcycle

The various alternatives are then displayed using an outline of the correspondent colour, and emissions are specified in a small print below each vehicle, with the same colour of the category. These colours were chosen specifically to discourage higher-emissions options: the green is commonly viewed as the environmental-friendly colour, while studies have found that red is usually associated with danger.[6] This is expected to raise implicit attention to each option, and to offset a default bias. The emissions are then specified, raising awareness on the impact of individual choices. Another characteristic of the nudge design aimed at offsetting the default biases is a change in the order of the presented options. The green category is displayed as the first option, and, given that not every user has or can use a bicycle, walking is prioritized. Then, the orange vehicles are displayed as the second option, while the red ones as the least ones. However, in larger cities, the length of the journey may be relevant, and substantial temporal differences between the various options may arise. This could lead people to consider the application as inefficient, as in larger cities it would present as the first choice a very temporal unfit one. Thus, some simple solutions could be introduced: the first option could for example be the greener one that is at most three times longer than the faster

[6] Karyn Pravossoudovitch (2014)

one, or the greener one provided that walking do not exceed, for example, 40 minutes. Further studies should address more precise thresholds that allow for avoiding that people stop using the application. More clever algorithms could also take into account the specific local context (such as more polluted areas, or presence of bicycle lanes) and integrate this in the ordering process.

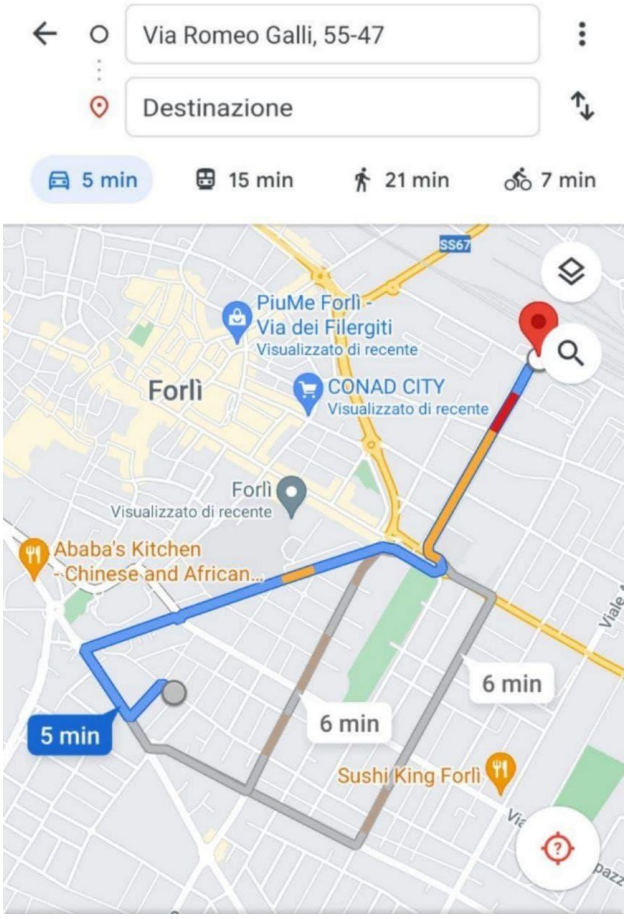
The application should then monitor GPS data and data registered when the user starts the navigation. CO_2 emissions are consequently recorded, and the application, if widespread, could even map transport pollution in the city, thus collecting statistics that may eventually be used to design regulations in specific areas, or for other purposes. In the nudge intervention, these data could also be used to evaluate how different users perform similar movements, and thus getting an average pattern of behaviour and emissions. Users with emissions averages below the mean or the median could be "awarded" in the application, and be displayed as "Eco-friendly mover" in their account. In the context of Google Maps, given that the same account is displayed also in a variety of other context (Google reviews, YouTube), assigning this title or colouring the account's name in green may lead to reputation biases in which people may want to be seen as environmentally conscious; if this helps choosing environmental options, the average CO_2 emissions would decrease, making it more challenging to obtain this award, and eventually leading to a virtuous cycle. However, if average emissions are still to high, this could be a backlash measure; in that case, the awards could be given to people with average emissions below a certain pre-determined threshold. The effects of this measure are more difficult to assess in a pilot phase, given that it could be useful only when the application is widespread, and the awards are considered as so.

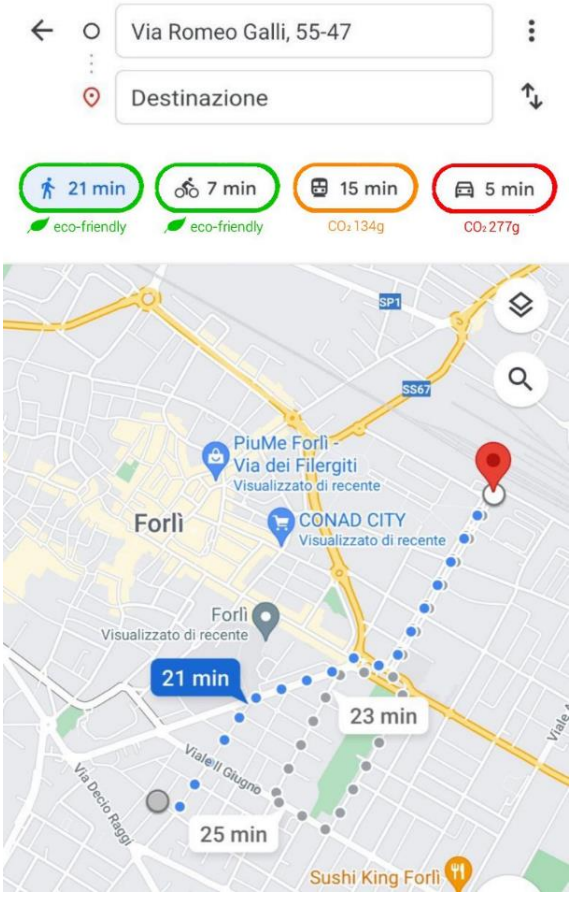
Finally, monthly reports about users' movements could be sent via email– as Google Maps already does – and enriched with information about emissions. If users chose environmental friendly options, they could be even told, on average, how much they saved in economic terms, given that public transport and driving are measurably more expensive than walking or cycling. Moreover, additional information could be sent on how to furtherly reduce emissions; e.g. partnerships with afforestation organizations

and companies that could plant trees for discounted prices in exchange for the visibility that the application provides, may also be useful in suggesting how to reduce net carbon emissions. Also, the option could also display the calories consumed with active means of transport. However, for matters of simplicity and in line with the aim of the nudging intervention, the pilot phase was specifically focused on the effect of colouring, reordering choices, and make explicit emissions.

Pilot phase

The pilot phase was conducted with two simple surveys, in which people were asked some personal information, and which means of transport they would choose to reach a "destination", showed a screenshot of a navigator app. In the two surveys, the destination and the starting point were identical, as the diverse timespans of the various options. These were chosen in a real-situation, and represent real suggestions of Google Maps. The only difference between the two was the presence of the nudge. The two screenshots used in the surveys are displayed below. The survey asked identical questions (translated from Italian): "How would you reach the destination?" "How old are you?" "Indicate your gender" "Do you have a car?" "Do you have a bicycle?" "What degree do you have/are you completing?".



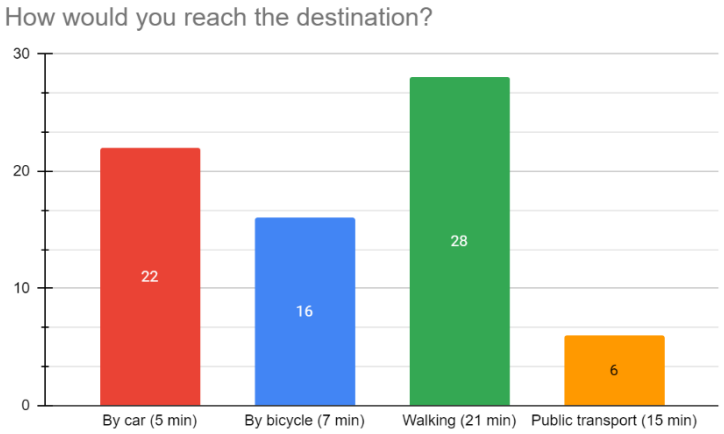


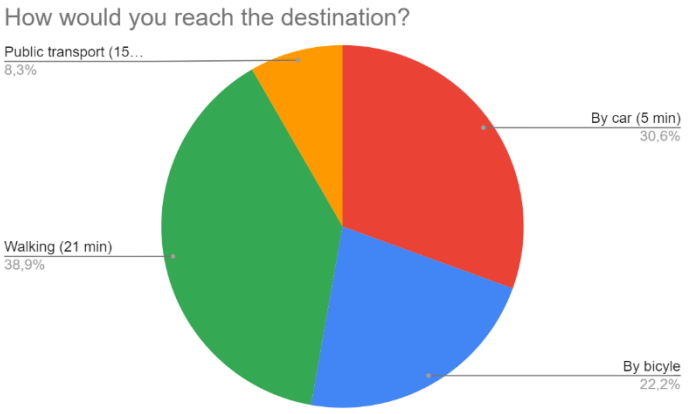
Method and issues

Before analysing the results of the survey, it is necessary to underline the methodological and critical aspects of the survey. First of all, this is a between-subject survey, as it aims at independently assess whether the nudge could be useful or not in changing behaviour towards more environmentally responsible choices. The two surveys circulated by word of mouth, and two links to Google Form surveys were sent together, along with the instruction of looking and responding only to one of them. Information on gender and age were useful for checking whether the two samples of responders maintained similar characteristics (and make general evaluations). However, this methodology leads to samples that are clearly not representative of the general population. Moreover, as the surveys reached 144 responder, with a sample size of 72 responders for the Nudge survey and 72 responders for the standards survey (the surveys were closed when they had an equal share, after 7 days of circulation), sample-size issues are possible. Clearly, methodological issues undermine the statistical value of the pilot phase, that was

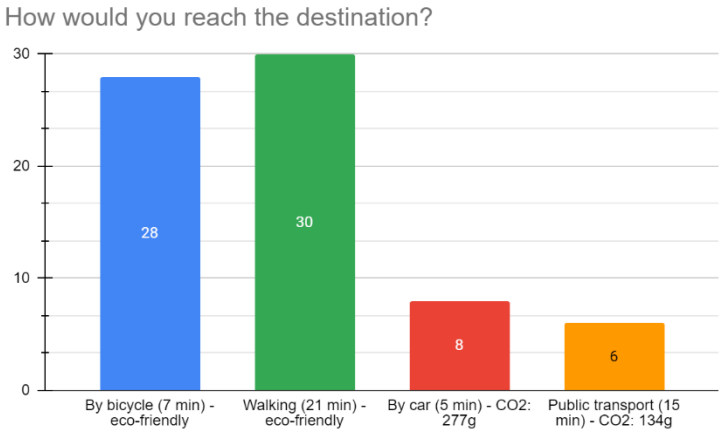
nonetheless useful to make general evaluations and assess whether there is a consistent difference in the responses, in line with the theoretical expectations.

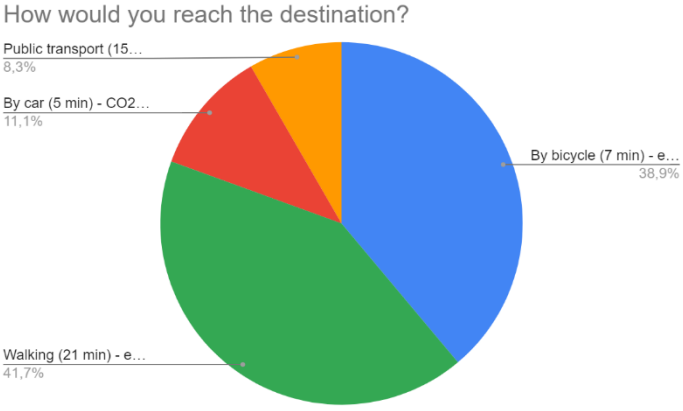
Pilot data: Standard survey





Pilot data: Nudge





By looking at aggregated responses, the only categories in which there is a significant difference are “By bycicle” and “By car”. As very similar answers were registered from the questions “Do you have a car?” and “Do you have a bycicle?” – the interval of “Yes” responses of both question in both surveys is roughly between 73% and 82% – the nudge seems to be effective in changing the behaviour of car users and push them in using bicycle instead. The shift from car to bicycle could be explained by the similar timespan that the two options present - 7 minutes by bicycle, 5 minutes by car -. Thus, car users

may want to reach the destination in a relatively short amount of time, and when faced with the nudge and made aware of the environmental matter, they choose the option that combines time-efficiency with environmental standards. This choice behaviour is also plausibly generalizable in most urban movements, in which the time-differences between car options and bicycle are generally small. More statistically-grounded studies need to be done in order to confirm (or reject) this preliminary finding, which is in line with the nudge aims and expectations; studies could also be done in larger cities to asses the impact of the nudge intervention in medium-length urban trips.

Back to the initial aim of the nudge intervention, in the pilot phase it is observable a plain reduction of per-capita emissions in the movement. In fact, in the standard sample, the total emissions amount at 6.898 kg of CO_2, hence around 95.8 g of emissions per capita; in the nudge sample, the total emissions are 3.020 kg of CO_2, around 41.9 g emissions per capita. The nudge results show a decrease of 56.3% of emissions.

This reduction is observed regardless of personal information, such as age or gender, even if it was observed that older people (especially in the category 61-70) tend to use (and possess) cars more than younger ones, for clear reasons (reduced mobility, higher income).

Finally, as the reduction in per capita emission is significant, it is plausible to assume that the nudge is effective. Further statistical studies, with more representative population samples are thus worth of being explored.

Possible impacts on health

The pilot phase showed how the nudge intervention could be effective in making people use bicycle instead of car in urban movements. The benefits of this intervention are therefore not only linked with environmental objectives, but also on healthcare ones. Several studies have assessed the possible environmental and health impacts of shifting from car to bicycle in urban areas trips. These studies are usually linked to the specific context of a city/region, thus they are generally useful to assess a potential impact, but

not completely generalisable. A study conducted by the School of Population Health of the University of Auckland,[7] in fact, found that in short trips – defined as movements of less than 7 kilometres – in New Zealand, if only 5% of car users would use bicycle instead, there would be an annual reduction of 22,065,000 litres of fuel ($37,069,000 of fuel savings), and a reduction of 50.167 tonnes of CO_2. Polluting molecules, correlated with bronchitis, acute respiratory admissions, acute admissions, and cancer, are reduced, with a positive effect on overall health. There is also clearly a positive health effect in increasing active mobility, linked with reduced risks for health. Thus if the nudging intervention could effectively lead to shifting users from car to bicycle, the effects will be visible also in terms of public health.

Concluding remarks

Even if limited by their statistical validity, the results of the pilot phase are encouraging. The nudging intervention could be therefore useful in modifying users' behaviour and measure and monitor its effects in terms of reduction of CO_2 emissions without imposing restrictions, that may be nonetheless necessary depending on the context. Monthly reports and other features discussed in the nudge design section but not tested in the pilot phase may also contribute to the effectiveness of the intervention.

[7] Graeme Lindsay (2011)

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