

HANDBOOK



DIGITAL NUDGING

FOR SUSTAINABLE MOBILITY

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Dynamic Mobility Nudge

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WHY SUSTAINABLE
MOBILITY IN CITIES
MATTERS

01

1



70% of the EU population lives in cities today, and this is projected to reach almost **84%** in **2050**.

2



23% of the EU's transport greenhouse gas emissions come from urban areas.

3



50 billion passengers were carried by buses, trams and metros in EU cities in 2018, saving 100 million car trips every day.

4



6 in **10** people aged over 15 never or seldom exercise or engage in physical activity, such as bicycling.

Source of the data:

https://ec.europa.eu/commission/presscorner/detail/en/fs_21_6781

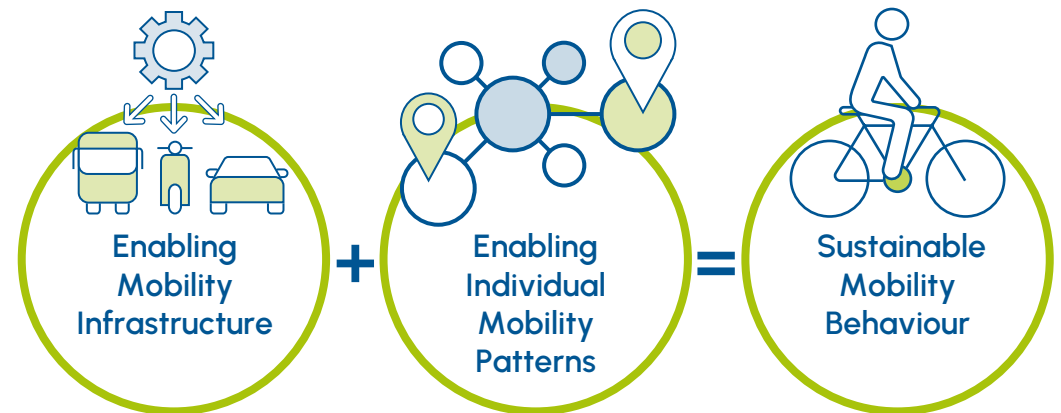
IS THIS HANDBOOK
RIGHT FOR ME?

02

What will I gain from reading this handbook?

If you are reading this handbook, you are interested in motivating people to use more sustainable mobility options, like switching over from driving their car to bicycling, walking or taking public transport. However, you might wonder why you need additional input when trying to encourage people to change their mobility patterns – after all, there are many examples already out there. Nevertheless, here we want to offer you a different perspective: rather than merely replicating examples from others that might or might not have worked, with this handbook, you will learn to think about **changing mobility behaviour in a more holistic way**. You will identify **barriers and facilitators** of individual behaviour by using a model of behaviour change, which helps you tackle the underlying problem, rather than assuming or guessing what might work. You will also realize how **digital tools** can be used to change behaviour, and that **data** can help these tools be more effective by **incorporating current situations and context**.

For these reasons, this handbook explains digitally enabled behaviour change for sustainable mobility, which means using digital tools to change behaviour in one's physical environment. You surely know about this from fitness and sports – are you wearing a smartwatch right now or do you have a smartphone app that tracks your physical activity? Then you have first-hand experience with digitally enabled behaviour change! We can transfer this idea to mobility, as we will demonstrate throughout the handbook.



Who is this handbook for?

This handbook is primarily intended to serve **local decision-makers** (e.g., city officials, urban planners) and **providers of transport infrastructure and services**, who have a stake in increasing sustainable mobility within their community. This handbook is not meant to be an exhaustive framework, but rather a resource to support shaping sustainable urban mobility and to ensure that already existing or planned mobility infrastructure will be used by the public. In turn, this handbook can also be used by **app developers** who are involved in building mobility interfaces and looking to expand their features to include digital interventions that target the motivational aspects of sustainable mobility. In addition, researchers of various disciplines focused on motivating sustainable mobility can also benefit from this handbook. We brought together **researchers from different disciplines** (e.g., psychology, geoinformatics, mobility research) in order to enrich the breadth of digital interventions within a situational context.

What is this handbook about?

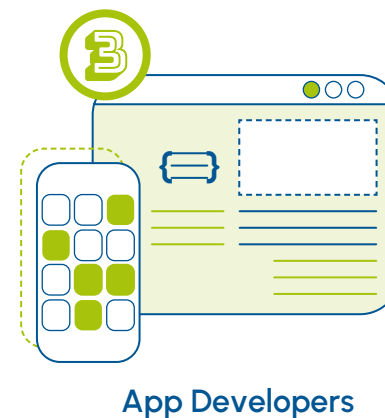
Local decision-makers (e.g., city representatives, transport planners and providers) are faced with the **challenge of promoting sustainable mobility** (walking, bicycling, and taking public transport) in order to reduce CO₂ emissions, improve air quality, reduce noise, provide attractive environments for increasing physical activity, and thus make the city a more livable place. A municipality's usual response, the use of **hard measures (by introducing new policies, infrastructure and bans)** is not always effective and cannot be implemented in every situation. Building additional infrastructure is not always an option – and even then, citizens need to be motivated enough to use it. As a result, the prospect of **additionally employing soft measures** (behavioural interventions that operate without restrictions or bans) has risen to prominence as a viable complement to policy measures and to support mobility infrastructure usage.



Local Decision-makers



Providers of Transport Infrastructure and Services



App Developers

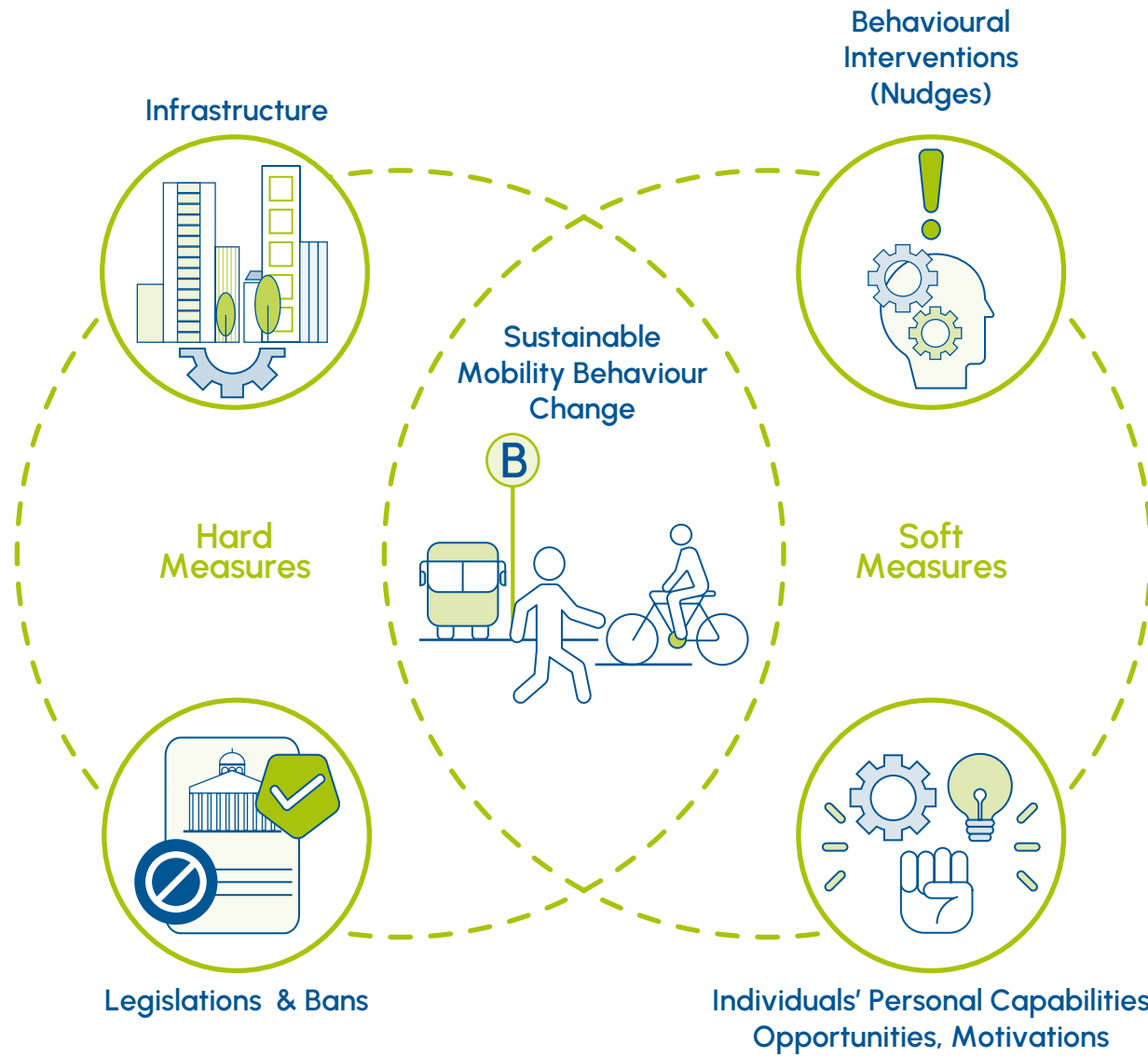


Researchers

Building **new infrastructure can surely attract new sustainable traffic**, for example, installing new bicycling lanes can lead to an uptake in bicycling traffic. However, **building infrastructure is also costly** and can take years to finish. Although improving mobility infrastructure should be an integral part of a city's long-term sustainable mobility strategy, local decision-makers should not only have a view on infrastructure alone and rather take on **a multi-faceted approach** (Wardlaw, 2014). **Actively involving, motivating and engaging citizens** to modify their mobility routines ensures successful uptake of new infrastructure and fosters the emergence of a sustainable mobility culture. A certain level of infrastructure needs to be there for people to be able to use it, however, **understanding and fostering personal capabilities** and motivations of people is also very important – and this is also our approach within this handbook.

Soft measures, which are commonly referred to as **nudges**, have been extended into the online realm and have been adapted in the form of mobile apps on smartphones. This handbook provides insights into **how these behavioural interventions** can be developed and **implemented in your city or region** to fit your specific circumstances. Its purpose is to help you design effective digital interventions that increase the use of sustainable mobility options by citizens, primarily by means of these soft measures. We showcase how these interventions can integrate **situational components** (e.g., weather or traffic conditions) that are crucial for mobility decisions – thus, increasing their effectiveness. By bridging theory and practice, we give best practice examples as to how such digital campaigns that promote sustainable mobility can be implemented. To apply the digital interventions proposed in this handbook, you do not necessarily need to develop a separate smartphone app; they can also be **integrated into existing apps** of different topics (e.g., for urban mobility, sports or city services that have their own app).





CRASH COURSE ON
BEHAVIOUR CHANGE

03

Why do people behave the way they do?

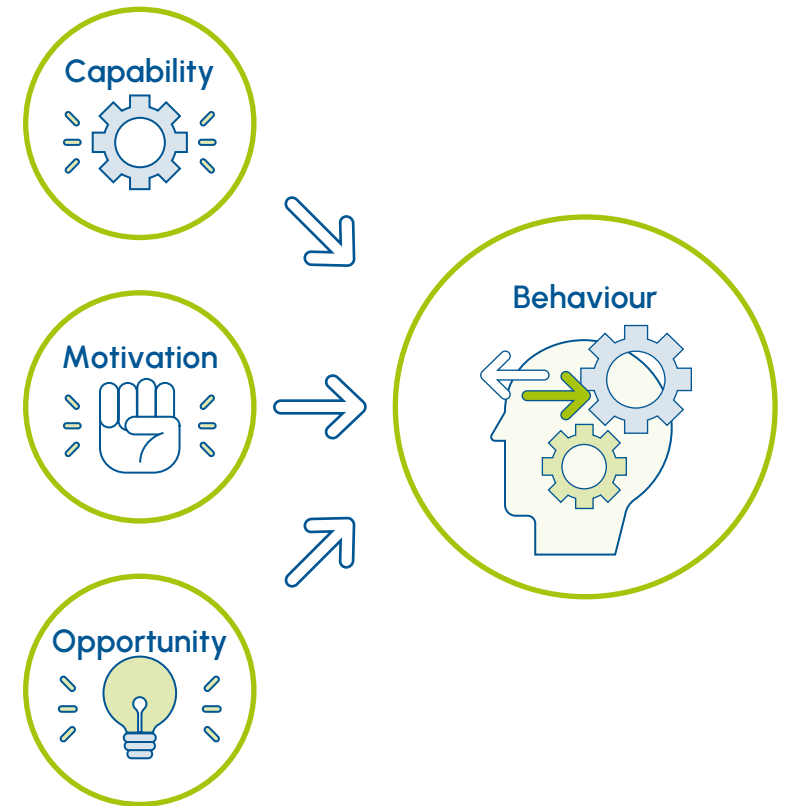
Why are people **routinely driving their cars**, even though they can easily walk, bicycle, or use public transport? Together with our **environment** and its **contextual specificities**, our behaviour is often driven by **habits and routines** – even the most irrational ones! To change a specific behaviour, we need to first understand what leads to this behaviour, ranging from cognitive reasoning to contextual information. For this, models of behaviour and behaviour change are a useful tool.

When investigating sustainable urban mobility choices, we recommend applying the **COM-B model**. Susan Michie and her team have developed this model to explain how a specific behaviour comes to be. This model is widely accepted, well-validated and has already been utilised to design countless effective interventions in the health field. We have transferred this same model into the realm of mobility, as it offers a holistic view of mobility behaviour (see Luger-Bazinger, Geser & Hornung-Prähauser, 2023).

To work with the COM-B model, one must think about whether current barriers or facilitators of someone's particular behaviour stem from their **capability, motivation, or opportunity** (see section "[Designing Behavioural Interventions](#)").



- ✿ **"C"** stands for "capability" and describes an individual's ability – both psychological and physical – to execute the said behaviour. This includes **psychological capabilities**, like their knowledge, skill, memory or attention, as well as **physical capabilities**, like their level of fitness. To some degree, this can be changed by a person (e.g., by learning how to ride a bicycle).
- ✿ **"O"** stands for "opportunity" and describes factors that lie in one's environment which facilitate a behaviour, including both an individual's **social and physical opportunities**. On the contrary, opportunity is not necessarily within the person's control; for example, whether one lives in an area with good public transport or not.
- ✿ **"M"** stands for "motivation" and describes one's **motivational processes**, habits, emotional responses or conscious decisions.
- ✿ Finally, the **"B"** in the model stands for "behaviour", with the other **elements in the model contributing to this specific behaviour**. In short, the model explains that a given behaviour will occur when a person has the capability and opportunity to engage in the behaviour and is more motivated to engage in the said behaviour versus an alternative behaviour.



Note:
Figure adapted from Michie, van Stralen & West, 2011

BEHAVIOURAL INTERVENTIONS AND NUDGING

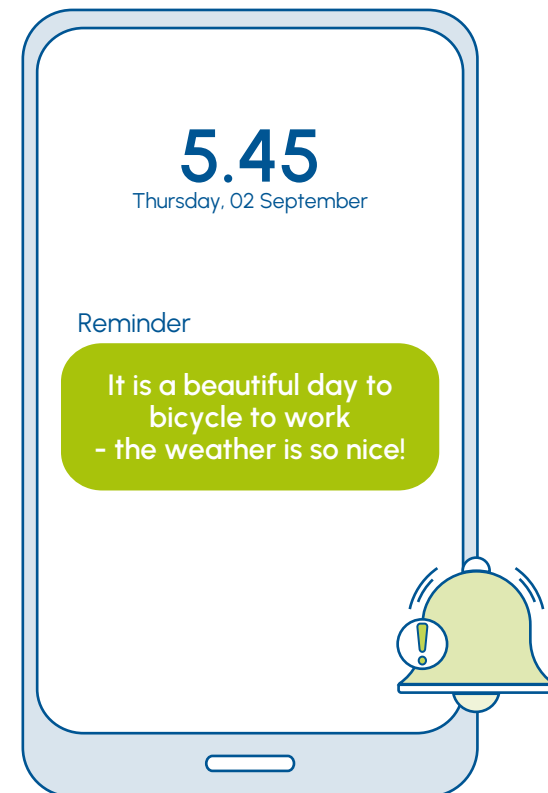


Behavioural interventions are used to guide behaviour into a certain direction. You might have heard the term **nudging**, which was coined by Cass R. Sunstein and Richard H. Thaler in 2008. Nudging does not restrict an individual's freedom to choose and does not operate with threat or severe economic consequences. Rather, nudging tries to **change the way that options for decisions are presented within the environment** in which we make these decisions (the so-called choice architecture) – usually by reframing, supplying new information or by providing social feedback. Nudging can be seen as one method of many behavioural interventions, and in this handbook, we will **often refer to behavioural interventions as nudges**, because it is one of the most well-known methods and a term that many people – especially city and government officials – are already familiar with.

In the following, we have listed examples of behavioural interventions for mobility behaviour. If you read through the previous section (“[Crash course on behaviour change](#)”) you might notice that the interventions target different aspects: some seek to raise motivation, some want to build individual capability and some want to create opportunities within the urban environment. **Behavioural interventions can be thought of as ways to remove barriers.** This is also how you can design your own behavioural interventions for sustainable mobility (see section “[Designing Behavioural Interventions](#)”).

Everyday example for nudging:

If you want to save paper in the office, change the default printing settings to print two-sided sheets instead of one-sided! People want to save paper but usually forget while printing and making the desired option the default remedies that. However, in case people want to print one-sided, there is still the option to change it back.



Examples of behavioural interventions for sustainable mobility:



Target Capability:

- Giving bicycle lessons to people who were not able to do so before
- Making bus schedules easier to understand and more accessible



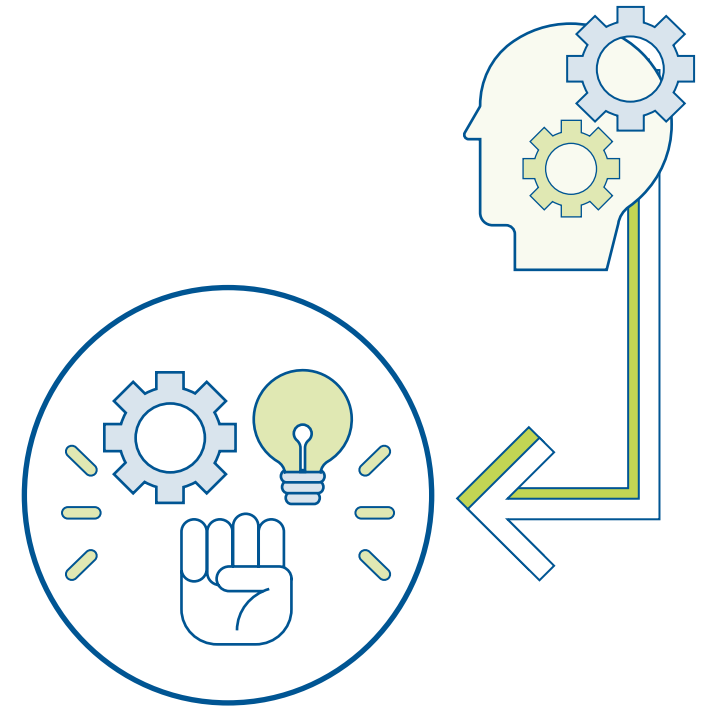
Target Opportunity:

- Giving out free tickets to public transport
- Offering attractive bicycle infrastructure, such as bicycle storage options



Target Motivation:

- Offering incentives if car is not used (e.g., giving out vouchers)
- Launching a campaign in a neighbourhood to engage families to walk or bicycle together



When awareness alone is not enough:

Purely informational campaigns that seek to raise awareness have led to mixed results, as people react differently to information depending on their values (Bolderdijk et al., 2023). While we can still use informational campaigns to raise awareness and encourage people to act on their values, there is a well-known value-action gap: even though people might value sustainable mobility and know the benefits, they still drive their cars every day. Therefore, we also need to understand their other barriers that hinder them from executing this behaviour.

DIGITALLY ENABLED
BEHAVIOUR CHANGE

05

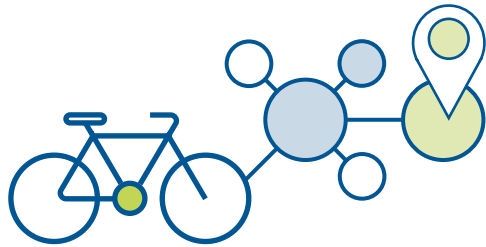


You are probably familiar with digitally enabled behaviour change – using **digital tools to change behaviour in the physical environment**. Many of us are wearing smartwatches or have installed apps that support leading a more active lifestyle. These digital tools monitor our **progress**, help us keep **track of our goals** and send **motivational reminders**. While these digital nudges are quite popular in the fitness and sports industry, other fields, such as mobility, stand to benefit from their use.

The Internet of Behaviour:

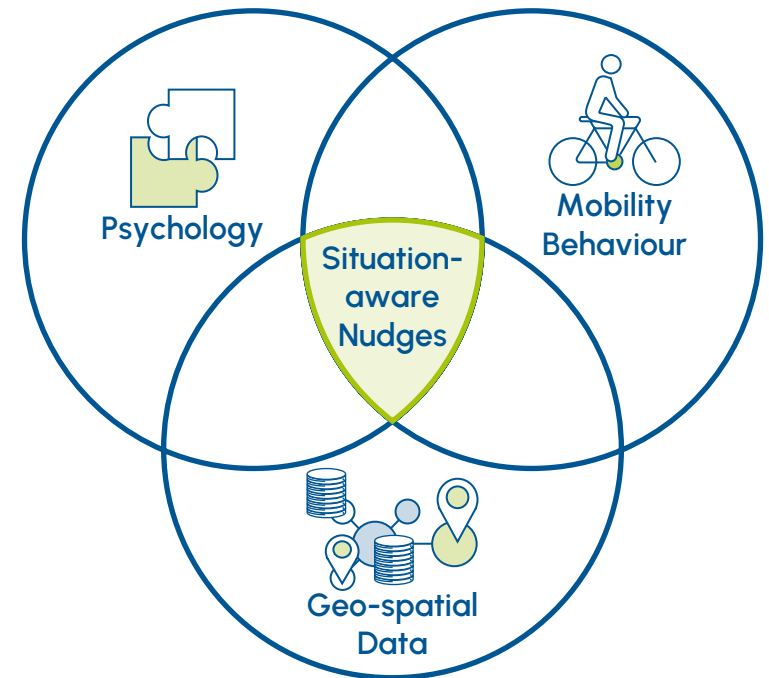
The Internet of Behaviour was named by Gartner as one of the top strategic technology trends for 2021. (<https://www.gartner.com/smarterwithgartner/gartner-top-strategic-technology-trends-for-2021>). The Internet of Behaviour is an expansion of the Internet of Things (IoT): the digital devices that we use every day leave behind information about our behaviour in the form of data, and this data can in turn be used to guide our behaviour. Digitally enabled behaviour change has therefore just begun!





Since 2016, the **use of digital nudges** has grown and they are estimated to be just as **effective** as regular nudges (Hummel & Maedche, 2019). As digital tools allow for the collection of user data, **personalised nudges** became possible; for example, by integrating data concerning people's past choices, preferences, their current environment or situational components. For mobility behaviour, data can concern **information about the person** (e.g., gender), a current **situation** (e.g., location) or **past behaviour** (e.g., mobility preferences). This is also the **interdisciplinary approach** we are following: bringing together psychology, mobility behaviour and geo-spatial data that inform the situational factors needed to design situation-aware digital nudges (see sections "[Situation-aware nudges](#)" and "[Digital nudging repository for sustainable mobility](#)").

Digital nudges also try to **remove the barriers** that hinder people from carrying out certain behaviours; for example, by reminding them or by making new information available. Although, it is worth noting that not all barriers can be eradicated by employing merely digital nudges (e.g., one's physical abilities or a city's infrastructure play a large role); however, the use of digital nudging can make a meaningful step by addressing the many psychological barriers that hinder us from making more sustainable mobility choices (like our motivations, social opportunities or psychological capabilities).



Review: Urban mobility apps to influence behaviour

In a review, Luger-Bazinger, Geser & Hornung-Prähauser (2023) provided an overview of urban mobility apps that utilise digital behavioural interventions to promote sustainable mobility within cities. These apps go beyond merely displaying information (e.g., bus schedules), but take the extra step by integrating digital nudges. In total, 26 apps were reviewed, which were available in at least 228 cities in 18 countries. The top **five** digital behavioural interventions employed by these apps are:

1. Feedback and Monitoring:

These functions present results of taken trips with metrics (e.g., carbon footprint calculation) for each trip taken, or the summary of all trips during a week.

2. Rewards (gamification):

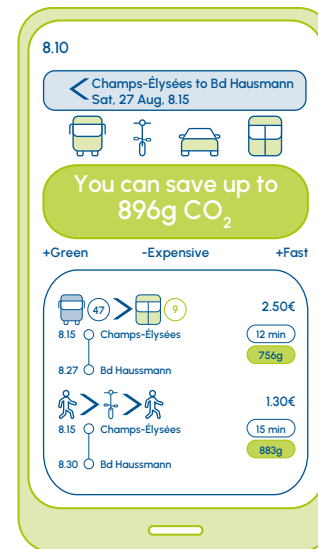
Gamification works by providing either social elements or monetary incentives:

a. Social incentives: These features include badges, leaderboards, trophies, gamified points and enable comparison to other members' results within an online community.

b. Monetary incentives: This form of rewards scheme works by earning points for sustainable trips which can be redeemed for prizes, vouchers or cash, and is typically part of a sustainability initiative of a city or company.



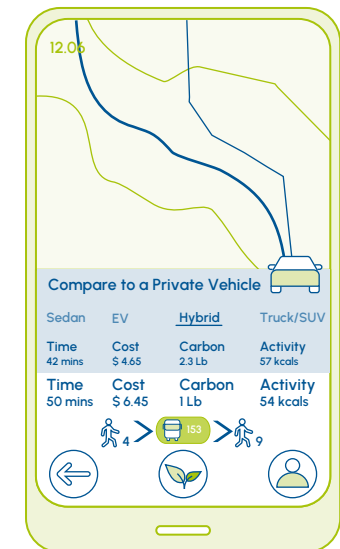
Ecomode (FR)



Ummadam (AT)



Cowlines (US/CA)



3. Planning:

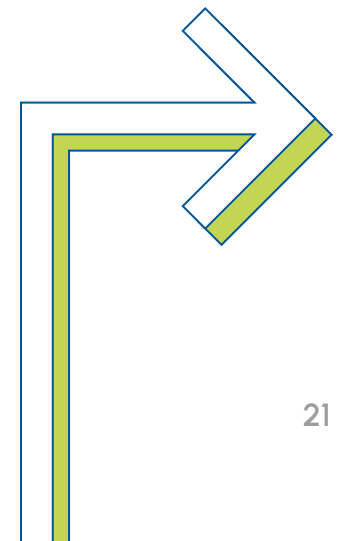
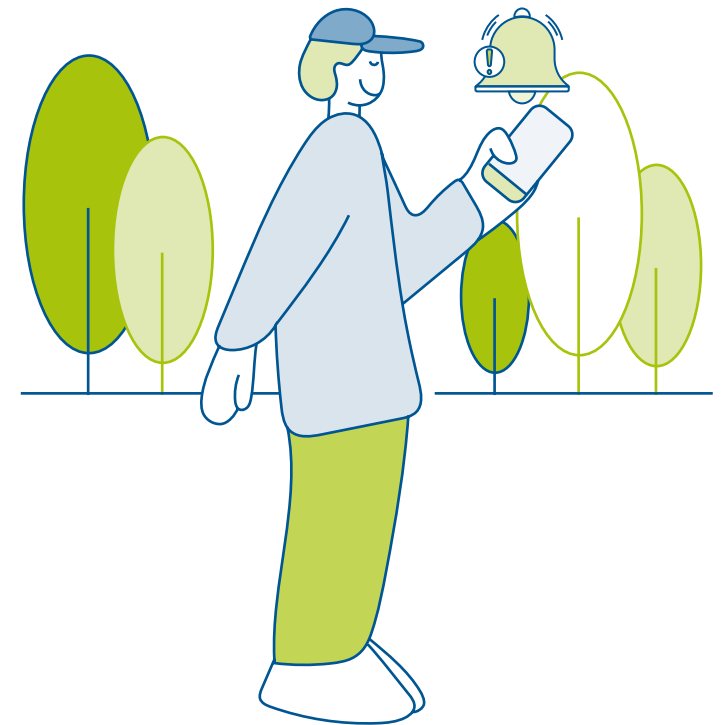
This functionality presents all routing options to get to the user's destination, highlighting the "greenest" route or comparison between different mobility modes.

4. Reminders and prompts:

This is implemented through push notifications, which remind and prompt users to keep choosing sustainable mobility. Motivational reminders focus on environmental, fitness or social aspects of choosing more sustainable modes of mobility.

5. Knowledge and education about consequences:

Educating users about the environmental benefits of adopting sustainable mobility options, as well as informing about the existing urban infrastructure that is around them.

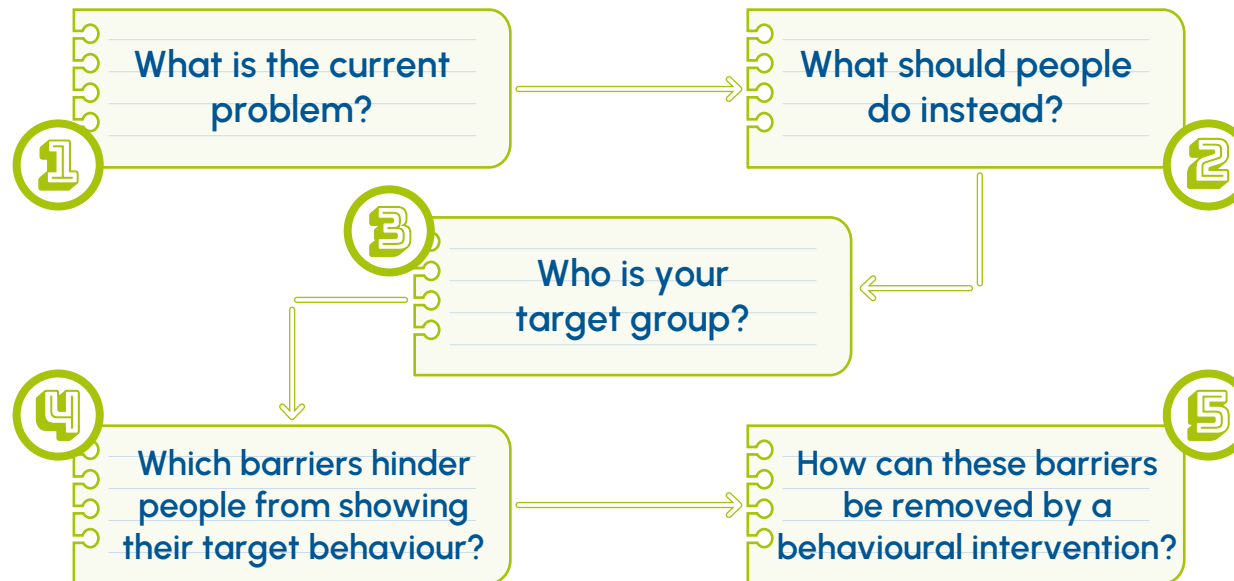


DESIGNING BEHAVIOURAL INTERVENTIONS





Now that we have had an introduction to behavioural interventions, nudging and a model of behaviour change, we can get to work. When designing behavioural interventions, we recommend that you take **several steps** to think about the specific dilemma you wish to solve and the corresponding behavioural solutions.



1. What is the current problem?

Think about the current problem in terms of behaviour and try to be as focused as possible. For example:

“ There is a traffic jam on a major street every morning when people travel to work, as too many people are commuting by car at the same time, and it is irritating for commuters as well as stressful for residents. ”

2. What should people do instead?

Specifying this as closely as possible will help in the next steps where we think about barriers for alternative behaviour. Thinking about what people should do instead in terms of behaviour is an important step because then we know what alternatives we can work on. For example:

“ Commuters should opt to use public transportation or their bicycle for their commute multiple times a week. ”

3. Who is your target group for an intervention?

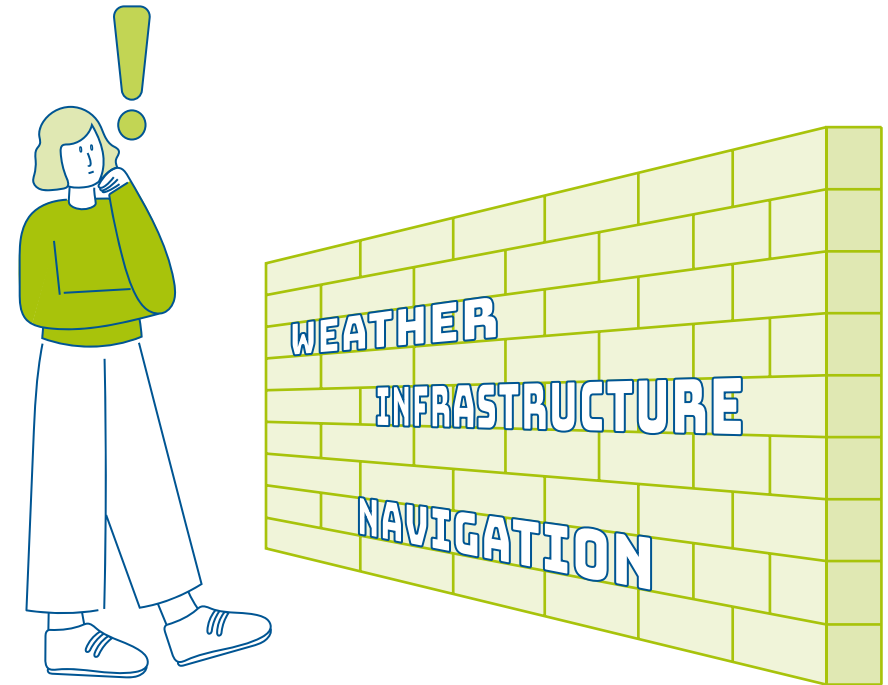
Who are you trying to reach? People all have diverse backgrounds, but if you think closely about your target group, it helps in finding commonalities. For example:

“Employees of the three biggest companies in a certain district within the city.”

4. Which barriers hinder people from showing the target behaviour (in terms of motivation, opportunity, capability)?

You can start by listing all the reasons this target group is doing something else other than the target behaviour. You can talk to your target group or use existing data and information (e.g., mobility surveys, focus groups, mobility infrastructure) for a first analysis, and think about the barriers in terms of motivation, opportunity and capability. Take the following examples:

- **Barrier 1:** The target group is motivated to use their bicycles; however, they are not sure whether they are **capable** of bicycling in rainy weather, leading to them choosing the car during uncertain weather forecasts.
- **Barrier 2:** There is sufficient sustainable mobility infrastructure and there are many opportunities for opting to use it; however, many people in the target group have positive feelings connected to driving their personal vehicles as they think that by doing so, they save a lot of time. This affects their **motivation** to switch their mode of transportation.
- **Barrier 3:** The target group is motivated to and possesses the opportunity to take public transportation; however, they are faced with a lack of knowledge of the available routes and timetables and find the city mobility app too difficult to navigate, making this a barrier in **capability**.



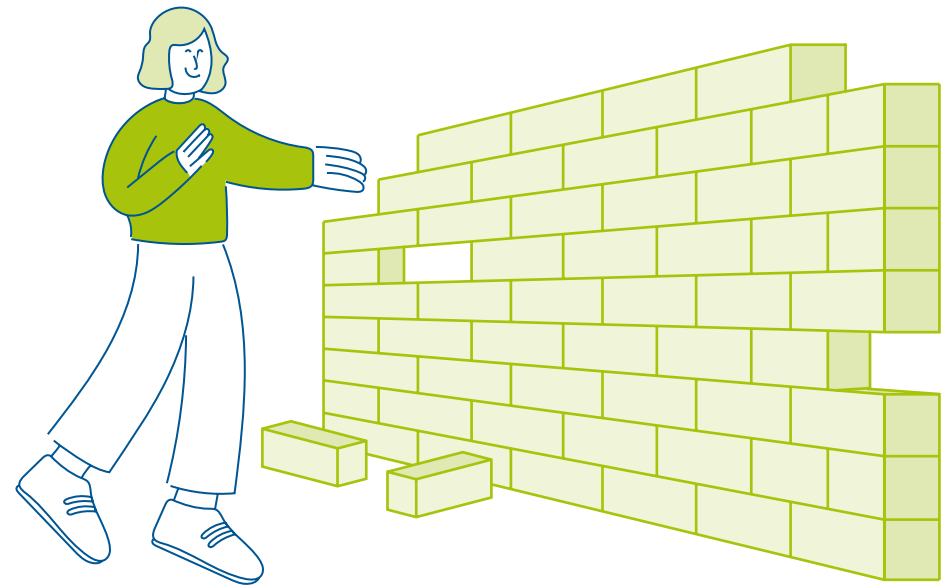
5. How can these barriers be removed by a behavioural intervention?

The intervention should focus on removing the barriers of behaviour while being realistic about what is possible to target. Does the intervention need to focus on people's social or physical **opportunity**, is it a physical or psychological **capability**, or is it a matter of **motivation** (see section "[Crash course on behaviour change](#)")? You have identified barriers in the previous steps and can now think about how to remove them:

• **Removing Barrier 1:** *Digital tips, prompts for planning on bicycling in the rain (e.g., displaying proper bicycling gear) as well as building a sense of community ("wave hello to other all-weather bicyclists") might encourage one to choose the bike in case of a rainy weather forecast– all of these can be encouraged via digital nudges.*

• **Removing Barrier 2:** *This motivational aspect could be targeted by reframing the time and cost of driving a car vs. commuting sustainably (e.g., incorporating more physical activity with bicycling can save time at a gym, time in public transport can be spent on reading or listening to one's favorite podcasts). This can be a digital behavioural intervention via a smartphone app.*

• **Removing Barrier 3:** *The behavioural intervention can target capability to help understand the schedules and routing of sustainable mobility options, and to improve the app itself to make it more understandable.*





Name: Patricia, accountant,
lives in the city of Urbania
Age: 27, married, no children

Current behaviour: Drives her car to office

What she could do instead: Ride her bicycle or take the bus to the office at least three times a week.

Barriers: Has positive emotions with using a car as she sees it as a time saver (motivation) and has a low level of fitness (capability).

Removing barriers with intervention: As Patricia has access to Urbania's excellent public transport system, a smartphone app from the transport provider can help her figure out the actual time spent on the bus. Furthermore, incorporating a digital nudge at the same time can be used to reframe the time that is spent on the bus and walking from negative to positive (e.g., by using the time for a fun activity, such as listening to a podcast or reading a book). In addition, Patricia can also be reminded that moving every day during her sustainable commute contributes to her overall fitness level.

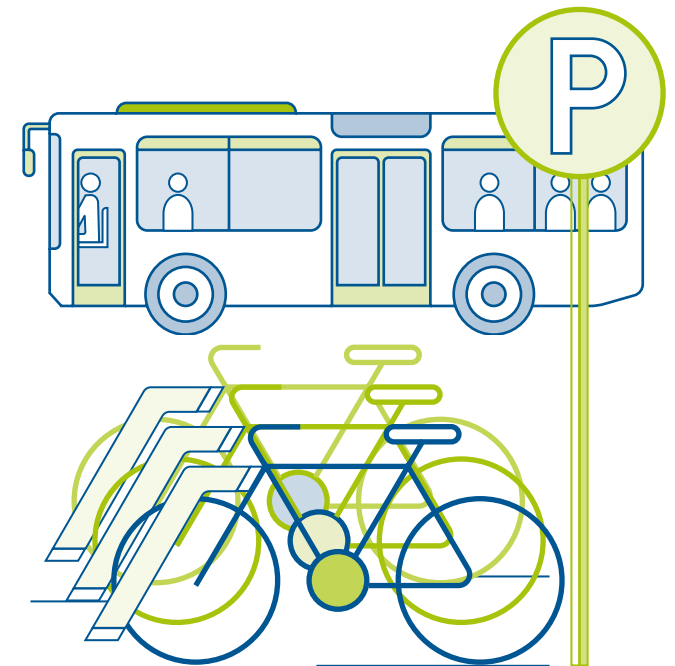
Examples for behavioural interventions in the mobility field

In this section, you will find examples of behavioural interventions that remove the barriers to opportunity, motivation and capability, which can help you when designing your own behavioural interventions.

Opportunities:

Interventions for opportunity usually entail **changing the environment a person is in**. For mobility, there are some changes that can be implemented by a city, with a greater number of them concerning infrastructure. *Note: Because this barrier is mainly combated by improving infrastructure, the use of digital nudging that alleviates barriers in this area is quite limited. Below you will find some examples:*

- “ • *assuring that existing bicycle lanes are safe (e.g., separated from car lanes)*
- *installing proper lighting along walkways to make them safer at night*
- *installing new public transport routes along with new stops, and increasing the frequency of these routes*
- *offering attractive bicycle infrastructure, including bicycle storage options*
- *giving out free tickets for public transport*





Motivations: Motivation might look different from person to person. Here, it is worth differentiating between **intrinsic and extrinsic motivation**. Intrinsic motivation is when motivation stems internally from a person (e.g., holding oneself to an ideal one believes in), while extrinsic motivation is when motivation is dependent on external factors (e.g., receiving praise). We can try to change both kinds of motivation, but there are theories which propose that developing intrinsic motivation is more beneficial for long-term change. Still, external factors like incentives can support habit formation.

Below are some examples of how to target somebody's intrinsic and extrinsic motivation:

“ **Intrinsic motivation:**



- reminding people of their values and identity (e.g., healthy living, environmental consciousness)
- reminding people about the positive consequences that come with the said new behaviour
- appealing to people's identity (“you are someone who values the environment!”)



“ **Extrinsic motivation:**



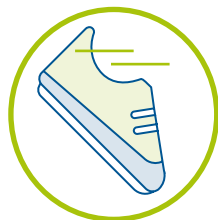
- rewarding the behaviour with vouchers or prizes
- making the behaviour fun by incorporating gamification elements
- underlining the social aspects by organizing teams or involving neighbourhoods or families



Capabilities: Capability can be both psychological (knowledge, skill, attention) and physical (physical abilities, fitness levels).

Below are examples of how to target these kinds of capabilities with behavioural interventions:

“ **Physical capabilities:**



- launching free fitness courses in a local park
- introducing bike lessons for adults who never learned how to ride a bike



“ **Psychological capabilities:**



- making information about public transport schedules easier to access and understand
- teaching how to fix a bicycle
- teaching how to ride a bicycle comfortably in bad weather, such as rainy conditions



SITUATION-AWARE NUDGES





In other fields, such as health, it is quite common to not only design digital behavioural interventions in a similar manner as we just showed you, but to also combine the **behavioural interventions with information about the relevant context of a person** to increase effectiveness. The basic idea behind this is that a person's decisions and behaviour are also very dependent on the current context (or "opportunity" as you read in previous chapters). By considering situational variables, we get a more realistic picture of person's current context, and in turn, the behavioural interventions have a greater chance of being effective (Wang & Miller, 2019).

When talking about the situation of individuals, we refer to the **built, the natural and the dynamic environment**. The built environment and its organization are fundamental for opportunities. If there aren't any safe bicycling paths, hardly anyone will consider bicycling as a viable mobility mode. In other words, the **built environment is the backbone for any opportunity**. But there is more: the natural environment has a direct impact on how pleasant we perceive our surroundings.

Additionally, the presence of **green space and blue space** along routes increases their attractiveness enormously. There is overwhelming evidence that people tend to bicycle and walk more in these settings. Regardless of the built and natural environment, dynamic variables, or variables that are in constant flux, greatly influence mobility choices. These are, most notably, weather conditions. Together, all three aspects can be digitally represented and integrated in a **Geographical Information System (GIS)**. The spatial and temporal reference allows for an overlay of environmental data layers, and thus can be used to integrate situational factors when selecting the most appropriate nudge in a given context.

Let's **illustrate** this idea with a few examples. Right now, we are not taking into account data availability and how to integrate and squeeze out different data sources, but we are still sticking to the basic idea of designing situation-aware nudges that are appropriate and effective:



Persona A: Michaela

Michaela lives in the same town where she works. Her workplace is approximately four kilometers from her home. Since she has enough parking space at home and in the company’s parking lot, **she is used to driving to work by car**. However, she is becoming increasingly frustrated by the town’s traffic. Unfortunately, the **public transport connection** to her destination is **poor**. Furthermore, the walk to the bus stop is **unpleasant** and Michaela perceives the environment as **unsafe**. Moreover, she would need to change buses twice for only a short trip. However, the city administration just extended the bicycle network in Michaela’s neighborhood. With this **new opportunity**, she can ride predominantly on physically separated bicycle paths along a scenic creek to her workplace.

Which nudges would be more appropriate and effective in this situation?



“Walk to work. Daily physical activity improves your health!”

The distance is probably too long. Moreover, the walkability in Michaela’s neighborhood leaves a lot to be desired. Thus, the recommendation to walk to work is not feasible for at least two reasons.



“Take the bus. There is a connection to your destination!”

Although Michaela would be able to go by bus, she will never regard this as a viable option. Every additional transfer in a public transport journey reduces its appeal. Apart from that, Michaela’s nearest bus stop is not very accessible.



“Enjoy riding through nature and save time. Take your bike to work!”

This nudge takes into account the perfect bikeability in Michaela’s neighborhood and refers to the positive experience she could enjoy. The distance is perfect for bicycling, which would also prevent her from being stuck in congestion. By following this advice, Michaela can reduce her commuting time, enjoy the fresh air and get some exercise.



Persona B: Nenad

To go to work, Nenad **must commute every day to another city**. By car, this takes him approximately 40 minutes. On some days, he combines his commute with grocery shopping or visiting his favorite gym, which is halfway to work. Nenad is used to taking the car, but **the rising prices** at the petrol station make him re-think his decision. The company he is working for offers annual tickets for public transport and job bicycles, where bicycles can be purchased at a discounted price. Nenad has tried out a gravel bike once and wonders whether he should use the gravel bikes as his main source of exercise when the weather is pleasant – **instead of going to the gym** – and take the light railway for the rest of the days. The next stop is only a five minute walk from his home.

To set up a system that facilitates situation-aware nudging, the data — demand as well as the challenge of integrating data from different sources and deriving meaningful information requires some effort. We proposed a set up that is able to cater to the demand for situation-aware nudges, made available as an open access paper (Loidl et al. 2023 in the References section).

Which nudges would be more appropriate and effective in this situation?



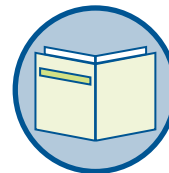
“Enjoy the sunshine. How about walking to work?”

Such a recommendation is obviously ridiculous if the destination is a 40 minute drive away. Not only is this nudge ineffective, but recommendations such as this one erode any trust into the reliability and relevance of the system.



“The weather will stay nice the whole day. Are you ready for the challenge of bicycling to work?”

This nudge contains crucial information, namely a positive weather forecast for the day. In addition, the nudge text acknowledges the long distance to ride and frames it as a challenge.



“The trains this morning have enough capacity. Use the time on board to read a good book.”

With this information, Nenad can be sure that he will get a free seat on the train, which is easily accessible from his home location. The hint to use his commuting time for a favorable activity makes him more motivated to do so.

DIGITAL NUDGING REPOSITORY FOR SUSTAINABLE MOBILITY



Our team has already designed **a set of free and open access digital nudges** in a so-called **“nudging repository”** in an Excel file that can be used as push notifications within apps or as e-mails (access here: <https://zenodo.org/record/7620003>). Based on the insights described in the previous chapters, the content of these interventions was designed using the behaviour change technique taxonomy of Michie et al.’s COM-B model (2013). **Our digital nudging repository** can be used to motivate several **different modes of sustainable urban mobility choices** in different contexts: bicycling, walking or using public transport – and for either commuting or leisure purposes.

It is our hope that this **repository helps you** – researchers, city officials or organizations that work with a mobile application – send out **push notifications** to your users at the most basic level. In turn, reviewing the repository can help you understand the underlying logic of the nudges, which you can apply or adapt to fulfill your specific needs.



Even more, the innovative aspect of this nudging list is that it **considers an individual’s current situation** (e.g., weather, traffic, nearby infrastructure), with the most relevant nudge in a given moment selected according to the current situational context data (see section [“Putting the nudging repository into practice”](#)).

However, it is worth noting that integrating such environmental data is not mandatory, and the nudging repository can also be used on its own without such data.



Structure of Nudging Repository:

- Nudges can target different modes of mobility. Therefore, if one is interested in only targeting bicycling, the nudging repository can be filtered for that mode.
- As already noted, nudges can be selected according to different trip purposes (leisure or commuting).
- Nudges within the nudging repository can also be used with or without situational data ("situation-aware"). Without situational data, the nudges would have to be sent out on fixed time schedules (e.g., once a day, in the morning), instead of depending on situational factors.
 - If you want to use situational data, we have specified what kind of information would be needed for this nudge to be sent out (see section ["Canvases and inspiration: Information for situation-aware nudges"](#)).
- Overall, 166 digital nudges are in the repository, developed from 46 different behaviour change techniques.



How a digital nudge is categorised in the nudging repository:

| | |
|---|--|
| Nudge text (for push notification) | Imagine how proud you will be today if you bicycle to work, even if the weather is not perfect! |
| COM-B element | Motivation |
| Behavioural intervention | Information about emotional consequences |
| Description | Provide information (e.g., written, verbal, visual) about emotional consequences of performing the behaviour |
| Mobility Mode | Bicycling |
| Situation-aware? | Yes |
| Situational information that determines sending out the nudge | Weather forecast for current day: rainfall. For user location: good bicycle lanes / good bikeability, reasonable bicycling distance to destination. |
| Trip purpose | Commuting |
| Timeframe for nudge | Weekday mornings |

PUTTING THE NUDGING
REPOSITORY INTO PRACTICE

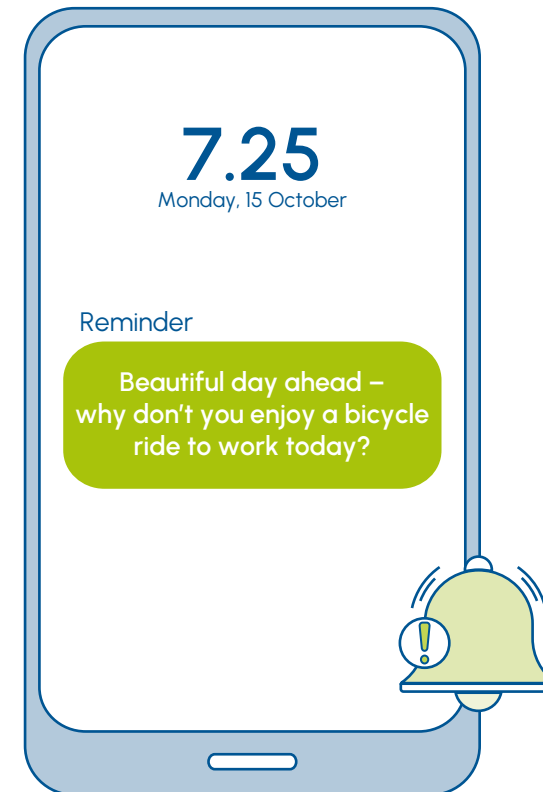


Our own nudging repository was **tested out in Salzburg** to see whether we can bring situation-aware nudges into the field. For this, we created the **campaign** “Science City Aktiv Mobil” that took place in a neighbourhood in Salzburg to motivate more sustainable commuting. Besides the use of a smartphone app that delivered digital nudges to our participants, the campaign involved multiple offline events and get-togethers in the neighbourhood. To spark their motivation, users could collect gamified points in the app when they commuted sustainably to work (e.g., receiving two points for each day they commuted by bicycle).

Science City Aktiv Mobil

- ☀️ **March 2023 – May 2023**
- ☀️ **60** participants from local companies
- ☀️ **Promoted modes of mobility: bicycling, walking, public transport**
- ☀️ **Neighbourhood in Salzburg, Austria**
- ☀️ **Four** events held
- ☀️ **Smartphone app for digital behavioural interventions**
- ☀️ **Living lab methods with explorative approach**

For the creation of **situation-aware nudges**, the necessary contextual information was translated into data requirements. Thereafter, these different data sets were integrated into a **data hub**. The data hub is a central data warehouse where real-time and static data are collected, integrated and linked to the nudging repository. Based on situational factors, which are translated into ontologies, suitable situation-aware digital nudges (push notifications) were selected and delivered to the smartphone app via an API.



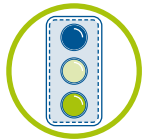
The following data were used to define the specific situational context of individual users in our campaign:



- **Weather:** Data on hourly forecasted air temperature, amount of precipitation and wind speed



- **Public transport:** Data openly available such as national data concerning the locations of public transport stops and their timetables



- **Traffic situation:** Data on current and forecasted state of traffic



- **Car-parking:** Real-time occupation rates of car parking facilities



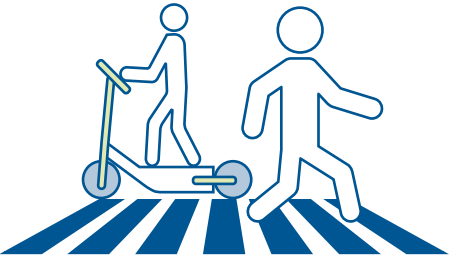
- **Street Network:** Openly available, authoritative representation of the street network for deriving several quality indicators



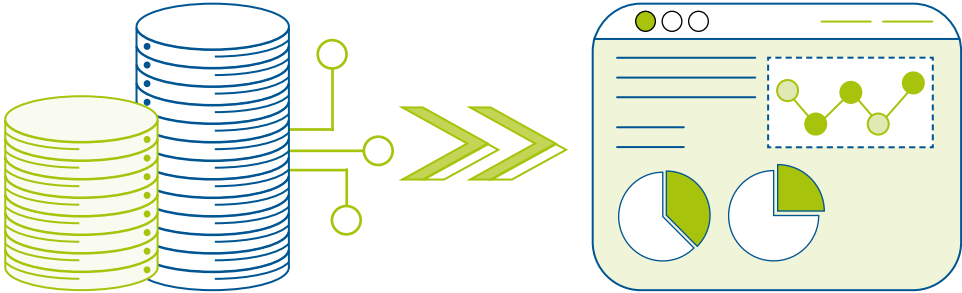
- **Walkability & Bikeability:** Calculation of an indicator that expresses the suitability of a street for pedestrians and cyclists respectively



- **Mobility Survey:** For the definition of thresholds that describe reasonable situations (e.g., maximum walking distance to bus stop), data from the last national, representative Austrian mobility survey were used



With implementation of the data hub and with the nudging repository, we successfully implemented an architecture that **automatically delivers situation-aware, data-driven digital nudges**, with the current context and situation determining the nudge a person receives. For example, if the weather forecast was rainy and the bicycling infrastructure was adequate, then a corresponding nudge was sent out to the users via a push notification on the smartphone app with.



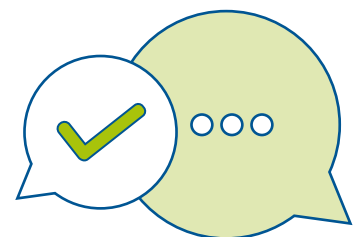
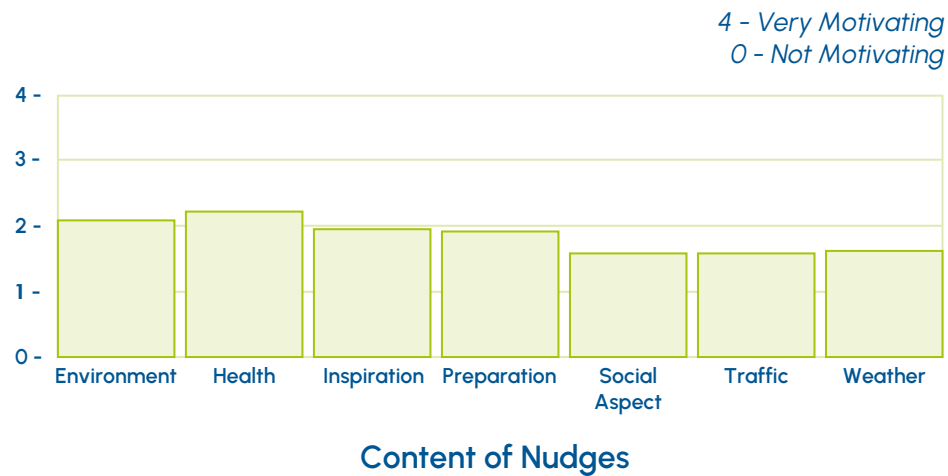
Multiple data sources aggregated to a dashboard for sustainable mobility
(See section “Using data for multiple purposes”)



Explorative Results and Feedback from the campaign

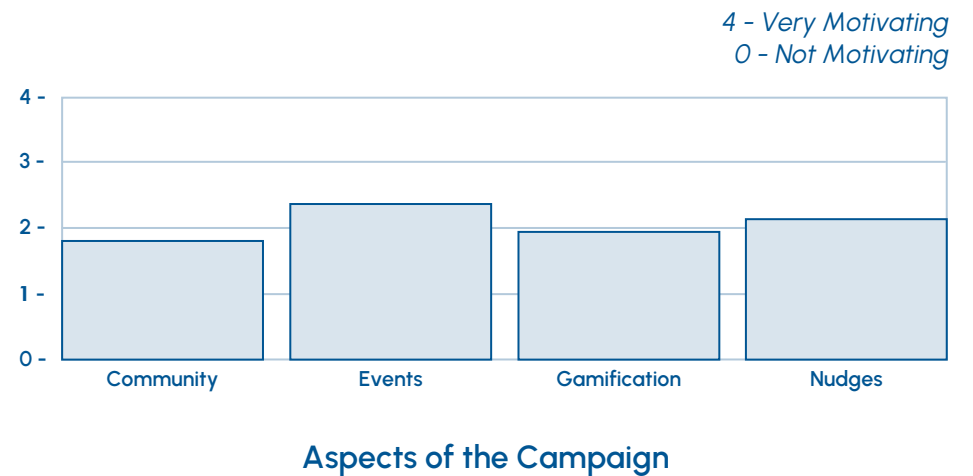
We asked the participants of our campaign to rate how motivating they thought the different nudges were. They reported that nudges concerning their **health, the environment and inspiration** to keep going were the most motivating.

How motivating were the different contents of the nudges for choosing sustainable modes of mobility?

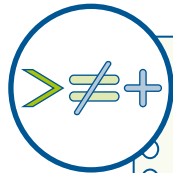
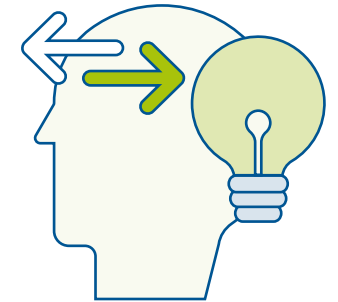


Regarding feedback from participants concerning our campaign, the events held were rated as the most motivating, followed by the nudges themselves; this shows that it is a **good idea to provide some real-world context** if you use digital nudging.

How motivating were the different aspects of the campaign for choosing sustainable modes of mobility?



Lessons Learned when using digital behavioural interventions within a mobility campaign



More is not always better: Sending out too many push notifications can overwhelm users. When you do not properly time out the nudges to take place at different intervals or you are too aggressive with your mobility campaign, your efforts can backfire.

Tip: Consider that less is more with the nudges – in our experience, two is the absolute maximum for push notifications per day. Plus, the more personalized the nudges are, the more relevant they will be perceived.



Testing before getting started: Not properly integrating the various data points needed to produce desired situation-aware, useful nudges is detrimental to your efforts.

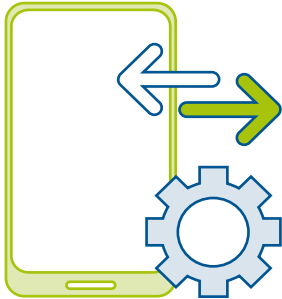
Tip: We recommend a test run for at least two weeks with a friendly user group that gives detailed feedback.



Events are important: Digital tools still need real-world context, and you need time to onboard people into your idea for digital nudging. This can be done via written instructions, but events can also serve this purpose as well.

Tip: We launched a mobility campaign with multiple events, such as talks and community lunches to onboard people and help them use the app.





Incentives work: Incentives are helpful in attracting more participants and keeping them engaged. Incentives can take the form of prizes after a certain goal was reached or a raffle of bigger prizes.

Tip: You can also foster community by providing incentives (e.g., hosting a group picnic). Special events with unique experiences are usually more appreciated and are more sustainable than giving away merchandise.



One size does not fit all: Not personalising your nudges to tailor diverse audiences, situations and mobility modes can mean that you lose your target groups or subgroups (e.g., people with disabilities, people taking care of elderly or children).

Tip: Consider a broad group of inhabitants in your city and their lifestyle, along with their opportunities, capabilities and motivation. By doing so, you can fulfill their diverse needs. It is often the group left out who needs it the most.



Quality in, quality out: The better the data are and the more data are accessible, the better quality the situation-aware nudging will be.

Tip: Any investment into sound data pays off in terms of the quality of services that are built upon the data.

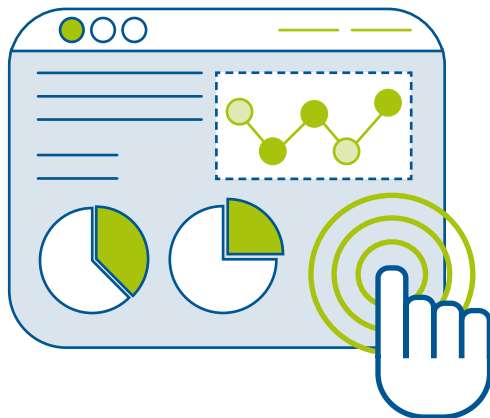


USING DATA FOR MULTIPLE PURPOSES

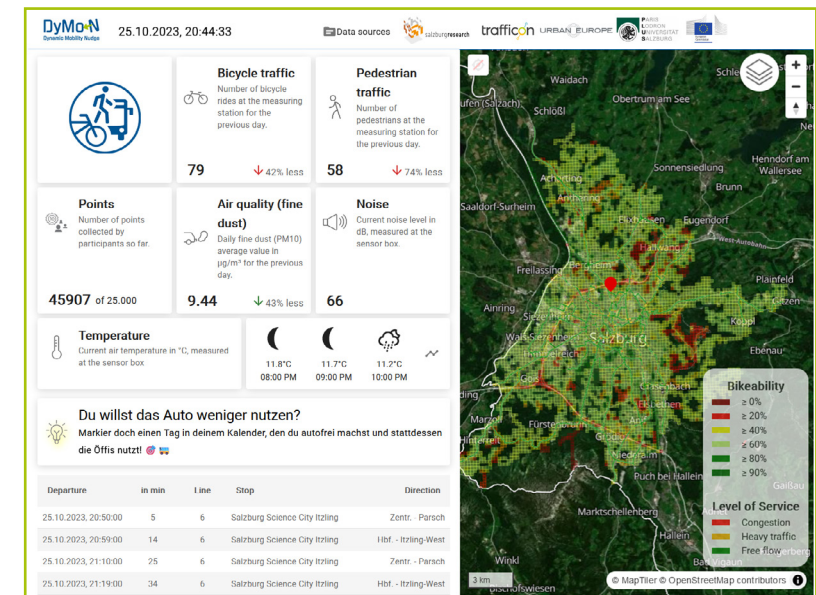
10

The idea of using data to enable situation-aware, digital nudging can seem daunting at first. However, the **collected data can also be used to feed it into multiple products**. For example, we used the data not only for situation-awareness of our nudges, but we also built a **data dashboard** from it that displays multiple indicators for sustainable mobility in a visual and focused format.

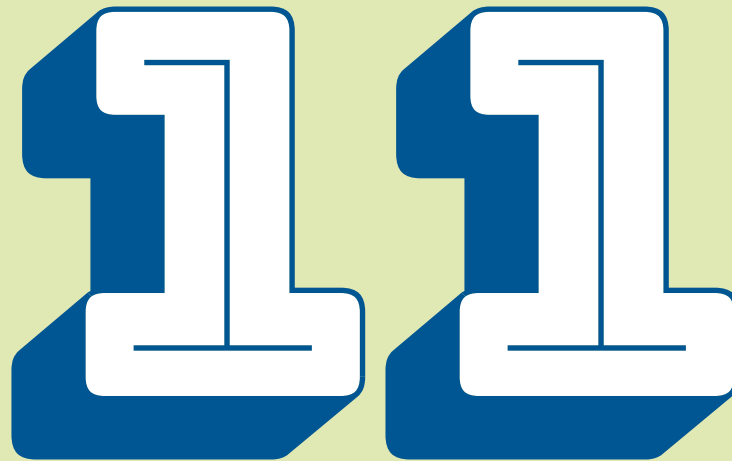
A **dashboard presenting data for sustainable mobility** serves the purpose of offering thorough, up-to-date insights into many areas of transportation that support environmentally friendly actions. The availability of public transportation, the locations of electric vehicle charging stations, bicycle infrastructure, and traffic congestion levels may all be displayed on dashboards like ours. By enabling consumers, decision-makers, and enterprises to make educated choices, this data promotes the use of environmentally friendly transportation methods. Integrating such varying data points in a dashboard can contribute to lowering carbon emissions, easing traffic congestion, enhancing air quality, and encouraging stakeholder cooperation while searching for an environmentally friendly and sustainable mobility ecosystem.



For inspiration, here is the dashboard which we used, which received positive feedback from its ecosystem members(<https://dymon.eu/dashboard/>):



DATA REGULATIONS TO KEEP IN MIND





What you need know about data

! **Disclaimer** - data protection legislation is dynamic and subject to change

Personal data

Due to the nature of handling user data while operating a digital mobility application, there are a number of data privacy and security concerns to consider. One of the most prominent concerns relates to the **responsible handling of users' personal data**. In recent times, the responsible handling of user data and protecting the user's privacy rights has been comprehensively tackled in European legislation. For example, the General Data Protection Regulation (GDPR) has been in effect since 2018 (European Commission, n.d.; Regulation 2016/679), and has established the following legally binding principles when one handles users' personal data:

- Personal data must be processed in a **lawful and transparent manner**, ensuring fairness towards the individuals whose personal data is being processed (*lawfulness, fairness and transparency*);
- There must be **specific purposes** for processing the data and the company/organisation must indicate those purposes to individuals when collecting their personal data. A company/organisation can't simply collect personal data for undefined purposes (*purpose limitation*);
- The entity must collect and process **only the personal data that are necessary to fulfil that purpose** (*data minimisation*);
- The entity must ensure the personal data are **accurate** and up to date, having regard to the purposes and correct it if not (*accuracy*);
- The entity can't further use the personal data for other purposes that aren't **compatible** with the original purpose;
- The entity must ensure that personal data are **stored for no longer than necessary** for the purposes for which it was collected (*storage limitation*);
- The entity must install appropriate **technical and organisational safeguards** that ensure the security of the personal data, including protection against unauthorised or unlawful processing and against accidental loss, destruction or damage, using appropriate technology (*integrity and confidentiality*).



Original figure from:
The principles of the GDPR (reference to Planet Compliance, n.d.)

Sensitive personal data

It is worth noting that the **personal data gathered for the purpose of implementing sustainable mobility apps are generally not considered to be 'sensitive personal data'**, which are personal data considered to be particularly sensitive and perhaps compromising to one's freedoms – and thus, must adhere to a set of more stringent legislation (e.g. health related data, racial or ethnic origin data, etc.) (Regulation 2016/679, Article 51). When working with the apps that we propose in this book, we believe that these very stringent rules can largely be avoided. However, if you plan on integrating, say, the app's interface with users' health data from their wearable devices, please be advised that this additional layer of legislation may be applicable to you.

Beyond personal data

In order for you to install digital behaviour interventions with situation-aware nudges, you need other kinds of data, for example, meteorological data or public mobility data. In recent times, **accessing such data has been made easier due to legislation that promotes the free flow of public information**, such as the EU Directive on Open Data and the Re-use of Public Sector Information (Directive 2019/1024). Moreover, many of the datasets that would be needed to build situation-aware nudges are considered to be high-value datasets in the European Union, whose re-use is prioritised by making it readily available (e.g. geospatial, meteorological and mobility data and all types of relevant situational data are all considered high-value according to this Directive – and thus, freely available). As of the time of writing, you can find open European data on its centralised portal (<https://data.europa.eu/en>). Additionally, public data are available on national and municipality websites (e.g., Open Data Austria portal). **Assess your data requirements and examine what is suitable for you!**

While a growing amount of data is generated every day, only a fraction becomes accessible. Authoritative data are increasingly published according to regulations as outlined above. However, operational data from public transport operators or cell phone providers, which are only two examples of highly relevant data in our context, largely remain locked-in. Proprietary data might come along, however, at comparably high costs. Thus, we need to distinguish between **available** and (reasonably) **accessible** data. Sometimes, it might be **smarter to work with less accurate data** or use an alternative dataset as proxy variable **instead of investing** too many resources into proprietary data. Apart from data availability and accessibility, you need to consider the **suitability of data** for your specific purpose. For instance, “I need weather data!” could mean a lot. You might need to tap a completely different data source for accurate forecast data than for the information if it is currently raining or not. We therefore recommend **defining your information** demand as detailed as possible and deciding on this basis which types of data you need. As soon as you know the requirements for your data, you can evaluate different data sources and assess their respective suitability for your intended purpose. Using a **data assessment matrix** is an investment that definitely pays off in terms of transparency (you can trace back the delivery of a single nudge to all used data sources) and efficiency. You can find an example of our data assessment matrix here:

<https://zenodo.org/record/7573410>

Only a minority of data are going to be available and accessible in the format, structure and resolution that you require for your application. Thus, you need to process the data and integrate data sets from various sources. **In the DyMoN project that this handbook is a part of, we designed a data hub that serves this purpose.** If you decide to run such a data hub of your own, you might find our publication on this topic useful (Loidl et al. 2023 in the references section).

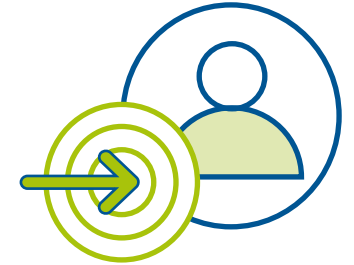


CANVASES


&

INSPIRATION

**LET'S GET STARTED WITH DESIGNING BEHAVIOURAL
INTERVENTIONS FOR SUSTAINABLE MOBILITY !**



Personas: Who are the target users you wish to reach with your efforts?




NAME:
OCCUPATION:
LOCATION:
AGE:
MARITAL STATUS:
NO. OF CHILDREN:

Current Behaviour:

What they should do instead:

Barriers:

Behavioural interventions:



NAME:
OCCUPATION:
LOCATION:
AGE:
MARITAL STATUS:
NO. OF CHILDREN:

Current Behaviour:

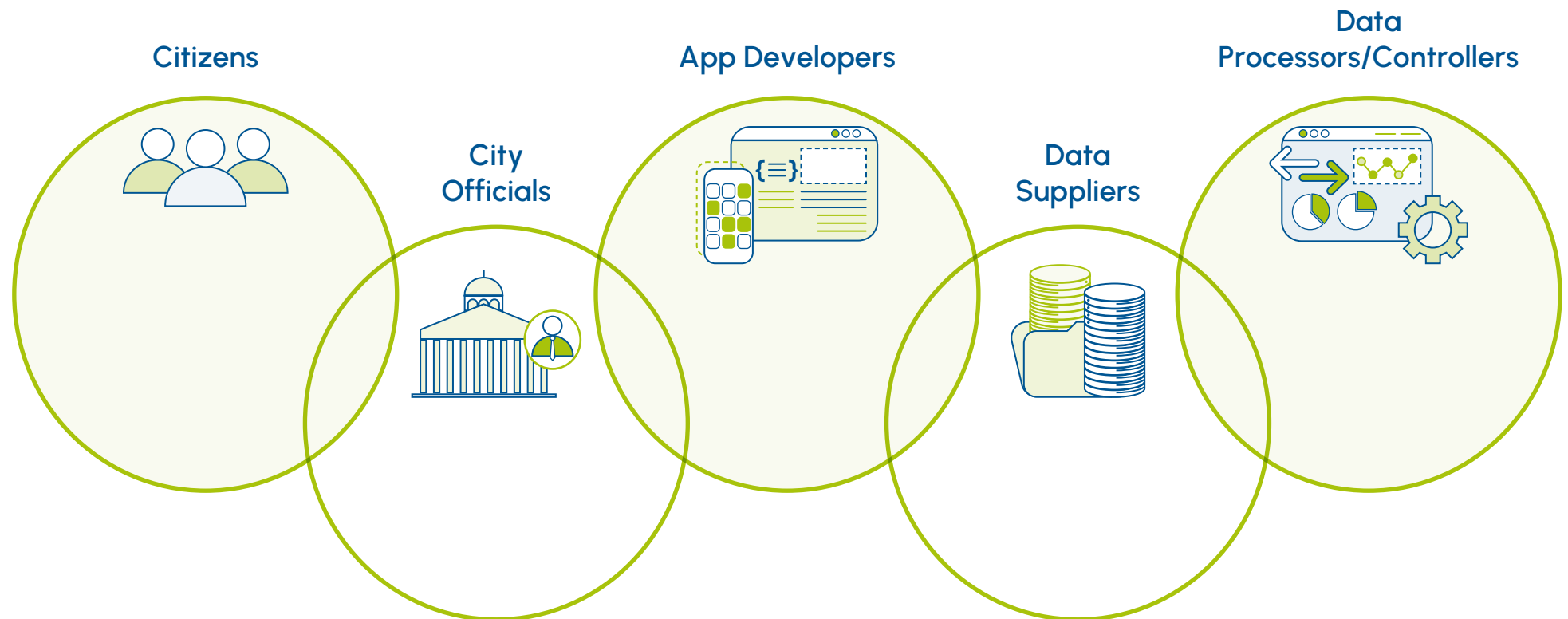
What they should do instead:

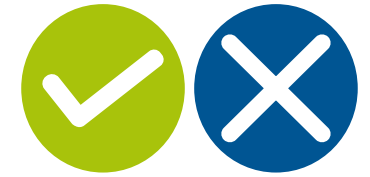
Barriers:

Behavioural interventions:



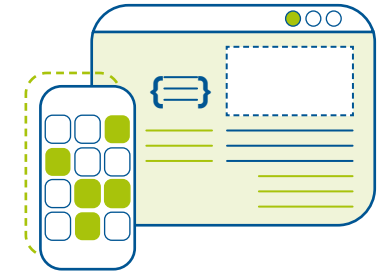
Which stakeholders are needed to realise your sustainable urban mobility campaign?



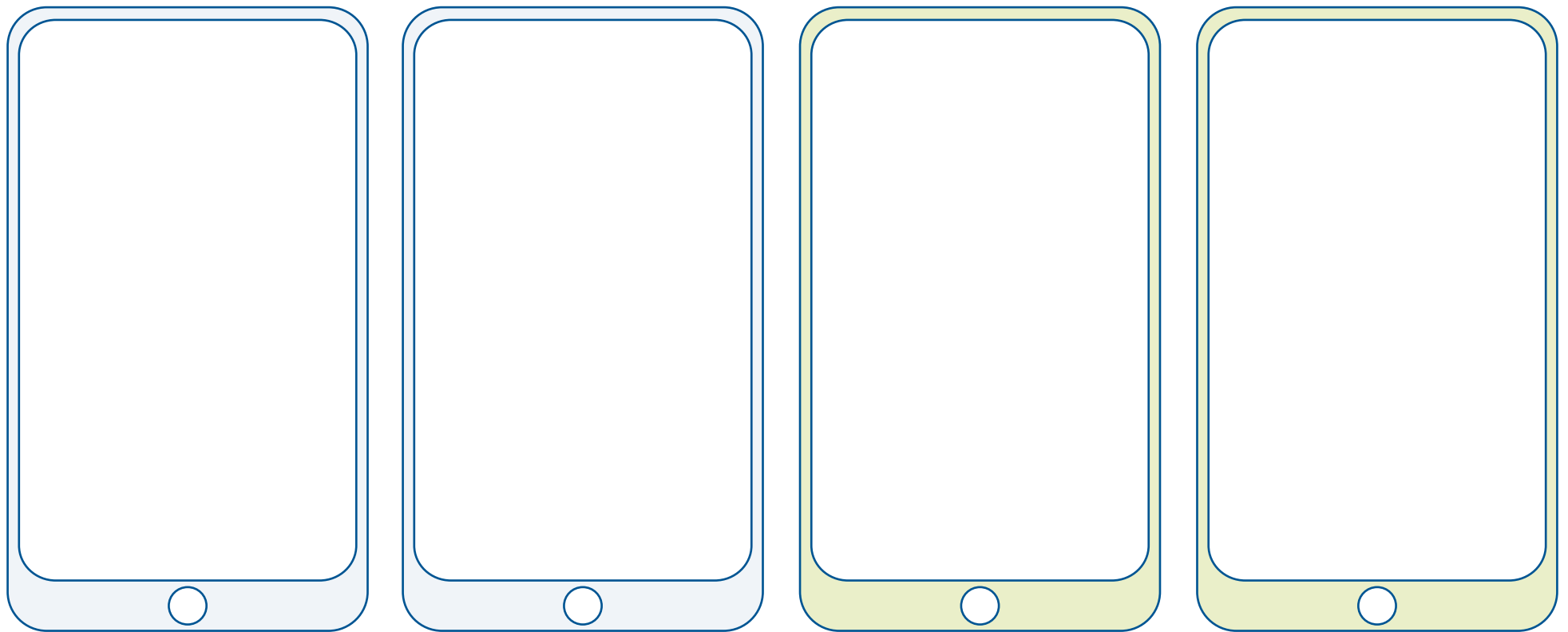


Sustainable urban mobility campaigns in your city: What do you face?





What would the ideal mobility nudging app look like for you?





Canvas: Information for situation-aware nudges

| Information needed  | Purpose  | Importance (on a scale from <i>1= not important to 5 = very important</i>)  | Possible data source  |
|--|---|---|--|
| Weather forecast for next day | Informing about good weather ahead and suggesting commuting by bicycle | 5 | Open Data Weather [2023]. |
| Green walkways within cities | Suggesting the most enjoyable walks to users | 3 | Open Street Map [2022] |
| | | | |
| | | | |
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ABOUT THE PROJECT

DyMoN

Dynamic Mobility Nudge

This handbook was written within the Dynamic Mobility Nudge project, an interdisciplinary project that brings together psychology, geoinformatics, mobility research, software development, innovation and social sciences for creating new digital solutions for changing mobility behaviour. Find more information about results and other activities on our website: www.dymon.eu

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<https://www.trafficon.eu/en/company/>

Sustainability InnoCenter (Sweden)
<http://sustainabilityinnocenter.com/>

Uppsala University (Sweden)
<https://www.cie.uu.se/civil/>



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