Nudging Review

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	Authors:
	Claudia Luger-Bazinger, Salzburg Research
	Veronika Hornung-Prähauser, Salzburg Research
	Guntram Geser, Salzburg Research

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Table of content

List of Tables

List of Figures

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Project coordinator	Salzburg Research Forschungsgesellschaft mbH (SRFG), Salzburg, Austria; project coordinator: Dr. Claudia Luger-Bazinger
Project partners	University of Salzburg, Department of Geoinformatics, Austria
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1   Purpose of the document

This deliverable is a result of WP 2 "Repository of nudging methods and content". The objectives of this WP are:

1. "Review of behaviour change design and nudging methods for sustainable mobility
2. Collection and analysis of user needs involving smart city managers and citizens
3. Development of the design and content of the nudging repository and handbook
4. Validation of the content by experts and smart city managers"

This deliverable contributes to objectives 1 and 3 in task 2.1: "Scientific review of nudging methods: Literature review of approaches for behaviour change and nudging methods, identification of best practice examples, and selection of the most effective methods for fostering sustainable mobility with nudges."

Therefore, this document provides an overview of nudging methods and nudging examples for sustainable mobility, and describes the selected framework under which the nudging repository and other project tasks and results related to nudges (e.g. handbook, dashboard, set-up of proof of concept) are developed.

2   Executive Summary

This deliverable describes what is needed in order to design behavioural interventions that encourage people to use more sustainable modes of mobility more often. Such measure are certainly needed, especially in the face of climate change, but reducing car traffic, emissions and noise can also make cities more liveable places. With the wide use and possibilities offered especially by mobile devices, there have been considerable efforts already in the mobility field to change behaviours with digital interventions. However, the efforts are often not as effective as they could be, because many of the interventions in the mobility field operate without any theoretical model of behaviour change. In this deliverable, we discuss why and how interventions should be firmly rooted in appropriate theories, and for the mobility field, we suggest to use an already existing model of behaviour change, the COM-B model developed by Susan Michie and colleagues. This model can help in determining which elements lead to a specific behaviour (i.e. capability, opportunity, motivation) and how these elements can be targeted with a behavioural intervention. A taxonomy of behaviour change techniques supports designing specific interventions based on the COM-B model. The model will serve as theoretical behaviour change model for the DyMoN project, for designing the set of (digital) behaviour change interventions (nudging repository) for encouraging use of sustainable mobility modes, and for informing city representatives on how they can motivate more sustainable mobility within their cities.

3   Introduction

Action needs to be urgently taken in order to fight climate change. While multiple problems are related to the issue of global greenhouse gas emissions, the choices for individual mobility are certainly contributing to the problem: Transport accounts for a quarter of Europe's GHG emissions (European Environment Agency, 2018). However, even in cities, where alternative, more sustainable options would be available (in contrast to more rural areas where options are limited and infrastructure is less developed), there is still a large dominance of car use in the modal split of transport in the cities and their surroundings (European Platform on Mobility Management, 2018). It is be essential to motivate people to use more sustainable forms of transport instead of individual car use (e.g. walking, bicycling, public transport), as 'hard' measures such as regulations, restrictions or laws are not always possible, effective or desired by governments or policy makers. Therefore, researchers are exploring other means for motivating individual behaviour change ('soft' measures), but it appears that sole promotion or information on more sustainable ways alone does not motivate people enough to choose differently (Huber et al., 2017). In light of the need of behaviour change, interventions based on behavioural sciences (such as psychology, behavioural economics) have been proposed to increase policy effectiveness (Ewert, 2019), with the concept of nudging being one of these interventions. We discuss the potential and limitations of behaviour change interventions (especially nudging) for mobility behaviour, show how nudging and related methods have been used for changing mobility behaviour so far, and point out a different approach: We suggest that it is worthwhile to look into other fields where behaviour change has been researched and successfully applied for years and methods are firmly rooted in theoretical concepts, instead of testing a number of methods in an unstructured way which leads to mixed results. The COM-B model, stemming from public health research (Michie et al., 2011), can serve as such a theoretical framework that could help in designing interventions for the mobility sector. For DyMoN, the COM-B can serve as an appropriate framework for developing the nudging repository, handbook and related project results.

4   The rise of nudging

Of all the various techniques and methods for changing behaviour, especially in public policy, the most widely known of the 'soft' interventions is probably nudging. Nudging is seen as a suitable instrument to promote behaviours that are beneficial for individuals and the society and therefore has been adopted to support public policies. The concept of nudging describes how people can be steered in a particular direction without limiting the freedom of choice of their own decision, as nudging is a method to change people's behaviour without threat, forbidding or severe economic consequences (Thaler & Sunstein, 2008). Stemming

from psychology and behavioural economics, nudging uses interventions that are cheap to implement and also easy to avoid, and seeks to alter the way choices and the related environments are presented and processed (Ly & Soman, 2013; Thaler & Sunstein, 2008). Nudging builds on the 'dual process' theory (Kahneman, 2012; Thaler & Sunstein, 2008), proposing two different systems of cognitive processes: System 1 ('automatic') is processing information fast and effortless in a quasi-automatic way, system 2 ('reflective') is slower in processing, controlled and requires much more cognitive effort. System 1, where many of our everyday decisions and behaviours are based on, is prone to errors, and leads to heuristics and biases. Nudging is taking this into account, and by changing the environment in which decisions take place (the so-called 'choice architecture'), nudges guide our decisions and behaviour through re-framing, cues and rearrangement or new information. Different versions of nudges are available, and Sunstein (2014) identified the ten most important kinds, ranging from simplification to social norms. One famous nudge is the default: Most people comply with the default, and utilizing this, it has been shown that just changing the default from non-participation to participation promote financial savings and contribution to retirement plans that was not achieved through other means (Beshears et al., 2009; Thaler, 1994).

In recent years, digital methods to change behaviour have come to the center of attention (Schneider et al., 2018; Weinmann et al., 2016), as use of digital tools (e.g. smartphones, tablets) has risen rapidly in society. Nudging in a digital environment means that a digital tool (e.g. a website or an app) is used to influence decisions either in the digital or the analogue environment, for example, a notification within an app is used to motivate a person for a healthier lunch choice (Lembcke et al., 2019). The accompanying data collection can be used to make nudges more personalized by using relevant data about a person (e.g. gender, past behaviour) (Mills, 2020). Personalized nudges have been shown to be more effective than nudges that are targeted very broadly (Peer et al., 2020), offering even more potential to this method.

Nudging has been experimented with in various fields and the research literature is fast growing (Lehner et al., 2016; Meske, 2017; Sunstein, 2014), although most experience with nudging so far comes from the health sector (Hummel & Maedche, 2019). A recent meta-analysis showed a small to moderate effect of nudges that intervene at the level of the choice architecture – an effect size that should not be underestimated, considering the low costs of nudges compared to other types of intervention (Beshears & Kosowsky, 2020; Mertens et al., 2022). Altogether, nudges seem like a perfect method to change behaviour as they do not require much effort for their design or implementation, are cheap and can remedy shortcomings of other types of interventions like financial incentives, educational campaigns or restrictions and bans, while still arriving at the same intended result: Behaviour change at

an individual level. Reflecting this intention, nudging methods (and others such as 'boosting') are often grouped under the generic term of 'behavioural intervention', although they build on insights of different disciplines such as psychology, cognitive sciences, behavioural economics and other social and behavioural disciplines (OECD, 2017).

5   Behaviour change for sustainable mobility

Nudging and related behaviour change methods have been discussed as a potential approach for motivating more sustainable behaviour, such as energy conservation, healthy food choices, and also, mobility behaviour, though it might be less suited for the latter as Lehner et al. (2016) suggested. Motivating people to choose a more climate-friendly vegetarian option over a meat option for lunch in the cafeteria is much less complex than motivating people to change their daily commute, as mobility behaviour results from a number of decisions, influenced by many parameters, and deeply rooted in routine and dependent on infrastructure. Nevertheless, research has explored the possibility of using behavioural interventions for changing mobility behaviour, either with analogue or digital means. For example, travelers on public transport were encouraged to identify as sustainable travelers in public transport by being given a travel card holder showing this message, leading to increased bus use (Franssens et al., 2021). Digital methods have come to the center of attention of motivating sustainable mobility, due to the frequent use of smartphones in everyday life, including before and during trips. There have been a number of studies utilizing digital methods for changing mobility behaviour. For example, travel feedback provides information (on a website or app) on many aspects of taken trips with different modes of mobility, such as greenhouse gas emissions, number of steps taken or calories burned (Jariyasunant et al., 2015). Similarly, many research projects and studies have explored personalized, data-based travel planning, that suggests, for example, to take the most environmentally-friendly mode of mobility (Anagnostopoulou et al., 2020; Sanjust Di Teulada & Meloni, 2016). Related to that, it has been explored which types of travelers would be most receptive to suggestions for more sustainable travel modes (Semanjski et al., 2016). Other researchers have designed and trialled apps that display information about one's ecological footprint that results from different mobility choices (Shankari et al., 2015). Furthermore apps with a number of the aforementioned features have been developed (Jylhä et al., 2013), and additional functionalities such as goal-setting have been introduced (Schrammel et al., 2015). The power of social influence when utilizing an online community has already been shown to be effective for other forms of sustainable behaviour like energy conservation (Abrahamse & Steg, 2013). This could have potential for mobility behaviour as well: Apps for encouraging sustainable mobility behaviour often work with challenges within a community of app users (Schrammel et al., 2015). The effect of social comparison (Festinger, 1954) has also been explored: One way

to influence people's behaviour is to provide them with information that a relevant social group is displaying a particular behaviour, and this can also be applied within the digital environment of an online community, notifying users that their peers are bicycling or walking a lot and motivating user to keep up with them (Luger-Bazinger & Hornung-Prähauser, 2021). Apart from published research, a number of organizations, cities and communes have initiated programmes building on similar principles (Klementschitz et al., 2020), drawing on knowledge from nudging and behavioural economics and using key techniques from them. Many of these programmes are also trying to utilize the perfect timing for an intervention, for example, it is assumed that residential relocation offers a window of opportunity to change mobility habits (Alta Planning & Behavioural Insights Team, 2018; De Vos et al., 2018).

5.1   Effective behaviour change?

As one can see from the short and not exhaustive overview in the previous section, there have been various attempts to change mobility behaviour, especially with digital means. Due to the popularity of the term and the context of public policy making, nudging is frequently used, although nudges only constitute a subset of various behavioural interventions (Ewert, 2019). While a plethora of research as well as practice examples can be found, it seems that many of the approaches of behaviour change in the mobility field are often repeated, especially within programmes of cities or municipalities (e.g. community-aspects, providing information of ecological footprint). A meta-analysis (Semenescu et al., 2020) on 'soft' interventions (such as nudges) on car use shows that these efforts have an effect – these techniques can indeed reduce individual car use. However, not all methods are equally effective: The biggest effect in terms of reduction of individual car use can be achieved by targeting cultural, social and moral norms. Travel feedback (such as receiving feedback on the amount of greenhouse gas emissions, calories burned for a trip, etc.) produces a lesser effect, even though it is commonly found among the 'soft' intervention methods. The meta-analysis also found the effect of mobility behaviour interventions related to residential relocation much less clear-cut than one would expect.

Even though behavioural interventions such as nudges are cheaper than financial incentives and easier to implement than regulations or laws, they require some effort to apply. However, looking into the many mobility related digital nudging studies, it appears that some methods have been applied over and over again (e.g. apps suggesting more sustainable modes in routing or offering rewards for bicycling). It should be noted that the gold standard for using behavioural interventions is to evaluate them in an experimental setting, ideally a randomized controlled trial (OECD, 2019), however, apart from some noteworthy exceptions (Cellina et al., 2019), this is very rarely put into practice in the field of mobility. In addition, researchers have criticized that behavioural interventions in mobility are very rarely grounded

in any theory of behaviour change (Möser & Bamberg, 2008; Sunio & Schmöcker, 2017). This can limit their effectiveness and does not enable a real understanding of their effects and which aspect of the intervention actually works (Cellina et al., 2019), leading to a trial-and-error approach in interventions that seems to be repeated.

5.2   Theory-based interventions in the mobility field

Rooting behaviour change interventions firmly on theories is a rarity (Chng & Sanchez, 2021), and if theories are used, the theory of planned behaviour (Ajzen, 1985, 1991) is selected by a majority of the studies as a review showed (Hoffmann et al., 2017). However, the theory of planned behaviour comes with its own problems: In other fields, such as public health, research has called for leaving the theory of planned behaviour behind as its usefulness and validity were called into question (Sniehotta et al., 2014). While its simplicity seems convincing, researchers keep adapting and adding factors to the theory in order to make it more suitable. This also happens in the field of mobility, what Chng and Sanchez deem "add-on culture" (2021, p. 5), while urging researchers to use better suited theories in order to increase effectiveness of interventions in the mobility field.

Researchers have been called to action to use interventions that are firmly rooted in behaviour change theory in order to design better, more effective interventions (Arnott et al., 2014). However, a plethora of theories of behaviour and behaviour change have been proposed, Davis et al. (2015) identified over 80, and it is difficult to evaluate which ones could be useful for the mobility field. We suggest another approach: Instead of introducing yet another new or modified behaviour change theory specifically for the mobility field, we should look elsewhere and focus on the implementation of interventions. After all, the mobility sector, especially with the urgency of interventions against climate change, needs immediate and effective action. One field where there is a lot of experience with the development and implementation of behavior change methods is public health. Notably, the COM-B model (Michie et al., 2011, 2013) and the related taxonomy of behaviour change interventions could serve well as a framework for the development of interventions in the mobility field.

6   The COM-B Model for changing behaviour

The COM-B model (Michie et al., 2011) proposes that a specific behaviour "will occur only when the person concerned has the capability and opportunity to engage in the behaviour and is more motivated to enact that behaviour than any other behaviour" (West & Michie, 2020). Therefore, the relevant elements of the COM-B model, as its acronym suggests, are capability, opportunity and motivation that are interacting to generate behaviour (see Figure 1).
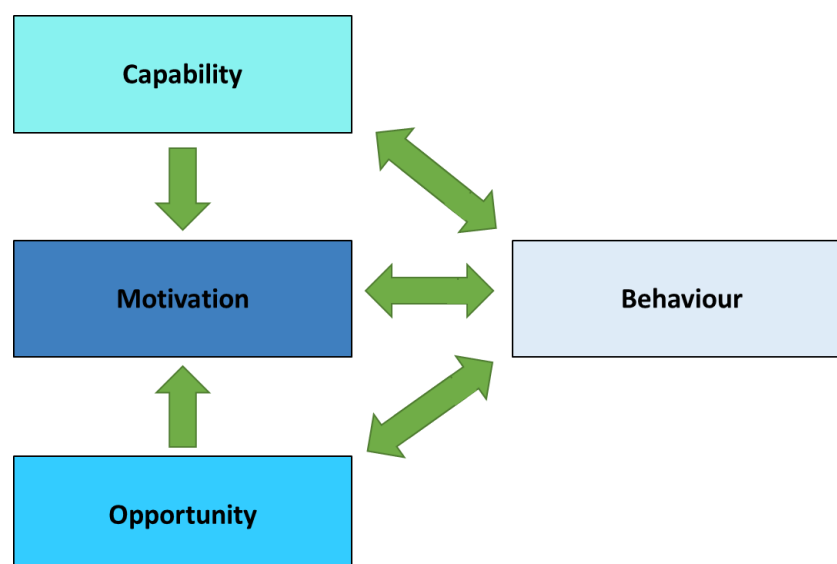
Figure 1. The COM-B Model (Michie et al., 2011).

Capability is related to the individual person's ability, both psychological and physical, to show the relevant behaviour, it describes psychological capability like knowledge, skill, memory or attention as well as physical capability like fitness level or not being hindered by an impairment. Opportunity describes factors that lie in the environment of the person which make a specific behaviour possible; it is related to both an individual's social and physical opportunity. Opportunity is not necessarily in the person's control, for example, living in an area with good public transport. Motivation relates to motivational processes as well as to habits, emotional responses or conscious decisions, it includes both automatic and reflective motivational processes. The COM-B model was also included in a behaviour change wheel (BCW) that already referenced different types of interventions (e.g. training, restrictions) and policy categories (e.g. guidelines, regulation) (Michie et al., 2011). In addition, the Behaviour Change Technique Taxonomy v1 (BCTTv1) has been developed, which can be described as a fusion of the COM-B model with the Theoretical Domains Framework (TDF) (Cane et al., 2012). The BCTTv1 is a collection of 93 different behaviour change techniques that are grouped into 16 categories. The behaviour change techniques are the 'active ingredients' of behaviour change interventions (Scott et al., 2020). The BCTTv1 can be used for coding interventions (e.g. in a review or meta-analysis), but more importantly to our case, it can also be used for designing effective interventions. Indeed, it has been shown that interventions that are based on behaviour change techniques are more effective than those which are not (Dombrowski et al., 2010; Michie et al., 2009).

6.1   COM-B Model in the mobility field

The COM-B model and the BCTTv1 are not meant to be just theoretical models where reality might fit to certain degree or that are oversimplifications of actual behaviour, which is a common critique of the theory of planned behaviour. They are meant to be tools for designing and implementing interventions, and this has been done in the domain of (public) health for years (Gould et al., 2017; Munir et al., 2018). Instead of introducing yet another new or altered model of mobility behaviour, maybe it is time to borrow from other disciplines that have designed have been designing interventions for decades. Adopting the COM-B model in the face of a lack of theories in mobility behaviour change has already been suggested some years ago (Arnott et al., 2014). However, to our knowledge, the model has not been applied so far to motivate people to use more sustainable forms of transport, but a recent study used it to design effective messages to provide safe travels within potentially crowded public transport during the COVID-19 pandemic (Krusche et al., 2022). The COM-B model and its components stem from the field of public health, but its elements certainly also fit for mobility behaviour, as it is a general model for describing behaviour change. With the help of the BCTTv1, various interventions can be screened and implemented.

6.2   Capability, opportunity and motivation for sustainable mobility

One strength of the COM-B model is the focus on the three different elements that can be addressed. Figure 2 gives an example of how considering capability, opportunity and motivation could lead to using a bicycle instead of the car for a commute to work.
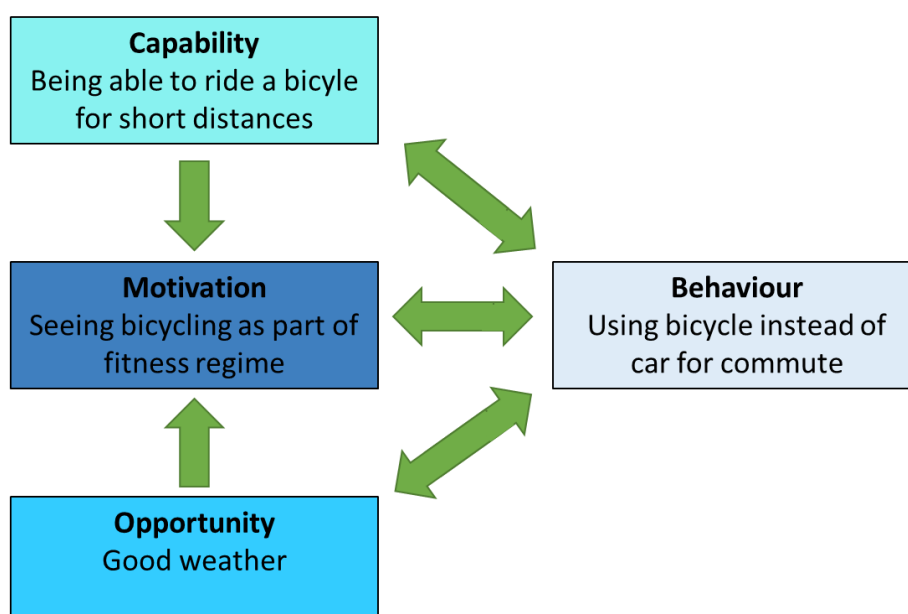

Figure 2. Exemplary interaction of opportunity, capability and motivation for changed mobility behaviour (adaption of the COM-B model for the mobility field).

As proposed by the model, the elements individually as well as in combination could lead to changed behaviour (i.e. switching from car use to bicycle), however, the strongest effect would probably be achieved if all elements occur at the same time, that is, a person is motivated, capable and has the opportunity. For designing the intervention, the intervention should focus on influencing these elements while being realistic regarding what can be targeted. Does the intervention need to focus on the social or physical environment of people, is it a physical or psychological capability, or is it a matter of motivation? Just like in the field of public health, it is important for changing mobility behaviour to reflect on what the focus of an intervention is: If there is no sufficient public transport in an area (e.g. few bus lines with irregular or unreliable schedules), no matter how much motivation is targeted, there will not be much changed mobility behaviour. It would be more realistic to focus on providing or making people aware of better or different opportunities, before adding motivational elements. Similarly, if there is good bicycling infrastructure, but the target group lacks the capability to ride a bicycle, targeting motivation might only help if people are encouraged to partake in lessons to learn bicycling (i.e. acquire a new capability). Specifying the wanted target behaviour and clearly identifying if barriers to this behaviour stem from capability, motivation or opportunity are central for working with the COM-B model. It is also important to analyze what barriers people currently face regarding the three different elements; Table 1 gives examples for the elements that are hindering people to use more sustainable forms of transport.

Table 1. Barriers to changing mobility behaviour from car use to more sustainable alternative mobility choices as derived from the COM-B model.

COM-B element	Factors	Examples of barriers
Capability	Physical	o Not skilled to ride a bicycle o A physical disability o Low level of fitness, e.g. feeling tired after a longer walk
	Psychological	o Not knowing how to buy a ticket o Finding bus plans and connections too difficult to understand o Not knowing where to safely store a bicycle
Opportunity	Physical	o No safe bicycle lanes or walking routes o Rain or snowfall o No reliable public transport available
	Social	o Having small children or elderly family members to take care of o Bicycling to the office seems not to fit with professional status o Car use is prevalent among peers
Motivation	Reflective or automated	o Negative opinions about public transport o Positive emotions connected to using the car o Not wanting to waste time in public transport or walking

The focus of interventions are of course different for various stakeholders: Cities might be able to change physical opportunities by changing infrastructure or public transport policies, research projects might target motivation through 'soft' interventions, grass-roots initiatives might focus on capabilities of people by offering training (e.g., a course to learn bicycling). In addition, it has been pointed out that a change in physical environment (e.g., a new segregated bicycle lane) might lead to a change in judgment of this environment (Panter et al., 2017). Therefore, working with the COM-B model can also help taking account of the complex interaction between the environment and its perception.

Another interesting facet where the COM-B model can contribute is the role of situational factors. Especially when it comes to active mobility such as walking or bicycling, situational factors like weather are important for decisions. Similarly to just-in-time adaptive interventions in health (Nahum-Shani et al., 2018), which select the appropriate timing for

delivering a behaviour change intervention, this can also be utilized for the mobility field. For example, when working in a digital context, reminders, information, or social comparison could be delivered when the weather outside is good, promoting an immediate decision to walk or bicycle instead of postponing it. This aspect of situation-awareness could be used to help any of the other behaviour change techniques for finding the perfect timing.

6.3 Example of using the COM-B model in practice

The following fictitious example illustrates how the COM-B model can be used in practice. A company wants to contribute to environmental sustainability and decides to encourage their employees to bicycle to work. The human resources department sets up a virtual challenge for employees to take part in: Each kilometer bicycled is rewarded with a point, and those having collected most are recognized within the company as "bicyclists of the month". However, after a while human resources realizes that only employees who have already been avid bicyclists are actively participating, there is not much engagement from other employees.

Using the COM-B model, this company would have specified their target behaviour more thoroughly, that is, the goal behaviour is a switch from using the car to bicycling instead of getting people who bicycle already to make even more kilometers. From this, the company could have written out the potential barriers that people who still choose their car every day would face: For example, people do not see themselves as someone who regularly rides a bicycle (motivation), they do not like to be sweaty when arriving at work (capability, motivation), they do not feel safe on the bicycle (capability) or on the road (opportunity) or they have to bring their kids to school on their way to work (opportunity). With this analysis, the company could use behaviour change techniques (as noted in the BCTTv1) to target the barriers: Showing employees how many others in the company are using a bicycle (e.g. via display on a website or an app), building a community of bicyclists who can share information and tips for cycling safely, offering a room for taking a shower to feel fresh after bicycling to the company, rewarding employees who shift to and maintain bicycling. Interventions could also be delivered within a time-frame of optimal opportunity (situation-awareness), for example, the warmer summer months, a week without rain, or when new bicycle lanes have just opened. Not all barriers can be removed by the company (e.g. lack of safe bicycle lanes), so it is important to focus on where this is possible.

7 Conclusion

Interventions to encourage people to use sustainable modes of mobility more often are certainly needed, especially in the face of climate change, but reducing car traffic, emissions

and noise can also make cities more liveable places. With the wide use and possibilities offered especially by mobile devices, there have been considerable efforts already in the mobility field to change behaviours with digital interventions. However, the efforts are often not as effective as they could be, because many of the interventions operate without any theoretical model of behaviour change. We argue that effectiveness in this field does not primarily depend on particular behaviour change interventions that should be pursued, but rather future interventions should be firmly rooted in appropriate theories. For effective interventions one can certainly rely on already existing theoretical models that have proven useful for implementation, such as the COM-B model. Together with the Behaviour Change Technique Taxonomy (BCTTv1), this model can help in determining which element that leads to behaviour (i.e. capability, opportunity, motivation) can and should be targeted with an intervention, and then specific interventions can be designed. This will be an excellent starting point for designing interventions for the mobility field.

8   Using the COM-B model as framework in the DyMoN project

The COM-B model will serve as theoretical behaviour change model for the DyMoN project, and for designing the (digital) behaviour change interventions aimed to encourage less car use in favour of more sustainable mobility modes.

- For the design of the nudging repository, which is a set of possible, situation-aware behaviour change techniques that are delivered via an app to citizens, the BCTTv1 is being used. Each behaviour change technique (i.e. the "nudges") is also categorized whether it targets capability, motivation or opportunity. As the nudges will be delivered in a digital format, in the form of notifications or features within an app, the possibilities are of course limited. Most of the interventions in the nudging repository focus on motivation or capability, some of them on opportunity. However, the situation-awareness can be combined with these interventions as the additional element of opportunity.

- For the DyMoN handbook for city representatives, the COM-B model will be introduced as theoretical framework, and city representatives will be encouraged to think about all three elements when selecting or designing new behaviour change interventions. However, it is important to underline that a lack of one element (e.g. no suitable public transport) will mean a limited effect on changing behaviour. Therefore, nudges or behaviour change techniques cannot be regarded as a compensation for lack of infrastructure or other appropriate opportunities which lie outside of what an individual

person can change. However, cities have the possibility to offer these opportunities, something that research projects or grassroots organizations can only advise on.

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