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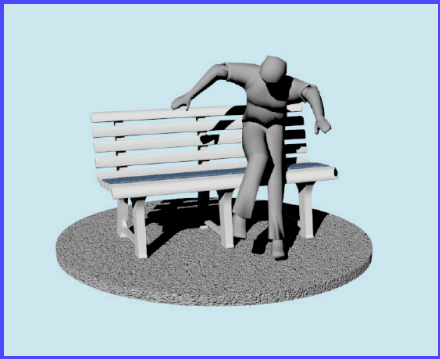

Smart Bench:
A speculative design to create critical awareness of Data-driven Nudging in the Smart City

Colophon

Project

Smart Bench:
A Speculative Design to Create Critical Awareness of Data-driven Nudging in the Smart City

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Project Summary

The Smart Bench is a speculative design aiming to create critical awareness about the social implications of Data-driven Nudging in the Smart City.

The project originated from a critical perspective on Smart City as a leading urban development paradigm. Many cities labelling themselves as smart cities competitively implemented advanced technologies like artificial intelligence (AI), pervasive sensor networks, or internet of things (IoT) for infrastructural or economic purposes (Kitchin et al, 2015; Townsend, 2013). This enabled ubiquitous extraction and monitoring of urban behavioral data, facilitating more efficient, resilient, and frictionless urban governance.

Data-driven nudging emerged as vast aggregate of citizen behavioral insights became available to be implemented into the concept of 'nudge', a libertarian paternalistic strategy of behavior change (Ranchordás, 2019; Thaler & Sunstein, 2008). Citizen behaviors can be steered more elaborately through targeted and dynamic adjustment of choice architecture enabled by development of analytical algorithms. Pervasively embedded network of urban sensors has made this new type of nudge more invisible, thus more powerful. Hence, data-driven nudging is raising ethical concerns in terms of behavioral manipulation, ubiquitous surveillance, and urban depoliticisation (Kitchin et al, 2015; Lanzing, 2018; Ranchordás, 2019; Void et al, 2018; Yeung, 2016). Making matters worse, citizens's level of awareness not only on data-driven nudging itself but also on smart city in general turned out to be significantly lacking (Government Europa, 2018; Jameson et al, 2019).

The project addresses the lack of awareness of the presence of data-driven nudging and its social implications by designing a speculative experience of Smart Bench. The Smart Bench is an intelligent bench which is designed to nudge citizen behaviors according to a predetermined algorithm. Because smart technologies tend to reproduce pre-existing prevailing biases, the purpose of the design is to make them experiential to the general public. Participants are invited to try out the bench and a special interface where they could take a look at the software principles behind it and have a unique opportunity to adjust the nudging algorithm for others. As they proceed along the experience, participants can experience the discriminatory implications of data-driven nudging and openly discuss its application for urban governance.

The evaluation results confirmed a fruitful capacity of speculative design in terms of materialising an abstract unfamiliar concept and evoking critical awareness on its potential implications. Most of all, the design provided participants with a space for open discussions about the necessity of data-driven nudging for urban governance and further reflect on pre-existing discrimination in our current society.

Executive Summary

The entire process of the project is divided into four phases based on Double-Diamond structure (Figure 1). The project started on 17th of September 2019 and ended on 29th of April 2020.

1. Discover (DS): Foundational research was conducted. Initially, a primary research was conducted regarding the topic of the Smart City in general. This research involved investigating various academic papers, books, essays, lectures, and news articles. During this phase, I aimed to explore essential issues surrounding smart cities together with their association with the technological development and to detect driving factors, concerns, opportunities, and the effects of them. Based on this primary research, data-driven nudging (DDN) was identified as an important element dominating the operational logic of smart cities which is likely to have significant impact on people's daily lives. Thus, the secondary research focused on DDN in smart cities.
2. Define (DF): DDN's definition, its essential qualities, specification, and its social implications were identified and a conceptual framework was formulated based on this. Citizens' lack of awareness on potential social implications of DDN was defined as the main problem to be addressed through the project. Speculative and Critical Design (SCD) was selected as a relevant design approach and design space was formulated by determining design goals, effects, requirements, and target context.
3. Develop (DV): Several design elements were explored during this phase to identify relevant narrative theme and interaction for the speculative experience. Controversial urban behaviors were identified to be used as a narrative theme of the experience. Various concepts were ideated and possible data proxies were explored. Eventually, the concept with an interaction strategy that best meets the design goals and requirements was chosen to be further developed.

4. Deliver (DL): The final concept of Smart Bench and Algorithmic Interface was further developed and refined. User experience was evaluated through iterative interface testing. The bench's physical form and technical wiring of different sensors and actuators were carried out. Unfortunately, due to COVID-19 outbreak, the final prototype evaluation initially planned to be conducted at IDE Faculty of TU Delft was substituted with remote online evaluation session. With the simulated experience of Smart Bench and the interface, the final prototype was evaluated and analysed generating numerous insights regarding the possibility of speculative artefact in evoking critical awareness about abstract concept of DDN.

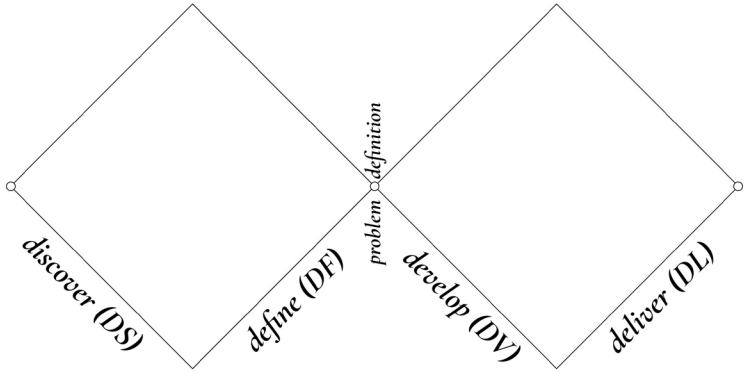

Figure 1. Double-diamond structure

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1 INTRODUCTION

1.1 Smart City: A Mythical Existence

Over the last decade or so, Smart City has become the leading urban development paradigm throughout the world (Hollands, 2008; Kitchen et al, 2015; Townsend, 2013). Often in collaboration with big tech corporations, increasing number of cities are designating themselves as "smart". This trend is quite understandable given the benefits this smart transformation presents to the cities. Many Smart City initiatives promote themselves with promises of economic revenues ranging from influx of foreign businesses, local employment opportunities, and more talented work force (Sadowski, 2016). Implementation of advanced technologies, one of the key elements of these initiatives, is recognized as reassuring virtue to become a globally competitive city with future prosperity (Hollands, 2008). Despite smart city's somewhat experimental nature, mentioned alleged advantages are attractive enough to compel many cities to dream up their new era with this smart urban transformation.

As forecasted already in 1997 at World Forum on smart cities, countless examples of new smart cities have been created universally with one-size-fits-all model in various scopes (Kitchin,2015). Some cities, like Songdo or Dholera, were built from the scratch powered by the initiatives of the central government. They materialised fictional imageries of frictionless, automated future cities (Poole, 2014). Meantime, in other cities, like London or Amsterdam, municipalities are at the center of the initiative exploring smart ways to implement new technologies. Cities play a role as a 'living lab' where various experiments are carried out and the list of cities born or renewed into smart cities is increasing steadily. China started its own 500 smart city pilot projects, India is aiming to build 100 smart cities, and Saudi Arabia declared to put $500 billion in building a Middle Eastern Silicon Valley which will be 33 times the size of New York City (Wainwright, 2019).

Figure 2. A scenery of the first Smart City : A crowd watches a newly erected automated traffic lights at Ludgate Circus, London, in 1931

<source: https://www.theguardian.com/cities/2014/dec/17/truth-smart-city-destroy-democracy-urban-thinkers-buzzphrase >

Figure 3. A Futuristic Image of Songdo Smart City

<source: https://www.businessdestinations.com/featured/south-koreas-songdo-city/>

As stated so far, it is hard to miss news articles or tech magazines' reports about smart cities. Technologically advanced societies are today surrounded by futuristic cyanic imageries of smart cities and we can name numerous example projects and initiatives thereof (Figure 3). But still, it is difficult to pinpoint what exactly the Smart City stands for (de Waal & Dignum, 2017; Jewell, 2018; Kitchen et al, 2015; Ranchordás, 2019; Townsend, 2013). Many researchers concur the hardship of identifying fundamental prerequisites of a Smart City. To quote Anthony Townsend, the word 'smart city' has become one of the "vaguely evocative terms that no one bothers to translate" (Townsend, 2013, p. 15). Then what are the aspects that make the Smart City such an ambiguous concept that resists a singular definition?

The uncertainty surrounding the Smart City stems from its idealised, ambiguous, and invisible quality, which can be summarised by the term 'mythical'. Its mythical existence arises from these three core qualities of the Smart city: extensive and idealised narrative, unclarity of the agency, and invisibility of the technical infrastructure. In the following I will touch upon these qualities through three specific aspects: the ambiguity of different definitions, corporatisation of the cities, and digitisation of the infrastructure.

Ambiguous Definitions of 'Smartness'

As cities are more and compelled to compete with other cities for flows of people, resources, and capital, they become increasingly compelled to stay with up to date with the latest trends and search for their own unique selling point. This trend comes as a result of the increasing hegemony of neoliberal ideology. As national governments withdrawing financial support to local governments, compelling cities to seek for their own identity and competitively market brand themselves (Hetherington & Cronin, 2008). Each city's interpretation of 'smartness' is influenced by their local identity, which encompasses their particular hopes, fears and

corresponding urban development visions. This results in the current situation where countless cities are labelling themselves as a 'smart city', while actually meaning different definitions of smartness. At the moment, the term 'smart' entails a wide variety of connotations: creative, entrepreneurial, innovative, metropolitan, intelligent, and so on (de Waal & Dignum, 2017; Hollands, 2008).

However, this imprecise interpretation of smart city formulates certain self-congratulatory assumptions (Hollands, 2008). Supported by its pro-business and neoliberal mentality, smart cities market themselves in euphemism of growth. Their top-down style development also reinforces the assumption that some sort of community 'consensus' already exists on positive effects of the smart city. It plants a false assumption that becoming a smart city will solve any urban problem, taking advantage of smart city's futuristic images cluttered with various adjectives like 'cyber', 'digital', 'intelligent', or the latest rookie, 'eco-' (Greenfield, 2013; Sadowski, 2016). These ideologically laden terms tend to obscure societal problems such as unemployment of the digitally illiterate, gentrification, social polarisation, excessive power consumption, etc., as well as their banal material realities such as cables and data centers (de Waal & Dignum, 2017). Thus, the ambiguous definition of the smart city downplays potential side effects and promotes people to overlook alternative critiques, eventually formulating an idealised narrative of a future city full of positive and uncritical suppositions.

Corporatisation of Cities

The concept of the Smart City considerably runs on a logic of efficiency to increase the local economic performance, This promotes cities to become entrepreneurial and pragmatic for the purpose of enticing potential business partnerships. As it is obvious from many smart cities' collaboration with multinational tech-conglomerates like IBM, Cisco, Siemens, or Google, distinction between public and private sector is

rapidly being obscured. Corporations are involved in smart city projects rather continuously, acting as a vendor, builder, and maintenance entity for their city-clients (Sadowski, 2016).

To boost up the development, cities often initiate projects that share comparable characteristics with what Easterling (2014) calls the "free zone", not only in terms of capital but also as to citizen data and information. Like the examples of New Songdo City of South Korea or King Abdullah Economic City of Saudi Arabia, some smart cities go hand in hand with the economical free zone where foreign capitals can easily penetrate through various deregulations, tax exemptions, and cheap labor (Easterling, 2014). Furthermore, a mutational version of the free zone, so-called, cities as living laboratories emerged in the realm of information and data science (Schinkel, 2016). City labs represent deregulation of informational access where corporations obtain possibilities for mobilizing urban data for smart experimentations, demos, and testings.

As many smart city projects' identity grow more and more hybrid, agency of various smart transformations become unknown and inexplicit. Namely, the entity in charge is not clear anymore. It is very difficult to tell whether certain smart city project is held by a government initiative or a public-private partnership, or is outsourced to a private company. This new formula of entity is what Keller Easterling (2014) specified in her book as Extrastatecraft, which is the often undisclosed activities outside of, in addition to, and sometimes even in partnership with statecraft. Corporatisation of the smart cities pave the way for the extrastatecraft to permeate all kinds of infrastructure spaces, changing urban spaces into pseudo-public space (Jameson et al, 2019). It also solidifies the relationship between a city and citizens into that of 'service provider' and 'consumer' because the general confusion over the agency of the action - issues like who is responsible, who owns the project, or who funded it, etc - raises the barrier for citizen participation.

Digitisation of Infrastructure

One of the major changes that take place as cities become smart is the informational systematisation of the urban infrastructure[1]. Due to the development of Information and Communications Technology (ICT), infrastructure components can not only communicate more rapidly with their respective control centers but also between themselves. Vast units of physical components and resources can be remotely controlled and their repetitive employment can be easily automated. Thus, through the digitisation of urban infrastructure, cities could manage it more precisely and more comprehensively.

Boosted by technological development, urban infrastructure's function is being extended to data proxies, generating an informational surplus. They no longer function as a mere physical space, but a platform, on which various miniaturised sensors continuously collect information and communicate digitally encoded data through the wireless networks (Easterling, 2014). Since these informational surpluses are regarded as a prerequisite for maximum efficiency and cost reduction, cities actively invest in implementing advanced technologies like Artificial Intelligence (AI) making their systems even "smarter". Infrastructures as platforms are constantly being patched and updated behind the scene with new functions, increasing an overall dependency on software (Townsend, 2013).

Dispositional transformation of urban infrastructures towards a software-based coded platform makes their existence less visible to citizens who are not decision-makers themselves. So to speak, for them, it is not what it looks like anymore. A function of a mere street is no longer fully comprehensible, which traditionally is to carry traffic and provide public spaces for interaction. Newly added functions, such as traffic flow supervision or crime prevention,

1 Urban infrastructure here signifies both built environment (such as buildings, roads, bridges, tunnels, pipelines, electrical and communication cables, etc) and transports (such as trains, buses, boats, etc)

hide behind the traditional function, making it difficult for people to know what each infrastructure is actually doing. The cause and condition of the problem remains unknown to ordinary citizens, having no choice but to wait until the system is finally fixed or refreshed (Kitchin et al, 2015).

1.2 Smart Technologies: Towards the society of ubiquitous monitoring of urban behavior

While the definition of Smart city remains arcane, there is a general consensus over viewing the implementation of smart technologies as a common constituent of a smart city (Hollands, 2008; Kitchen et al, 2015; de Waal & Dignum, 2017; Townsend 2013; Ranchordás, 2019; Sadowski, 2016). Smart technologies refer to various advanced technologies developed based on present day ICT communication infrastructure. They comprise of both computational technologies like Artificial Intelligence (AI), Machine Learning (ML), blockchain, virtual reality (VR), augmented reality (AR) and augmented hardwares like Internet of Things (IoT) and wearable sensors such as a police officer's body cam. To reach their urban ideals, cities actively implement smart technologies in every nook and corner of their urban environment as Adam Greenfield described it as 'everyware'.

The application of smart technologies enables far more efficient urban governance through the quantification of numerous urban phenomena. Cities can now collect, communicate, and "crunch" (analyse) formerly indeterminate data and turn them into meaningful information that can be applied to numerous urban affairs ranging from public health to waste disposal (Consult Australia, 2018). For instance, due to development of computer vision - a field of AI specialized in visual analysis - a simple surveillance camera footage data can be segmentally analysed and extract a variety of information like time-specific crowdedness, travelling speed, pedestrians' age, gender, or technically, even their identity.

Furthermore, due to rapid technological development the capacity of ubiquitous monitoring is being enhanced beyond the level of present urban phenomena overview. Increased capacity of continuous data accumulation and the development of analytic softwares are generating information about information. With the help of corporate technology partnership, cities can identify patterns or correlations of these urban information which are utilized to develop predictive algorithms, opening up a possibility of ultimate efficiency and more detailed control (Townsend, 2013). Thus, smart technologies are transforming smart governance into another level of algorithmic governance, enabling cities to monitor the urban environment more systematically and prevent undesirable upcoming urban phenomena as well.

Citizen behavior has emerged as a valuable data source along with city environmental data which can be collected, communicated, and analysed for more efficient urban governance. This has multiple reasons. First of all, municipalities can make use of citizen behavioral data as a reliable ground for urban decision-making. Previously indistinguishable micro-interactions of people can be now numerically quantified and produce actionable insights that can solve certain urban problems. Since data considers itself as neutral, cities are embracing behavioral data and insights as fair warrants for their decisions. These urban solutions are often mistakenly supposed to be free from ideology (de Waal & Dignum, 2017). As geographer Rob Kitchin puts it, data 'are capta, meaning they are actively captured, not simply found as givens' (Schinkel, 2016). Furthermore, through ubiquitous monitoring of citizen behavior and pattern analysis, cities can obtain an overview on significant variables affecting urban management. Cities invest in smart city technology to increase their resilience in anticipation of various crises. Last but not least, behavioral insights enabled efficient and frictionless urban behavior change without

evoking unnecessary disagreement or confrontation (Boyer, 2015; Jewell, 2018). Since decision-makers can comprehend the cause of certain local problems based on data, they can deploy subtle interventions - instead of heavy sanction - to resolve undesirable consequences in a more cost-effective way.

Data-driven Nudging (DDN) emerged as a concept of urban governance that encompasses both operational logic of smart cities and intensive application of behavioral data. It is a recent strategy for urban behavior change which is implemented to address social, economic, and environmental issues by efficiently optimising citizen behavior. In the following chapter, DDN will be investigated in depth from its definition, operational principles, implementation, and its social implications.

2

DATA-DRIVEN NUDGING AND THE SMART CITY

Cities have been using the strategy of nudge, adjusting the choice architecture of citizens to elicit their behavioral change for the sake of desirable urban environment. As these cities become smarter, their nudging strategy also becomes more sophisticated. There is a clear tendency of integrating data science and ICTs with nudge, prompting an advanced version of nudging - defined as DDN in this project. DDN opens up possibilities for cities to change citizen behaviors more efficiently through their pervasive infrastructure of smart technologies. It enables a more targeted and responsive nudge with increased subtlety, making the process of behavior change even more seamless and frictionless compared to more traditional nudging strategies to affect the choice architecture. With the power of predictive analytics and big data, it is highly probable that the intelligent nudge can be fully automated in a near future.

The shift towards DDN will patently have considerable impact on people's daily lives. Several ethical concerns are already being raised within academia. However, due to its hidden inscrutable nature, it is very difficult for ordinary citizens to be aware of it. Lack of open social discussion with citizen involvement worsens the absence of awareness. This chapter unravels what DDN is and how it is implemented in smart cities, analysing it with multiple perspectives. The main characterisation of DDN is translated into a conceptual framework, which will be applied in the design phase. The potential social implications of DDN are explored as well to determine the problem scope and approach which will be further elaborated in the next chapter.

2.1 Behavior Change

Nudging and Choice Architecture

The concept of 'Nudge' first came into definition by an economist Richard Thaler and a legal scholar Cass Sunstein. Nudge is defined as any aspect of choice architecture - an arranged context in which people make choices - that changes people's behavior in a predictable way (Thaler & Sunstein, 2008). It differentiates itself from other traditional means of behavior change strategies like prohibition, sanction, in that nudge is a non-regulatory measure. Nudge adjusts the way in which choices are presented without reducing or eliminating any option, so it remains to be easy and cheap for the subject - the nudgee - to bypass (Lanzing, 2018; Ranchordás, 2019). For example, school cafeterias implementing nudge will adjust the order in which the food is presented, instead of banning the consumption of fatty and sugary food on the premises (Thaler & Sunstein, 2008). Since interventions that are accounted as nudge are not carried out in a direct and immediate manner, nudge's application is usually unnoticeable and intentions are not transparent in principle.

The basic premise of nudge is that humans make bad decisions due to their cognitive biases (Thaler & Sunstein, 2008; Ranchordás, 2019). Despite their ability of logical thinking and reasoning, human predictions are usually biased and flawed within the context of choice making, leading to wrong decisions. Nudge acknowledges this irrationality and utilises human biases and fallacies, like status-quo bias, in making desirable options easier to be chosen by people. Intentionally setting the desirable option as a default is a good example of bias utilisation. It uses the human tendency of inertia which leads people to just go for the default option without carefully examining the other options (Ranchordás, 2019; Li et al, 2018; Void et al, 2018).

Nudge earned considerable interests outside of the academia and private sector as well. It has been actively implemented in public policies

and urban governance under the name of libertarian paternalism: the idea that it is possible to influence people's behavior for better consequences while still preserving their freedom of choice (Thaler & Sunstein, 2008). This is in line with cities' recent shift towards neoliberal rationality and the shift towards a managerial mode of governance (Harvey, 1990). Neoliberal cities seek to solve their urban problems using the 'model of the market' while the spirit of nudge optimizes citizens' behavior, thereby returning high efficacy with surprising then that both smart city's promises, increased performance and efficiency, and its methods, such as nudging, match well with cities' neoliberal mode of the governance (Sadowski, 2016).

2.2 Understanding Data-driven Nudging

What is Data-driven Nudging (DDN)?

During the last decade, cities witnessed how private corporations have improved their performance using DDN and recognised its powerful potential in changing citizen behaviors with low cost (Ranchordás, 2019). Nudge became more systematic through the integration of behavioral insights with digital technologies and data science (Yeung, 2016). The usage of vastly accumulated pool of urban data plays an important role in this new type of nudging. Behavioral assumptions or evidence are gathered through the collection, calibration, analysis, and interpretation of urban data which comprise of both individual data and environmental data. Information about citizens' behavioral insights can be continuously updated and expanded through the feedback loop in which nudging data and people's resulting behavioral choices are used to enhance the accuracy of the nudge (Lanzing, 2018).

Since DDN is a recently concept, there are still various terminologies

and definitions referring to it. Listed below are some of the terminologies that are frequently mentioned in the literature.

- **DDN (Data-driven Nudging):** Nudging based on big datasets containing citizens' behavioral insights enabling more accurate and systemetic behavior change (Ranchordás, 2019)
- **Hypernudge/Hypernudging:** The algorithmic real-time personalisation and reconfiguration of choice architectures based on large aggregates of data (Yeung, 2016; Lanzing, 2018)
- **Data-driven targeting:** A change of choice architecture supported with various forms of technology that collects vast amount of data about individuals' lives (Void et al, 2018)
- **Persuasive profiling:** A collection and application of a profile, indicating which influence principles are expected to be most effective for specific individual, to achieve her change of behavior (Kaptein et al, 2015)

Among these terminologies, Sofia Ranchordás's term, 'DDN' was chosen as a main term which will be continuously used in this project since it successfully entails both properties of nudge and the intensive utilisation of big data, which is the common defining element of all the terms listed above.

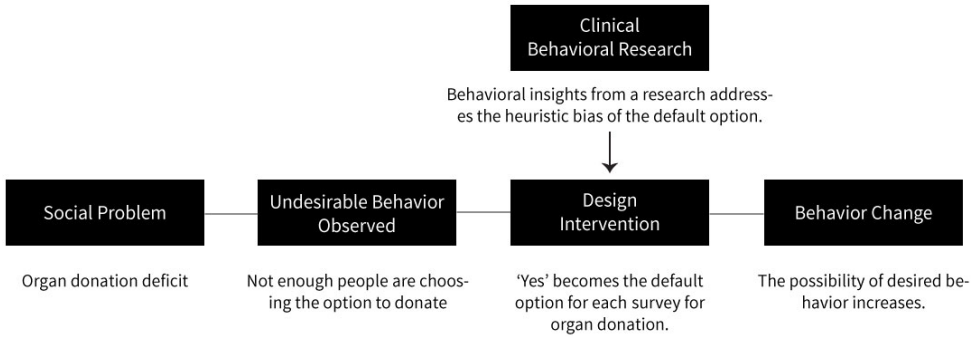
To locate main characterisation of DDN, its qualitative specifications were mapped out in comparison with the regular nudging and speculative future state of automated regulation (Figure 4). The figure clarifies the distinction between the regular nudging and DDN, further conjecturing how it can progress towards a probable format of future nudge.

As it is shown in the figure, regular nudging and DDN share similarities in its core objective and partial warrant. Their objective is both to change people's behavior without enforcement to better manage

	REGULAR NUDGING	DATA-DRIVEN NUDGING	AUTOMATED REGULATION
HUMAN AGENCY	Exists. Citizens make final choices.	Less so. Choice architecture further narrowed down while citizens are not aware of it.	None. Individual choices no longer exist. Society's operation in full automation.
OBJECTIVE	To change people's behavior without enforcement		To maintain automated 'goodness'
WARRANT OF NUDGING	Clinical prediction based on academic research, experience, or anecdotal pieces of infromation	Real Time Data + Clinical prediction based on data chains of executed nudge - behavioral result - improved version of nudge	Unsupervised Self-learning Algorithm Newly generated data become automatically synthesized into a self-improvable regulatory artificial intelligence
INTERACTIVITY	Static	Dynamic, Responsive	Fully Responsive or even Proactive
APPLICATION	One size fits all	Personalised (Targeted Crowd)	Personalised (Individual Level)
VISIBILITY	Subtle yet sightable if slight attention paid	Invisible and uncertain existence	Invisible but tacitly apparent
EXAMPLES	Displaying healthier items on people's eye level Setting the default option as 'yes' whileinquiring people for organ donation	Installation of pop-up prompt in the GP referral system to reduce the waiting time Changing the street lighting and diffusing a specific scent to mitigate aggressive behaviors	-

Figure 4. Chronological evolution of nudge and respective qualitative specifications

Regular Nudge



Data-driven Nudging

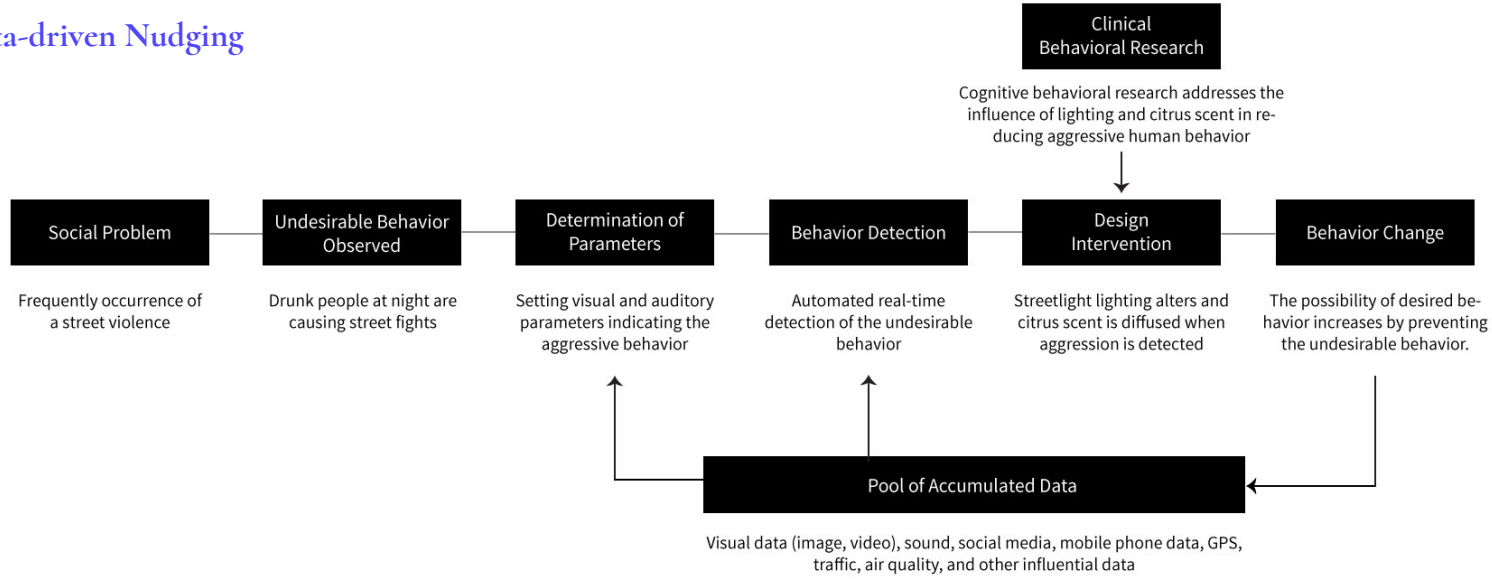


Figure 5. Different operational process of Regular Nudging and Data-driven Nudging

a collective problem (Yeung, 2016). They aim to achieve a set of allegedly[1] socially positive outcomes like improved citizen welfare, economical usage of urban infrastructure, energy conservation, cybersecurity, and so forth. In terms of warrant, DDN has extra source of behavioral insights than the regular nudging. While the regular nudging mainly take academic research results proved by cognitive experiments, anecdotes, and heuristic experience as its logical basis, DDN adds real-time behavioral data to this. In DDN, clinical predictions being used as a complementary basis, real time big data formulates a continuously updating informational choice architecture formulating a data chain, a looping sequence of data-processing. The process uses analytical softwares like machine learning to discover patterns and correlations and converts them into behavioral knowledge which will be in turn applied to improve the DDN (Yeung, 2016; Kaptein et al, 2015). Figure 5 on the previous pages depicts the different processes of the regular nudging and DDN using their respective examples.

Since implementation of smart technologies and big data endows unique qualities to DDN compared to its former, it has patently become more sophisticated, invasive, and powerful. Fundamentally, 'good nudges' should be sightable, easy and cheap to opt out if wanted, and capable of maintaining the good faith that the desired behavior will be better for the nudgee's welfare (Thaler & Sunstein, 2008). However, several characteristics of DDN point out that there is a widening gap between DDN and the good nudge (Lanzing, 2018). Since DDN incorporates the usage of built-in sensors and actuators, the nudges are mostly invisible to the nudgees. Second of all, opting out is as well difficult in this type of nudging because its existence is either too subtle to be noticed in the first place by nudgees or too sophisticated and responsive to escape (Ranchordás, 2019). The capacity of DDN is rapidly expanding along with

1 The reason why it says 'allegedly' here will be elaborated in detail in the subsection: depoliticisation of Section 2.4

the development of real-time data processing and predictive analytics, narrowing down the possible extent of behavioral choices that people can make (Lanzing, 2018; Yeung, 2016). Last but not least, it is hard to gauge whether governmental institutions' intentions and measures are entirely for the good of nudgees. It is because corporates with private interests are likely to be involved in the construction process of supporting technologies like big data driven decision-making algorithms(Kitchin et al, 2015). The involvement of private sector adds confidential quality to the 'black box' nature of the algorithms (Lanzing, 2018; Void et al, 2018). Actual measurements are obscured behind generic long-term objectives of smart city initiatives, preventing citizens to be knowledgeable about its specific operational details or even its existence (Jameson et al, 2019)

As a behavior change strategy

So far, DDN has been analysed from the perspective of nudge as an urban governance strategy. To diversify the understanding of DDN, I also investigated the literature by Nynke Tromp, Paul Hekkert, and Peter-Paul Verbeek which classifies a different set of strategy designs to foster socially responsible behavior based on four different types of influence on user experience (Tromp et al, 2011). Its original purpose is to give designers some guidance about when to apply which strategies, but locating DDN's position within the four types of different influence was useful in understanding it from the perspective of the citizen nudgee, rather than from that of the institutional nudger. Additionally, the literature provides two core dimensions to better elucidate the essence of DDN.

In their article, behavior change strategies are classified in four different types of influence on user experience: coercive, persuasive, seductive, and decisive (Tromp et al, 2011). The classification is based on two dimensions of force and salience. The force represents how weak or strong the strategy is exerting influence and the salience represents how implicit or explicit its influence is. For instance, coercive design is strong

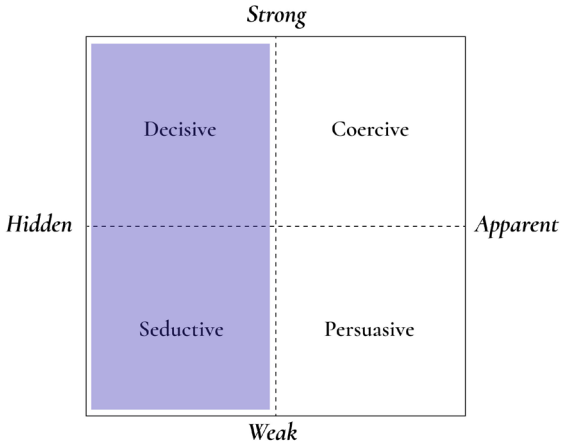


Figure 6. Four Types of Product Influence on User Behavior based on the Dimensions of Force and Salience (Tromp et al, 2011)

and explicit that people are well aware of the influence since it is visible and at the same time, people experience it as inevitable influence, like the example of a speed camera to discourage fast driving.

Since the nature of nudge which focuses on adjusting the decisional choice context rather than per se the choices themselves matches better with the implicit salience, DDN can fall into either categories of seductive design or decisive design. You can say that the influence of seductive design - which is implicit and weak - matches well with the spirit of libertarian paternalism and the epitome of frictionless DDN that many smart cities long for. When people are seduced to change behavior, they are not aware of the influence and they believe that they are behaving according to their own will since the behavioral redirection force was weak to be acknowledged. Decisive design, which is still implicit but has strong force, can represent the transitional state of DDN heading towards the speculative era of automated regulation. Data-driven Nudging and Smart Cities

Data-driven Nudging and Smart Cities

Smart cities are readily incorporating DDN as a complementary measure to boost the efficiency of the urban governance. United Kingdom was the first European country to organise their own Behavioural Insights Team (BIT, also known as 'nudge unit') since 2014, which started as a small unit of public officials, which is now transformed into a social purpose limited company making 14 million pound of profits a year (Quinn, 2018). BIT utilises behavioral psychology to change citizens' habits and actions for successful operation of public policies, such as helping citizens with debt to acquire saving habits or reducing the patient referrals to overbooked hospitals through a pop-up prompt in the referral system. In Boston, the city introduced a real-time mobile driving application called 'Boston's Safest Driver'. It provides a responsive feedback on citizen's driving based on collected personal and traffic data. And it nudges them to drive carefully with weekly incentives (Ranchordás, 2019).

There are several examples of DDN application in smart cities of the Netherlands as well. In Eindhoven, smart lampposts embedded with various urban sensors like wifi-trackers, cameras and 64 microphones were utilised to transform the street of Stratumseind into a safer place (Naafs, 2018). Stratumseind, one of the busiest dutch nightlife streets, has been struggling with frequent fights and disturbance caused by drunk people (Figure 7). To solve this problem, the municipality implemented the smart lamp posts which adjust the light intensity and diffuse the scent of orange to cleverly calm down their aggressive behaviors (Figure 8). The camera sensors were also used to visually analyse the aggressiveness using image recognition technologies and to alert police officers for further action. Meanwhile, Enschede city council has been generating the data chains regarding people's visiting records to their city and locational preferences without their consent (Newsroom Enschede, 2017). In Utrecht, quite nuanced information of youngsters' behaviors - such as the number of

Figure 7. The busiest bar street of Stratumseind

<source: https://indebuurt.nl/eindhoven/wp-content/uploads/2018/11/stratumseind-vroeger-algemeen.jpg>

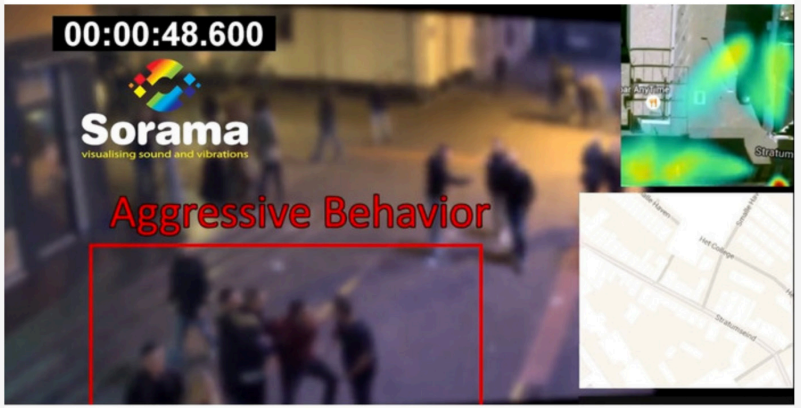


Figure 8. Living Lab Stratumseind recognizes its citizen behavior through smart cameras

<sourc: https://www.ed.nl/eindhoven/netwerk-van-hypermoderne-camera-s-op-stratumseind-in-eindhoven-gaat-politie-helpen~a1e8acee/116086182/>

people, their age group, how close the youngsters are - are collected for the purpose of nuisance prevention and various predictions regarding their school drop-outs or poverty (Naafs, 2018).

And it seems very likely that dutch smart cities' technological capacity will be enhanced as many corporations are trying to import advanced analytical softwares like gait recognition technology, which can identify individuals in real time by the way they walk and move (Giordano, 2019).

2.3 Conceptual Framework

The results of literature research were put together to formulate a conceptual framework which aggregately maps crucial characterisation of DDN. Five interrelated key attributes that distinguish DDN from the regular nudging and other forms of behavior change strategies were identified. Based on different levels of each attribute, various spectrums of DDN could exist, ranging from those that already exists to the speculative form of future DDN.

Objective

The core objective of DDN is to change people's behavior. Usually, it holds somewhat paternalistic purpose of urban welfare promotion such as improving citizens' well-being or economic prosperity and encouraging healthy or sustainable choices (Ranchordás, 2019). There are two directions of urban behavior change: either to encourage the desired behavior or discourage the undesired behavior (Tromp et al, 2011). For instance, a nudge to discourage the undesired behavior of sleeping in the open can be installing benches with a wavy seat (Omidi, 2014). A nudge to encourage the desirable behavior of transportation fare payment can be to endow an additional purpose of a free lottery ticket to people's ticket. Both directions neither punish people for conducting the undesired behavior

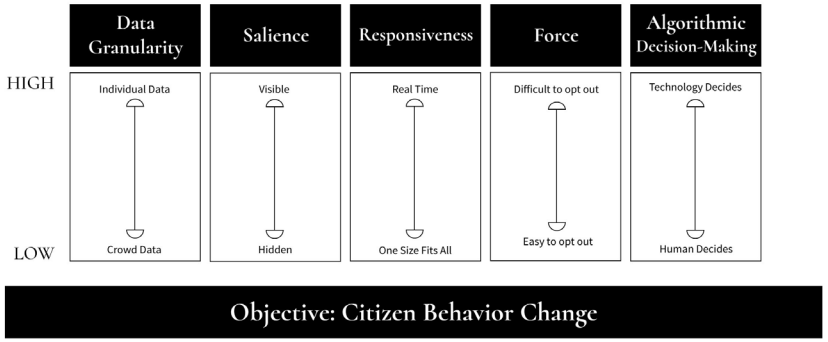


Figure 9. The Conceptual Framework

nor make the desired behavior as mandatory.

Data Granularity

DDN attempts to increase the accuracy of nudge by integrating personal or environmental data in a massive scale, context, and from multiple sources (Yeung, 2016). Data granularity signifies how detailed and nuanced these accumulated data can be: from abstract mass data to targeted crowd data and to personal data. The advancement of data collecting techniques and analytics enhanced the level of data granularity and boosted the possibility of personalised nudging. Nowadays, it is easily understandable that wifi-connected personal phones could be used to infer individuals' detailed activities and intentions (Greenfield, 2013). DDN can discover behavioral patterns and their correlationship with certain categories of population, producing a detailed behavioral profile (Lanzing, 2018; Void et al, 2018; Ranchordás, 2019). However, these profiles can be misleading in a sense that they omit sociopolitical contexts and local interpersonal relationships

regardless of its technological objectivity (Ranchordás, 2019).

Salience

The salience attribute signifies how visible the nudge is. Due to its inherent nature of hiddenness stemming from the application of smart technologies, DDN is prone to have low salience attribute. Highly implicit DDN can reinforce the feeling of fake autonomy, making the nudgee to feel that she is the one who is making her own decisions (Tromp et al, 2011).

Responsiveness

This attribute represents the level of responsiveness in DDN, influenced by its pervasively networked quality, collecting, combining, and analysing urban data real-time (Lanzing, 2018). Integrated with high level of data granularity, DDN can be implemented in a targeted fashion, as opposed to regular nudging which is 'one size fits all'. While regular nudging applies the same intervention to everyone basing on general theories about human behavior, DDN can dynamically alter the actions of specific group of people or individuals (Void et al, 2018). When it is of its maximum level of responsiveness, DDN is not merely real-time but ahead of time, predicting the occurrence of undesirable behaviors in advance to take action. Its accuracy of prediction is more sophisticated compared to that of the regular nudging, since DDN's decisional intervention is designed based not only on clinical predictions based on academic behavioral research, but also by real-time data constantly collected and processed by the predictive analytics (Ranchordás, 2019).

Force

Force attribute represents the intensity of the intervention in terms of steering people's behavior. The possibility to resist the adjusted choice architecture become slimmer as DDN becomes more forceful. When forceful DDN is applied, people will find their behavior as externally

regulated, influencing the perceived level of autonomy. Increased force of DDN is mainly because DDN became more dynamic, powered by its increased level of data granularity and responsiveness, making it harder for citizens to opt out of or contest against the adjusted choice architecture (Yeung, 2016).

Algorithmic Decision-Making

The attribute of algorithmic decision-making signifies DDN's level of dependency on algorithms or analytical software while making certain decisions or deploying nudge to citizens (Jewell, 2018). Surely, a fully automated decision-making system is yet nonexistent speculative future, development of pattern analytics and predictive algorithms is bringing it forward. Nudging strategies and urban decisions were previously determined by researchers and civic servants. But as technology progresses, machines and programs can take over their jobs to some degree. The system can detect citizens' aggressive behavior and trigger sensory actuators to nudge them to calm down. The initial rule base of nudge may be created by human but now, it is the algorithmic system that makes actual decisions using the logic it has synthetically acquired.

2.4 Social Implications

From the perspective of urban governance, DDN provides several benefits. First, it may endow cities with increased resilience to cope with urban crises happening in unprecedented scale and severity. Second, since it enables targeted and real-time nudge with least administrative works, it can reduce the municipal labor budget. By triggering personalised nudge only in corresponding specific contexts, we can save people's time and energy (Void et al, 2018). Last but not least, behavior sensor networks and the technologies of scientific analysis can provide cities with more holistic picture of citizens' lives and needs.

However, on the other hand, DDN's operational principle encapsulated in above mentioned main attributes holds potential social implications. It raises multiple ethical concerns in terms of behavioral manipulation, ubiquitous surveillance, and urban space depoliticisation (Kitchin et al, 2015; Lanzing, 2018; Ranchordás, 2019; Void et al, 2018; Yeung, 2016;).

Decreased Level of Citizen Autonomy

As citizens' behavioral choice architecture is more elaborately designed, DDN can put citizens' autonomy at stake by drastically narrowing down the range of choosable behaviors. Karen Yeung and Marjolein Lanzing elucidates about this issue in detail proposing a concept of decisional privacy which complements the conventional idea of informational privacy[2]. They argue DDN can potentially interfere with individuals' decisional privacy, which is an important right for people to pursue a self-determined life (Lanzing, 2018). Especially, in case of forceful DDN, nudgees' freedom to choose their own behavior, identity, and ways of life without interference is threatened, even though they didn't participant in undesirable behavior themselves (Lanzing, 2018). And without the decisional privacy, it is no longer clear whether people are the agents of their own choice.

Increased Level of Surveillance

Formerly indeterminate data about citizens' whereabouts and behaviors are now not only visible but also can be quantified by the governmental entities. And due to technical collaboration with corporates, people don't have any clue to what extent the access to these data is granted.

Personalised and targeted nudge is economic and convenient but on the other hand, it can threaten the concept of social fairness by creating a new

2 An ability to control who has access to one's personal information and to what extent

form of discrimination (Jameson et al, 2019; Void et al, 2018). It can classify people, through which it can inadvertently disclose socially marginalised people's vulnerable identity or be used in terms of private interest such as personalised insurance service. For instance, Dutch government enforced the registration of sex workers so that their partners or family members who depend on their income are not accused of human trafficking. The datafication of sex workers' personal information enabled the government to supervise the individuals with more precision. But meanwhile, it made sex workers hypervisible in the system and undermined their privacy by which they protected themselves from conventional stigma of their professions (Jameson et al, 2019)

Depoliticisation

DDN's dependency on algorithm to detect undesirable behavior and employ interventions can eliminate the possibility of public contestation and presume consensus over the society's desirable behavior (Jameson et al, 2019; Jewell, 2018). Smart cities' framing of data and algorithms as non-ideological and scientifically objective source of urban decision-making can mitigate the opportunities for democratic human participation of posing questions, disagreement, or resistance (Kitchin et al, 2015; Jewell, 2018). People have less space for contestation due to its responsive and implicit nature, having no choice but to simply conform to the decision without knowing its rationale and operational mechanisms. Meanwhile, the objectivity of the data might be actually not true. The urban problems many smart cities propose to solve are not comparable to an error or a bug that appears in a program. They are complex problems involving different people with own interests and sociopolitical contexts with intertwined history (Easterling, 2014; Kitchin et al, 2015). Hence, it is quite likely that the informational grounds of DDN may be actually incomplete or even biased.

Second of all, DDN effectively presumes the consensus on which behavior is considered desirable (Sadowski, 2016). People are more prone to be subjected to the preset standards of a normative citizen by the governance entity without having thorough civic discussions (de Waal & Dignum, 2017; Lanzing, 2018). Cities nudge people to be a good citizen, orderly citizen, or a good consumer. While this norm are treated as 'common sense' and logical, a norm itself is already a very political term that imposes some stakeholders' interest (Sadowski, 2016).

Unaware Citizens

As more than two-thirds of the world population will reside in urban areas by the year 2050, it is becoming more important for citizens to be well informed about the impacts of urban smartification and DDN. However, several studies have shown that citizen awareness of the Smart city considerably lacks behind its pace of development. A research conducted with US citizens revealed that less than two-fifths of the respondents knew or had heard of the term 'Smart city' (Gamble, 2014). 4 years later, another study was carried out in UK only to prove that not much has been changed since, showing 68 percent of its respondents did not know what a Smart city was (Government Europa, 2018).

Furthermore, studies have shown that there is a deficit of available knowledge for citizens to understand about the smart city and that people with low education and low income will be most excluded from this information. Significant number of respondents expressed concern about the smart city initiatives pointing out the lack of available information as a main reason (Government Europa, 2018; Jameson et al, 2019). Shazade Jameson, Christine Richter, and Linnet Taylor's focus group study on Amsterdam Smart City and citizens' perception thereof revealed that citizens are acknowledging their lack of knowledge in smart city's operational mechanism and what kind of implications it will bring to their everyday lives (Jameson et al, 2019). And it is anticipated that less educated

and lower income citizens are most likely to be isolated from these information (Gamble, 2014).

2.5 Problem Definition

Data-driven nudging (DDN) is increasingly playing a significant role in the urban governance of smart cities. As an advanced version of nudge, it expands the capability of urban behavior change strategies enabling more systematic and responsive measures, through which cities can resolve their problems with efficacy and resilience. In the meantime, many scholars foresee critical social implications that DDN will bring about regarding individuals' level of autonomy, ubiquitous surveillance, and political governance. However, there is still a considerable lack of citizen awareness on DDN. Citizens don't understand or know about this invisible mechanism that can have great impact in reshaping the cities they live in.

This project sets its problem scope to lack of citizen awareness on DDN because it is of the most importance to elicit open and collective recognition of DDN to open up a critical social discourse to tackle with its potential consequences. I will address this defined problem by amplifying the potential effects of a city operated by the mechanism of DDN and making aforementioned key attributes of DDN visible and experiential through a speculative design artefact.

3 CREATING THE DESIGN SPACE

In previous chapters, I explored the background issues regarding smart cities and converged the focus of the project upon DDN as an operational logic of smart cities. Potential limitations of this logic and public unawareness of it were defined as the main problem to address in this project. Based on the problem definition, Speculative and Critical Design (SCD) was chosen as a suitable design approach. Target users and the context are considered as well to get more concrete picture of the evaluation setup. Eventually, design goals and effects are resolved to set the general design guideline of the project.

3.1 Speculative and Critical Design (SCD)

Critical Design practice views design as a method to raise questions towards existing conventional values (Dunne & Raby, 2013; Johannessen, 2017). Initially influenced by 1960s radical architecture and avant-garde art as a critical theory, critical design was popularised by Anothony Dunne and Fiona Raby during 90s. Soon critical theory became closely bound up with design as the theory extended itself to the realm of popular and consumer culture and as interaction design emerged connecting products and technologies with people (Bardzell et al, 2012). Critical design focuses on the role of a design to address critical reflections on the development and role of technology in society (Dunne & Raby, 2013; Mitrović & Šuran, 2016). By materialising its social implications which have great impact in our everyday lives, Critical Design Practice aims to ask questions to the users, facilitating them to reflect on such implications. The design can vary from narrative concepts to artefacts and system, opening public discussions about issues that are either invisible or not present yet but worth contemplated upon.

Critical design practice rethinks not only about the role of the design activities, but also regarding the role of a designer and further about the ethical responsibility of the design community. Namely, three different interrelated approaches constitute this design practice: considering designers as reflective being who questions their own design practice; re-examining the design discipline in a macro-perspective; directing the design discourse towards social and political issues (Mitrović & Šuran, 2016).

Speculative Design is a subset of critical design which uses design as a means of critical thinking by conjecturing how things could be in the future (Dunne & Raby, 2013). It evokes informed imagination for plausible

future in people while touching upon critique about the present (Dunne & Raby, 2013; Auger, 2013). Speculative design also partially overlap with discursive and critical design since its design functions as a provocation object to evoke public debate or a philosophical analysis (Auger, 2013). Based on logical acknowledgement of emerging technology, it uses artefacts not only to provide a space for speculative future contemplation but also to include the public in critiquing, re-thinking, and analysing the contemporary technology and new social consequences thereby (Mitrović & Šuran, 2016).

Speculative and Critical Design (SCD) integrates both characteristics of Speculative Design and Critical Design practices (Mitrović & Šuran, 2016). It critiques the present perceptions of products, technologies, or norms and evokes open discussions by materialising the speculative future into an experience.

SCD was chosen as a relevant framework for this project due to following reasons. First of all, a speculative artefact of an alternative future endows the abstract concept of DDN tangible materiality and can function as a medium to experience yet unknown consequences of DDN. By creating an experiential speculative space, people can better understand the abstract and complex consequences of DDN with a clear association with 'here and now' that they live in. In this sense, SCD approach of this project can be comparable to Candy's Experiential Futures methodology rather than Showroom program of critical design which focuses on exhibition and display of an artefact or visual media (Koskinen et al, 2011). The abstract concept of DDN and its speculative social implications will be rendered into a design artefact that can be interactively experienced by the audience (Candy, 2018).

The existence of tangible artefacts makes the plausible futures directly interactable, which facilitates laymen to collectively discuss about the unfamiliar topic more comfortably by giving them a source to refer - putting names on previously inscrutable phenomena. Hence, in this

project, creating a stimulating yet persuasive experience becomes very important in order to address alternative futures of DDN that users can easily relate with (Auger, 2013).

Secondly, SCD approach is necessary to convey the problematic implications of DDN and to trigger people to critically question the necessity of its applications. Until now, there have been already many attempts to involve citizens into the smart city discourse. However, they generally lean towards the purpose of educating and successfully consolidating them into the smart urban system, offering not enough space for critical discourse regarding the topic of what smart cities do and what their operational mechanisms are (Jewell, 2018). Therefore, SCD is not only relevant but also necessary to address the defined problem of this project. The insights from the critical research conducted in previous phases - key attributes of DDN and potential effects there of - are going to be materialised into rather extreme but scientifically possible scenarios. If successful, the perceptional and intellectual provocation of these scenarios will achieve the following goals: provide an experiential space free from banal and self-congratulatory promotions of smart city initiatives and effectively trigger critical reflection on the extensive application of DDN.

3.2 Rotterdam as a Branding Identity

The dutch city of Rotterdam (Figure 10) was used as a branding identity of the design to make the speculative scenario more convincing and thus maintain the suspension of disbelief. By utilizing aesthetic elements and locational context of Rotterdam as a smart city, the design can facilitate the audience to willingly suspend their disbelief and conform to believe in the alternative future of the prototype (Dunne & Raby, 2013). Thus, audience can maintain to be immersed in the experience of the artefact from an unfamiliar imaginary space without feeling it to be fake or unreal.

Figure 10. A view of Rotterdam
<source: http://www.digitalsocialstrategy.org/bac/2016/12/05/rotterdam-the-next-smart-city/>

Rotterdam holds a strong potential as a context for the final design. Distinct from other dutch Smart Cities like Amsterdam or Eindhoven, Rotterdam still stands at its fresh start as a Smart City, having initiated the projects relatively in recent years. It has been over a decade since Amsterdam began promoting projects under its own Smart City initiative (Macpherson, 2017) and Eindhoven also kicked off its Intelligent Community during early 2010s, currently participating as a member of European Union's Horizon 2020 project (Smith 2018). Rotterdam being a freshly launched Smart City, the design can offer its citizens the opportunity to understand the new change and appraise its pros and cons before the whole smart infrastructure settles down. Users can conjecture how Smart City can transform their daily lives and this immersive experience can bring about civic voices, which will contribute to the city

in a long run to build more citizen-centred Smart City.

Additionally Rotterdam's overall population is adequate to test out whether the design succeeds to achieve the desired goals and effects. Originally developed as a port city, it still holds a high proportion of low-educated labor force population compared to other dutch cities. It is also a home for many minorities due to a considerable influx of immigration during its economic growth. Thus, Rotterdam could be a suitable context in terms of observing direct effects of the design to inform laymen citizens about complicated concepts. Furthermore, Rotterdam's cosmopolitan atmosphere, having 40 percent of its population from foreign origin, can add diversity to the civic speculation, making the evaluation results more convincing.

Target users of the design will be ordinary residents of a smart city. Since a significant lack of awareness within citizens and the difficulty of obtaining proper knowledge regarding smart cities were discovered, the design will mainly focus on changing this status quo. Interim iterative testings will be conducted with professionals and design students to evaluate the experience flow but they were also occasionally asked to put themselves in the laymen's shoes.

3.3 Design Goals & Effects

Identified social implications of DDN are intricate intricate in a sense that many stakeholders with contradicting point of views are involved. Smart city initiatives generally hold enormous economic burdens in case they fail to launch the project which makes it even more difficult to examine subsequent risks. And high-tech mechanisms developed to power DDN are complex enough for laymen to grasp what is happening behind the flashy portrayals of future cities. In fact, the implications of DDN are rather macroscopic and impalpable which requires open public discussions involving diverse members of the society to be carefully reflected on.

However, mentioned conditions of smart city initiatives and characteristics of DDN as its operational logic hinder open discussions from happening. First of all, important decisions regarding the initiatives and the application of smart technologies on cities are still made in a very top-down manner. Usually they are carried out as a collaborative project between a governance entity and some private corporations. As a consequence, it remains to be difficult for individual citizens to accurately fact-check pros and cons of these urban initiatives and to question or voice their opinions about them like the example of Sidewalk Toronto project- a collaborative project of Google's Sidewalk Labs and Waterfront Toronto - whose original plan recently had to be downsized due to longstanding controversy over privacy infringement and data harvesting (Deschamps, 2019).

Inscrutable nature of information and communications technology also adds up to the knowledge discrepancy between specialist decision makers and laymen citizens. Of course, there has been several attempts over the world to engage citizens into the Smart City discourse: simple physical signs noticing the existence of urban sensors, open data websites, participatory workshops, game contents, or mobile applications. However, many projects emphasize on the provision of technical experience alone by offering an opening for citizens to tinker with few uncontroversial urban sensors such as air quality sensors (Amsterdam Smart City, 2016; Smith, 2018). Taking these into account, an alternative means of citizen engagement seemed necessary which could provide more balanced information about the Smart City's operational logic.

Therefore, this project aims to create critical public awareness towards the Smart City and its operational logic of DDN. To fulfil this objective, the design will offer an alternative perceptional space facilitating ordinary citizens to understand hidden dynamics of the smart infrastructures. By providing an opportunity to experience materialised consequences

of DDN, citizens could conjecture possible future cities where its urban environment is data-drivenly optimised for maximum efficiency. The project will eventually seek to trigger some sort of open discussion about the necessity of smart cities and for whom these smart technologies exist.

From this perspective, two main design goals and desired effects were determined. A list of design requirements was also set to serve as a functional guidance for ideation.

Goal 1

The design will provide a space for participants to experience the existence of DDN and its implications.

Goal 2

Based on that, the design will evoke critical awareness and trigger open discussions about the implementation of DDN and its potential social consequences.

Desired Effects

- Participants can experience the operation of DDN.
- Participants can be critical and reflective about the discriminatory potential of DDN.
- Open discussions about the application of DDN is elicited during and after the experience.

A List of Requirements

- An urban issue that the design is basing on should be easy and intuitive enough for ordinary citizens to understand and familiar enough to relate with their daily lives.
- The design should effectively convey 5 key attributes of DDN through the user interaction: (1) data granularity, (2) hiddenness, (3) responsiveness, (4) forceful change of choice architecture, (5) the extent of algorithmic decision-making
- The design should be provocative enough to elicit curiosity and questions from the participants.
- The design should be convincing enough to build an immersive experience.

4 CONCEPTUALISATION

This chapter covers design activities carried out in Develop (DV) phase. Possible speculative scenarios were brainstormed and explored through the open questionnaire to identify casual but disputable undesirable urban behaviors that are relevant to be used as a ground context of the design. The identified undesirable behaviors were taken into account for believable yet provocative idea generation. Amongst various concepts with different interaction strategies, the concept of teen repelling bench was initially selected. The concept was initially evaluated to determine the relevant interaction strategy and was refined into the Smart Bench with the addition of other functionalities enabled by data collection through diverse proxies.

4.1 *Identification of Relevant Undesirable Behaviors*

An online survey was carried out to discover the relevant speculative scenario with the potential for provocation that ordinary citizens could easily relate to. Thus, the survey's objective was to identify the undesirable urban behavior (1) which can be casually spotted within people's daily routine and (2) has disputable level of undesirableness so that some sort of intellectual tension can be formulated regarding whether it is relevant to apply DDN. The online survey aimed to discover the casual undesirable urban behavior that locates itself in the gray zone of undesirableness. The main research questions were:

- Which urban problem is relevant to be implemented in the design of a speculative scenario?
- What kind of urban behaviors are disputably undesirable according to the general public? Meaning those behaviors of which the undesirability can be both defended and contested.

28 people between the age of 18 and 34 with previous or present experience living in a city participated in the survey. The survey asked their level of annoyance towards several urban behaviors using the Likert scale of 5 possible answers (I don't care - Not annoyed at all - Hardly annoyed - Somewhat annoyed - Strongly annoyed). The survey used 20 brainstormed cases of undesirable behaviors that can be easily discovered in our daily urban lives. Additionally, if participants had other suggestions other than already presented examples, they could fill those in as a short answer, which were also taken into account for inspirational purpose. The entire survey form can be found in [Appendix. B].

The behaviors that are neither 'strongly annoying' nor 'not at all annoying' were identified first as a possible example contexts. These behaviors had relatively high and even percentage of response in the options of 'somewhat annoyed' and 'hardly annoyed'. Behaviors like teenagers loitering in a park, homeless people asking for money, drivers unnecessarily honking horns, and all-night partying neighbors revealed divided opinions whether it is a clearly undesirable urban behavior (Figure 11). They were identified as ordinary yet disputably undesirable behaviors and were actively taken into account during the concept generation process since these behaviors will make the design provocative yet believable.

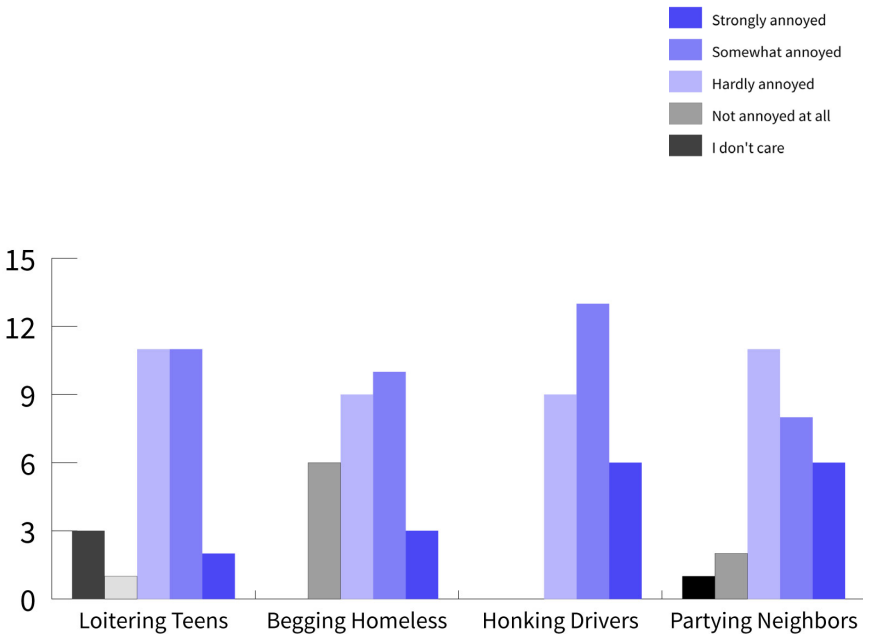


Figure 11. A response ratio graph of controversially undesirable urban behavior

Meanwhile, people perceived certain behaviors as clearly undesirable. Public behaviors like littering, spitting, urinating, and vandalising, over 90 percent of the participants found it either strongly or somewhat annoying. These behaviors were not considered as a possible context for the design because there is a general consent about their undesirability. They are not controversial enough, so they would preclude the possibility for discussion. On the other hand, behavior like protesting was not perceived as an undesirable behavior to most of the participants, hinting that it is likely to evoke excessive provocation if used as a behavioral context to be rectified in the prototype.

Some interesting contexts were suggested by the participants as well. Many of them were related to bikes: locating old bikes on parking spots, riding a bike without a light, slow cyclers, or tourists crossing the bike lane without looking both sides. People also mentioned homeless people lying on benches, drunk or mentally ill people approaching, and people texting on the phone while walking as a common undesirable urban behavior they witnessed.

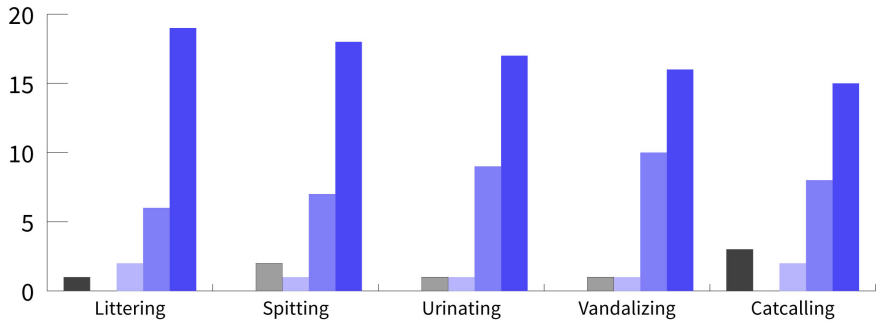


Figure 12. A response ratio graph of clearly undesirable urban behavior

4.2 Concept Ideation & Selection

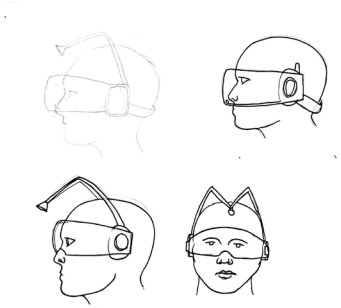
There were several interaction strategies for conveying the experience of DDN. Since the act of nudging involves the 'nudger' and the 'nudgee', different interaction strategies could be generated depending on different ways to mediate these roles. Audience, a virtual character or an artefact were considered as possible entities of the nudger. Audience and a virtual character were considered as possible entities for the nudgee. This created 6 possible strategies of interaction which is shown in Figure 13 below. This matrix was utilized to generate diverse ideas with different interaction strategies and interaction strategy E, F were avoided since they were less suitable to the first design goal of creating a space for participants to experience the existence of DDN.

Nudger / Nudgee	*Audience*	*Virtual Character*	*Artefact*
Audience	A	B	C
Virtual Character	D	E	F

Figure 13. A matrix of possible interaction strategies of nudger-nudgee experience

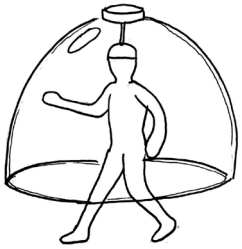
Possible concepts were ideated and sketched considering the diverse variety of interaction strategies and disputably undesirable urban behaviors that were identified in the previous stage. In total 8 concepts were generated, some dedicated to a single undesirable behavior and some that can use multiple undesirable behaviors in omnibus format. Diverse formalities were explored as well that can effectively convey the experiential speculation of data-drivenly optimised urban living.

1 *Wearable Headgear*



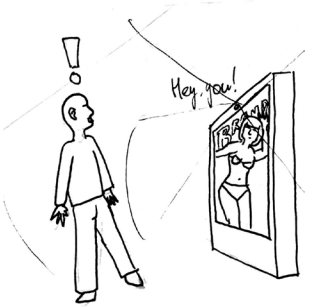
A user can experience DDN through wearing a headgear that dynamically nudges her/him through various sensory stimulation: diffused scent, sounds, and visual hue change. The user can wear this intelligent artefact and walk around the city by her/himself, providing her/him with a solitary augmented reality experience based on an imaginary scenario of an alternative dystopian future where all citizens are obliged to wear this headgear for resource optimisation.

2 *Wearable Transparent Dome*



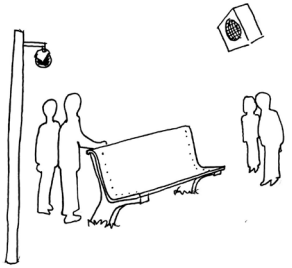
It is a wearable dome which projects visual augmented reality of an urban environment with some sensory stimulation. This concept differentiates itself from Concept 1 in a sense that here environment shown on the inner walls of the dome will change, instead of the user themselves. One can experience dynamic rearrangement of the environment to minimize any urban hassle and maximize individuals' productivity.

3 *Interactive Advertisement Wall*



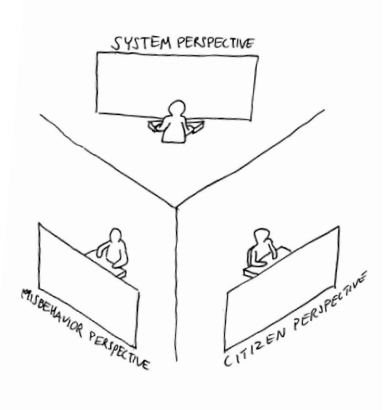
It is an interactive wall advertisement which target attracts specific demographic groups for maximum economic profit. It presents a speculative era where each individual's private and behavioral data became a fossil fuel of economy and privacy earned a new concept of transparency. Individuals are constantly exposed to a circumstances where they are nudged to certain behavior beneficial for corporations and prosperous society like consumption, production, and bodily function.

4 *Teen Repelling Bench*



This concept is about a public bench that targets young kids loitering in public space. The bench extracts various behavioral and environmental information of these kids like how many they are, how loud noise they are making, whether they are smoking or drinking. When the bench notices inappropriateness, high frequency (Hz) sound which only young people are able to hear will be deployed to steer them away without causing any nuisance.

5 *Three-way Interface*

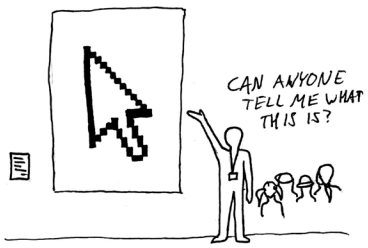


A concept informing people about the operation of data-driven system and how it affects the autonomy of people defined as undesirable and ordinary citizens respectively. Three participants will take different roles as a system, citizen, and a misbehaver and will use a joystick interface to try their best from their own perspective. A participant playing a system will be confronted with different kinds of DDN options and can deploy them according to her/his values and interests, which will directly affect the choice architectures of other two participants without them noticing.

6 *Good Citizen Maker*

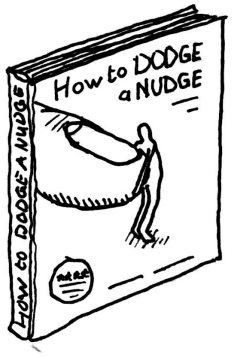
A single (or multiple)-player digital game where users discreetly nudge their own virtual avatar using an interface. Player's goal is to succeed in changing their citizen avatar's urban behavior so that it can stay as a good citizen. Each time, the avatar is about to behave badly, several nudge options will be presented to the audience to make decisions. Through this concept, audience can learn about what DDN is and how DDN works in the urban environment in a playful way.

7 *Anthropological Museum of Automation*



In the speculative future of full automation, people made a museum to remember how it used to be in the past where 'making a choice' was one of the daily human activities. This concept projects a scenery of a distant dystopian future where everything is systematically optimised, thus no more human decision-making is necessary. It can be materialised through a format of an artefact exhibition or a graphic media.

8 *A Guidebook of DDN Resistance*



A self protection guidebook teaching people how to get away from DDN in the era where every human choice is strategically manipulated for what is considered as 'social good'. This concept is set in a relatively nearer future than Concept 7, where the notion of human agency still existed and citizens were already aware of the existence of DDN due to its intensive implementation. The form of this concept can be a book or a poster.

Among 8 concepts, Concept 4 was selected considering its simplicity, technical feasibility, and its near future likelihood. And Concept 5 was chosen as the next best considering its potential for audience engagement. The undesirable behavior of loitering teenagers around the public bench was simple enough to be reproduced with design compared to other examples identified by the survey. Moreover, a public bench as a design artefact holds a familiar presence, endowing the design certain level of dailyness and great potential to be rematched with other undesirable behaviors located in a gray zone of inappropriateness like panhandling or partying neighbors. Secondly, it seemed feasible with current level of technical knowledge. Concept 5 seemed to be partially possible as well if it could be altered into an offline experience or merged into Concept 4. Furthermore, a temporality of Concept 4 is relevant to make a convincing yet provocative speculative design in a sense that it is neither too alienated from the present into a far away future nor too identical to the present (Auger, 2015).

The mutual audience interaction of Concept 5 can be selectively applied to Concept 4 since its interaction strategy is likely to enhance participants' engagement. It can liberate audience from the position of a spectator and make the experience more tangible and interesting. For simplicity of interaction, a perspective of misbehaver can be left out, leaving the perspective of 'the nudger' and 'the nudgee' to be experienced by the audience. To test out the potential of merging Concept 5 into Concept 4, interaction testing was carried out with a few designers. The results can be found in the next section.

4.3 Interaction Walkthrough Testing

The interaction walkthrough testing was carried out to examine user's understanding about the concept scenario of Concept 4 and determine the specific interaction strategy between those of Concept 4 and its enhanced version which partially integrates Concept 5. Two interaction strategies were evaluated based on how well it fulfilled the design goals: (1) Concept 4 which takes the interaction strategy of an individual self-experience where the user only interacts with the nudging bench (user-bench interaction) and (2) the mutual audience interaction strategy of Concept 5 added to Concept 4, where after the user-bench interaction, the user becomes the nudger and applies DDN to the forthcoming user through the interface.

The testing was carried out using low-fidelity prototypes of bench actuation and the nudging interface (Figure 14). Couple of usual chairs were attached together to simulate the bench and the bench's actuation was Wizard of Oz (WoZ)-ed[1] using high frequency sound (15-16kHz) and changing the light brightness of the testing room. The interface was a low-fidelity paper-based prototype made with cardboard, through which participants could shift between three different algorithmic versions: optimum safety, optimum air quality, and optimum pleasance. Three groups of 2-3 designers took part in 30-minute-long session which was divided into two parts. Participants were walked through the experience of one concept after another and were asked to talk about their experience.

1 The Wizard of Oz (WoZ) prototyping is an experimental method frequently used in Human Computer-Interaction (HCI) research in which test subjects interact with a computer system believing to be autonomous, but is in reality operated or partially operated by unseen human actor (Gombač et al, 2016). It is a method that is often used when the realisation of an experience requires advanced or non-existent technology.

Figure 14. Testing materials: Couple of chairs and a low-fidelity paper-prototype of the interface

In the first design concept testing, participants were guided to imagine that they are present in a public showcasing event of Smart Bench that Rotterdam municipality is planning to launch in a near future and were asked to try out the bench. In the midst of them spending time on the bench, high frequency sound was abruptly deployed and the lighting of the bench area brightened whenever they started talking too loud. After the bench experience, people were asked to share their opinions on what they just experienced.

Afterwards, the second concept testing began. The first half of the experience was exactly identical to the previous testing but an interface experience followed this time. Participants were guided to the interface where they could change the settings of the algorithm which operated the bench (Figure 15). Through this, they could adjust different algorithmic versions of the Smart Bench ranging from optimum safety, optimum air quality to optimum pleasantness. Each version had pre-set thresholds of several data captured - like the number of people, noises, and age - to determine whether each value is being maintained. Participants were asked to freely decide the algorithmic version to nudge the forthcoming audience who will approach the bench.

The Second Design Concept

The majority of the participants understood the concept of DDN better through the second concept and they felt this experience more powerful than the first design. After the startling experience of the actuating bench, the interface interaction functioned as a significant moment where people could finally realize what kind of critical data sources the bench is collecting and utilizing. Participants could become aware of unfair biases that were present in the algorithm through the interface which reflected certain perspectives of the decision-makers who invented the algorithm. They acknowledged how the system utilizes biased selection of personal or environmental urban data in assessing whether the alleged socially

positive state is being maintained and classifying citizens to predict their probability of doing undesirable urban behavior.

Moreover, participants showed an active interest to stay and observe how the bench would work after they changed the settings. While adjusting the algorithmic settings of the bench, a few participants identified with other participants and forthcoming audience, expressing inner conflict about their choice which might contradict with other people's decisions.

However, they did reveal some confusion regarding the interface, perceiving it as a democratic tool for participatory DDN, which is not the intention of the design. To solve this, user input could be made visible to the audience. Additionally, the bench should be directly observable from the location of the interface so that participants can witness the influence of their nudging activity in real-time.

Figure 15. Participants thinking out loud while testing out the prototype

The Smart Bench experience

The first design concept of sole user-bench interaction succeeded in evoking irritation from the experience of being nudged. However it gave the participants a sense of incompletion since the design failed to provide them with the reasons for the bench's actuation, leaving participants' question of 'why did the bench just nudged me?' unanswered. To borrow one participant's expression, it is highly likely that people could end up perceiving the actuating bench experience as something 'accidental' and fail to understand that the bench just wanted to nudge them off of it. Most importantly, people cannot understand the principle of DDN, which is a key experience the design should convey.

Regarding the sequences of the different algorithmic versions, it was suggested to put positively nuanced version in the first and then move towards a controversial version so that the design can gradually increase the level of criticism.

More explicit sensory stimulation is necessary

It was made clear that the sensory stimulation wasn't provocative enough to induce participants' curiosity to figure out what is actually going on in the bench. The change in light brightness did not succeed to evoke clearly uncomfortable emotion within the participants and the high frequency sound was too subtle and weak. Since it was not startling enough, participants maintained to stay on the bench even after its actuation. Additionally, the sound was not hearable to everyone in a same way so depending on their physical age of ears, some couldn't even hear the sound while for some of them, it was obviously loud. For clearly provocative experience, the sensory stimulation should be more clear and straightforward so that it can trigger any participant's curiosity to proceed to the next stage of interaction.

4.4 Identifying Data Proxies

To discover additional behaviors that can be detected by the Smart Bench, possible proxies of data collection were ideated. Both already existing and speculative or imaginary data proxies were explored. The points where any behavioral data could be extracted were brainstormed based on different contexts - people resting on a bench, people sleeping on a bench, a women sitting on a bench at night alone, etc - and parts of the bench - bench legs, a bench back, or sittings, etc.

Two types of data proxies were considered:

1. personal/environmental data that can be considered to be benign and seem to be necessary for governance purposes and
2. data the collection of which can be quite controversial, capable of raising questions about its legitimacy or accuracy.

In total 18 data proxies were ideated as it is listed in Figure 16. Each one was examined in following aspects: whether it is technically feasible to be captured, whether any meaningful information about citizens' behavior can be inferred from it, and whether its measurement contributes to any urban value that Rotterdam municipality would speculatively seek. Especially, the last aspect was carefully thought through by conjecturing what a future city - that actively applies DDN to its public facilities - would want to achieve on a municipal level.

After careful examination, three benign data proxies and two controversial proxies were selected to quantify whether three different urban values - public health, cleanliness, and safety - are being maintained and to nudge people's usage of the bench. Firstly, health index of people (BMI) was chosen as a data to measure the health level of people who are sitting on the bench. By combining height information through camera

Benign Data	*Data Proxy*	*Controversial Data*	*Data Proxy*
Number of people	Camera or Force Sensing Resistor (FSR)	Age of people	Camera (Computer Vision): Face recognition
Length of their stay	Force Sensing Resistor (FSR), or IR sensor	Ethnicity of people	Camera (Computer Vision): Face recognition
Voice loudness of people	Microphone module or Noise sensor	Gender of people	Camera (Computer Vision): Face recognition
Whether anyone is smoking	Smoke detector or air quality sensor	Socioeconomic status of people	Camera (Computer Vision): Shoes type recognition
Brightness of the area	Light sensor	Educational level of people	Camera (Computer Vision): Glasses detection
Temperature of the area	Temperature sensor	Residential neighborhood people are from	MAC address identification: location information
Sitting posture of people	Force Sensing Resistor (FSR) or pressure sensor	Whether there is a mutual interaction between people	Camera (Computer Vision): Facing direction recognition
Health index of people (BMI)	Camera (Computer Vision) - Height & Force Sensing Resistor (FSR) - Weight	People's emotion	Camera (Computer Vision): Face recognition
Time of the day	Digital timer		
Neighborhood the bench is located	GPS chip		

Figure 16. A Chart of Ideated Benign and Controversial Data and its Proxy

sensor and weight data through a force sensing resistor (FSR) or IR sensor embedded in the seating, it seemed feasible to be captured. And it is plausible to infer lack of physical movement which is undesirable for both present and speculative city since it signifies a loss of productive labor force. The other benign data, the length of stay can be used as a nudging matter to differentiate the staying time of the citizens based on their health.

The socioeconomic status and ethnicity were selected as data sources that can provoke the audience since it is rather personal and controversial data for a public facility to collect. Especially, the socioeconomic status was an experimental choice being completely speculative. Though it is imaginary concept to measure how wealthy people are through their shoes type, it seemed feasible to be materialised through camera sensors attached to the bench legs and the feed analysed using computer vision. And a scenario could be formulated that a city can maintain cleanliness or pleasantness of the neighborhood through detecting socioeconomic status of people using the bench in advance and reducing their length of stay. For instance, undesirable urban behaviors like homeless people sleeping on public benches or loitering young kids could be recognized through this speculative data proxy. The length of the stay data can be applied here as well to control these citizens' usage of the bench.

Lastly, ethnicity was selected as a data source to measure safety levels of the neighborhood, functioning as the most dystopian scenario of the Smart Bench. It can formulate the most drastic and controversial alternative future of a city utilizing citizens' personal data of inborn traits as a predictive indicator for aggressive or criminal behavior that has not yet happened. It is comparable with the fictional scenario of predictive crime prevention depicted in Steven Spielberg's film, Minority Report (2002), in which a future society with extreme surveillance technologies catches supposed criminals even before they commit their crime. This film raises ethical questions about society's blind faith in risk prediction

technologies for alleged value of public safety. Similarly, the Smart Bench tackles probable aggressive behavior of certain citizens, based on their ethnic profile, by changing people's choice architecture in terms of staying in the public space.

In this third, dystopian scenario, it was thought that the design would be able to raise awareness and questions. Awareness of social realities and biases that often go unrecognized and questions concerning the implications of blind faith in technology to increase public safety. If added to the prototype, the scenario of the concept revealing controversial usage of data and biased definition of public safety is highly likely to evoke interesting discussions about the implementation of DDN. This scenario was also related to the local context of Rotterdam, which is infamous for its so-called 'Rotterdam Law', a regulation for the urban spatial management of future residents based on their household income, allowing or banning them to settle in certain strategic urban locations. This notorious law can be recognised as discriminatory in practice because it effectively manages the behavior of certain ethnicities through their income (Schinkel & van den Berg, 2011). Thus, a discriminatory bench cannot be too far from the local social reality. The scenario's commonality with the present could make the bench's concept to remain relatable and conjecturable to the audience despite its extreme and unethical plot.

The benign data of citizens' voice loudness was thought to be used with the ethnicity data to hinder people with certain ethnicities to talk in loud voices. The integration of two data can create a speculative scenario of nudging certain ethnicities to keep quiet so that others don't have to be intimidated by loud conversation noises of people with high probability of crime. And the voice loudness data can be collected through microphone modules or noise sensor. Thus, these five data - BMI data, socioeconomic status, ethnicity, length of the stay, and voice loudness - were selected to be used in the prototype for more complex version of Smart Bench, which has three different algorithmic versions for public health, cleanliness, and safety

5 MATERIALISATION

This chapter covers the process of the final concept refinement and the develepment of the Smart Bench and the interface. The wireframe of the user interface was designed to maintain the participants' suspension of disbelief and make the speculative artefact more immersive. Interface designs were tested with a few designers to communicate the problematic future of DDN and articulate its key attributes in an experiential manner. The data flow of the artefact's system was thought through considering the technical opportunities and constraints. Physical forms of the experience were decided considering the current test location of the IDE faculty. The user experience journey was made to illustrate all the stages participants will go through and to inspect the overall experience flow.

5.1 Interface Design Evaluation

Interface design evaluation sessions were conducted with 8 fellow designers to identify the design elements that facilitate or hinder successful storytelling. Designers were selected as test subjects to obtain credible feedback in terms of UI design and iteratively redesign the interface. The health version of the Smart Bench was used to test out the design elements. Participants interacted with three different styles of interface layout and shared their experience.

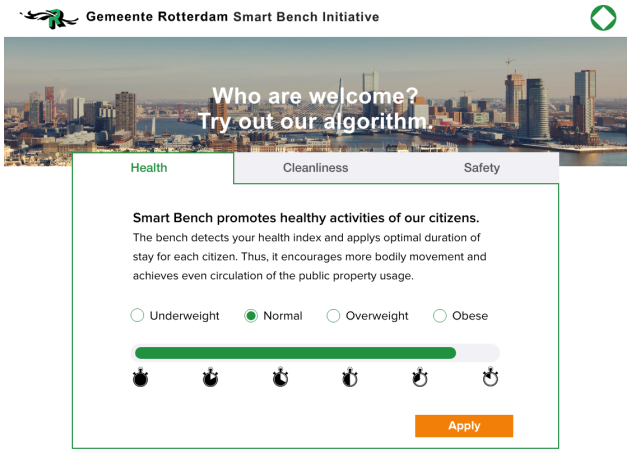


Figure 17. Interface Style 1: Single Selection with Radio Group Button

Style 1 Single Selection with Radio Group Button (Figure 17)

A selection of a single citizen category evoked confusion within the participants and this style failed to convey the operational principle of the bench. Most participants ended up perceiving it as a bench that allows only one citizen category. And most importantly, this style didn't provide the experience of nudger, since there wasn't enough interaction points for the participants to achieve a feeling that they are adjusting the algorithm.

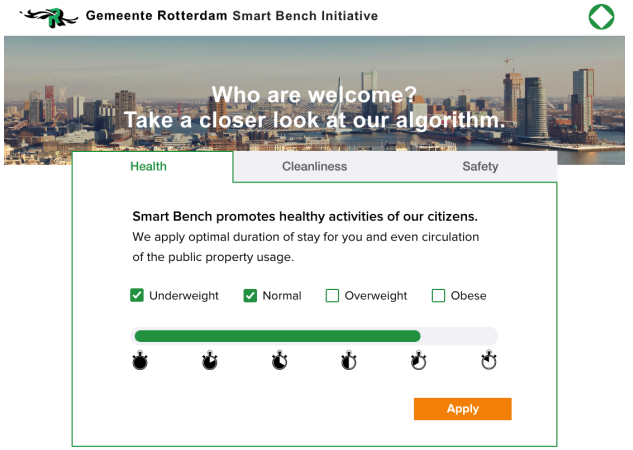


Figure 18. Interface Style 2: Multiple Selection with Checkbox

Style 2 Multiple Selection with Checkbox (Figure 18)

Participants understood the operational principle better in this style. By clicking different checkboxes and seeing the changed amount of time length for different combination of citizen categories, they acknowledged that the city is not welcoming overweight and obese citizens. They found it more sophisticated and nuanced, but it took them comparatively more time to fully understand how it works.

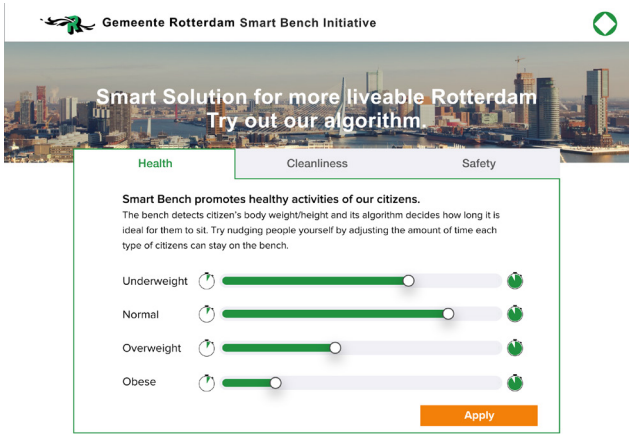


Figure 19. Interface Style 3: Adjustable Sliders

Style 3 *Adjustable Sliders (Figure 19)*

The layout sufficiently allowed for participants to interact with the sliders. They felt it interesting to adjust the time bar independently by themselves. Participants could sense some presence of biased algorithm when they first confronted the initial state of each sliders. However, changing the amount of time for each category of population gave them an impression that it is an interface that democratically receives citizen opinions to decide whom can stay for how long in this public bench. This interpretation was interesting but didn't serve the original purpose of conveying concept of discriminatory algorithmic decision-making of DDN. Additionally, some misunderstood the bar interface thinking that it is to adjust the number of people, not the time, which could have been due to unclear timer icons.

Eventually, the multiple selection design element of Style 2 was confirmed to convey the most accurate story of the data-drivenly nudging Smart Bench and meet the original design goals. Though, to reduce the number of clicks needed to explore the influence of different demographic

combinations on the length of time, the checkbox UI could be slightly improved. And other minor refinements were made to make the message of the interface clearer. the following were other elements that should be changed or added for clearer understanding of the interface.

5.2 System Data Flow Diagram

A system data diagram was first created to overview the full technical potentiality and then some adjustments were made taking time limitation and programming ability into consideration (Figure 20). Several operational parts were changed to Wizard of Oz (WoZ) prototyping, as long as it conveys the same design effect. The initially planned visual recognition analysis with openCV Eventually, Wizard of Oz prototyping took over openCV analysis of citizen height, ethnicity, and socioeconomic status due to the time constraint, thus omitting the usage of webcams as a visual data input source. FSR sensors were still used to detect the human presence.

Furthermore, for consistency in three different algorithm versions of the Smart Bench - health, cleanliness, and safety -, it was concluded to make the target of actuation the same. Unlike the other two versions, the safety version was initially planned to intervene on the voice loudness of participants, nudging them to quiet down through the actuation. Concerns arose during the previous interface design evaluation that the sudden change of target actuation can cause confusion within the participants. Therefore, the usage of a microphone module was left out, making the actuation to focus on nudging participants' length of stay.

Considering the feedback from the interaction walkthrough testings, more explicit actuation methods were used. The sensory stimulation of light brightness became no longer adequate since the main hall of IDE faculty was set to be the testing setup and the high frequency sound had

to be refined due to its subtlety which failed to induce clear provocation. These actuations were replace with haptic vibration on the bench's seating/ back part and acute alarming sound using eight vibration motors and two speaker modules. These actuators were attached to the bench, generating a very clear and provocative sensory stimulation.

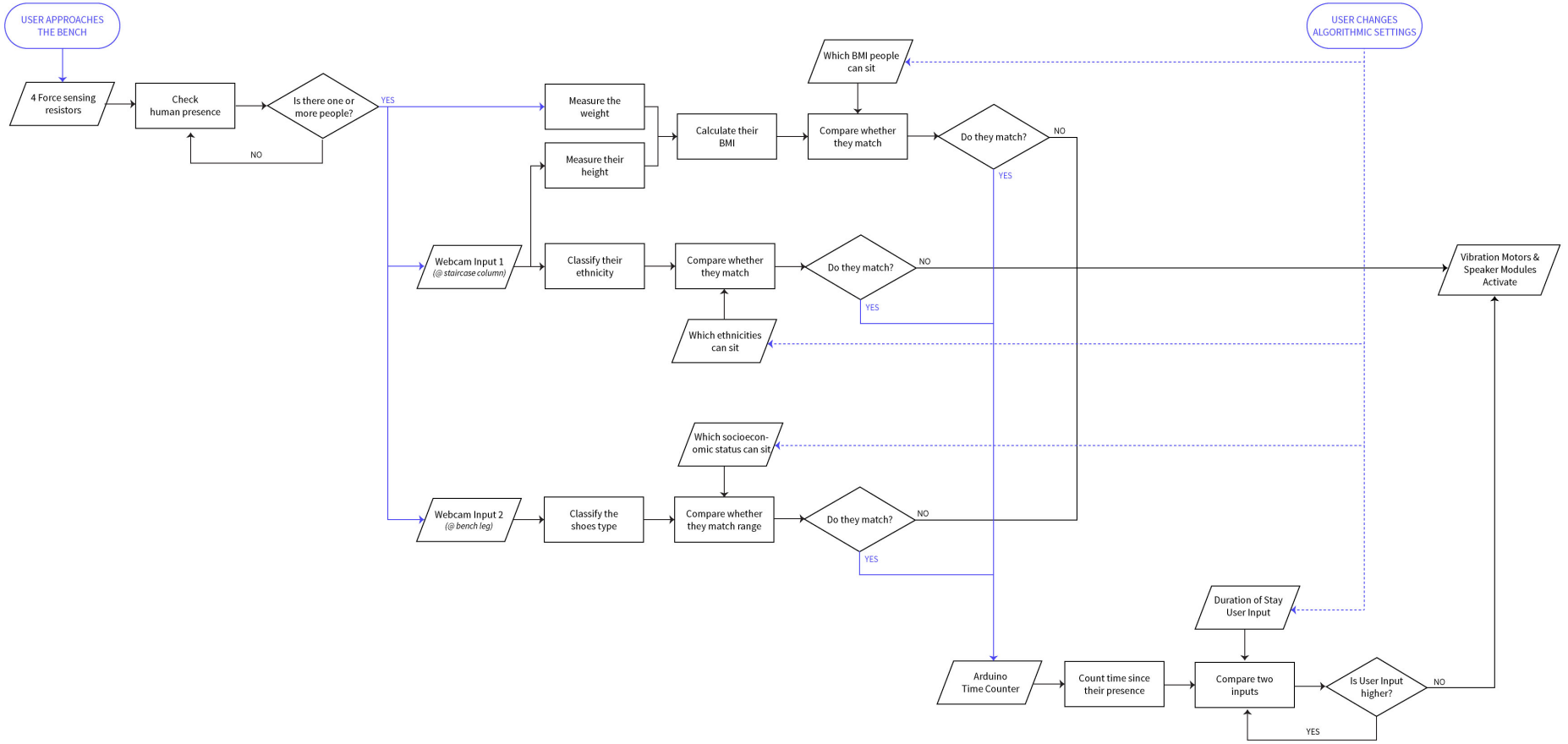


Figure 20. System Data Flow Diagram

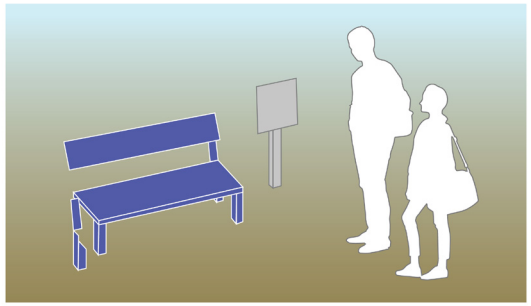
5.3 User Experience Journey

The user experience journey was created to preview the entire stages of the experience. The visual illustration of the user experience was helpful in segmenting each stage's interaction goals and foreseeing possible user emotions, interactions, and barriers.

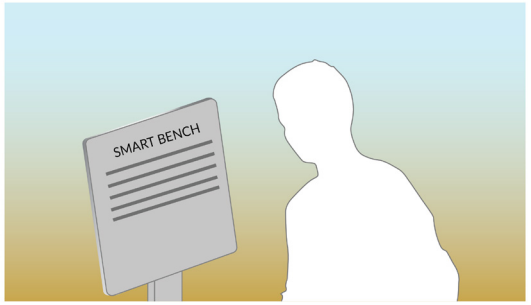
Phase 1 Intrique

1. User approaches the Smart Bench.
2. User discovers the guide panel which has a short description of the smart bench.

[1]



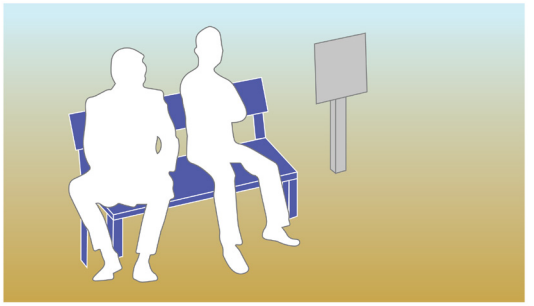
[2]



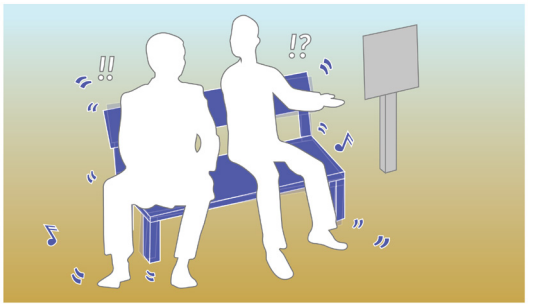
Phase 2 Provoke

3. User sits on the bench, taking a closer look at it.
4. After few seconds, the bench vibrates and makes alerting sounds.
5. User startles and stands up wondering what just happened.

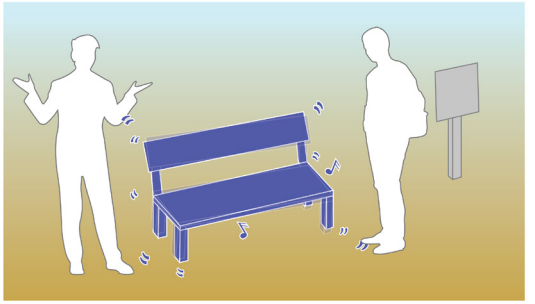
[3]



[4]

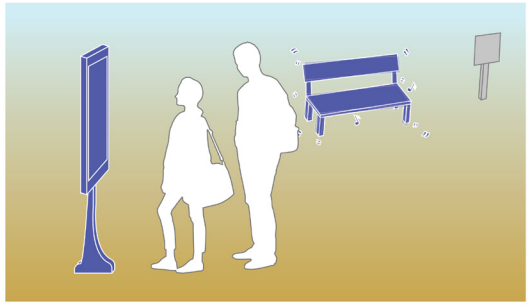


[5]

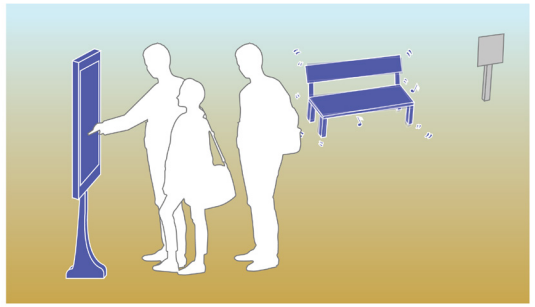


6. User is guided to the algorithm interface.
7. User interacts with the interface adjusting different parameters by herself/himself.
8. User retry the bench again or watch others being nudged by the bench which is operated by the new algorithm she/he has just set.

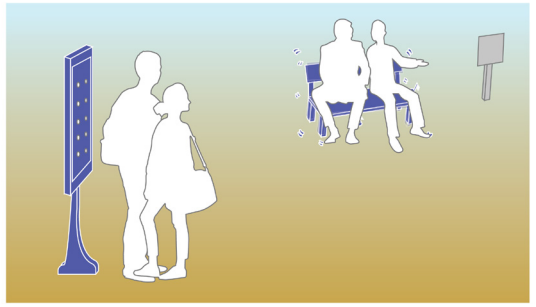
[6]



[7]



[8]



5.4 Concept Brief: Smart Bench Showcase

The final concept evaluation was planned to openly take place in the main hall located on the ground floor of Industrial Design Engineering Faculty of TU Delft (Figure 21). The entire experience involving the Smart Bench and the Interface was planned to be placed between the Service Point and the study space as a showcasing event of a newly invented Smart Bench. Sensor embedded bench was going to be placed in the hall, visible from the point where the interface is located. And participants would be able to interact with the interface through the iPad device placed few meters away from the bench.

Figure 21. Planned evaluation location of the main hall

The Smart Bench

Smart Bench used an aesthetics of a conventional public bench with FSR sensors and actuators - vibration motors and speaker modules - embedded under the sittings and back (Figure 22 & Figure 23). A short description would be placed beside it introducing it as a new Smart Bench Rotterdam municipality aims to launch in a near future. After the Bench experience, participants would be guided to the interface.

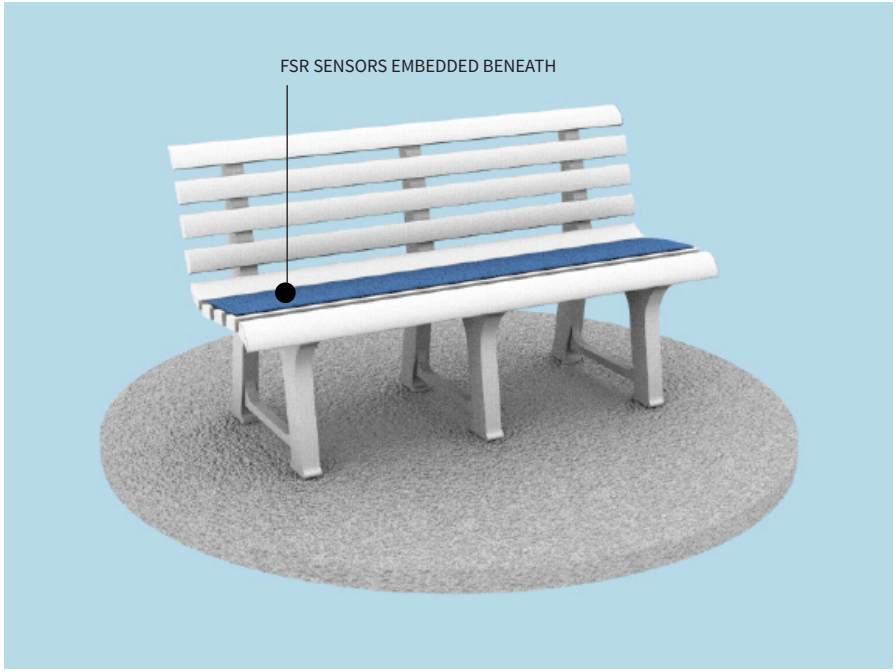


Figure 22. The front side of the Smart Bench with a conventional look of a public bench

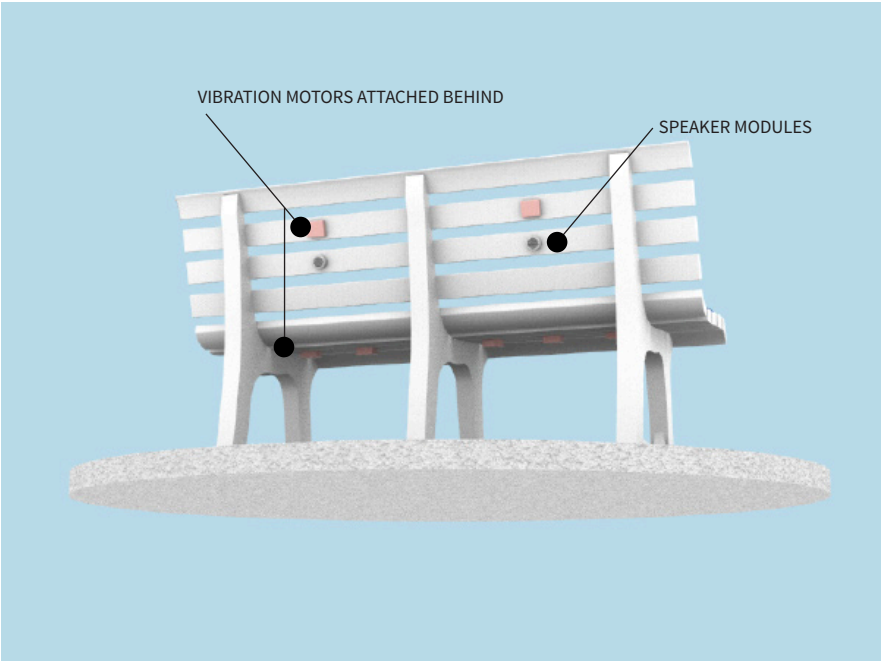
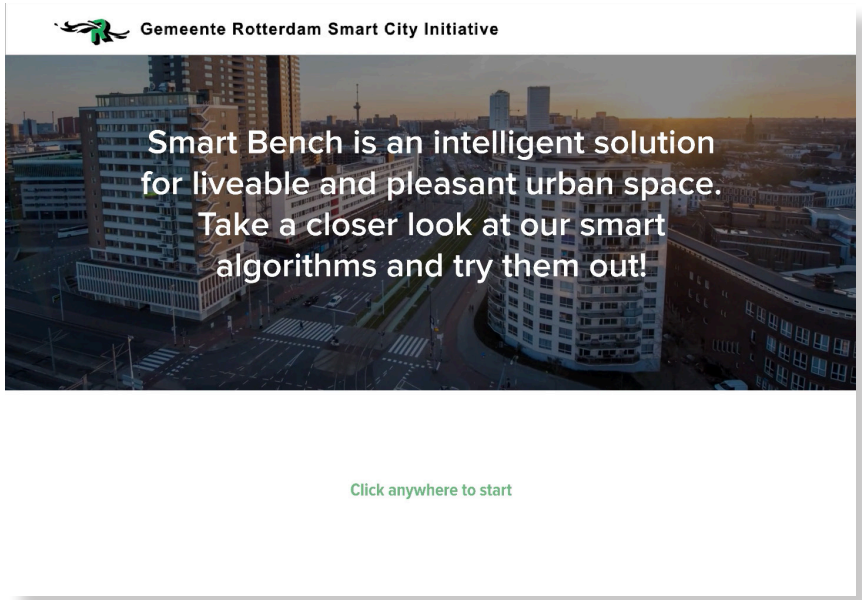
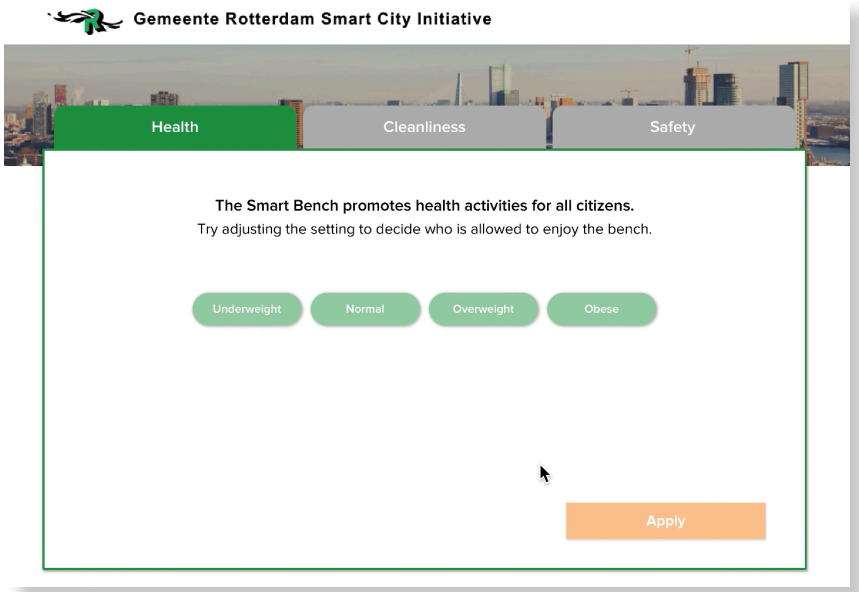


Figure 23. The back side of the Smart Bench with actuators attached

The Algorithm Interface

Based on design decisions made during the previous stages, an interface wireframe was first created, which can be found in [Appendix C]. Instead of timer icon, duration of stay was numerically indicated ranging from 10 to 60 seconds. An interaction loading page was included before the tab page and pop-up window showed up if the user clicks the 'Apply' button to update the bench system. The final design of the algorithm interface was made into a visual style of Rotterdam municipality and participants could easily interact with it through iPad device. Screenshots of Figure 24 show the interaction sequence of the interface.





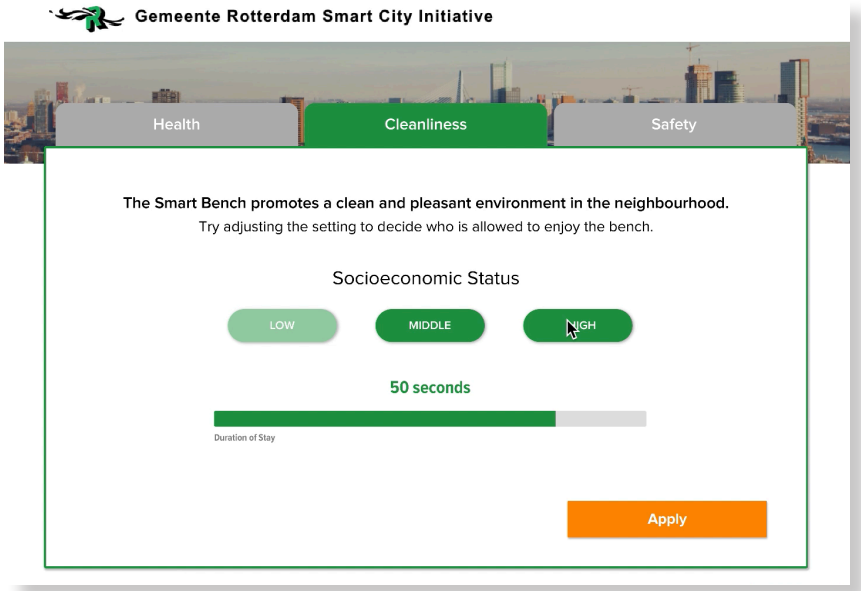
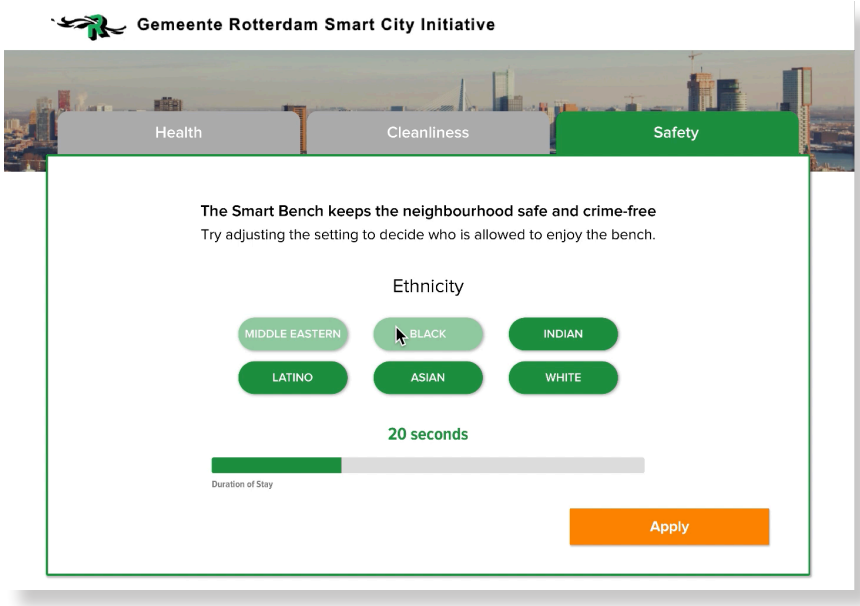
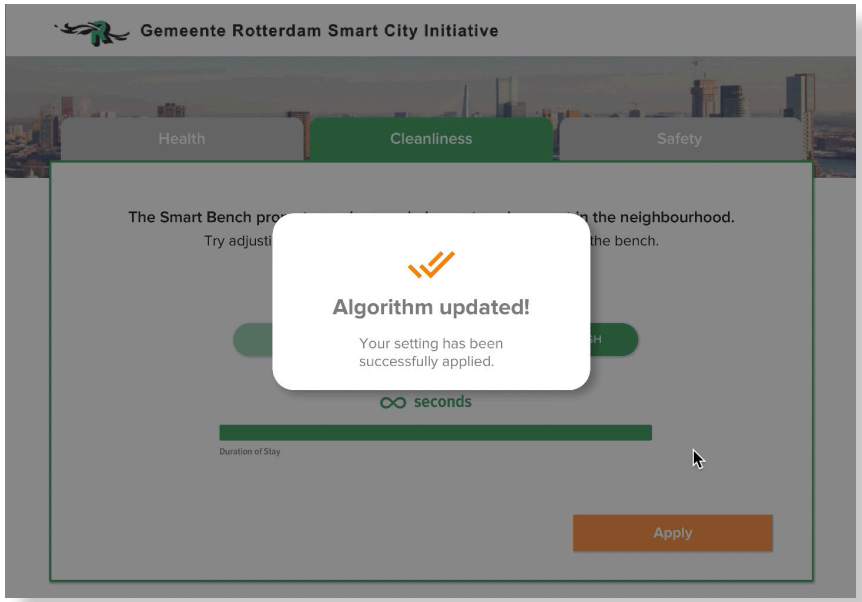


Figure 24. The Screenshots of the Algorithm Interface


Gemeente Rotterdam Smart City Initiative
Health
Cleanliness
Safety
The Smart Bench keeps the neighbourhood safe and crime-free
Try adjusting the setting to decide who is allowed to enjoy the bench.
Ethnicity
MIDDLE EASTERN
BLACK
INDIAN
LATINO
ASIAN
WHITE
20 seconds
Duration of Stay
Apply


Gemeente Rotterdam Smart City Initiative
Health
Cleanliness
Safety
the neighbourhood.
the bench.
Algorithm updated!
Your setting has been successfully applied.
seconds
Duration of Stay
Apply

6 DISCUSSIONS

This chapter is about the evaluation of the concept and how the concept testing session was actually carried out. The results suggested a change of plan and offered some meaningful insights. Interesting key findings will be introduced in terms of the design itself and the achievement of desired effects formulated during the Define phase. Finally, spotted limitations of the design and some recommendations will be addressed for future improvement.

6.1 Concept Evaluation Setup

Due to the COVID-19 outbreak, the concept evaluation was carried out remotely in an online webinar format. In total eight people participated in this online testing sessions: four of them participated in pairs and the others took part individually. All participants' professional grounds were related to design field consisting of four master students - whose majors varied from Design for Interaction (DfI), Integrated Product Design (IPD) to Visual Communication Design -, two product designers, a researcher and an independent media artist. All participants had previous or present experience of living in a city and their average level of prior knowledge on the topic of Smart City or DDN ranged from no prior knowledge to average knowledge.

Participants were requested to think out loud throughout a 40 minute-long session, many of which were compelled to be extended to 60 minutes due to active discussions and comments from the participants. Each session was divided into four parts: introduction, simulated bench experience, interface experience, followed by a short interview.

Part 1 Introduction

At the start of each webinar, participants were given the basic information about what the experience would entail. They were verbally introduced that they are now at an open event organised by the Rotterdam municipality showcasing the Smart Bench to the general public. A supplementary explanation was provided that in this event, citizens are the first person to try out this intelligent bench and are offered with a special opportunity to tinker with the algorithm thereof themselves before its official citywide implementation. When it was clear that participants acknowledged this imaginative setting, they were guided to the following part of the session to meet the bench.

Part 2 Bench Experience Simulation

The physical experience of the Smart Bench was substituted with an animated keynote presentation (Figure 25). The interviewer shared her screen to the participants so that participants could watch the presentation while hearing her voice. It graphically simulated the bench-user interaction. Participants were guided to virtually take a sit on the bench. After certain seconds had passed since the they confirmed that they sat on the bench, an alarming sound was actuated and the bench depicted in the presentation started visually vibrating. The simulation used the alarming sound which had similar intonation and duration as the speaker module that were actually embedded into the physical Smart Bench. And the vibrating action of the Bench was simulated with animated movement lines. After the simulation, participants were asked to talk about how they would react in this hypothetical situation.

Figure 25. A Screenshot o f a Bench Experience simulation

Part 3 *Interface Experience*

Participants were then guided to the interface. The interface was introduced as a temporary opportunity provided by the municipality for citizens to playfully experience the algorithm embedded in the bench by freely adjusting the core settings of the bench. Web browser link of the interactive prototype was sent to the participant so that they could easily interact with it on their own computers (Figure 26). They were asked to share their computer screen through Skype so that their interaction could be observed in real time. Throughout the interface experience, follow up questions were asked occasionally to participants regarding their spoken thoughts or actions to capture their intentions, thoughts, and emotions.

Part 4 *Post-Session Interview*

After the interface experience had been completed, a short post-session interview was conducted. Participants were asked several questions regarding the experience design itself. Lastly, participants were invited to further comment or give additional feedback on the session in general.

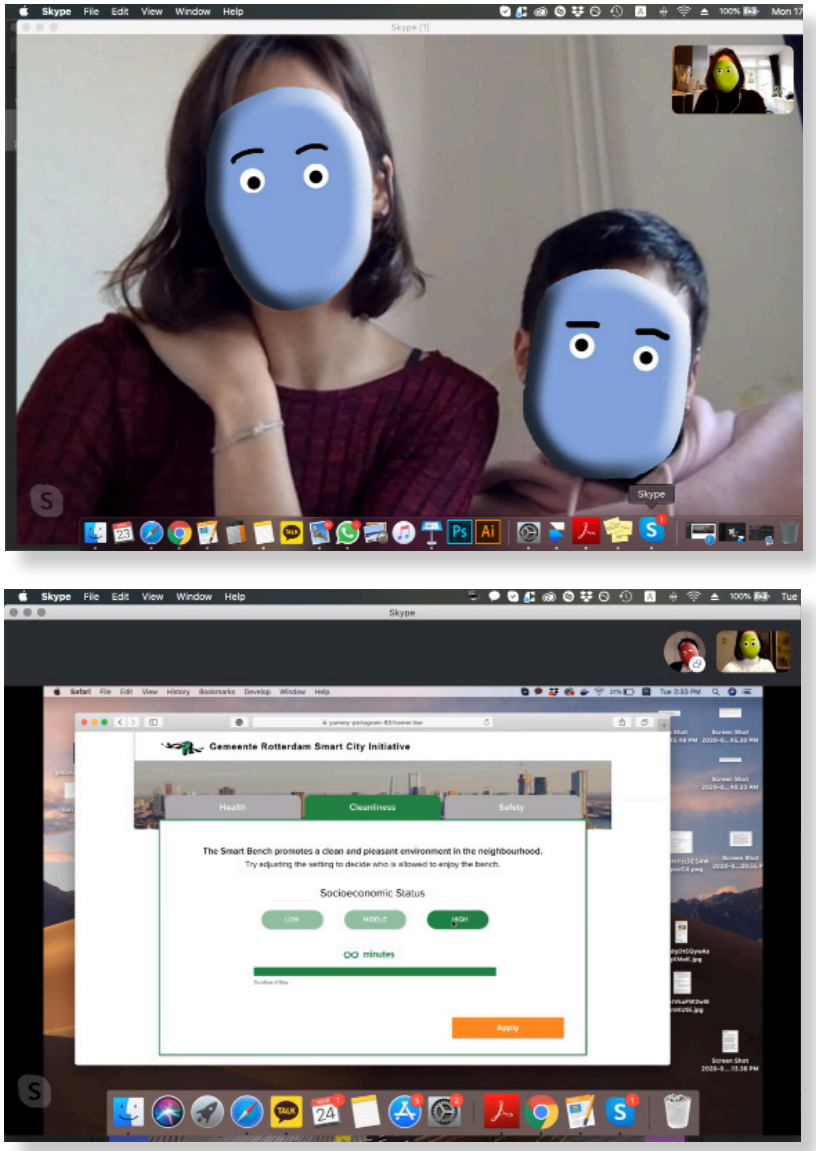


Figure 26. Screenshots of the Remote Interface Experience and Evaluation

6.2 Key Findings

Bench Experience

The virtual simulation of the actuating Smart Bench successfully induced certain level of startlement and curiosity from the participants. When the alarming sound and visual vibration began, all participants answered that they would first stand up to have some distance from the bench. The emotion ranged from instant negative feelings like annoyance and upsetment to subsequent curiosity and a sense of challenge. 3 participants hinted willingness for a retry saying, "I will pick another bench to sit on (P_1)" or "maybe I will anyway try to sit on it for a while to see what happens (P_2, P_3)". 2 participants revealed a clear sign of curiosity on what is enabling the bench's actuation and where the sound is coming from.

> *P4: "I will feel like I am interacting with an artefact in like a media art fair. I will stand up but will be curious to look for what is enabling this interaction."*

Given the fact that the simulation sufficiently evoked desired emotion of startlement and certain level of curiosity to move on to the next experience, it is quite probable that the actual setup of the physical Smart Bench will successfully work to produce even more interesting insights.

Findings about the Design Goals

To evaluate how well the concept met the two design goals, follow-up questions were occasionally asked while the participants were interacting with the prototype to investigate whether the Desired Effects (DE) had been elicited through the experience.

DE 1 Participants experiencing and understanding the implications of DDN

All participants could eventually understand the concept and the implications of DDN being executed by the bench. Participants acknowledged the concept of DDN more clearly as they proceeded from the first tab 'health' towards the last tab 'safety'. 5 people responded that they fully understood what the bench is doing and this number gradually increased to 7 when they were asked while interacting with the third tab. The design intention had been accomplished as the majority of the participants started from the first tab and gradually moved on to the second and third tab.

> *P2: "It promotes healthy activities. Heavier your are, shorter you are allowed to sit on the bench.",*

> *P3: "It prefers high class people.",*

> *P4: "You can sit longer if you have high socio-economic status."*

It was also interesting to witness that participants naturally utilised their personal experience as a reference to better grasp the operation of the bench. Things that they have thought about or have observed from their daily lives facilitated participants to picture imaginable scenarios of how this bench would work in a real city settings.

> *P1: "Maybe this bench is here to prevent homeless people or young people who keep smoking weed from staying on the bench for a long time.",*

> *P8: "I think it is based on a stereotype, but also at the same time it*

is bit true, since most dangerous people on the street, they are often middle eastern people."

Remarkably, this participant appears to recognize the problematic of stereotypes in general while reinforcing them at the same time. This can be read as a defence for DDN solutions and techno-solutionism in general, which are elements this project aimed to critique. At a minimum the speculative nature of the design helped to open up this discussion.

Furthermore, during the experience of first two tabs - health and cleanliness -, participants were able to comprehend the abstract principle of DDN's urban governance. They understood that DDN determines certain types of people or behavior as preferable and that these are reproduced by a governing approach of optimisation. They recognized that the bench's system presets certain citizen lifestyles, such as healthy or consumerist, as desirable standards and discourages people who do not match these standards with lower level of comfort. And thereby people can be eventually nudged into changing their lifestyles in line with more desirable standards determined by city management.

P6: "It seems like this bench wants to incorporate other categories of people into normal category. It only treats 'normal' people as an individual.",

P7: "After doing other two (tabs), I can understand. I think there is some kind of a citizen class that the municipality implicitly set."

In general, participants experienced certain level of intimidation and dread originating from the disharmony between the Smart Bench's purpose and its actual functions. They perceived the bench as something alienated from its original usage in a sense that a bench - a familiar public facility that

they encounter everyday - is collecting personal information and private indexes to discreetly prevent certain people's usage. The emotion of anxiety was also detected which was due to the Smart Bench's low salience of data collection points. A few participants felt anxious because of the fact that they cannot know how the bench is capturing those private indexes and to what extent the bench knows about them.

P6: "It feels bit alienated because a bench is a public facility but I need to have someone else's permission to use it."

P1: "I wouldn't dare to sit down. I am not a bad person but I am still afraid what if I don't qualify."

DE 2 *Evoking critical awareness and reflection on the discriminatory potential of DDN*

First of all, the experience successfully evoked critical awareness on the discriminatory potentials of DDN. Participants found the unfairness of the algorithmic decision-making relatively more concerning than data collection itself. They criticised the embedded system associating certain urban values like pleasant atmosphere or safety with citizens' private indexes like socio-economic status or ethnicity. Participants acknowledged stereotypes inherent in the algorithm and remained skeptical to the neutrality of the data even if the algorithm was based on some statistical proof with actual database.

P4: "It is discrimination that the bench draws correlation between people's ethnicity and the safety.",

P6: "The government excluding certain types of people is regarded as against humanity. And I also don't want to restrict other people's

usage just because I want to be more convenient."

Second of all, different level of criticism on DDN was discovered depending on which urban value it had been implemented: citizens' health, neighborhood cleanliness, or crime-free safe environment. Participants' critical thinking was especially stimulated during the activity of adjusting the algorithmic settings themselves to nudge forthcoming audience. In general, many people felt guilty and found it problematic to exclude certain categories of population and formulated altruistic empathy towards the people who are allowed to sit less.

Nevertheless, participants showed the most generosity towards the health-promoting bench compared to the other two. A tendency of accepting the well-meant intention of promoting citizen health was observed, which led to a certain degree of tolerance of the municipal paternalism. And no one showed a mistrust of the accuracy of the bench determining each citizen's degree of obesity. While adjusting the algorithmic settings to allow everyone to sit with shortest duration of stay, one participant even hinted a positive conformity to the bench saying that it would help overweight people to not feel alone to stand up and go for an exercise.

P1: "I am quite lazy so I would feel upset if I had to get up for my obese friend because of the bench, but since I understand the goal of the bench, I have a sympathy for the heavier people. So I would be active with them.",

P7: "Except the health tab, other tabs are causing a separation in the society."

The urban values of cleanliness and safety brought about more resolute criticism and some disbelief on the categories of data the bench collected.

Most participants became aware of its exclusiveness and injustice, leading to a contemplation on whether the municipality properly defined what a clean, pleasant, and safe neighborhood signifies. Especially, viewing citizens' ethnicity in association with the possibility of a crime provoked severe opposition by 'being too racist'.

P2: "I feel that this algorithmic system is a reflective system of the society. I would go against this system because it looks like it is supporting racism."

Meantime, there were still few opinions of accepting the implementation of DDN for the sake of these urban values, either because the values had prior importance or since they reckoned DDN doesn't really infringe individual human rights. These participants argued the necessity of surveillance to protect such important value that we don't want to take the risk of losing. And they rather found DDN benign since it still preserves individual autonomy to hang around, merely shifting its location of occurrence away from the public space which is an action already being taken by the local police in the present times. P5 invoked the example of people being alright with the strict security surveillance at an airport to address that a perfect state of anonymity can be sacrificed for everybody's safety and underlined that if an individual remains transparent and has nothing to hide, no personal right will be infringed by it. Two of the participants even proposed what can be improved to build a better data system for more efficient safety maintenance.

P8: "I don't want trashy people or kids smoking weeds hanging around the public bench to sit because they are annoying. They can smoke it in other places, not in a public space. I don't think it is dangerous."

P8: "I think the ethnicity statistics depends on which neighborhood the bench will be located. For instance in Brabant, there is hardly a foreigner. So most crime causing people will be white rednecks. Then the ethnicity option should be different."

Furthermore, critical awareness on techno-solutionism of DDN was also spotted during the session. The interface triggered people to question the relevance of the solutionist approach, using smart technologies to steer undesirable population or behavior away from the public space. Doubts were raised regarding the effectiveness of DDN arguing that putting restrictions on people's behavior will not solve the actual problem.

P5: "I find the cleanliness bench the most disturbing. Of course, homeless people can be weird and smelly, but the city should tackle the problem in a different way. What they actually should do is to prepare free rooms for them to sleep."

Last but not least, the speculative scenario of the Smart Bench provoked participants to reflect on the present state of urban governance and perceived DDN as something similar to what is already happening nowadays. Participants realized that the absurd operation of the Smart Bench is actually not detached from discriminatory beliefs of the present time that are so unconsciously prevalent in our society that they are familiar with. The design successfully triggered people to connect the experience of DDN with the world that they live in.

P5: "In Milan, they put spikes on the street benches already so that people cannot sleep there. But it will just move these people to other side of the street. It will not solve the issue."

P2: "The logic that the bench contains sometimes make sense. However, deep down it is based on false belief that we interiorized within our culture. Since I was young, I hear these news saying that the criminal is from middle eastern country or migrants are coming to our country to commit crimes. And we also hear when someone is asked whether his community is safe, they tend to answer like this: 'there are some migrants, beggars, pickpockets..'. This actually could have stemmed from racism and discriminatory beliefs."

P4: "At the same time, I find this bench's safety algorithm quite eurocentric. For example in Korea, which is a mono-ethnic country, major crimes are mostly related to the population of male, like the example of frequent sex crimes. However, in Europe, many violent crimes have some sort of relationship with ethnicity, like the issues of terrorism or immigrant crimes. So I think this ethnicity-safety relationship is quite western minded."

DE 3 *Eliciting open discussion about the application of DDN during and after the experience*

Since the final evaluation had to be carried out remotely with people in isolation, public discussions involving couple of participants were not feasible in reality. Nevertheless, during the two sessions where two participants respectively took part in, several interesting topics were discussed between the participants. Particularly, active dialogues were elicited during the activity of adjusting the settings to nudge other people.

Topics that were discussed ranged from the rightness of the DDN implementation, validity of ethnicity as a data criterion to predict neighborhood safety, to a meta level of context interpretation. The discussion around the rightness of the DDN stemmed from the different level of critical awareness on the force attribute of DDN.

P7 opposed the implementation of DDN, regarding it as forceful, thus hard to resist. P7 found the actuating bench limiting individual autonomy and discriminatory in a sense that the rights of people with lower socioeconomic status were more restricted than those with high socioeconomic status. On the other hand, P8 disagreed with P7's point of DDN limiting the individual autonomy by arguging that unwelcome citizens can still hang around somewhere else so their freedom of action is still conserved. It was interesting to observe that the status quo of many municipalities' action on the homeless issue - often through bans or police intervention to displace them - worked as a warrant to defend DDN. P8 didn't view DDN as something unfamiliar or new but rather a method of necessary policing to which some technologies were added.

P7: "It's bit dangerous to think that we can limit people based on their status. It is about human rights.

P8: "What they do now is also similar to this bench's system. People call police to get rid of those white kids hanging out smoking weeds because they will cause trouble. That's what they do currently."

Another discussion was initiated by P8 on the relevance of ethnicity as a criterion for crime-rate prediction and safety maintenance. The participants first shared the view that the stereotypes shouldn't be included in the system. However, upon condition that the bench's algorithm is based on a statistical data, their opinions diverged. P8 distinguished the logical usage of racial data for public good from laymen's general stereotypes. P8 emphasized on the positive outcome of a detailed safety control, considering possible prejudice on certain ethnic groups as something that should be put up with. P7 expressed a concern on this idea from the fact that criminals' ethnicity doesn't represent the cause of the crime. The possibility of basic right infringement of innocent individuals

had been raised, referring to previous real examples of injustice that such hasty generalisation had brought.

P7: "I don't think it is right to apply statistics. The fact that high percentages of terrorists are middle eastern people doesn't mean that they should be restricted."

P8: "If big part of a certain ethnicity is causing a trouble, they are the one who is ruining the rest. So people who has the same ethnicity might also suffer from this generalisation but it's for a bigger good."

The final discussion was more of a conversation than a dispute, triggered by different interpretations on the reality of the prototype's context. Participants discussed and imagined the possibility of an alternative future of the Smart Bench. P3 indicated a strong disbelief on a realisation of such discriminatory bench and some confusion on the likeliness of the bench's hidden intention. Meanwhile, P2 made a remark on this response, presenting a new interpretation on the bench's controversial features. P2 interpreted the interface as a sociological study the municipality is carrying out with the intention to test out its citizens' values. It was very exciting to observe a new unintended layer of speculative scenario being created by the participant's own imagination since it seemed like an affirmation of the bench's capacity to evoke different imaginative possibilities.

P3: "It is bit vague and confusing. Is it the municipality just showing around the bench or are they trying to make you aware of the racist measurement?"

P2: "It think it intends to reflect how people perceive other people, which reveals people's own inclusivity and values through the activity of restricting other people to sit on the bench. It makes people to realise their own hidden values.

Findings about the Experience Design

Feedback on the experience design itself were received during the last part of the session. Participants were asked a few questions to evaluate how well the predefined 4 Design Requirements (DR) were materialised. Given to the fact that all participants' professional backgrounds were closely related to the design field, detailed comments and some design suggestions were made.

DR 1-1 Intuitiveness of the interface

A series of interactive activities in three different tabs gradually facilitated participants to understand the concept of the Smart Bench and experience DDN's discriminatory implications. Though, more than half of the participants expressed difficulty understanding how the buttons - representing certain population category - work. The buttons' preset evoked confusion, making participants spend the most time interacting with the first tab to figure out the mutual correlation between the buttons.

Whether a button is toggled on or off was dependent on the other button which had been just clicked by the participant. All the buttons which represent the population category that are allowed to sit longer than just selected category were automatically toggled on when certain button is clicked by the user. 2 participants understood it fast that more inclusive the bench becomes, less time is allowed to the population categories that has been selected. But for the others, it was not intuitive enough to grasp the relationship between the amount of time allowed and the combination of buttons. They either thought the button interaction was the result of some error or needed some hint from the interviewer to fully understand

how it worked. It is likely that since this method of button interaction - toggle buttons being mutually influenced by other button that has been clicked - is not common in conventional websites, it increased participants' cognitive load.

P1: "I don't get why when you click 'middle' button, 'high' button also turns green.",

P4: "It is confusing to recognize whether it is possible to choose multiple categories of people or not. It is not clear that when I click 'middle', then 'high' status button will be also automatically selected and that the amount of permitted time will be influenced by the middle status."

DR 1-2 Familiar and relatable context and topic

In general, majority of the participants admitted that the situational context of a public bench felt familiar and found it directly relatable to their daily lives. The casual everyday existence of a bench as an urban object effectively drew affinity to the prototype which contributed to the overall experience in two ways. It not only boosted the understanding of the bench but also amplified the emotional agitation when the participants noticed its functional dissonance.

P1: "It was quite relatable because I also have certain people that I don't want to sit with."

P4: "Since the steering algorithm was embedded inside a conventional bench form, I felt as if I just got deceived by the bench and felt scared."

On the other hand, a drawback of the aforementioned agitation was also

detected. When the participant perceived the Smart Bench's alternative features as too alienated from her/his preconception of the familiar public bench, it can rather hinder the immersiveness of the design. One participant pointed out that since a public bench is a familiar object to him, the prototype of intelligent bench felt bit 'too far-away future', making it hard to believe in the scenario and eventually turning him off. This could be interpreted as a result of the imbalance in familiar aesthetics and alternative aesthetics. Through familiar appearance, the bench succeeded in suspending participants' disbelief but due to lack of design elements that subtly hinted the speculative aspects of the alternative future, participants might have experienced a sudden transition in space. By intentionally disclosing the data capturing elements of the bench or endowing the bench with unique appearance in case of real life testings could be a solution to prevent this turn off.

DR 2 *Understanding of the 5 key attributes of DDN through user interaction*

After the experience, participants were able to discern the 5 key attributes of DDN: data granularity, salience, responsiveness, force, algorithmic decision-making. The short interview and conversation during the session revealed that participants successfully recognized these attributes from the experience and could talk about the perceived level of each attribute when asked.

Most of the participants perceived the attributes of data granularity, responsiveness, and force of the bench's DDN to be high and the attribute of salience to be low. They comprehended that the bench discreetly collects fairly personal data in real time, whose nudge was difficult to opt out. Some participants found it hard to assess the level of data granularity due to hidden data collection points, since it was difficult for them to assume how the bench is capturing certain personal indexes like socioeconomic status or ethnicity. For this reason, some suggested the design to have some disclosure of data input source.

More than half of the participant acknowledge the attribute of algorithmic decision-making but 3 participants found it rather hard to recognize. This was mainly because they were bit clueless on the origin of the algorithmic association the bench utilized due to its hidden DDN. For instance, they weren't sure whether the correlation between the safety and ethnicity is made by human decision-makers or by the machine learning. Additionally, participants' dual experience of the nudgee and a nudger created a misunderstanding that the citizens are nudged by other human citizen, not the algorithm itself. This can be due to the remote testing environment where it is almost impossible for the participants to discover the embedded sensors and actuators on the bench themselves. For accurate evaluation, an evaluation with the real bench seems necessary.

DR 3 *Provocativeness of the design to elicit curiosity and critical questions*

Six participants agreed that the design initiated provocation. The design effectively created puzzlement within the participants whether the prototype is supposed to be a serious product or a ironic object. All participants eventually realised that it is a speculative scenario with the intention of critique, but a few participants remained still confused until the last part of the interview. The prolonged confusion can be effectual in eliciting stronger self-contemplation and discussions. But still, it is preferable that the participants realise its critical attitude and probable future scenario at the end of the experience. In this sense, additional evaluation with the original target users seems necessary since the entire testing subjects had design-related education to recognise the design criticism.

> *P1: "I kept asking to myself, 'is it a good design or is it supposed to be racist?'"*

P4: "At first, I was really unsure whether it is a new type of panopticon. Like a new surveillance system, bit neo-Nazi styled, that attempts to filter out excellent citizens using new technologies."

Meanwhile, more than half of the participants found the design provocative, which in principle is a a positive achievement as that was what sparked many discussions. However, the design's tone of storytelling received some meaningful criticism, in that it is too explicit and blatant, suggesting that it could be more subtle and indirect with added nuance.

P3: "I find the message of the design too straightforward, too black and white, exaggerated with no nuance."

Additionally, participants perceived different level of provocation per tab. People felt most provoked towards the Safety Tab since it was hard for them to imagine such discriminatory bench can appear in such a country with an international orientation and open mentality like the Netherlands. Cleanliness Tab evoked less provocation since many participants saw some similarities with what municipalities are already doing and Health tab had the least provocation due to its well-meant intention.

DR 4

Convincing and immersive experience

It could be inferred from the participants' response that the high level of provocation had a considerable influence on people to regard the bench as less convincing in reality. It was fairly difficult for them to believe that Rotterdam municipality will make such a bench. To reduce this perceptional bridge between the bench and the present time, the feasibility of the bench's intelligent features should be more visible so that the design could retain the unfamiliarity of the alternative future while clearly revealing that these features are already quite realizable with the current state of smart technologies. In this way, the design could remain

convincing throughout the entire experience by attaining the suspension of disbelief about possible futures.

P3: "The design is clearly confronting, but the fact that I personally don't believe that the municipality will do this makes me think that this doesn't make sense."

The interface layout design resembling the visual style of Rotterdam municipality had positive effect in persuading participants of its seriousness. And many participants lamented the lack of the actual physical bench experience and showed an interest in the full-scale testing placed in the midst of a real urban area.

6.3 Limitations & Recommendations

Limitations

Absence user-artefact interaction in physical context

A change in plan due to Covid-19 outbreak had a drastic influence on the intactness of evaluation sessions. Originally, participants were going to interact with the bench artefact located in the open space of Rotterdam city, on which sensors and actuators are attached out of sight. And participants could check where these sensors and actuators are if they intend to do so. However, without a physical bench, it was difficult for the participants to acknowledge that the bench is technically equipped with sensors measuring their health, socioeconomic status, and ethnicity. For this reason, some participants were not convinced with the scenario of the Smart Bench, finding it out of the blue futuristic. Furthermore, since participants could not check the bench functioning based on the algorithmic settings they just applied, it obscured the possibility of

subsequent asynchronous user-user interaction of previous participants nudging the forthcoming participants.

Too specific test subjects

It is likely that the test subjects with design background had certain influence on the results of concept evaluation. Although it was an international crowd, all participants had a design related background and were highly educated. This might have influenced the level of concept and interface layout understanding and the provocation level. Thus, for more accurate and realistic evaluation of the prototype, another testing session might be necessary to be carried out with laymen subjects who hold corresponding qualities of the original target user.

Insufficient understanding of the testing context

The hypothetical testing context that participants are attending a public showcasing event of the Smart Bench should be made more clear. Observation during the interface experience made it clear that people didn't really pay attention to the written explanation on the initial loading page. This often led to misunderstanding of the testing context, creating confusion within the participants over what circumstance they are interacting with the algorithm interface. Thus, a usage of a short promotion video with audio recorded step-by-step guidance before the interface experience can be added to achieve clearer understanding of the context.

Recommendations

Toning down the storytelling through making the data points more explicit

The interface's straightforward storytelling can be toned down to a subtle nuanced message. The current design conveys the concept of citizen data utilized to steer their behavior in an openly discriminatory and racist manner. It definitely created a provocative experience but turned out to be bit excessive, leading participants to find the operation of the bench far predictable and the concept bit unbelievable.

To convey the story of manipulative DDN while keeping it subtle and appropriately provocative, the design can use the intermediate data instead - shoes brand or speaking voice loudness - , rather than the final information inferred therefrom like socioeconomic status or ethnicity. In this way, participants will be confronted with the data source that is subtle enough to hold the mystery around why such data is being captured for a pleasant or safe neighborhood. And when they eventually find out, for example, that the bench identified their socioeconomic status through what kind of shoes they were wearing, it can effectively underline that supposedly neutral information could actually have been extracted from a poor dataset. It can add some fun factor to the design by letting certain appropriation possible on the spot, since the participants can be in the other participants' shoes and experience the bench differently reacting.

Meanwhile, the disclosed data source can make the scenario more convincing and immersive.

Making the aesthetics of the bench into a unique form which explicitly displays its data capturing feature could be also helpful.

An open testing setup for group participation

After conducting both individual sessions and group sessions, it can be concluded that testings with multiple subjects is recommended. Participants engaged with the interface more enthusiastically in the presence of their counterparts. Interesting discussions were generated while commenting on each other's thoughts, decisions, or feelings. Many contrasting opinions and complementary remarks were made during the individual sessions as well, which could have been more fruitful if these had been exchanged between each other. Thus, in the future it is advised to carry out in an open testing setup encouraging group participation so

that multiple people can simultaneously interact with the bench and the interface.

Implementation of more advanced technology

The completeness of the bench and the interface can be improved by implementing some advanced programs and hardwares. A Raspberry Pi microprocessor can be used with a webcam module to actually capture visual inputs of people's shoes or their heights. This data can be analysed using open source Teachable Machine tool and openCV to train an algorithm that distinguishes people's socioeconomic status based on their shoes (or calculates people's BMI by integrating their weight data retrieved from the FSR sensors and the height data). Thus, it can be developed into a fully working prototype.

Possibility of an all-in-one Smart Bench experience

An all-in-one version of Smart Bench experience can be considered as an alternative design. It can be an alternative plan in case 'the nudger' interaction doesn't elicit desired effects during the on-spot evaluation. The current design consists of two artefact-user interaction - one is user-bench interaction and the other is user-interface interaction - and an asynchronous user-user interaction - when later participants are nudged by the algorithmic settings adjusted by previous participants. The user-bench interaction is 'the nudgee' experience and conveys the message that the algorithmic governance can steer your behavior without you even noticing it. Meanwhile, the user-user interaction represents 'the nudger' experience, communicating the message that algorithms and data can never be neutral since they reflect certain values and interests of few decision-makers. However, since it was impossible for the participants to experience the complete 'nudger' experience due to the absence of the physical bench, some participants couldn't understand that 'nudger' participants play a role of the temporary decision-makers who influence the algorithmic operation

of the bench with their own values and interests.

Therefore, an alternative design with simplified message, 'Smart Bench for good citizens' can be explored as a spin-off and tested in an all-in-one format without the interface. It can be the intelligent bench itself which immediately actuates when it senses 'bad citizens' by using the same data sources as the original design. In this way, the core message of the design can be simplified into addressing that an algorithmic governance can steer your behavior based on your behavioral and personal data. The second message about the bias of data and algorithm can be experienced through a playful activities of participants trying to change themselves - like their make-up styles or clothings - so that they fit to the standard of a 'good citizen'.

7 CONCLUSION

7.1 Project Conclusion

The project started from two main research questions: which urban element best encompasses the problematic nature of Smart City and whether design can evoke critical awareness on this for ordinary citizens. During the first part of the project, data-driven nudging was identified as an emerging operational logic of smart cities that will have considerable influence in people's every day lives. Five key attributes of data granularity, salience, responsiveness, force, and algorithmic decision-making were defined, depending on the level of which various spectrum of data-driven nudging can exist. And three crucial implications of data-driven nudging - decreased level of citizen autonomy, increased level of surveillance, and depoliticisation - that ordinary citizens are unaware of were identified as well.

During the prototyping phase, several design elements and concepts were explored to discover the most effective way of communicating the abstract concept of data-driven nudging and its implications by making it experiential. The evaluation session of Smart Bench revealed the potential of speculative experience as a catalyst for critical awareness and open discussion about the discriminatory behavior manipulation of data-driven nudging. Through the double-sided interactive experience of being nudged and becoming a nudger, participants successfully perceived the core principles and social implications of data-driven nudging by relating to their own daily lives. Especially, participants became critically aware of the unrecognized biases that can be present within the data-driven algorithms of data-driven nudging, leading to a series of enthusiastic discussion about its necessity for better urban governance. The design formulated an experiential space where people can comfortably talk about formerly impalpable and abstract matter from their own perspective. It was also interesting to observe similarities in logic between the participants who admitted the necessity of data-driven nudging and smart city promoters.

Furthermore, the algorithm interface made it clear that participants did not perceive the operation of Smart Bench detached from the current society they live in. They could reflect over various matters of the present regarding individual autonomy, the municipality's governance, and preexisting discriminations in our society.

Further research can be carried on what design effects of in-situ, all-in-one version of current Smart Bench would bring. And the experience should be tested with a wider audience in an open and public setting with multiple number of people simultaneously interacting with the prototype.

7.2 Reflection

This project continuously awakened me of a necessity of speculative and critical design in the society that we live in where no sufficient time is allowed for contestation and self-reflection. During the research, I realised that the frictionless efficiency powered by disruptive technologies - a typical goal that I have been educated as a designer to pursue - can actually reinforce the status quo of structural inequality and belittle the importance of political discourse. I think that we are living in an era where advanced technology became a new authority and it is highly likely that this tendency will continue as more uncertainties arise. With the current COVID-19 outbreak this has become even more apparent. Giant tech companies like Apple and Google are taking initiative to develop a contact tracking app with their technological capacity, while governments such as in the Netherlands, are showing interest in implementing such apps.

This is why we need more design for criticism facilitating people to face real causes of the crisis yet to happen and contemplate on what we are sacrificing for the hegemonic pursuit of efficiency. The project was a great opportunity for me to explore the potential of design as a medium of communicating abstract concept of disruptive technologies and

initiating critical questions about its application to which we have become accustomed. It was really meaningful to sense the influence of the design through observing people actively engaging in a political discourse and raising critical yet reflective questions. Because at this point, what society needs is smart questions rather than smart technologies.

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ii. APPENDIX

Appendix B. Questionnaire form about undesirable urban behavior

Exploring the urban undesirables

Hi, I am Jooyoung and this survey seeks to identify undesirable urban behaviors happening in the city and how much people are annoyed by certain behaviors. The result of the survey will only be used for the purpose of ideation for my graduation project and will not be shared to other parties than myself.

* Required

1. **Please select your age** *
   Mark only one oval.
   - ◯ Less than 18
   - ◯ 18-24
   - ◯ 25-34
   - ◯ 35-44
   - ◯ 45-54
   - ◯ 55 and over

2. **What is your gender?** *
   Mark only one oval.
   - ◯ Female
   - ◯ Male
   - ◯ Prefer not to say
   - ◯ Other: _____

3. **Have you ever lived in a city?** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No *After the last question in this section, skip to question 5.*

4. **If you lived in a city, in what city have you lived?**
   You can list several.
   _____

If you ever lived in a city, you can participate in this survey based on your actual experience. If you never lived in a city, you are free to base your answer on what you've heard from others or what you think is happening.

5. **Here are some examples of undesirable urban behaviors. How annoyed do you feel about these behaviors?** *
   Please choose one response per row.
   Check all that apply.

	I don't care	Not annoyed at all	Hardly annoyed	Somewhat annoyed	Strongly annoyed
Urinating on the street	☐	☐	☐	☐	☐
Free-riding bus/metro/train	☐	☐	☐	☐	☐
Painting a graffiti	☐	☐	☐	☐	☐
Random stranger shouting 'Ni Hao' to someone who has asian appearance	☐	☐	☐	☐	☐
Feeding pigeons	☐	☐	☐	☐	☐
Homeless or beggar asking for some money	☐	☐	☐	☐	☐
Neighbor throwing a home party all night long	☐	☐	☐	☐	☐
Drunk people on the street	☐	☐	☐	☐	☐
Littering	☐	☐	☐	☐	☐
Jaywalking or driving through a red light	☐	☐	☐	☐	☐
Teenagers hanging out in a park drinking and smoking weed playing loud music	☐	☐	☐	☐	☐
Catcalling	☐	☐	☐	☐	☐
Vandalizing	☐	☐	☐	☐	☐
Traffic jam	☐	☐	☐	☐	☐
Drivers honking horns when it's unnecessary	☐	☐	☐	☐	☐
Riding a bike on a wrong lane	☐	☐	☐	☐	☐
Protesting	☐	☐	☐	☐	☐
Throwing cigarette buds while biking	☐	☐	☐	☐	☐
Spitting	☐	☐	☐	☐	☐
Talking loudly on a phone in the silent train cabin	☐	☐	☐	☐	☐

6. **Please suggest any other undesirable urban behaviors you are annoyed about.** *
   The more suggestions, the happier I will be
   _____

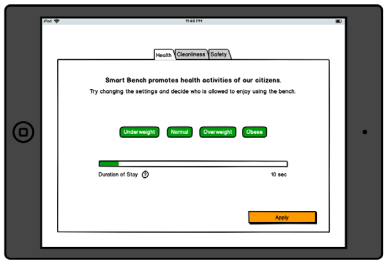
Powered by Google Forms

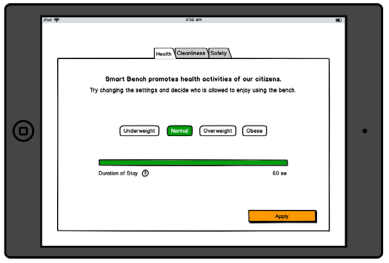
Appendix C. Interface Design Wireframe

WIREFRAME : TAB1 HEALTH

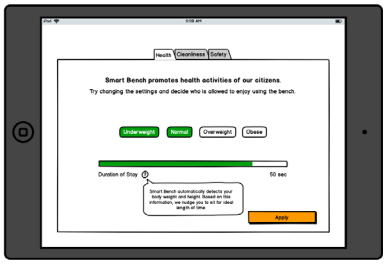
Start Page

Option Selections





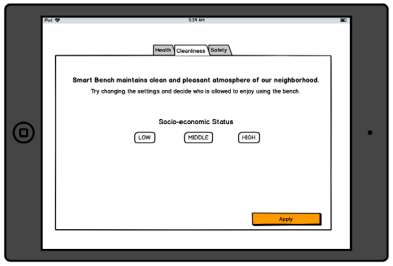
Hover Additional Description



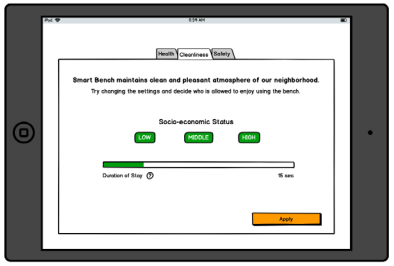
Click Apply Button

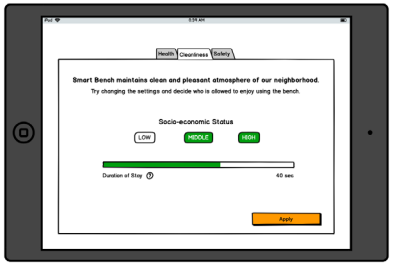
WIREFRAME : TAB2 CLEANLINESS

Start Page



Option Selections





Hover Additional Description

Click Apply Button

WIREFRAME : TAB3 SAFETY

Start Page

Option Selections

Hover Additional Description

Click Apply Button