

# **Learning from Toronto**

## **An Experiment in Participatory Urban Data Visualization**

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## **Abstract**

Despite the unprecedented amount of data about the world that is collected and produced in our increasingly information-dependent societies, the possibilities for significant differences between human perception and actual data on the same phenomena are all but reduced, as are their potential effects on environments and communities. This thesis explores the opportunities offered by data visualization and interaction design to reveal and address such disconnect and to challenge widespread misconceptions by generating a deeper and more engaging understanding of information. These principles inform the proposal for a methodology for visual, interactive communication of data within urban environments, aimed at generating an iterative exchange of information between citizens and institutions. A concrete application of this proposal is investigated through the development of a digital platform for urban data visualization addressing issues within the city of Toronto.

## **Dedication**

I dedicate this thesis to Francesca, my partner in life and in design, who supported me through my path in the MDES program with endless wisdom and patience. I wouldn't have been able to reach this result without her. I also wish to thank my parents Enrica and Dario who have always encouraged me to invest in myself and in my passions. Their support was invaluable, and has been able to completely overcome the physical distance between us.

Finally, I wish to thank the late Professor Tomás Maldonado. He was an incredibly brilliant and humble person, and I was extremely lucky to know him. During our long conversations in his book-lined studio, in between stories on his career and discussions on politics and life, he helped me to start believe in myself as a designer.

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I must express my gratitude to Giorgia Lupi and all the amazing people at Accurat for welcoming me in their team last summer: they helped me grow as a designer beyond my wildest expectations, and also provided me with key suggestions on how to further develop my thesis work.

Finally, I wish to thank the people who kindly agreed to participate in the user testing sessions I conducted during this research. Their contribution has been a fundamental element for the development of this thesis.



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## Introduction

As the worldwide urban population grows at an unprecedented rate, cities are one of the key scenarios in which increasingly complex challenges—both at local and global scales—need to be addressed. Data visualization offers invaluable opportunities to investigate, analyze and understand the complexity of urban environments. It can provide new methodologies, new languages and new types of information that allow citizens to get a better understanding of the spaces they live in, and that are well-suited to inform decision-making at the institutional level. Most important for the purpose of this research, is how data visualization can support new forms of civic engagement and agency, as it allows not just insiders, but potentially all citizens, to use the data collected within cities towards a positive impact for the whole community. Recognizing how this democratization of information can directly involve citizens and institutions in discovering and confronting issues and opportunities within cities, led me to identify two main avenues of inquiry for my research.

I investigated a methodology that could foster a dialogue between people and institutions through visualizations of urban data. This strategy is aimed at disseminating information about cities while at the same time allowing citizens to share back their personal knowledge as the people who inhabit and transform them—with the conviction that such an iterative process could represent a resource for all parties involved in the dialogue to better understand their cities.

At a higher level, I also explored the methodology as a tool to investigate the relationship between people and information. Research on this topic led me to identify this relationship as increasingly complex and problematic, as the wealth of data about the world we live in that is currently produced, collected and disseminated doesn't prevent the existence of potentially profound misperceptions and cognitive biases in the way this data is perceived.

Therefore, I focused on cities as a framework to investigate these issues, exploring the hypothesis that identifying and measuring gaps between citizens' perception and urban data on the same topic might lead to a better understanding of the challenges faced by urban environments—and highlighting the crucial role graphic design, interaction design and data visualization can play in this process.

I finally developed a design proposal based on the principles of the methodology I researched, and focused on the city of Toronto, as its size and multicultural background make it a complex space facing many urgent issues that can be explored and addressed through design and data visualization.

My years of academic and professional experience in architecture and urban planning provided me with a valuable background to investigate the spatial and social complexity of cities, and to explore drawing as a design interface to represent the world, a visual code to communicate tangible and intangible issues. Studying and practicing graphic design allowed me to experiment with the tool of drawing beyond the technical and analytical realm I was familiar with, towards more expressive and experimental forms of visual communication. From a personal point of view, I chose to focus my research on data visualization as a discipline that, from a designer's perspective, takes the best from both worlds: it can allow a high degree of expressiveness, especially when its goal is the presentation of data rather than its analysis, while maintaining a very concrete purpose—visually communicating information in an effective way.

The following chapters will outline my journey through this research: Chapter 1 focuses on information and design theories at the core of the research; Chapter 2 presents the discipline of data visualization and its current use as a way to investigate urban environments; Chapter 3 provides an outline of the city of Toronto, focusing on current issues of urban relevance and on how public urban data is currently available and disseminated in the city; Chapter 4 describes the design methodology I devised to investigate the research hypothesis, outlining the research and practical explorations

through which it was developed; Chapter 5 presents the first design proposal I produced to put the outlined methodology into practice; Chapter 6 summarizes the usability testing I conducted to evaluate the proposal, presenting the findings from the study and highlighting how they were helpful to implement a further design iteration on the proposal. Appendix A provides the visual outcomes of the design work conducted during the research.

## Chapter 1

### Information, Perception and Interaction

Through millennia of transformative actions, both on its own body and on the earth's environment, mankind has shaped a world—what design theorist Tomás Maldonado called *human environment*<sup>1</sup>—that has been increasingly characterized by a growing degree of complexity. At the core of this process, scientific, cultural and technological developments have allowed new affordances to our species, increasing our control over the surrounding environment, but at the same time contributing to unforeseen issues, introducing unexpected dimensions to humanity's challenges and, ultimately, adding to the complexity of our world. In order to address this complexity, especially following the dramatic acceleration brought about by the industrial revolution, the need to acquire, organize and understand information rapidly grew to become a real necessity, as architect and information designer Richard Saul Wurman already pointed out in his 1989 seminal work *Information Anxiety*, claiming the world was moving "toward information-dependent economies."<sup>2</sup> Wurman in fact recognizes that information has indeed been one of the core concepts of the global cultural discourse in the last century but argues that "this mantra of our culture has been overused to the point of senselessness. [...] The word inform has been stripped out of the noun information, and the form or structure has disappeared from the verb to inform."<sup>3</sup>

If information was a mantra of the 20th Century, in recent years this concept seems to have been supplanted in media and in the cultural discourse by another, related but very different, buzzword:

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1 Maldonado, T.(1972). *Design, nature, and revolution: Toward a critical ecology*. U.S.A.: Harper & Row.

2 Wurman, R. S. (1990). *Information Anxiety*. New York: Bantam Books, 39

3 *ibid.*, 38

*data*. The widespread use of this word (together with a variety of related concepts, such as data-driven or big data) is a natural reflection of the interconnected human environment in our day and age, which produces and stores more data than ever<sup>4</sup>, and increasingly relies on it for its functioning and development. Furthermore, especially within the media, this word has become a symbol charged with enormous expectations, often presented a-critically as an invaluable resource that could grant us new powers to handle our environment's complexity—as demonstrated by the diffusion of the expression "data is the new oil."<sup>5</sup> Yet, as statistician Nick Barrowman points out in an article titled "Why Data is Never Raw,"<sup>6</sup> this superficial approach fails to address the inherent complexity within the concept of data, so much so that its meaning remains rather obscure, at least to the general public:

"A curious fact about our data-obsessed era is that we're often not entirely sure what we even mean by 'data': Elementary particles of knowledge? Digital records? Pure information? Sometimes when we refer to 'the data', we mean the results of an analysis or the evidence concerning a certain question. On other occasions we intend 'data' to signify something like 'reliable evidence' [...]"<sup>7</sup>

In fact, scholars, designers, analysts advocating for a more critical approach to data argue that the mere availability and wealth of such a resource is not enough to gain a deeper, accurate and more

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4 Gordon, E., Mihailidis, P. (2016). *Civic media: Technology, design, practice*. Cambridge, MA: The MIT Press, 152

5 The first use of the expression, much more nuanced before becoming a slogan, is attributed to mathematician Clive Humby "Data [...] *It's valuable, but if unrefined it cannot really be used. It has to be changed into gas, plastic, chemicals, etc to create a valuable entity that drives profitable activity; so must data be broken down, analyzed for it to have value*". In Haupt, M. (2016, May 2). "Data is the New Oil"—A Ludicrous Proposition. Retrieved on March 2, 2019, from <https://medium.com/project-2030/data-is-the-new-oil-a-ludicrous-proposition-1d91b-ba4f294>

6 Barrowman, N. (2018). Why Data is Never Raw. *The New Atlantis*, Number 56, Summer/Fall 2018, pp. 129-135. Retrieved on March 2, 2019, from <https://www.thenewatlantis.com/publications/why-data-is-never-raw>

7 *ibid.*



meaningful understanding of the world we live in: as Wurman demonstrated, data and information are strongly related, but it is important to recognize them as two clearly distinct concepts:

“raw data can be, but isn’t necessarily, information, and, unless it can be made to inform, it has no inherent value. It must be imbued with form and applied to become meaningful information. Yet, in our information-hungry era, it is often allowed to masquerade as information.”<sup>8</sup>

Wurman points back to the etymology of information claiming that it is first necessary to give data a form: that is, laying out an effective organization of the resource to make it understandable, so that it can transition to information. Without this translation process, “raw” data is hardly useful to make inferences, inform decisions, and increase our understanding of the world.

## **Perception**

It could be argued that Wurman’s visionary work is still very much on point today, as recent, dramatic events in the social and geopolitical realm, all influenced by new relationships between the production and consumption of information, made the distinction between data and information all the more worthy of recognition. From the viral spread of fake news on social media and their tangible socio-political impact on many countries, to the diffusion of ideas that challenge scientific facts such as the value of vaccines or the existence of climate change; from the unexpected outcomes of the U.S. Presidential Election and of the Brexit Vote, to the theorization of the concept of post-truth<sup>9</sup>: all of these phenomena can be read as warnings that the wealth of data available to our global

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8 Wurman, *ibid.*, 38

9 Post-truth was declared Word of the Year 2016 by Oxford Dictionaries, and defined as “*relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief.*” Retrieved March 3, 2019, from <https://www.oxforddictionaries.com/press/news/2016/12/11/WOTY-16>

community, alone, is not enough to allow a better understanding of the world's complexity. In fact, they demonstrate how the distance between human perception and data on the same phenomenon can reach surprising and worrying dimensions.

A particularly in-depth study on this subject was developed by Bobby Duffy in *The Perils of Perception*<sup>10</sup>. The book presents the results of an extensive research conducted by Ipsos MORI since 2012, with over 100,000 interviews across 40 countries to investigate "the gap between people's perceptions and the reality,"<sup>11</sup> and uses them as a starting point to reflect on the inherent biases of human understanding of information. Research participants were asked to share their personal guess about a variety of topics about their country, using simple questions such as "What proportion of the population of your country is aged sixty-five or over?"<sup>12</sup>, or "What percentage of people in your country do you think are immigrants?"<sup>13</sup> In the vast majority of cases the analysis of answers revealed a relevant difference (FIG.1) between how people perceive the world and the actual information about the topics addressed. One of the most interesting insights emerging from this research is the fact that these profound discrepancies continue to exist despite the unprecedented amount of data most of us are immersed in, every day: as Duffy says, citing Dartmouth College Professor Brendan Nyhan, "Misperceptions differ from ignorance insofar as people often hold them with a high degree of certainty...and consider themselves to be well informed."<sup>14</sup> Therefore, Duffy argues, it is difficult "to change people's misperceptions simply by giving them more information, as though they are an

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10 Duffy, B. (2018). *The perils of perception: Why were wrong about nearly everything* [E-reader version]. Retrieved from [www.amazon.com](http://www.amazon.com)

11 *The Perils of Perception*. Retrieved March 4, 2019, from <https://perils.ipsos.com>

12 *ibid.*

13 *ibid.*

14 Duffy *ibid.*, 9

**Q. What proportion of the total household wealth do you think the wealthiest 1% own?**

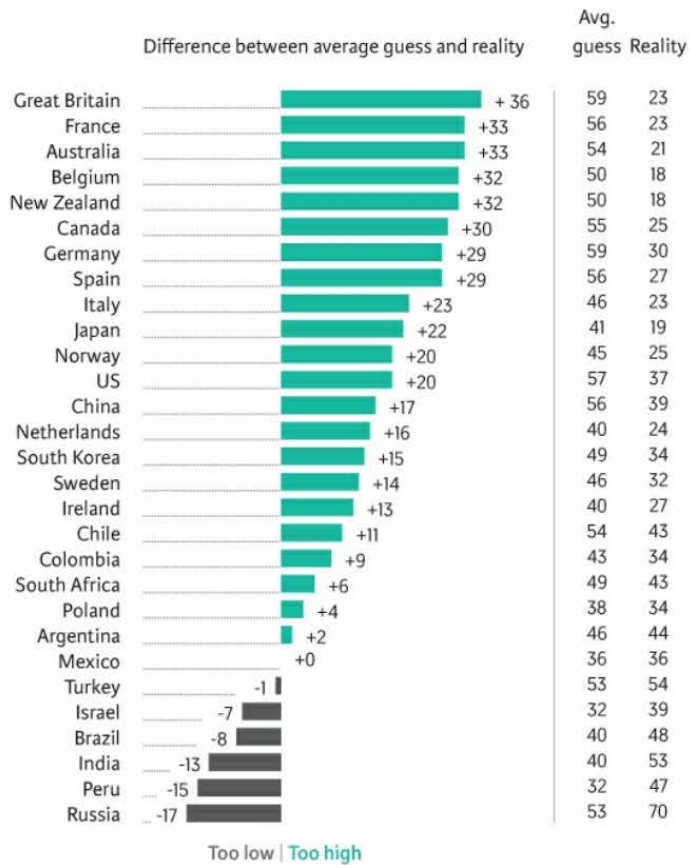


FIG.1 - Visualization of the difference between average guess and actual data from one of the questions in the *Perils of Perception* study

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INCORRECT. CLICK ANYWHERE TO ADVANCE

**More people were killed by other physical violence than sharp objects or firearms in Canada.**

30% guessed correctly in Canada.

NEXT QUESTION

**In Canada in 2015, do you think more people were killed by firearms, sharp objects such as knives or other physical violence?**

- Firearms
- Sharp objects such as knives
- Other physical violence

FIG.2 - One question from the *Perils of Perception* public online survey

empty vessel just waiting to be filled with facts that will fix their mindset and behaviour.”<sup>15</sup> The book is also accompanied by a website where readers can participate in an interactive quiz (FIG.2) to answer some of the questions that were used in the study. Consistent with the spirit of the research, users are presented with the actual data about each question only after they have answered it, in order to highlight the potential differences, together with information about the average answer from other users, and sources of the data.

The current relevance of investigations regarding misperception and cognitive bias is also highlighted by several recent examples of research carried out to gain a better understanding of these issues from the perceptual and cognitive point of view. A study that is particularly valuable for the sake of this research, since it addresses such topics from the point of view of information visualization, is “A Task-based Taxonomy of Cognitive Biases for Information Visualization,”<sup>16</sup> by a research team at Northwestern University. The paper presents an extensive investigation which identifies 154 different types of cognitive biases, and organizes them into a taxonomy that represents an important resource for further explorations on the issue, especially from the visual perspective. Unlike previous attempts in this sense, the taxonomy presented in the study is in fact “*task-based*. It organizes biases based on the experimental tasks they have been observed in, in order to help visualization researchers identify biases that may affect visualization tasks.”<sup>17</sup> Biases are classified into seven task-categories: estimation, decision, hypothesis assessment, causal attribution, recall, opinion reporting and other. Furthermore, this work provides an extensive list of references in visualization research related to each specific type of cognitive bias. This study therefore represents an extremely valuable support for

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15 *ibid.*

16 Dimara, E., Franconeri, S., Plaisant, C., Bezerianos, A., & Dragicevic, P. (Accepted/In press). A Task-based Taxonomy of Cognitive Biases for Information Visualization. *IEEE Transactions on Visualization and Computer Graphics*. <https://doi.org/10.1109/TVCG.2018.2872577>

17 *ibid.*, 2

explorations on the relationship between human perception and data, providing resources to better understand the complex variety of biases that can emerge in the communication of information, and how the design of visualizations can possibly contribute to address them.

## **Interaction**

The Perils of Perception online strategy introduces another key concept: the possibility for users to interact with information, taking an active part in the communication process without being “empty vessels”<sup>18</sup> waiting to be filled. The increase in the possibilities for user interaction is a trend that has been growing together with the diffusion of digital technologies and graphic user interfaces, eventually expanding to all kinds of media. Interaction design is being increasingly used as a way to generate engaging, and most importantly effective, communications of information, from simple examples such as the *Gapminder Test*<sup>19</sup> developed by Hans Rosling’s *Gapminder*<sup>20</sup> foundation, to more sophisticated, interactive data journalism pieces like those published by *The New York Times*<sup>21</sup>. The way interactivity is developed in these works ranges from being merely navigation-based, to including detailed visualizations users can actively query, filter, modify to explore the topic addressed; they all share the belief that interactivity can enhance (visual) communication. Among the first to delve into this subject was information designer and entrepreneur Nathan Shedroff in the late 1990s with his essay “Interaction Design: A Unified Field Theory of Design.”<sup>22</sup> In the text Shedroff presents the understanding spectrum (FIG.3), a four-step cognitive model proposed as a theoretical guideline for

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18 *ibid.*

19 *Gapminder Test 2018*. Retrieved March 4, 2019, from <http://forms.gapminder.org/s3/test-2018>

20 *Gapminder*. Retrieved March 4, 2019, from <https://www.gapminder.org>

21 *The New York Times*. Retrieved March 14, 2019, from <https://www.nytimes.com>

22 Shedroff, N. (1994). *Interaction Design: A Unified Field Theory of Design*. In Jacobson, R. E. (1999). *Information design*. Cambridge, MA: The MIT Press, 267

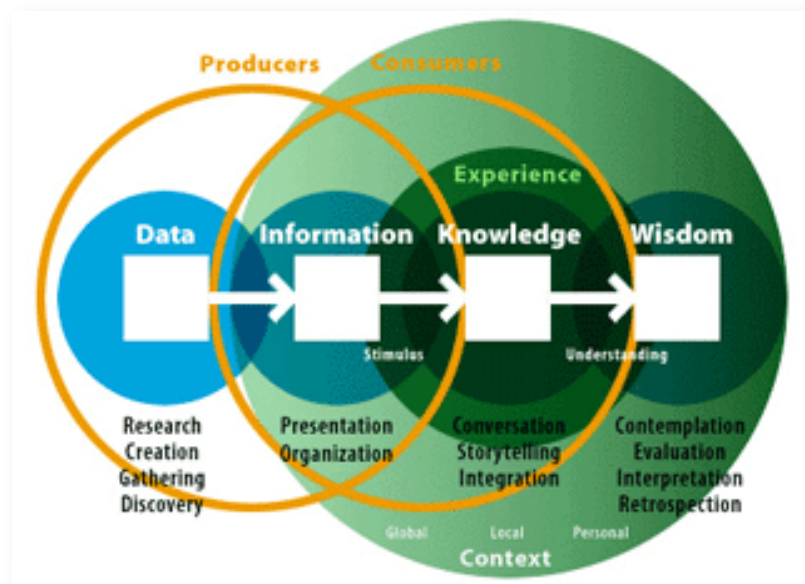


FIG.3 - Nathan Shedroff - The Understanding Spectrum

the then-nascent discipline of information design. The spectrum consists of four progressive levels of information assimilation, which Shedroff identifies starting from Wurman’s theory, arguing that “just as data can be transformed into meaningful information, then information can be transformed into knowledge and then, further, into wisdom.”<sup>23</sup> He theorizes that the necessary component in order to make the further step towards knowledge and wisdom is interaction: “Knowledge is a phenomenon we can build for others, just as we can build information for others from data. This is done through interaction design and the creation of experiences [...]”<sup>24</sup> Shedroff therefore highlights the fundamental role of design in building the compelling experiences, between people or systems, that can allow knowledge to be communicated<sup>25</sup>—also recognizing knowledge is “the highest level that we, as designers, can affect directly[...].”<sup>26</sup>

<sup>23</sup> *ibid.*, 271

<sup>24</sup> *ibid.*, 271

<sup>25</sup> *ibid.*, 273

<sup>26</sup> *ibid.*, 273

The works I presented in this chapter introduce key concepts that are at the core of this thesis. Duffy's *Perils of Perception* highlights the importance of investigating the difference between what people perceive and what data tells us. My research proposes a reflection on how design might be used to visually reveal this gap, with the conviction that direct comparisons between data and people's perception on the same phenomenon might help institutions and communities in uncovering unforeseen issues and foster a more critical approach to data, encouraging people to recognize—and therefore question—its inherent biases. Shedroff's understanding spectrum represents the starting point for an exploration of how interaction design—together with information design and data visualization—might be used to add a dialectical, iterative quality to communication processes. This 25-year old theory is still relevant nowadays: the diffusion of user-generated content across different media has increasingly blurred the distinction between information producers and consumers, giving to an unprecedented quantity of people a role (or the impression of one) in the process of translation from data to information—thus amplifying the risk for the spreading of misinformation. This thesis recognizes Shedroff's idea of a communication strategy based on interaction design as a valid approach to address such an issue: in generating a deeper and more engaging experience of information—what he calls knowledge—interaction can in fact enhance its assimilation, possibly fostering the circulation of more accurate information among the public.

## Chapter 2

### Data Visualization for the Urban Environment

Cities across the globe have grown at an unprecedented rate in the past decades, and this tendency is predicted to continue in the future. In 1950, 751 million people were living in urbanized areas, accounting for 33% of the total population on the planet<sup>27</sup>. This figure has dramatically risen to 4.2 billion people living in cities as of 2018 (or 55% of the whole population)<sup>28</sup>, and, according to the most recent revision of UN's *World Urbanization Prospects* study<sup>29</sup>, it is expected to reach 6.7 billion, or 68%, by the year 2050. Such a phenomenon is one of the main challenges to the present and future of mankind: necessarily identifying cities as the scenario where increasingly complex issues need to be addressed—in order, as the UN's study points out, to successfully manage this growth towards a sustainable urbanization<sup>30</sup> that allows responsible development in the social, economic and environmental fields.

Urban environments, through their complexity and rapid growth, pose new urgent challenges, but they also offer invaluable resources that can be used to address them: each day, human life and technological networks within cities generate a massive quantity of data. This resource, if effectively collected, managed, organized, transformed into intelligible information and disseminated, can provide a variety of opportunities—not just for institutions, but for citizens as well—to generate a positive impact on the community and on its environment. As the case studies presented later in this

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27 United Nations DESA/Population Division (2018). *World Urbanization Prospects: the 2018 Revision*. retrieved March 7, 2019, from <https://population.un.org/wup/>

28 *ibid.*

29 *ibid.*

30 *ibid.*



chapter demonstrate, data about cities can be used for goals as diverse as conducting analyses, informing decisions, addressing known problems or uncovering hidden ones, spreading knowledge among citizens, and fostering civic engagement. It is this peculiar mix of urgent issues and promising opportunities that led me to identify the city as a theoretical, physical and social framework; one that is well-suited to investigate the topics introduced in the previous chapter.

As designer and professor Kristian Kloeckl points out, “the increasing pervasiveness of embedded and mobile connected devices has transformed the built environment from a predominantly stable and enduring background for human activity into spaces and objects that have a more fluid behavior.”<sup>31</sup> In order to look at cities from the point of view of information—an impalpable, ever-changing subject—it is necessary to adopt a perspective that goes beyond merely describing them in physical or spatial terms, so as to recognize the variety of tangible and intangible layers that make up the urban environment: as effectively underlined in the introduction to *Architecture and Justice*<sup>32</sup>, a remarkable project focused on workshops about urban data by Columbia University’s Spatial Information Design Lab and The Architectural League of New York,

“[...] a city is not simply a collection of people or buildings but rather a network of relationships, a dynamic and often unstable assemblage of interactions and forces. Information about the elements of these networks [...] is constantly exchanged and produced within and between them. Information is the oxygen of the networks that make up our cities.”<sup>33</sup>

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31 Kloeckl, K. (2017). The Urban Improvise. *Design Issues*, 33, 45

32 The Architectural League of New York, Spatial Information Design Lab (2006). *Architecture and Justice*. Retrieved March 8, 2019, from <http://www.spatialinformationdesignlab.org/publications/scenario-planning-workshop>

33 *ibid.*, p.4

A key theoretical support in this direction comes from architecture and urban studies literature; a seminal work in this field proved to be especially valuable to further develop a critical perspective on the urban environment. In *The Image of the City*<sup>34</sup>, planner and writer Kevin Lynch focused on investigating the quality of American cities from the visual point of view, crucially “studying the mental image of that city which is held by its citizens.”<sup>35</sup> One of the main goals of this project was exploring the possibility that new—and potentially better—urban design principles might emerge from comparing the image of the city in the minds of its citizens with the visual reality of the urban space<sup>36</sup>. In order to study this subject, Lynch introduced the concept of urban *legibility* (also called imageability), a way to measure the impact of a city’s visual quality on its image in the minds of its citizens—which he defined as,

“that quality in a physical object which gives it a high probability of evoking a strong image in any given observer. It is that shape, colour, or arrangement which facilitates the making of vividly identified, powerfully structured, highly useful mental images of the environment.”<sup>37</sup>

Therefore, for Lynch a city is legible if its districts, landmarks or pathways are easily identifiable, and can be easily grouped into an over-all pattern.<sup>38</sup>

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34 Lynch, K. (1960). *The Image Of The City*. Cambridge, MA: The MIT Press.

35 *ibid.*, 2

36 *ibid.*, 14

37 *ibid.*, 9

38 *ibid.*, 4

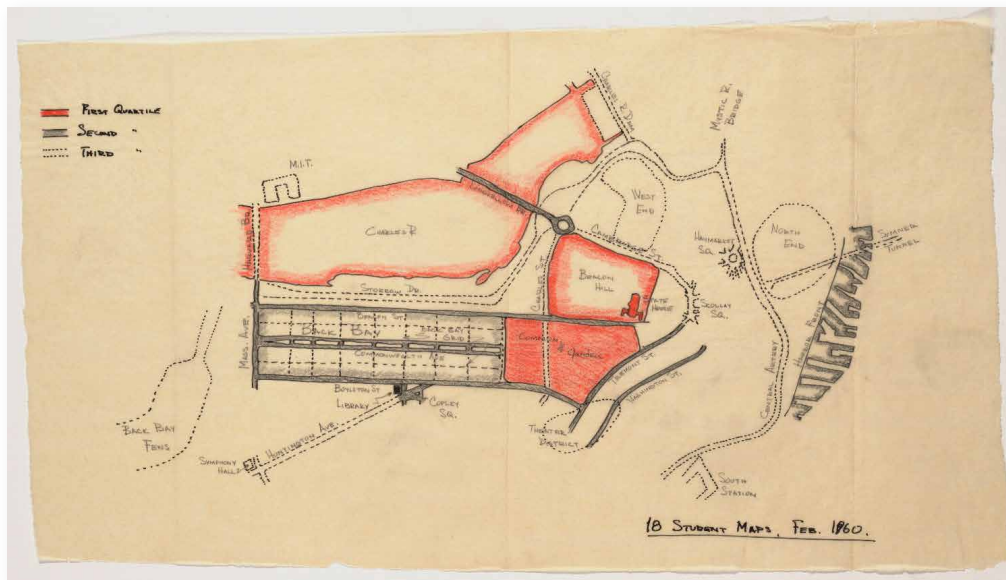


FIG.4 - One of the maps of Boston developed by Lynch and his team following interviews with inhabitants

Lynch recognized how aspirations for a sustainable, more human urban development could not be fulfilled without studying cities from the perspective of the people who inhabit them. He and his team directly involved citizens, asking them to share their personal view of the environment where they lived; even more importantly, a relevant part of this research was carried out *visually*, asking participants to draw mental maps of their neighbourhoods and cities from memory (FIG.4). This practice provided crucial visual clues on the differences and similarities between the “imagined city” and the physical one, that Lynch used as a starting point to generate new questions and, ultimately, a new theory for urban analysis and planning. Through the metaphor of legibility, Lynch hinted at cities as texts that are open to interpretation—pointing out the importance of considering the multiplicity of meanings the urban environment has for its citizens in the practices of analyzing it and planning its development.

These two aspects from Lynch’s work were fundamental in shaping two key research direction for my thesis: exploring the unique urban knowledge shared by citizens as a resource for positive and

innovative impacts on their community and environment, and investigating what urban legibility entails in the 21st Century city—with a focus on the benefits that an exploration of this concept through new technologies and methodologies might bring to urban communities. At the core of this thesis lies the hypothesis that, in our information-dependent era, Lynch’s concept of urban legibility might be a valid paradigm to investigate contemporary urban environments: specifically, by shifting the focus from their visual qualities to the invisible layer of information that increasingly influences the way cities are used, governed, developed, policed and appropriated by the people who inhabit them.

As Richard Saul Wurman pointed out<sup>39</sup>, in order to extract value from a mass of data, to make it useful and understandable to a whole community, it’s necessary to process it, transforming it into information. Design holds a critical role in this scenario: it operates the translation from data to information, but does so through a visual language. Design thus provides effective methodologies to present facts in an accurate, meaningful and possibly engaging way, facilitating access to complex information to different kinds of publics. Cities around the world have radically changed since physician John Snow famously helped Londoners overcome an epidemic by manually plotting locations of cholera deaths on a map<sup>40</sup>. The necessity for communicating urban data in a comprehensible form, for tools to allow a deeper understanding of the places we live, has arguably become more important than ever. The interconnected complexity of our cities calls for the visualization of that invisible layer, for images that force us “to notice what we never expected to see.”<sup>41</sup> Within this scenario, the discipline of data visualization is increasingly used at both institutional and community level as a powerful instrument to deal with the layered complexity of today’s cities.

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39 *ibid.* Wurman 1989

40 Tufte, E. (1997). *Visual Explanations*. Cheshire, CT: Graphics Press, 27-37

41 Tukey, J. W. (1970). *Exploratory Data Analysis*. Reading, MA: Addison-Wesley.

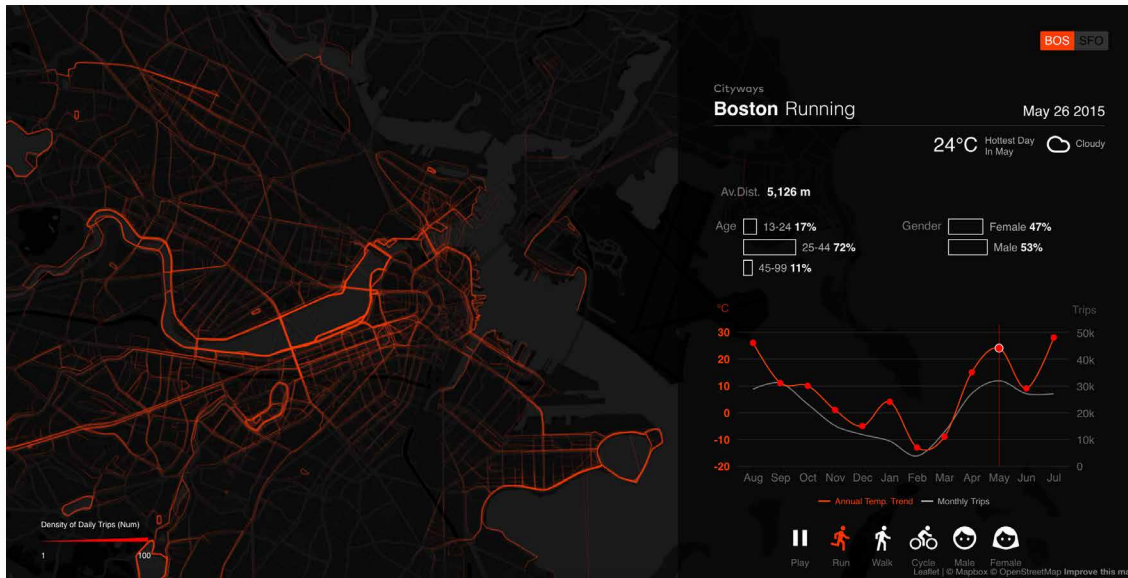


FIG.5 - Cityways - Boston Running: visualization of data from self-tracking apps recording different types of recreational movement in Boston

### Case studies

This thesis project was supported by research on the state of the art in the discipline of urban data visualization, with special emphasis on works that directly involve people in an interactive exploration of data, or that are based on crowdsourcing techniques to allow users to input information. Such research demonstrated both the variety of purposes visualizations can serve, and the diversity of subjects that are currently being developed and published: from academic research labs to public institutions, from design firms to news media, crucially including citizens themselves.

The contribution from academic research labs is critical to advancement in the urban data visualization field, both from the technical and the conceptual point of view. Among the most prolific and influential research teams is the MIT Senseable City Lab<sup>42</sup> whose philosophy argues that “the way we describe and understand cities is being radically transformed—as are the tools we use to

42 MIT Senseable City Lab. Retrieved March 12, 2019, from <http://senseable.mit.edu>

design them.”<sup>43</sup> Its mission, therefore, “is to anticipate these changes and study them from a critical point of view.”<sup>44</sup> This multidisciplinary team’s efforts result in projects that deal with the most diverse kinds of urban issues and data, from public transportation to cultural and social dynamics in the city. A valuable example of SC Lab’s work is the *Cityways*<sup>45</sup> project (FIG.5), which visualizes data from self-tracking applications used by citizens of San Francisco and Boston to investigate “the factors that influence outdoor human activity—such as weather, urban morphology, topography, traffic, the presence of green areas.”<sup>46</sup> Users can explore the data and compare information on different outdoor activities over one year through an interactive application that combines a map visualization with other types of graphs, also providing detailed information on demand.

In the last few decades, the diffusion of a global open data culture advocating for data that “can be freely used, modified, and shared by anyone for any purpose”<sup>47</sup> contributed to push many urban administrations to release urban data on web-based portals. At the forefront of research towards more accessible institutional portals, New York City is currently developing a government-sanctioned, comprehensive web platform to help city planners easily access and use data about the city. *Capital Planning Platform*<sup>48</sup>, developed by NYC Planning, is presented as “a place for planners to access the maps, data, and analytics that they need.”<sup>49</sup> Within this platform, the *NYC Facilities Explorer*<sup>50</sup>

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43 *ibid.*

44 *ibid.*

45 MIT Senseable City Lab (2017). *Cityways*. Retrieved March 12, 2019, from <http://senseable.mit.edu/cityways/>

46 *ibid.*

47 Open Knowledge International. Retrieved March 8, 2019, from [opendefinition.org](http://opendefinition.org)

48 *NYC Capital Planning Platform*. Retrieved March 8, 2019, from <https://capitalplanning.nyc.gov/about/facilities>

49 *ibid.*

50 *ibid.*

represents a particularly interesting example: users can access “the most comprehensive dataset of public and private facilities and program sites”<sup>51</sup> by either exploring an overview map, by picking a certain neighbourhood, or by specifically selecting among the extensive available categories—thus generating a customized map based on the data they need to access. Users can also combine the selected information with a variety of urban datasets from the city’s open data catalogue, and finally download the selected data. Even though this platform was implemented to facilitate the work of architects and planners, its simple visualizations and interface makes it accessible to a larger audience of people who are interested in exploring urban data. It represents a dramatic improvement from simply providing data in a tabular form—what the majority of institutional urban portals currently offer.

The development of open data culture also represents an invaluable opportunity for citizens to directly contribute to the collective knowledge about cities. If in the recent past the possibility to work with open urban data was limited to people with analytics, programming or design skills, today many platforms offer simplified ways for users to contribute with their own data. By following this approach, such practices benefit from insights from people whose daily lives take place in the urban environments that are the subjects of the analysis, facilitating connections and collaborations between citizens and institutions. As the Indian town of Chennai suffered severe flooding in 2015, a small group of technology-driven activists recognized that one of the main problems was the access to information regarding the extent of damages to roads and houses: they devised *Chennai Flood Map*<sup>52</sup> (FIG.6). This map-based web application gathers detailed, constantly updated information about the problem: “a reporting tool to crowdsource the location of flooded roads on an interactive

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51 *ibid.*

52 Ganesh, Anwar, Bhangar, Loganathar and Sankaranarayanan (2015). *Chennai Flood Map*. Retrieved March 5, 2019, from [osm-in.github.io/flood-map/chennai](https://osm-in.github.io/flood-map/chennai)

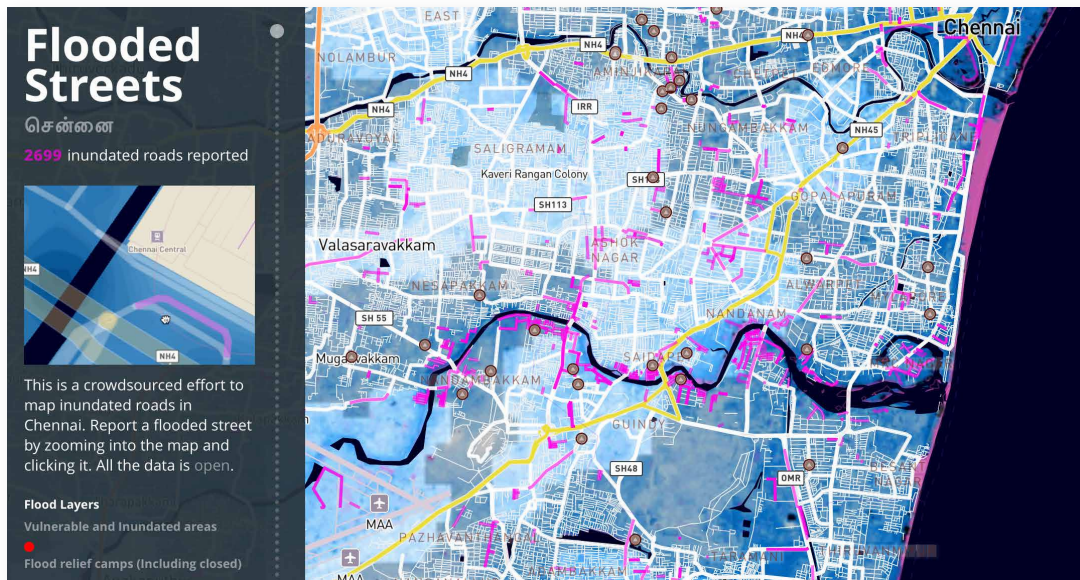


FIG.6 - *Chennai Flood Map*. The thick purple lines represent streets that were indicated as flooded by users

mobile friendly map.”<sup>53</sup> Through this simple idea the developers managed to collect over 15,000 reports in the two weeks following the flooding: the application was a critical instrument for the Chennai city government and inhabitants to coordinate recovery efforts.

Two years after the city of New York had passed a groundbreaking open data legislation<sup>54</sup>, allowing people to access an extensive archive of urban datasets, research analyst Ben Wellington opened a Tumblr blog called *I Quant NY*<sup>55</sup>. He started selecting a variety of topics that were related to the life of people within the city, such as cycling accidents, basement flooding or food quality. He analyzed the data he had found, visualized it and wrote short articles pointing out the result of his investigations. The blog very quickly gained local popularity, mainly because through its visualizations it helped citizens identify the features of—and even solutions to—everyday problems that would have been

53 *ibid.*

54 *NYC Open Data - History*. Retrieved February 5, 2019, from <https://opendata.cityofnewyork.us/open-data-law/>

55 Wellington, B. *I Quant NY*. Retrieved February 4, 2019, from <http://iquantny.tumblr.com>



hard to spot using traditional methods of analysis. An interesting example of this methodology is how Wellington decided to visualize on a map which fire hydrant was “responsible” for the most parking tickets in the city<sup>56</sup>. This exploration led him to discover that the two hydrants at the top of the list were placed close to parking spots that were badly indicated, misleading drivers about the prohibition to park there. The article spread virally first on the web and subsequently in newspapers, finally prompting a very quick intervention by the administration which redesigned the road markings to solve the problem. Such a simple and seemingly trivial example represents some of the opportunities offered by open data and design towards new forms of civic agency.

In recent years, the rising need and widespreading of possibilities to deal with data visually has deeply influenced the design industry. Many firms have embraced data visualization as both a new kind of service to provide their clients, as well as an addition to their overall visual vocabulary and offerings. An example of this, all the more interesting since it was developed as a joint effort between the industry and a public institution, is *Go Boston 2030*, Boston’s 20-year strategic mobility plan<sup>57</sup>. Design firm *Utile*<sup>58</sup> partnered with the public administration of the American city to “collect, analyze, and visualize data in order to communicate and predict the complex mobility needs of the city in the future.”<sup>59</sup> The products of this collaboration are a report and a series of digital tools based on very detailed visualizations of mobility data; their carefully crafted design makes them suitable to present a complex topic to a very wide audience of citizens. Worldwide, new design firms are also increasingly being established as primarily focused on information design and data visualization

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56 Wellington, B. (2014). Success: How NYC Open Data and Reddit Saved New Yorkers Over \$55,000 a Year [Blog Post]. *I Quant NY*. Retrieved February 10, 2019, from <http://iquantny.tumblr.com/post/87573867759/success-how-nyc-open-data-and-reddit-saved-new>

57 *Go Boston 2030* - Retrieved February 28, 2019, from <https://www.boston.gov/departments/transportation/go-boston-2030>

58 Utile Design. Retrieved February 28, 2019, from [www.utiledesign.com](http://www.utiledesign.com)

59 Zhu, S. (2015). *Go Boston 2030*. Retrieved February 28, 2019, from <http://www.siqizhu.net/go-boston-2030/>

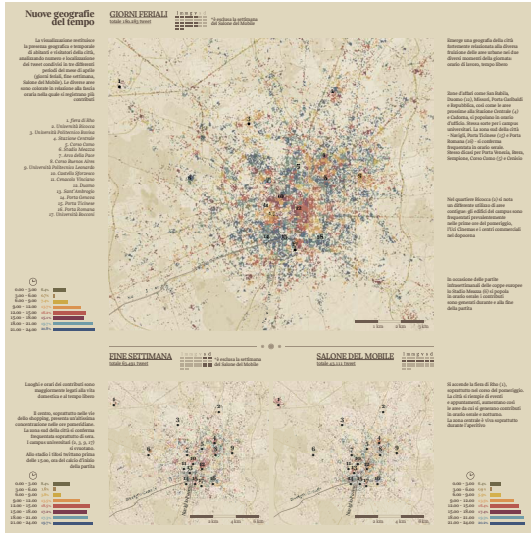


FIG.7 - *I Nuovi confini di Milano (The New Boundaries of Milan)*, developed for the \*Urbansensing project by Accurat, visualizes one month of geolocated tweets in the Italian city.

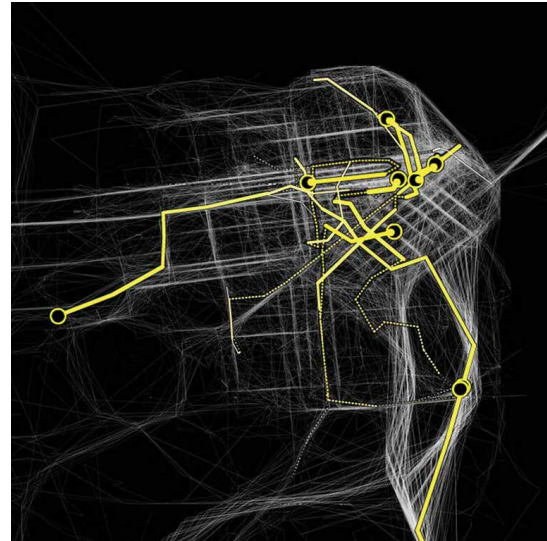


FIG.8 - Stamen. *Cabspotting*

methodology, a trend that has become particularly evident in the last decade. Many of these firms have produced visualizations focused on urban data, either for client work, for artistic installations, or for self-initiated research projects. The E.U.-sanctioned project \*Urbansensing<sup>60</sup> was developed by a consortium which included three design firms (Accurat from Italy, LUST from The Netherlands and sisu labs from Spain), whose goal was to develop a new product to help improve the urban design, city planning and urban management markets through “a platform extracting patterns of use and citizens’ perceptions related or concerning city spaces, through robust analysis of User Generated Content (UGC) shared by the city users and inhabitants over social networks and digital media”<sup>61</sup>. A variety of static and interactive design works dealing with the intangible layer of networks and communications in urban spaces were developed for the project (FIG.7)<sup>62</sup>. Another valuable project developed by a

60 \*Urbansensing (2013). Retrieved March 1, 2019, from [http://urban-sensing.eu/?page\\_id=5](http://urban-sensing.eu/?page_id=5)

61 ibid. Retrieved March 1, 2019, from <http://urban-sensing.eu/?p=876>

62 Accurat. *I Nuovi confini di Milano* (2013). Retrieved March 1, 2019, from <http://urban-sensing.eu/?p=876>

design firm working with urban data is *Cabspotting*<sup>63</sup>, by Stamen (FIG.8)—a dynamic, map-based installation which visualizes the movement of taxis in San Francisco, that is now part of the permanent collection of MoMA.

## Data installations

Web-based applications are an effective tool to increase awareness on urban data, yet it's important to recognize data visualization can be an extremely powerful way of communicating facts even outside the digital realm. Recent years have seen the development of many examples of interactive installations within exhibitions, visualizing data in the physical space with screens, projections or artifacts that inform users and allow forms of input from them. These practices can be extremely effective since they combine the power of visual communication with the immersive experience usually associated with artistic installations. The developments proposed in this research are based on the conviction that following a similar approach in the communication of urban data could help citizens gain a deeper understanding of the environment in which they live, ultimately encouraging them to question, explore, and change it. A recent example of this methodology is *Multiplicity*<sup>64</sup> (FIG.9-10), an installation developed by designer Moritz Stefaner for the Exhibition *123 Data*<sup>65</sup> held in Paris in 2018. This piece uses user-generated content (specifically pictures shared on Instagram) to create an unprecedented visualization of the French capital. By using machine learning algorithms, 25,000 photographs were sorted and grouped based on similarity and content, to create a visual map of the city "as seen through the lens of thousands of photographers."<sup>66</sup> The result reveals consistent clusters of similar activities for citizens and tourists—a very detailed portrait of Paris mainly focused on

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63 Stamen. *Cabspotting* (2008). Retrieved February 25, 2019, from <https://stamen.com/work/cabspotting/>

64 Stefaner, M. (2018). *Multiplicity*. Paris: Fondation EDF. Retrieved February 25, 2019, from <https://truth-and-beauty.net/projects/multiplicity>

65 Fondation EDF (2018 May 4 - 2018 October 6). *123 data*. Paris.

66 Stefaner, *ibid.*

monuments, cultural institutions and events, entertainment and leisure. The piece was projected on a large screen, connected to a console that visitors could use to navigate the massive quantity of visual material provided.

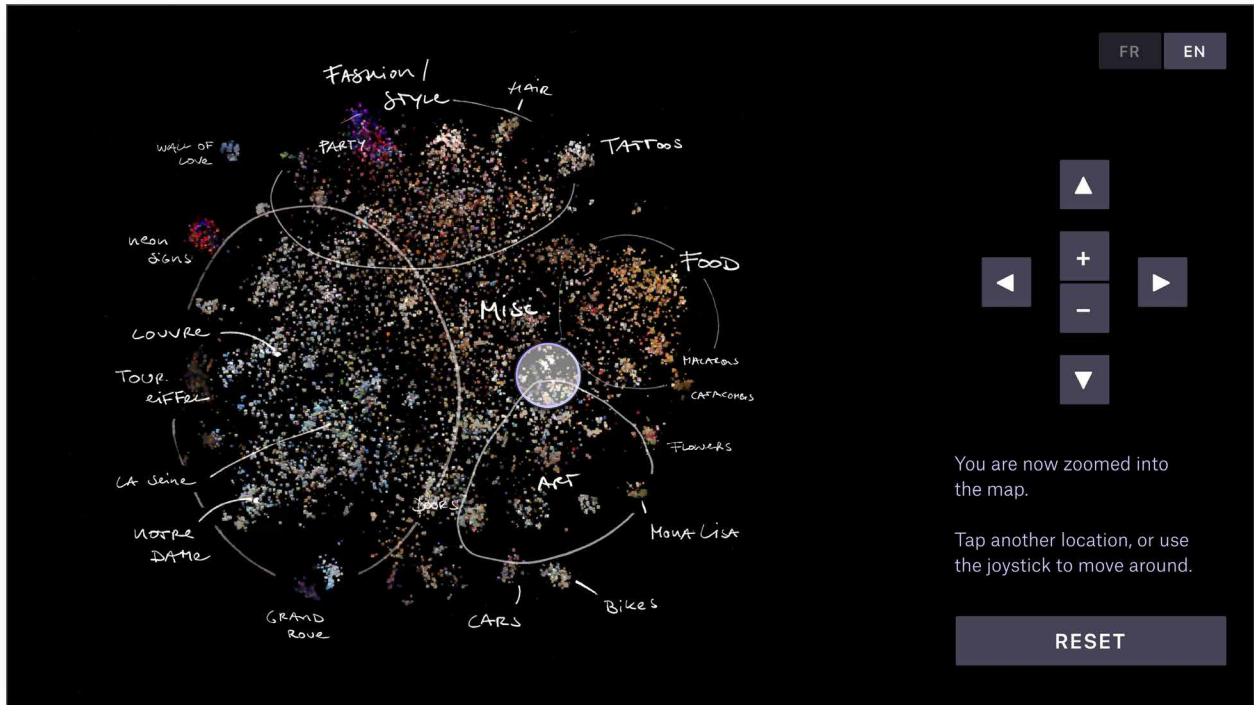


FIG.9 - *Multiplicity*. The interface that allowed visitors to interact with the installation

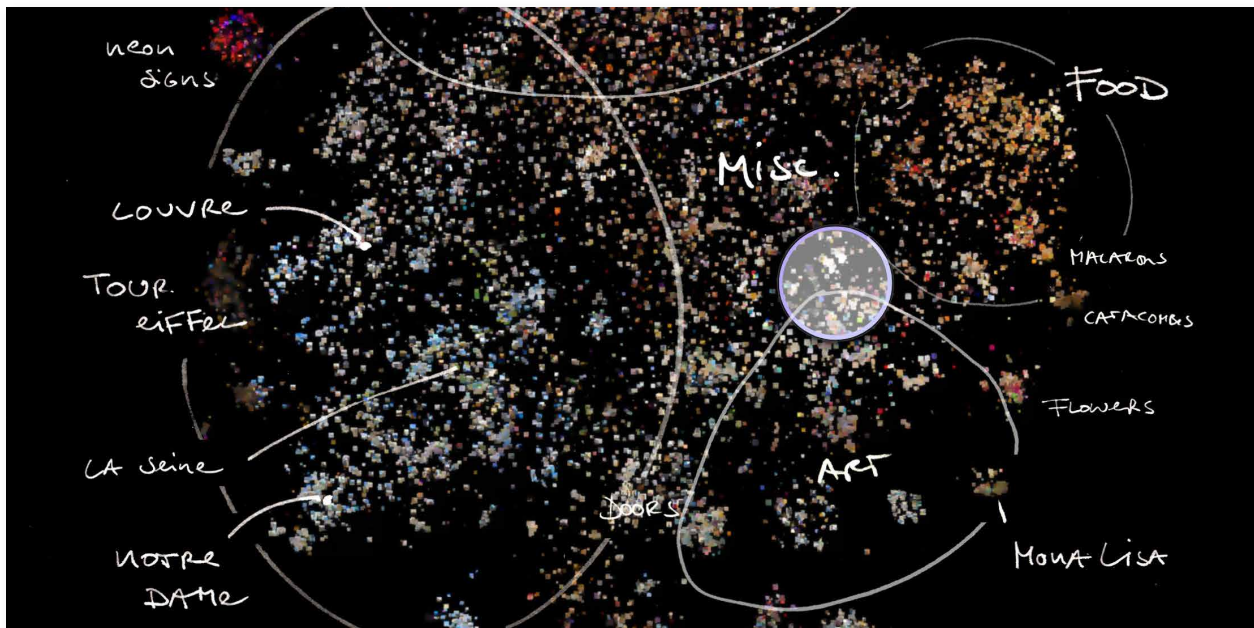


FIG.10 - *Multiplicity*. Annotations added by the author highlighting clusters of similar pictures detected by the algorithm: on the left, pictures of tourist attractions. On the right, pictures related to art and food.

## **Chapter 3**

### **Toronto: A Case Study**

There are several reasons why I decided to focus on Toronto for the development of my design proposal. The scale of this urban environment, the layered complexity of its human life and of its physical and informational networks provide a good framework to conduct explorations involving design, urban data and citizens—both for the wealth of data publicly available about the city, and for the variety of issues that might be addressed by using it. The city has a strong tradition in urban studies and in civic initiatives to foster the engagement of citizens in the debate on governance and developments within the city—spanning from the neighbourhood preservation campaigns championed by Jane Jacobs in the 1960s to a currently well-developed open data culture both at the level of public institutions and of initiatives coming from citizens. Finally, Toronto is the city where I have lived and studied for the past two years while pursuing my master’s degree. I have experienced this city from a particular perspective—that of an immigrant—implying that my knowledge about it was, and still is, limited, while at the same time representing a point of view shared by many of the people who live in this greater metropolitan area. I figured that investigating the city with the fresh eyes of a newcomer might have a positive impact on the research, as my exploration of urban topics within Toronto would proceed in parallel with, and be informed by, my personal discovery of its urban environment.

#### **Investigating urban issues**

With a population of over 2.9 million<sup>67</sup>, Toronto is a metropolis of international economic and cultural

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<sup>67</sup> Toronto at a Glance. Retrieved March 1, 2019, from <https://www.toronto.ca/city-government/data-research-maps/toronto-at-a-glance/>

relevance, whose official motto, "Diversity our strength"<sup>68</sup>, effectively represents a multicultural city in constant evolution. Within this dynamic and complex environment it's possible to recognize many issues of urban relevance that affect the lives of its citizens and pose concrete challenges to a sustainable development of the urban environment. My design research in this thesis project was therefore supported by an investigation on urgent issues within the city, based on information gathered from public institutions, civic organizations and news media. Many of the main issues emerging from this research are recurrent in many cities that share a similar urban scale with Toronto: for example, the steady growth in population<sup>69</sup>, resulting in a constant increase in the demand for housing spaces and public services; a public transportation system that struggles to keep up with the needs of its growing ridership<sup>70</sup>; the recent increase in the rate of violent crimes<sup>71</sup>; the difficulties generated by the extreme economic and cultural diversity across the population<sup>72</sup>. Obviously, the fact that these issues could be defined as typical for a metropolis of Toronto's size does not mean they would not be worthy investigating—as described later in Appendix A, in the first phase of my research I developed design work based on issues regarding public transportation and crime. Yet, one topic emerged from my explorations as one of the most serious, urgent and peculiar among the challenges the city is facing: the current state of its housing.

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68 Toronto History of City Symbols. Retrieved February 20, 2019, from <https://www.toronto.ca/city-government/awards-tributes/tributes/history-of-city-symbols/>

69 *Demographics of Toronto*. Retrieved March 1, 2019, from [https://en.wikipedia.org/wiki/Demographics\\_of\\_Toronto](https://en.wikipedia.org/wiki/Demographics_of_Toronto)

70 Moore, O. (2016, February 26). How Toronto's fragile transportation system is struggling to cope. *The Globe And Mail*. Retrieved February 20, 2019, from <https://www.theglobeandmail.com/news/toronto/torontos-highways-subways-struggle-to-cope-with-traffic-incidents/article28938155/>

71 The 96 victims of Toronto's record year in homicide. (2018, December 27). *Toronto Star*. Retrieved February 20, 2019, from <https://www.thestar.com/news/gta/2018/12/17/the-90-victims-of-torontos-record-year-in-homicide.html>

72 May, W. (2018, August 21). Toronto is more diverse than ever, but downtown is falling behind. *Toronto Star*. Retrieved February 20, 2019, from <https://www.thestar.com/news/gta/2018/08/21/toronto-is-more-diverse-than-ever-but-downtown-is-falling-behind.html>



## Housing in Toronto

The prices for residential units in Toronto have risen dramatically in the last decade, a fact eloquently highlighted in a recent report which presents Toronto as the city with the highest absolute increase rate for property prices in the second quarter of 2017, out of a list of other 150 'global cities'<sup>73</sup>—an increase of 29.3% over the previous year. More recent studies show that this phenomenon might be past its peak, yet its direct and indirect effects are still perceivable, both inside and outside the urban housing market. The rise in property prices is preventing more households from buying a home—a problem especially experienced by younger generations, potential first-time homebuyers, who increasingly choose to stay in the rent market instead, and by older households that struggle to find affordable residential solutions for downsizing. This rise in prices, paired with the introduction of stricter procedures to obtain mortgages, has arguably contributed to pushing an increasing number of people to enter—or stay in—the renting market. The condition of the renting market is possibly even more problematic: rates are steadily growing; there is a rising number of households that are renting units classified as unaffordable for their level of income, or classified as unsuitable because of the units' size, repair state or sanitary conditions: the 2016 Canada Census estimated the presence of over 240,000 households in core housing need<sup>74</sup>. The shift from owning to renting also affects the vacancy rate for rental units in Toronto, which is currently at a record-low level of 1.1%, a value considered deeply unhealthy by real estate analysts<sup>75</sup>. At the same time, recent years have seen a

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73 Knight Frank (2017). *Global Residential Cities Index - Q2 2017*, 3. Retrieved February 23, 2019, from <https://www.knightfrank.com/research/global-residential-cities-index--q1-2018-5666.aspx#archived-reports-year-2>

74 "Core Housing Need is the indicator used in Canada to identify households not living in, and not able to access, acceptable housing. It describes households living in dwellings considered inadequate in condition, not suitable in size, and unaffordable". Canadian Mortgage and Housing Corporation. Retrieved February 23, 2019, from <https://www.cmhc-schl.gc.ca/en/housing-observer-online/2017-housing-observer/housing-need-stable-in-canada-1-point-7-million-canadian-households-affected#note1>

75 Why 2019 could be one of Toronto renters' toughest years yet (2018, December 27). *BNN Bloomberg*. Retrieved February 23, 2019, from <https://www.bnnbloomberg.ca/why-2019-could-be-one-of-the-toughest-years-yet-for-toronto-renters-1.1188250>



spike in units bought for investment that were never occupied or never entered the real estate market: a phenomenon so prevalent that in 2017 the government of Ontario introduced new property taxes for foreign investors to combat it. The city's population is growing, and so is its housing stock; but the majority of new homes are built in condo buildings, generally featuring smaller and potentially more affordable unit sizes, yet often built in neighbourhoods with a high costs of living. The social housing ecosystem is also deeply suffering: Toronto Community Housing Corporation (TCHC)—the second-largest housing provider in North America with an estimated 110,000 tenants<sup>76</sup>—in 2017 estimated a need of over \$1.6B for urgent repairs to its aging housing stock<sup>77</sup>. A high number of tenants live in conditions that span from uncomfortable to dangerous, and, at least in one case, a whole residential compound was evacuated because of safety reasons, while its residents were eradicated from their neighbourhood and relocated to other TCHC properties scattered across the city. The implications of these complex issues go beyond the housing market as such, and are arguably contributing to exacerbating the already extreme imbalances across neighbourhoods with regards to income levels, crime rates, and ethnic segregation.

My research and design work addressing Toronto's housing issues was fundamentally based on analyzing and visualizing publicly available data on those topics. I retrieved data from Census Canada, the Toronto Real Estate Board, Canadian Mortgage and Housing Corporation, together with a variety of public and private organizations dedicated to addressing the housing problem. However, the most valuable resources for this project, and for the explorations that led me to identify housing as the main topic for the design proposal, were provided by the city's open data portal.

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76 Who We Are. Toronto Community Housing. Retrieved February 24, 2019, from <https://www.torontohousing.ca/who-we-are>

77 Pagliaro, J. (2017, September 27). City on hook for \$1.6 billion to fix crumbling public housing. *Toronto Star*. Retrieved February 24, 2019, from [https://www.thestar.com/news/city\\_hall/2017/09/28/city-on-hook-for-16-billion-to-fix-crumbling-public-housing.html](https://www.thestar.com/news/city_hall/2017/09/28/city-on-hook-for-16-billion-to-fix-crumbling-public-housing.html)

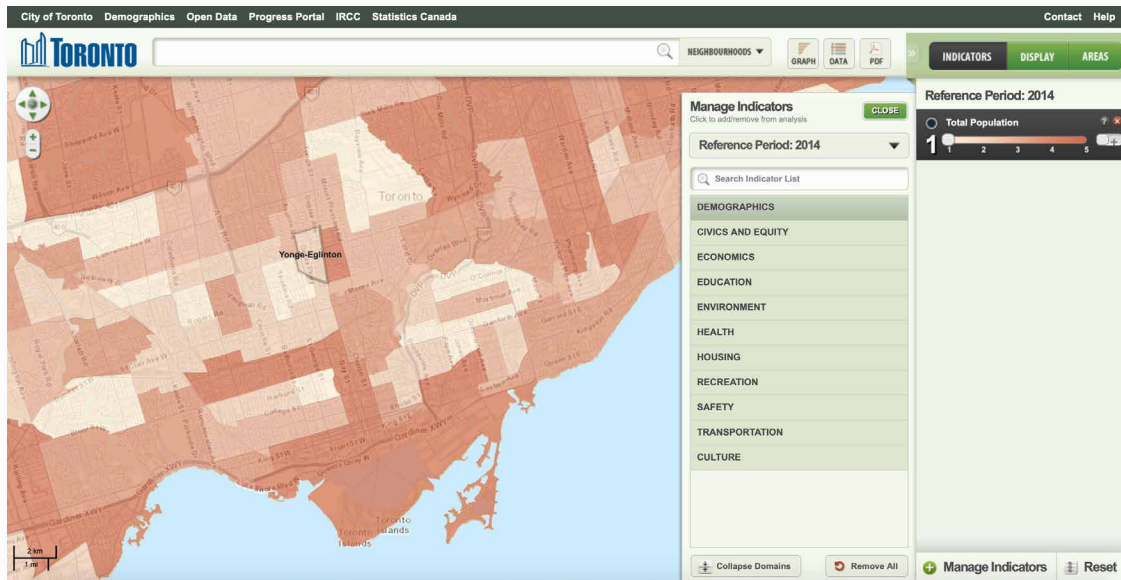


FIG.11 - *Wellbeing Toronto*. Map-based platform for the exploration of urban data in Toronto

## Open data in Toronto

Toronto's *Open Data Portal*<sup>78</sup> was launched in 2009 and has published a total of 258 datasets ever since, with more than 1,100 datafiles available<sup>79</sup>. In 2017, the city adopted an Open Data Masterplan for the years 2018-2022 to radically expand and improve its way of handling and publishing urban data. The guiding principles of this plan are: "co-develop with the public; release datasets that help solve civic issues; explore opportunities to improve City efficiency; and embrace inclusivity."<sup>80</sup> The portal features an extensive open data catalogue, in which users can search and download datasets in a variety of formats; it also provides several ways for users to access visualizations of urban data,

78 Toronto Open Data Portal. Retrieved February 24, 2019, from <https://www.toronto.ca/city-government/data-research-maps/open-data/>

79 *ibid.*

80 Deputy City Manager, Internal Corporate Services and Chief Information Officer (January 10, 2017). *Toronto's Open Data Master Plan*, p.2. Retrieved January 20, 2019, from [app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2018.EX30.12](http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2018.EX30.12)

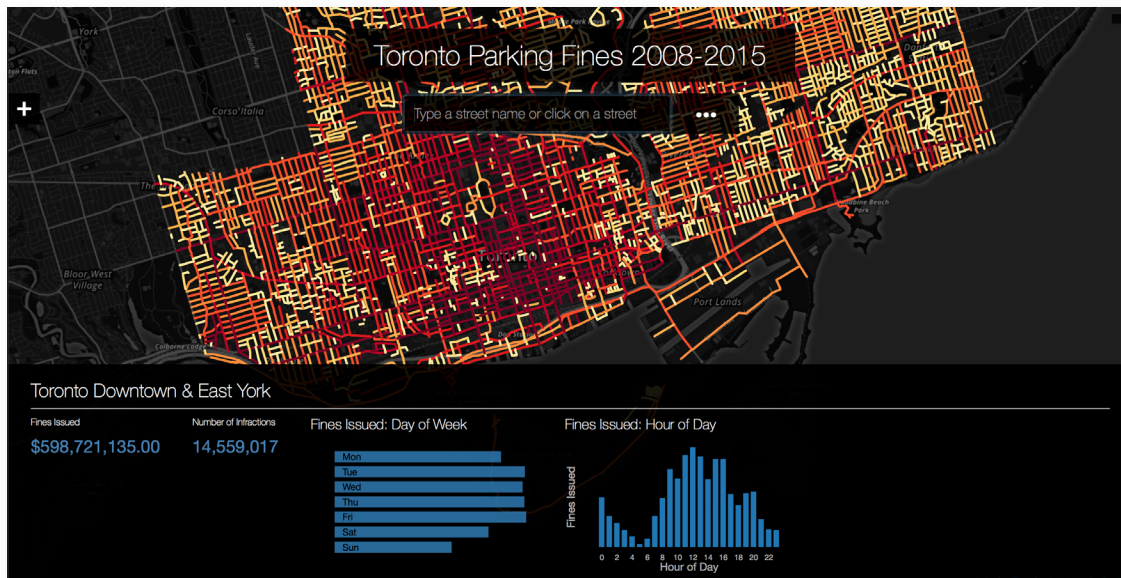


FIG.12 - Toronto Parking Fines 2008-2015

from the interactive, map-based application, *Wellbeing Toronto*<sup>81</sup> (FIG.11), which allows readers to compare different datasets across neighbourhoods, to the “gallery” section containing links to a variety of web-based applications and interactive visualizations based on data from the portal. The “portal” is a remarkable initiative, especially because many of its applications were developed by citizens and civic associations not directly associated with the city government. Because these platforms are not part of a consistent plan to visualize Toronto’s urban data, so they rely on a variety of visualization methodologies, graphic interfaces and modes of interaction that could limit the accessibility to this visual information, especially for users who might not be proficient with digital technologies. An interesting example of an interactive visualization developed from Toronto open data is a web platform called *Toronto Parking Fines 2008-2015*.<sup>82</sup> (FIG.12) This project visualizes eight years of parking fines on an interactive map of the city, using colour to provide an overall depiction of the differences in this phenomenon among different streets and neighbourhoods; users can type in

81 *Wellbeing Toronto*. Retrieved February 28, 2019, from <http://map.toronto.ca/wellbeing>

82 *Toronto Parking Fines 2008-2015*. Retrieved January 10, 2019, from [parkingto.herokuapp.com](http://parkingto.herokuapp.com)

a specific address or select a street from the map to access detailed information such as the number of infractions, the total amount of fines, day of week and hour of day in which fines were imposed. Interestingly, the system also uses this data to provide an estimate of the probability of getting fined at each specific location.

Recent years have also seen some artistic installations based on data being developed in Toronto; an especially interesting one for the purpose of this research is *Between Doors*<sup>83</sup>, developed by *LabSpace Studio* and exhibited in Toronto, Boston and Brussels in 2014-2015. The key difference from the examples previously outlined is that user interaction was not achieved digitally, in this project, but was based on movement within space. The installation, which was set up in a public square, asked people to answer very simple personal questions by opening and passing through a series of wooden doors that corresponded to their answers (FIG.13). This strategy produced a scenic result since each person's answers determined their unique path through the installation. The doors were equipped with sensors recording each visitor's choice, providing the authors with a comprehensive dataset that was used to generate visualizations showing how the audience responded to each question (FIG.14). Even though this project was not directly focused on the visualization of urban data, it represents a valuable reference for my research as an interactive methodology to engage people in reflection about information, as well as to produce visualizations of many people's perception on a variety of topics by directly involving them in the process of data collection.

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83 LabSpace Studio (2014). *Between Doors*. Retrieved January 10, 2019, from [labspacestudio.ca/post/between-doors/](http://labspacestudio.ca/post/between-doors/)



FIG.13 - *Between Doors*. A participant opening one of the doors in the installation to answer a question



FIG.14 - *Between Doors*. The corresponding visualization generated from answers collected on the question

## Chapter 4

### A Methodology For Communicating Information

The theoretical and visual research outlined in the previous chapters provided the basis for my work towards a design proposal aimed at testing the hypotheses at the core of this thesis project: how urban data visualization could be used to foster a two-way sharing of information between citizens and public institutions, and how it could provide a framework to study the relationship between *measures* of phenomena happening in cities and citizens' *perceptions* of the same phenomena. The peculiar nature of these two aspects led me to identify the main goal for this thesis as first and foremost the proposal of a methodology for the visual communication of information within urban environments, one that could be then developed and tested, through design research and practice, to address a variety of concrete urban issues. Such a decision implied that, before investigating this methodology from the point of view of visual design, the first crucial step was the need to devise a communication strategy.

An invaluable source of inspiration in this sense was a series of interactive articles developed for *The Upshot*<sup>84</sup>—the web version of *The New York Times*—since 2015. The series, titled *You Draw It*<sup>85</sup> (FIG.15-18), addresses a variety of topics of national relevance in the U.S.A., spanning education to politics, and heavily relies on simple visualizations of data to enhance the storytelling process and provide context for readers. Yet, it does so by inverting the conventional way information is exchanged between media and audiences: after a brief introduction of the topic addressed in the article, readers

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84 *The Upshot*. Retrieved March 7, 2019, from <https://www.nytimes.com/section/upshot>

85 Aisch, Cox and Quealy (2015, May 28). You Draw It: How Family Income Predicts Children's College Chances. *The Upshot*. Retrieved March 7, 2019, from <https://www.nytimes.com/interactive/2015/05/28/upshot/you-draw-it-how-family-income-affects-childrens-college-chances.html>

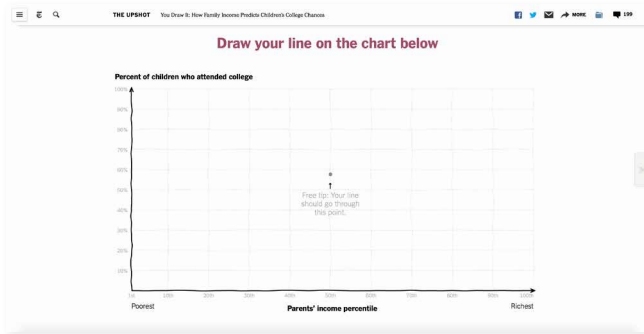


FIG.15 - *You Draw It*  
An “empty” chart prompting readers to draw their guess on the cartesian plane

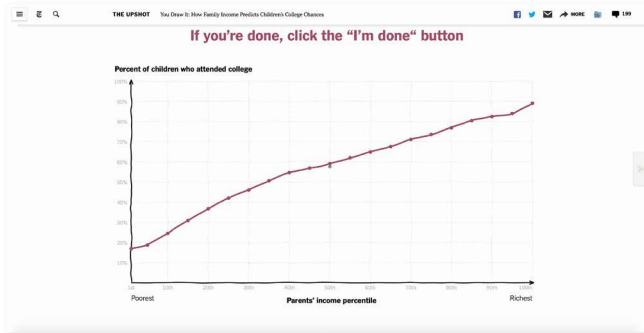


FIG.16 - *You Draw It*  
Submission of user's guess

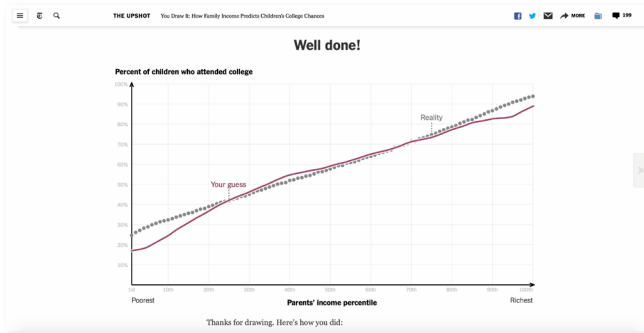


FIG.17 - *You Draw It*  
Visual comparison of user's guess and actual data

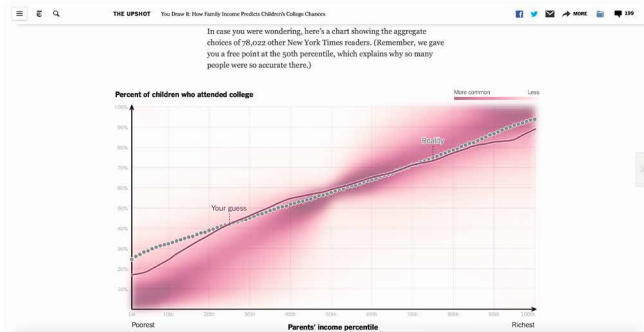


FIG.18 - *You Draw It*  
Aggregated visualization of over 78,000 guesses from other users added to the chart

are asked to share their guess about it before seeing visualizations of the actual data on the topic. The articles provide graphs and charts which are empty or partially complete, only including the basic structure of the visual model they are based on, together with instructions for the readers on how to interact with them to visually provide their answer, typically by drawing lines or moving sliders. Only after having shared their guess can readers observe actual data on the topic, which is visualized within the same graph they just manipulated, with consistent scales and visual languages. Readers visually compare their answers with the data and spot differences and similarities between them. Furthermore, in some of these articles graphics also portray an aggregated visualization of the guesses from many other readers, introducing a third element of visual comparison besides the reader's guess and the data. The evolution of the visualizations throughout these steps is accompanied by text sections guiding readers by providing additional context, information and data, including customized feedback to help them interpret the visual comparison between their initial input, the data and the inputs from other users.

Digital, interactive questionnaires are increasingly used in news media to engage readers by allowing them to 'have their say' on a certain topic: a recent example in Toronto is the *Toronto Star's How about you?*<sup>86</sup> initiative, which proposes very simple surveys related to the issues addressed within the newspaper's online articles. As seen in the case of the *Perils of Perception* study, the surveys can also be used effectively to introduce readers to a complex matter, by allowing them to respond to questions that were used in the study, and to see how accurate their answers are. Yet, the *New York Times'* series brings the practice of asking questions to readers to a higher level, since it does so using visual communication and data visualization.

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86 Kalinowski, T., (2018, November 13) Condos alone withstood housing correction, Re/MAX says. *Toronto Star*, retrieved March 7, 2019, from [https://www.thestar.com/business/real\\_estate/2018/11/13/condos-alone-withstood-housing-correction-remax-says.html](https://www.thestar.com/business/real_estate/2018/11/13/condos-alone-withstood-housing-correction-remax-says.html)



Through this strategy, readers:

- are provided with an accessible entry point to new, potentially complex matters;
- might more easily immerse themselves in the topic by sharing their personal perception, which in turn might foster their curiosity and awareness on the addressed issue;
- are actively engaged in the communication process, since information doesn't only flow from top to bottom, but is also exchanged back, bottom-up, from readers to the media platform;
- are helped to gain a better understanding of the visual models used to portray the issue;
- can effectively get a sense of the context and the scale of the issue, through direct interaction with the visualizations, and through visual comparisons between their guess and actual data;
- are prompted to reflect on differences and similarities between their guesses, other reader's guesses and the data—potentially having their personal perceptions confirmed, or challenged in the process.

Visualizations of data are generally developed to serve two different purposes: either to allow experts to conduct detailed, exploratory analyses of a phenomenon, or to present an issue to a wider audience of non-experts. The approach followed by the *You Draw It* series introduces several novel elements in the practice of data visualization that are especially promising for presentation purposes, as the articles target a diverse audience of people who would not necessarily be familiar either with the topic addressed or with the language of visualizations. Similar strategies are investigated in two studies by a research team at the University of Washington. For "Explaining the Gap: Visualizing One's Predictions Improves Recall and Comprehension of Data,"<sup>87</sup> they conducted experiments to evaluate if prompting readers of visualizations to provide self-explanations of the data, or predictions about it, could enhance their comprehension and recall of information. The researchers observed

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87 Kim, Reinecke and Hullman (2017). Explaining the Gap: Visualizing One's Predictions Improves Recall and Comprehension of Data. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*.

that “providing opportunities for users to interact with their prior knowledge improves recall of data values, and is more powerful when used with visualization than with text,”<sup>88</sup> and also stated that “[...] incorporating prediction tasks, as in our Predict-Explain-Vis, Predict-Only-Vis, Predict-Feedback-Vis also improves users’ ability to recall specific data. We hypothesize that predicting focuses a user’s attention on their prior knowledge, making them more likely to attend to the gap between their prior knowledge and the observed data when it appears.”<sup>89</sup> Another study from the same authors titled “Data Through Others’ Eyes: The Impact of Visualizing Others’ Expectations on Visualization Interpretation”<sup>90</sup> examines the effect visualizations of guesses from other people—what they define as “social information”—have on readers. They found that “[...] social information that exhibits a high degree of consensus leads participants to recall the data more accurately relative to participants who were exposed to the data alone. We also found that people are more susceptible to social information when they initially disagree with the presented data.”<sup>91</sup>

The design research and work developed for this thesis are based on the conviction that systematizing these innovative methodologies into a comprehensive communication strategy to address issues of urban relevance in Toronto might provide benefits not just to single users, but to a whole community of people who are directly or indirectly affected by the implications of the topics addressed. An analysis of many people’s guesses, compared with the actual data, will provide clues as to how urban issues are perceived in the community, in turn potentially helping public institutions, civic organizations and private citizens uncover insights on how to address them.

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88 *ibid.*, 10

89 *ibid.*, 8

90 Kim, Reinecke and Hullman (2018). Data Through Others’ Eyes: The Impact of Visualizing Others’ Expectations on Visualization Interpretation. *IEEE Transactions on Visualization and Computer Graphics*, 24(1)

91 *ibid.*, 9

## **An experiment in participatory urban data visualization**

Such a potential for positive impacts on the relationship between people and information led me to adopt and expand the interactive strategy devised by *The New York Times* to inform a methodology for the dissemination of urban information with the aim of generating meaningful, two-way connections between citizens and their cities. For the sake of this research, these two terms are intended in a broad sense: the methodology wouldn't just target—and potentially benefit—people who are residing in the city, but also city-users that experience its daily urban life. The word "city" is used to describe both public institutions, that have a central role in the collection, dissemination and policing of data generated within cities, as well as the urban environment itself—not limited to its physical space.

I identified the core elements and the scope for the proposed methodology, which I envisioned as:

1. Focused on presenting key urban issues to a wide audience of citizens and city-users.
2. Based on a participatory approach—relying on digital, interactive visualizations of data as the medium to ask citizens about their personal experiences of key urban issues, while providing them with relevant information about them.
3. Mainly—but not exclusively—accessible through mobile devices, allowing users to explore urban issues—and share their personal views about them—even from within the urban space itself.

These reflections in turn helped me formulate the main research question addressed throughout this thesis:

**How can the design of an interactive data visualization platform generate meaningful connections between citizens and their cities, and enhance urban legibility?**

This question addresses the three key points that informed the development of the proposed methodology. The need to devise a platform for the visualization and dissemination of urban data led me to focus on digital technologies as a suitable tool to quickly manage and communicate high amounts of complex information to a wide audience. The will to engage citizens and institutions in a dialogue through—and about—information implied the need to follow a highly interactive approach, based on fostering direct participation from users in the evolution of the platform’s content. Finally, the aim to address the relationship between images of the city as perceived by citizens and its reality prompted me to reflect on how visualizations could be used to investigate what urban legibility may entail in increasingly data-dependent urban environments.

### **Opportunities for urban communities**

As shown by the case studies presented in Chapter 2, digital platforms for urban data visualization provide a valuable framework for managing, analyzing, visualizing and communicating the variety of data that can be collected within cities. The digital realm offers a very wide range of visualization techniques, possibilities for interaction and, most importantly, a high degree of flexibility suited to cope with the rapid changes in urban environments and in the kinds of data that are collected about them. Furthermore, since the methodology is envisioned to target wide audiences of citizens, digital technologies provide an invaluable advantage in the task of quickly communicating information to a potentially large number of people, at the same time gathering information back from them. Finally, basing this methodology on digital technologies would allow the gathering of answers from users in consistent formats, to be used by the community and by institutions to conduct further analyses on urban issues. In this sense, the participatory component is crucial to the proposal. Allowing citizens to visually share their personal perception of urban issues wouldn’t just result in a more engaging experience for single users: if an adequate number of answers were collected on the platform, they could in fact provide a collective representation of what a sample of the urban community thinks,

fears, desires with regards to their city. An analysis of the comparison between many citizens' views and urban data on the same phenomenon might be useful, at least in two main ways: primarily, it could generate an iterative process by which feedback from citizens might be used to further develop the content provided in the platform, identifying new avenues of inquiry. Furthermore, the information gathered this way would arguably represent an invaluable resource for further analyses and implementations: as Bobby Duffy points out in *Perils of Perception*, "Our misperceptions can provide clues to what we're most worried about—and where we're not as worried as we should be."<sup>92</sup> In the spirit of the open data culture briefly outlined in the previous chapters, the anonymized data collected through the interactive survey would be constantly published to allow institutions, organizations and private citizens to explore them and use them to conduct further analyses and investigations. From the point of view of public institutions, the insights gained through this methodology might be used to better inform the development of policies and planning decisions; they could help administrations in uncovering concrete problems and opportunities that might not necessarily be evident by just looking at the data at their disposal; they might act as a stimulus to improve the way public urban data is collected, managed and disseminated. In this sense, the potential discrepancies between citizens' perception and public urban data, observed in the visualizations and analyzed through the data resulting from the survey, would in fact represent a starting point for institutions and civic organizations to generate new questions and delve deeper into the issues highlighted by the answers from users.

At the core of this proposal is the belief that the methodology could also foster the development of what Mike Cooley calls an *emancipatory technology*<sup>93</sup>: by fostering the development of a critical approach to public urban data, by avoiding the presentation of it as something necessarily accurate

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92 *ibid.* Duffy

93 Cooley, M. (1999). *Human-Centered Design*. In Jacobson, R. E. . *Information design*. Cambridge, MA: The MIT Press, 65

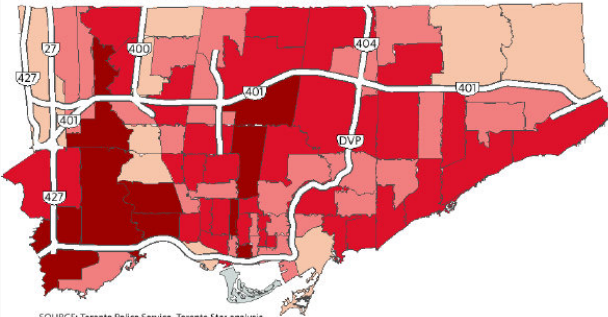
## Likelihood of being stopped if you're black increases halfway through 2013

GREATER LIKELIHOOD FOR BLACKS OF BEING STOPPEDS:

More than 1 to less than 2 times    Two to less than 3 times greater    3 to less than 5 times greater    More than 5    No data

The likelihood of being carded by police was higher for black people than white people across the city from **January to June of 2013**. In one area, the chances were 11 times greater. These figures are the result of a Star analysis using police and census data.

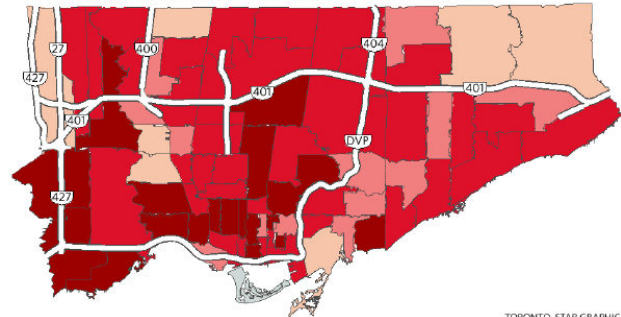
BLACKS UP TO 11 TIMES MORE LIKELY TO BE STOPPED IN SOME AREAS



SOURCE: Toronto Police Service, Toronto Star analysis

From **July through October**, carding plummeted, but the likelihood of black people getting stopped compared to white people actually increased and was 17.3 times more likely in one area.

BLACKS UP TO 17.3 TIMES MORE LIKELY TO BE STOPPED IN SOME AREAS



TORONTO STAR GRAPHIC

FIG. 19 - Choropleth maps from the article *Likelihood of being stopped if you're black increases halfway through 2013* - Toronto Star

and complete, this strategy will also provide citizens with an instrument to counterbalance the inherent biases of public institutional data. As Cooley writes in his essay on *Human-Centered Services*, "one of the main processes of current technological development is to render systems active and human beings passive. Our project's objective was to demonstrate that it is possible to design forms of technology that reverse this process, thus enhancing the activity and dominance of the user."<sup>94</sup>

Thus, the information resulting from an analysis of many people's contribution to the platform can also be used to provide the city with detailed information about urgent issues that would hardly be obtainable in different ways—like in the *Chennai Flood Map*<sup>95</sup> project. This information could in turn be used by citizens, organizations and news media to raise awareness and promote civic debate about them, as happened in the case of an investigative journalism series by the *Toronto Star*<sup>96</sup>

94 *ibid.*, p.66

95 Ganesh et al., *ibid.*

96 Winsa, P. (2014 July 25). Likelihood of being stopped if you're black increases halfway through 2013. *Toronto Star*. Retrieved February 24, 2019, from [https://www.thestar.com/news/insight/2014/07/25/likelihood\\_of\\_being\\_](https://www.thestar.com/news/insight/2014/07/25/likelihood_of_being_)

(FIG.19) which, through data analyses and visual representations, raised serious suspicions on the alleged bias of Toronto Police towards stopping black people more frequently than citizens of other ethnicities.

There are several reasons why I chose to define the proposed methodology as based on, and mainly accessible through, mobile devices. First of all, their worldwide diffusion is increasing, with the global mobile population estimated to grow from 2.4B in 2016 to almost 4B in 2021<sup>97</sup>. Besides, they are estimated to have recently overtaken desktop computers as the medium that is most used globally to access web pages<sup>98</sup>—a trend especially strong in rapidly-growing Asian and African countries<sup>99</sup>. From the point of view of this research, this scenario, and within it the diffusion of smartphones, social media, e-commerce and personal tracking apps, implies that an increasing amount of data within is collected—and generated within cities, as the Moritz Stefaner's *Multiplicity* demonstrates—via mobile devices. Yet, most importantly, my interest in these technologies mainly lies in their inherent *mobile* nature, and in their being increasingly designed—and used—as *spatial media*: a concept used in reference to technologies and practices that go beyond “[...] simply serving as a placeholder for emergent digital materialities with a locational component, [...] spatial media are importantly sites of potential relations between individuals; persons and places; and people, technology, and space/place.<sup>100</sup>” The proposal in this thesis acknowledges the crucial potential in mobile devices—and in

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stopped\_higher\_if\_youre\_black.html

97 Newzoo (2018). *Global Mobile Market Report*. Retrieved March 3, 2019, from <https://newzoo.com/insights/trend-reports/newzoo-global-mobile-market-report-2018-light-version/>

98 Statista (2018). *Percentage of all global web pages served to mobile phones from 2009 to 2018*. Retrieved March 3, 2019, from <https://www.statista.com/statistics/241462/global-mobile-phone-website-traffic-share/>

99 Statista (2018). *Mobile internet traffic as percentage of total web traffic in November 2018, by region*. Retrieved March 3, 2019, from <https://www.statista.com/statistics/306528/share-of-mobile-internet-traffic-in-global-regions/>

100 Leszczynski, A. (2015). Spatial Media/tion. *Progress in Human Geography*, 39(6), 729-751, 729

other related technologies—to generate innovative opportunities for connections between people (citizens), spaces (cities) and information (urban data). Therefore, my choice of the main medium for this project was focused on allowing potential users to explore information about cities right within the urban space. This choice was also instrumental in supporting explorations on the possibilities provided by technology to bring urban data visualizations beyond the limits of the digital world—to visually and spatially interact with the physical space of the city, and most importantly with the people navigating and inhabiting that space.

### **Potential limitations**

Focusing on digital technologies (especially mobile ones) necessarily poses limitations with regards to accessibility and inclusivity. The city-wide audience intended for the proposed methodology would necessarily include people who might not be proficient in the use of these technologies; people who might not own a smartphone—due to a personal choice or because they cannot afford one; people who might have difficulty in understanding the questions or the overall purpose of the platform; people unable to access it and share their contribution because of a physical condition; people who might be skeptical about sharing personal information on the platform. There are several strategies that might be implemented to mitigate these problems and ensure an experience as inclusive as possible for users. Some were directly addressed in the development of the design proposal, like the support for different languages, the complete anonymization of the data collected, the possibility for users to access resources make the questions more clear, the design choices for type-sizes, fonts and colours to maximize the accessibility of the interfaces, or the possibility to also access the content of the platform from a desktop browser. Other, more extensive actions can be envisioned for a potential implementation phase, like allowing the platform to support screen-readers for visually impaired people, finalizing its design to fully comply with AODA guidelines for accessibility, as well as devising strategies to involve citizens who don't own a mobile device—for example, organizing events where they could answer questions through analog visual devices.



## Chapter 5

### Learning From Toronto

After having outlined the scope and basic elements of the proposed methodology, the following step focused on design research and practice to develop a proposal that could put those principles into practice, to test their validity and limitations. The first goal in the design process was to investigate the strategy at the core of the methodology: using visualizations of data as a medium to ask questions to citizens. Therefore, in this phase I chose not to focus on a specific city or urban issue yet, in order to concentrate my efforts on devising structures and visual languages that could be as effective and comprehensible as possible, to explore the possibility of addressing a wide variety of topics through the proposed methodology.

#### Interactive visual survey

The first step in this direction has been an effort to systematize the approach proposed by the *New York Times* case study: this resulted in the proposal for an *interactive visual survey* in which users would go through five questions, each of them divided into four steps:

1. Presentation of the question in textual form, together with a related visualization. At this stage, the visualizations are either not portraying any data, or presented with default, placeholder values. Visual and text-based suggestions are provided to help users understand and interact with the graphics.
2. Interactive stage in which users can provide their answer by moving, modifying or drawing on visual elements within the graphics. Visualizations feature annotations, which dynamically update following actions from users, to provide references about the answer that is being submitted. Users can modify their answer multiple times before submitting it.

<b>What?</b>	- Which X is the most/less...?	Selecting
	- Which X has increased/decreased...?	Positioning
<b>Where?</b>	- Where does X happen...?	Selecting
	- Which direction does X follow...?	Positioning
<b>When?</b>	- When does X happen...?	Selecting
<b>Who?</b>	- Who is involved with X...?	Selecting
<b>How?</b>	- How many...? How much does X happen...?	Quantifying
	- How has X changed...? How does Y influence X...?	
	- How is X compared with Y...?	

FIG.20 - Summary of the research on meta-questions and on the possible corresponding interactions required to answer them

3. A visualization of actual data on the addressed topic is added to the visual model already portraying the user's answer—thus allowing for an immediate comparison between the person's guess and the data. Annotations provide numeric references, while customized, text-based feedback outline key differences and similarities between the guess and the data.
4. Graphics are finally enhanced with a visualization of the answers other users have submitted to the same question, overlaid on the existing visual models to facilitate comparisons with the information provided in the two preceding steps. More information and references are provided through annotations and text.

Exploring the possible implementations of such a structure entailed research on two, interrelated, fronts: on the one hand, the type of questions that citizens could be asked, on the other, the visual language that could be used to allow users to submit their answers and to compare them with actual data and guesses from other users. The research on the first subject proceeded with identifying a series of *meta-questions* (FIG.20), which also allowed a categorization of three groups of visual

models needed to support them, based on the kind of answer required. Depending on the question, users might in fact be prompted to *select* visual elements on graphs or maps (to answer questions like “Which urban area has the most/least frequent occurrence of a certain phenomenon?”); they could be required to *quantify* their answer by providing absolute values, relative ones or ranges of values (for questions like “What percentage of citizens do you think is affected by the phenomenon?”); they could also be asked to *position* a visual element, for example on a map (answering a question like “What is the most/least affected area within a certain neighbourhood?”).

These three categories informed the research on models for the visualization of data that could be suitable for the required tasks. Additional requirements for the visuals were the need to communicate information in a simple but effective manner while coping with the dimensional constraints of a mobile screen, and to provide an accessible and inclusive experience for a wide audience of citizens and city-users with diverse degrees of visual and technological literacy. An in-depth research on data visualization literature provided a crucial support in this phase, which drew from works by Jacques Bertin (*Semiology of Graphics*), Edward Tufte (*The Visual Display of Quantitative Information*, *Envisioning Information*), Alberto Cairo (*The Truthful Art*, *The Beautiful Art*), Manuel Lima (*Visual Complexity*), and John Tukey (*Exploratory Data Analysis*) to define a taxonomy of visual models that might meet these criteria—also to identify the graphs and charts that might already be familiar to users without backgrounds in design or data analysis. Visual and theoretical research was also critical in this phase, due to the need to investigate how the selected visualizations could support the simultaneous representation of the three main entities at the basis of the overall communication strategy: a single user’s guess, actual data on the addressed topic, and the guesses from many users. This research section was supported by a study of works by Colin Ware<sup>101</sup>, Christopher G. Healey<sup>102</sup>,

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101 Ware, C. (2004). *Information Visualization. Perception for Design*. (Second Edition). Waltham, MA: Morgan Kaufmann.

102 Healey, C.G., Enns, J.T. (2012). *Attention and Visual Memory in Visualization and Computer Graphics*. IEEE

Cleveland and McGill<sup>103</sup>, and Heer and Bostock<sup>104</sup>, aiming to look at what insights perceptual science could provide in order to establish a visual grammar to consistently and effectively depict three different entities in the same visualization across different visual models. Another fundamental support in this sense came from the elective course I attended outside the faculty of design, *Psychology of Data Visualization*, taught by Professor Michael Friendly who eventually agreed to serve on this thesis' supervisory committee as advisor.

Figures 21 and 22 summarize this visual research, showing the models that were selected and used as the basic visual material to explore the design of a consistent language that would be suitable to effectively portray the different sets of data in the same graph or chart. After several design iterations I finally identified colour as the visual component playing the key role in representing—and at the same time differentiating—the visualizations of the reader's guess and of the actual data. These are represented by two extremely contrasting colours; the areas where the two colours overlap—representing the cases in which the user's guess is coherent with the actual data—are depicted using a third colour, resulting from the chromatic overlay of the two original ones. I envisioned this strategy might prove effective in terms of perception: the very clear differentiation in colours avoids confusion on the user's side about which visual elements would depict his or her own answer, and which ones would represent the data. The colour palette used in this phase (shades of blue for the user's guess and yellow for the data) provides accessibility to color blind users, through an online open source tool developed for the specific purpose of designing accessible visualizations of data<sup>105</sup>. During my

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*Transactions on Visualization and Computer Graphics*, 18(7)

103 Cleveland, W.S., McGill, R. (1984). Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. *Journal of the American Statistical Association*, 79(387)

104 Heer, J., Bostock, M. (2010). Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design. *ACM Human Factors in Computing Systems (CHI)*, 203-212

105 Meeks, E., Lu, S. *Viz Palette*. Retrieved March 3, 2019, from <https://projects.susielu.com/viz-palette>

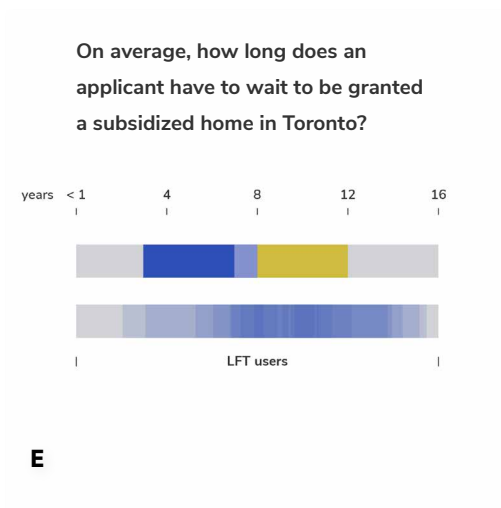
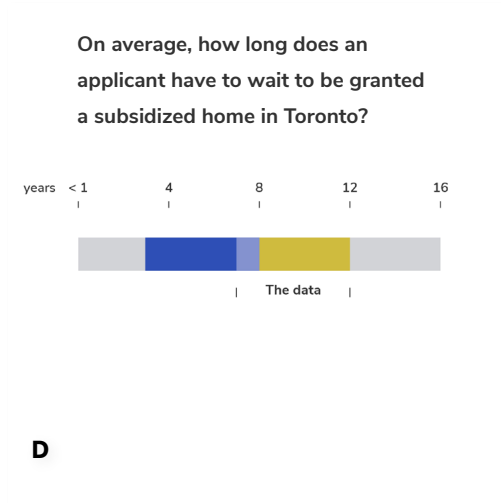
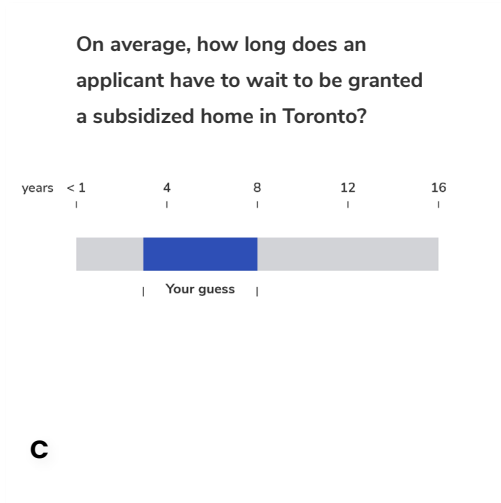
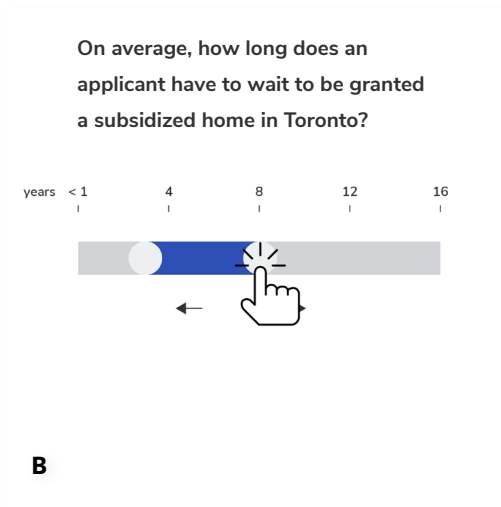
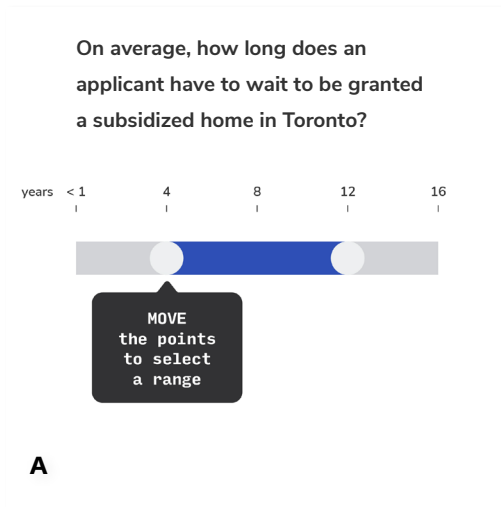


FIG.21- Visual language and main stages for the interactive survey: A - Question and suggestions on interactivity. B - User interacting with the visual. C - User submitting their answer. D - Visual comparison with actual data. E - Visual comparison with answers from other users.

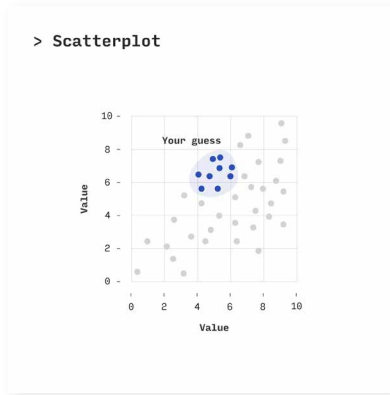
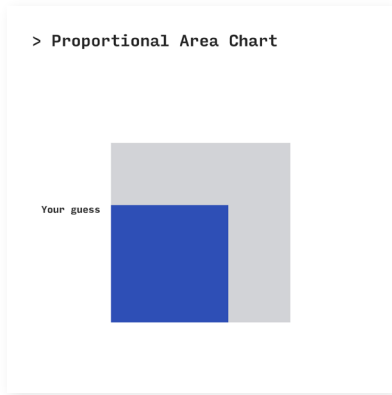
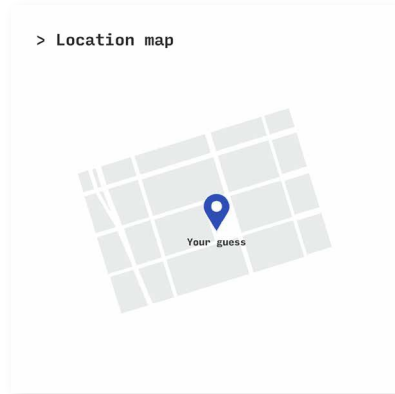
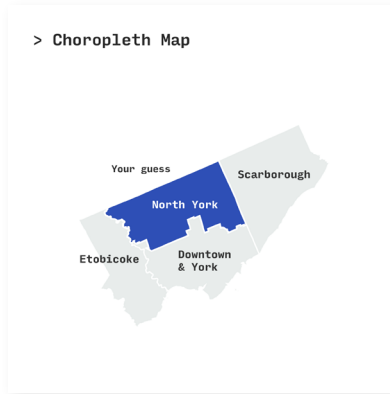
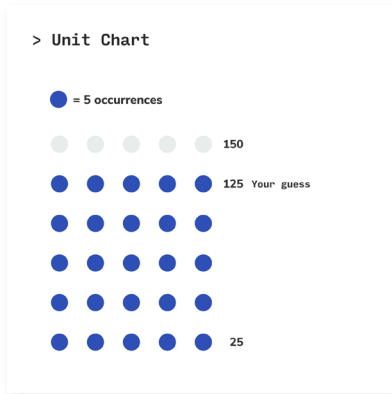
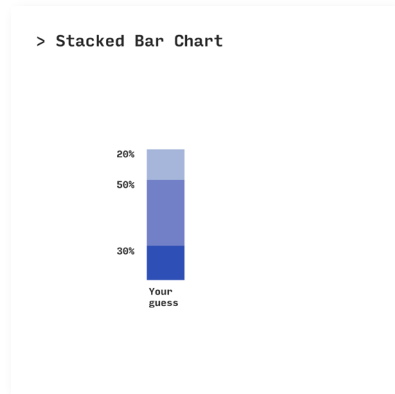
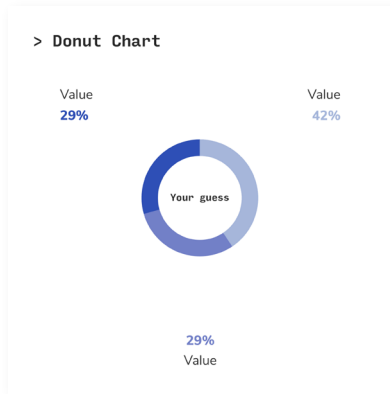
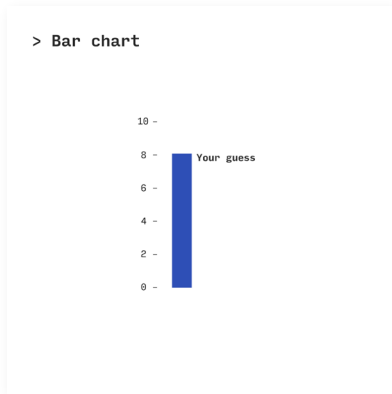


FIG.22a - Summary of initial design explorations on the possibility for different visual models to support visualizations of data, single user's guess and multiple users' guesses at the same time.  
Step 1 - user's guess.

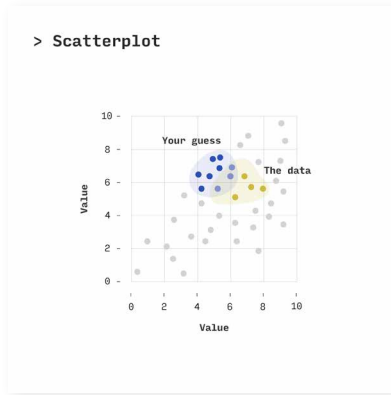
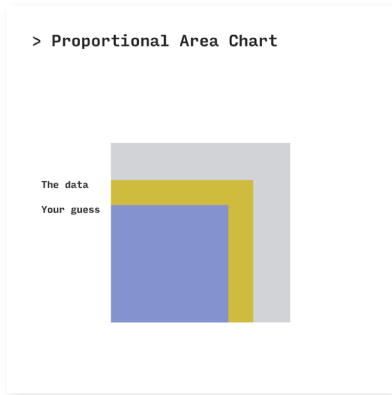
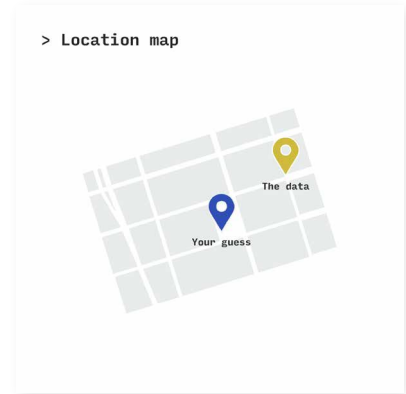
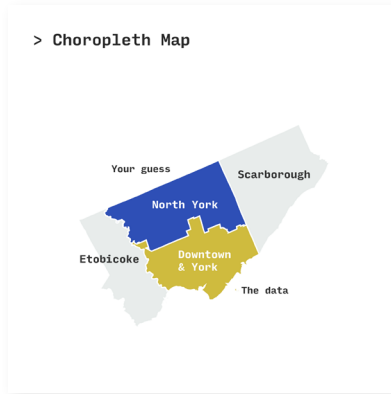
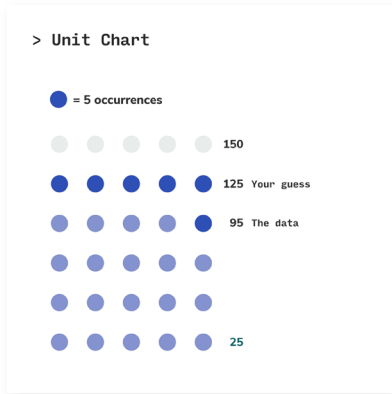
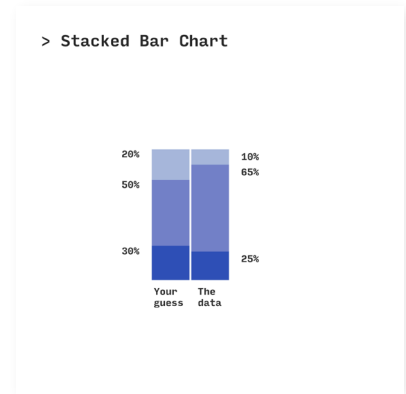
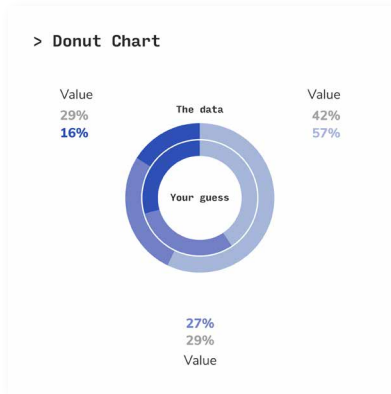
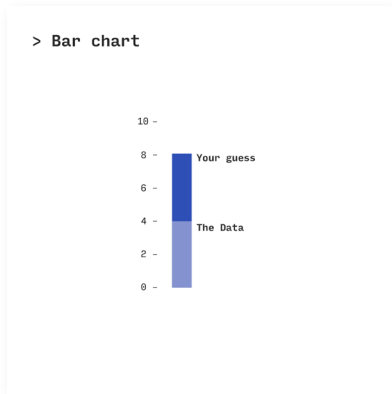


FIG.22b - Step 2 - comparison with actual data.

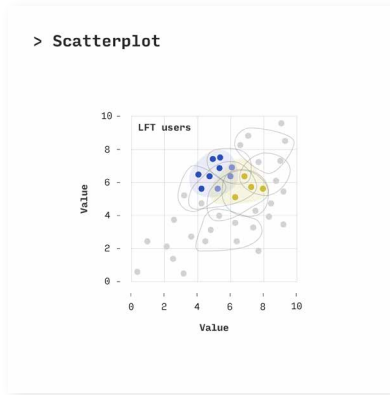
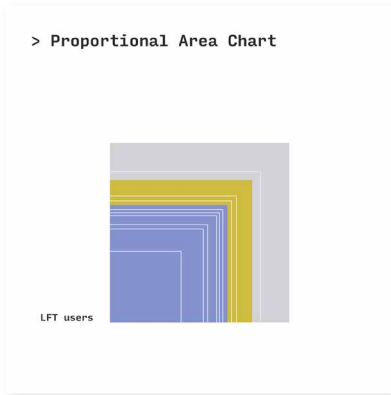
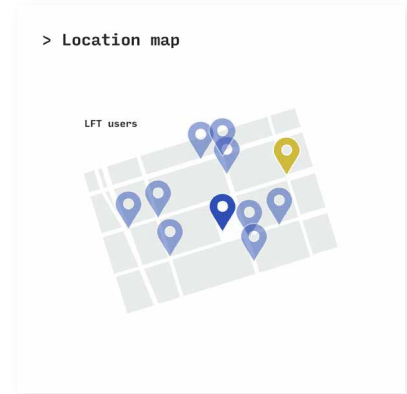
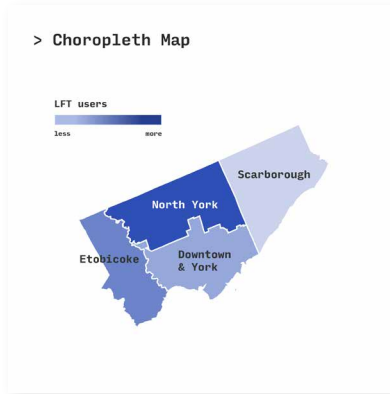
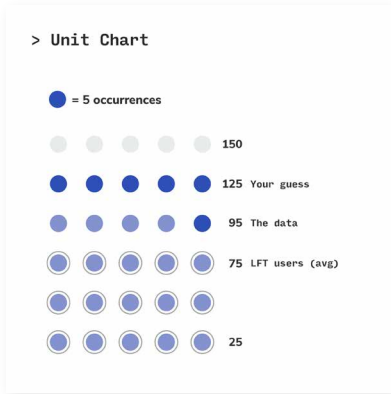
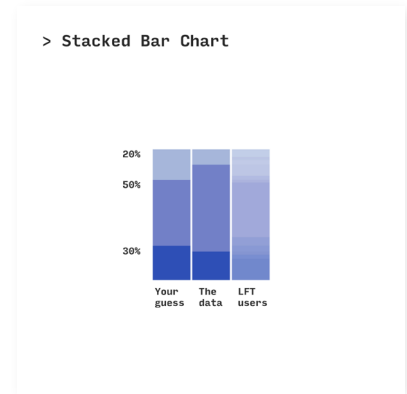
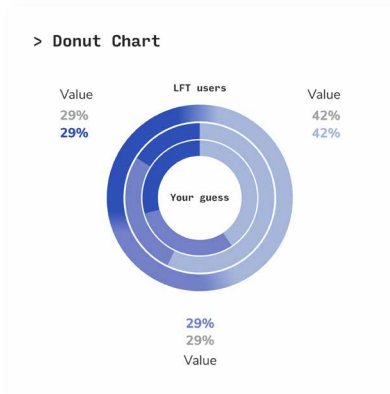
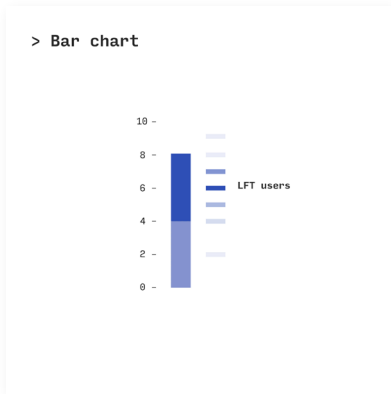


FIG.22c - Step 3 - comparison with guesses from other users.



research on how to apply this chromatic strategy to different visual models I recognized that it would not be effective in graphs that portray data as proportion of a whole: since by design they necessarily include more than one visual element, overlaying more features and different colors on them would result in a confusing and cluttered visualization. Instead, for these particular kinds of graphs, I proposed side-by-side comparisons which are portrayed in Fig.20 (donut chart, stacked bar chart).

The answers from other users are represented in different ways depending on the given visual model, ranging from dot-like, to linear, to planar elements to effectively depict a potential multitude of data without either obscuring the other elements in the graphs, nor the variations and patterns that could potentially be observable from such an aggregated visualization. Devising ways to portray guesses from multiple users was especially challenging; valuable methodological references in this sense came from the *You Draw It* case studies already presented, from *What The City?*<sup>106</sup>—a visualization project on urban spaces developed by German agency *Moovel Lab*—as well as from studies on the uncertainty in data visualization by *Midwest Uncertainty Collective*<sup>107</sup>, a valid reference on how to visualize the nuanced aggregated data from many people's answers.

### **The Learning from Toronto application**

After having explored the visual interactive survey from the methodological point of view, I focused on developing a design proposal that could put that strategy in practice. The main goal for this design phase was to formalize the strategy of asking questions through visualizations into a tool that could address concrete urban issues in the city of Toronto, and target its intended audience of citizens and city-users. The project was named *Learning From Toronto*, in an effort to symbolize the crucial two-

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106 Szell, Bogner and Reimann (2016). *What the Street!?*. Retrieved March 5, 2019, from <https://lab.moovel.com/blog/about-what-the-street>

107 Midwest Uncertainty Collective. Retrieved March 5, 2019, from <https://mucollective.northwestern.edu>



FIG.23 - *Learning From Toronto*: diagram of the application's structure

way, iterative nature of a platform that allows the city to gather valuable information by listening to its citizens, while allowing them to access data about issues of urban relevance, to learn more about the space they live in. The name is also a reference to the groundbreaking urban analysis study *Learning from Las Vegas*<sup>108</sup>, an important inspiration for my research—not in its detailed architectural analyses but in the open, observational approach it proposes for the study of a city, in its recognizing that even the most mundane elements in the urban fabric can be worthy of investigation, as they might provide clues and insights to better comprehend the structure of a city and the needs and behaviors of its citizens. In this sense, I drew a parallel between this approach and the necessity of looking at urban data—a mostly intangible entity, and as such possibly overlooked—to reach a deeper understanding of the complexity of modern cities.

Since the survey methodology is based on the will to investigate how the digital exploration of urban data could be implemented on mobile devices, a consequent design choice was to propose the implementation of *Learning From Toronto* (LFT) as a mobile-first application, whose organization needed to address two main goals: effectively introducing users to the project and to the principles of the visual interactive survey, and allowing detailed explorations of the addressed topics through further visualizations of data—available to all the users who wish to access more information on the

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108 Venturi, Brown and Izenour (1977). *Learning from Las Vegas. Revised Edition*. Cambridge, MA: The MIT Press.

given topic after having answered the questions. For these reasons, I devised a simple user-flow (FIG.23) composed of three main stages:

- 1. Access.** During the access phase users are introduced to the app through a brief video tutorial explaining its scope and, through visual examples, how the interactive survey works. They are also asked a number of onboarding questions to establish their demographics (which they can decide to skip)—as the anonymized results from these questions could be used to provide context to subsequent analyses of the answers shared by users. At this stage, users would also be able to pick the urban topic they are interested in exploring through LFT, out of a list provided in the application.
- 2. Visual interactive survey.** In this phase users go through a cycle of 5 questions on the topic they have chosen. The questions are meant to provide a high-level overview as comprehensive as possible of key points in the addressed issue. The goal in this phase is by no means to simplify the complexity inherent in all urban issues, but to provide an accessible and inclusive experience to users who, albeit being directly affected by that issue, might not be experts about the technical terms, concepts and values that are used to measure and describe it. In this phase, the structure of the visual interactive survey as presented in the previous chapter is maintained entirely, yet it is supported by a very simple user interface that provides suggestions on how to interpret the visuals and how to interact with them, also allowing users to submit their answers and navigate to the next questions. At the end of this stage, users can provide feedback about the survey, suggest the addition of new urban topics or of specific questions, as well as consult the sources of the data it is based on.
- 3. Further visualizations.** At this point, the users who are curious to know more about the addressed topic can choose to access further visualizations of data. The goal of these artifacts

is to delve deeper into the key points addressed in the survey, in their full complexity, providing a higher amount of information and details about them; for this reason, each visualization is related to one of the questions presented in the previous phase, illustrating the same sub-topic in more depth, as well as any related issues that might be relevant to provide a detailed picture of the phenomenon. Upon accessing them, users are first shown again the corresponding question from the survey, and the visual answer they have provided to it, in order to help them contextualize the sub-topic addressed. The design for each of these interactive visualizations is related to the visual model used in the corresponding question: this is done to facilitate users in interpreting the visuals, since they might have become familiar with their structure and meaning by directly interacting with them in the previous phase. This also allows the artifacts to build on models that are assumed to be known, so that users may explore more complex, experimental and evocative designs for the visualizations of related data. As shown by the case studies in Chapter 2, the interactive component is crucial in allowing an effective exploration of complex data: the artifacts developed for this phase are designed to be highly interactive, following what famed human-computer interaction researcher Ben Shneiderman calls “the Visual Information-Seeking Mantra: overview first, zoom and filter, then details on demand.”<sup>109</sup> These additional, more complex visualizations of data would be accessible in two ways: through augmented reality-based interfaces on the main mobile application, or through browser-based interfaces in the web version of the application. An example of one of these visualizations (*Unaffordable Rent in Toronto*) can be seen in figures 24-25. More documentation on this and other related projects is provided in Appendix A. The interactive visualizations I developed for the final design proposal are fully-functioning, browser-based applications implemented using HTML, JavaScript and CSS languages and the d3.js library. Though I completely programmed them, I must credit the invaluable online, open source contributions from designers and researchers in the data

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109 Shneiderman, B. (1996). The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. *Proceedings of the 1996 IEEE Symposium on Visual Languages*, IEEE Computer Society, Washington, DC

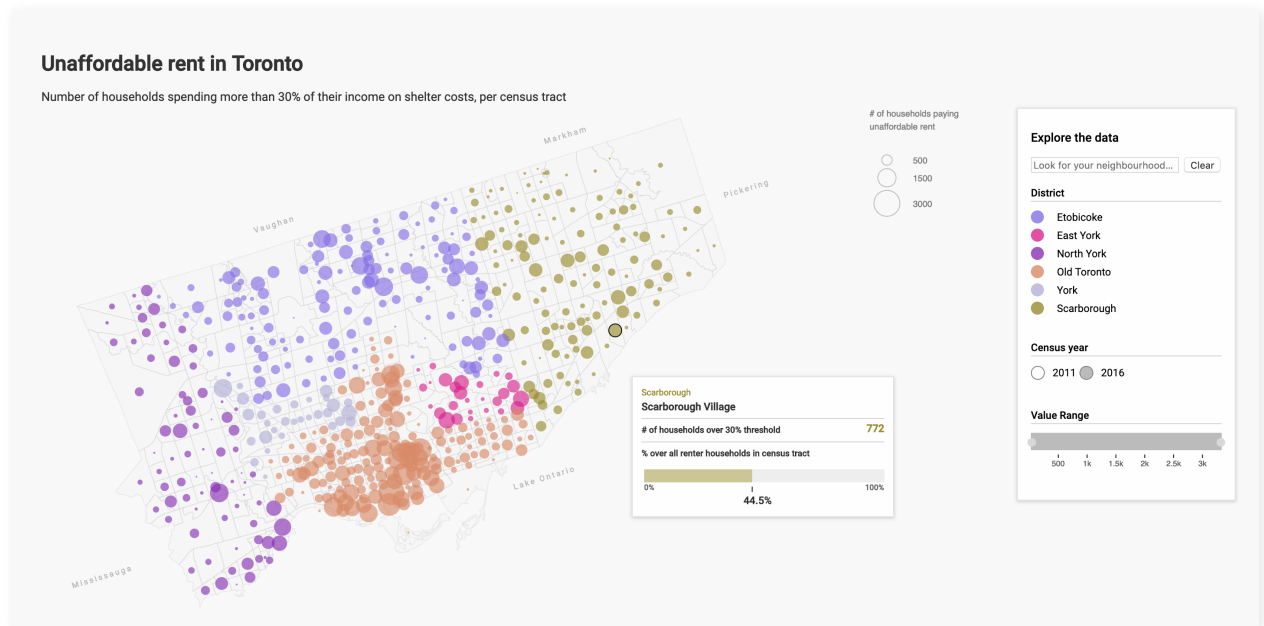


FIG.24 - *Unaffordable rent in Toronto*. One of the interactive, browser-based visualizations developed from the topics addressed in the interactive survey.

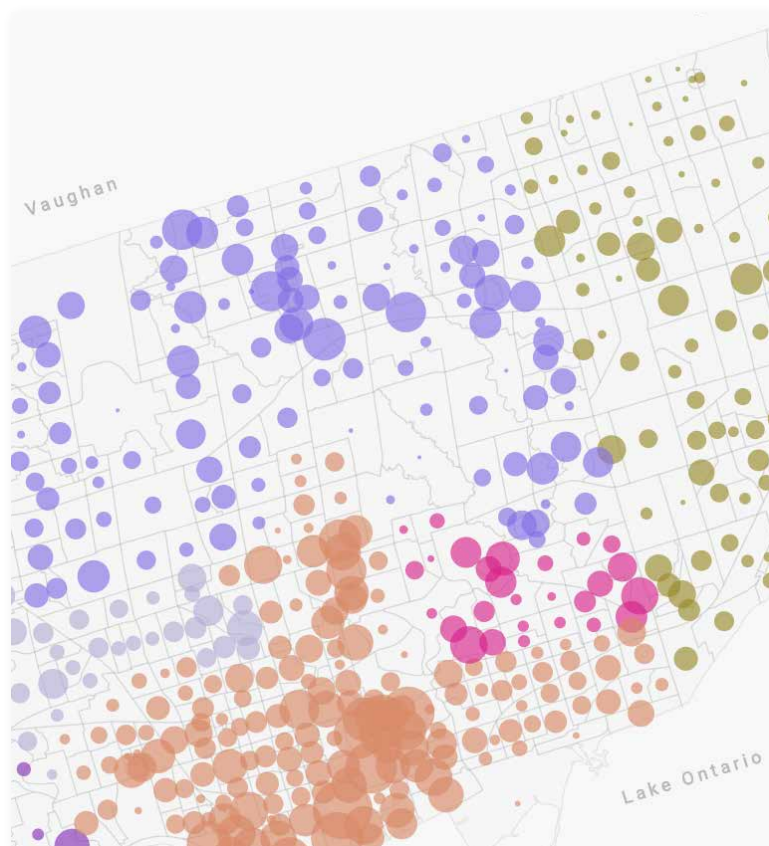


FIG.25 - *Unaffordable rent in Toronto*. Close up of the map

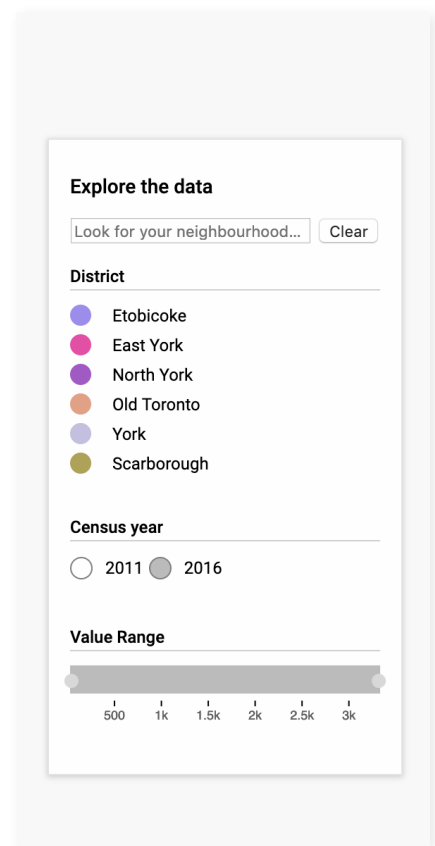


FIG.24 - *Unaffordable rent in Toronto*. Commands allowing interaction.

visualization community such as Mike Bostock, Nadieh Bremer, Elijah Meeks, that helped me learn how to turn my designs into interactive applications, and that in one case (visualization number 3, page 94), provided a basic framework on which I could build one of my projects.

### **Site-specific visualizations**

As previously outlined, the choice to propose a mobile application was informed by the will to investigate the possibilities offered by recently developed technology, to allow explorations of urban data right in the space of the city, and to generate novel, meaningful connections between citizens, urban space and visualized information about the city. Among the variety of technologies and affordances that mobile devices currently provide, the one that seemed more promising for the exploration of these topics, both from the conceptual and the technical point of view, is augmented reality. Scholars, computer scientists and designers have provided very diverse definitions of augmented reality, which could be outlined—in a broad way—as “a situation in which a real world context is dynamically overlaid with coherent location or context sensitive virtual information”[...] AR could provide users technology-mediated immersive experiences in which real and virtual worlds are blended [...] and users’ interactions and engagement are augmented.”<sup>110</sup> In the last decade, the use of this technology has been considerably widespread, particularly since it started being easily accessible through smartphones—prompting the development of a new market for AR-based applications. Despite its inherent technical and perceptual complexity, this technology has a great potential to create engaging ways to disseminate any kind of information, and has proven to be effective in supporting digital applications for purposes as diverse as art, commerce, entertainment, and education<sup>111</sup>. Two recent examples of AR-based applications developed in the city of Toronto,

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110 Wu, Lee, Chang, Liang (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, 62, 41-49

111 *ibid.*

which I had the opportunity to experience directly, can demonstrate this potential. The first one is an application developed by the city's Civic Innovation Office<sup>112</sup>: it allows municipal employees to visualize existing underground technological networks through a tridimensional representation on tablets-thus enabling them to identify the section where they need to operate without having to break ground to find it. The second one was implemented to enhance the visit to the Anthropocene<sup>113</sup> exhibition at Art Gallery of Ontario, where users were provided with tablets allowing them to visualize, and move around, AR-based "sculptures", or to trigger animations that enhanced the experience of the large-format photographs that were the main subject of the event. These very different examples provide clues to the versatility of augmented reality: from a tool focused on solving a concrete, mundane problem, to applications that can enhance an artistic experience. This technology still represents a novel, experimental territory for many disciplines, including data visualization.

A recent example of this kind of experimentation is an installation by the Department of Unusual Certainties<sup>114</sup> (FIG.26) presented in the *Diagrams Of Power* exhibition, organized in Toronto by OCAD University. By holding a tablet in front of a series of black and white photographs of government buildings from all over the world, visitors were able to visualize data about different countries' political systems: each image triggered a specific augmented reality response, which overlaid corresponding visual elements over the actual photographs on the tablet screen. Another recent project that is of particular interest in this sense is *Building Hopes*<sup>115</sup> (FIG.27), a collaboration between Google

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112 Toronto Civic Innovation Office. Retrieved March 1, 2019, from <https://www.toronto.ca/city-government/accountability-operations-customer-service/city-administration/staff-directory-divisions-and-customer-service/civic-innovation-office>

113 Art Gallery of Ontario. (2018 September 28 - 2019 January 6). *Anthropocene*. Toronto.

114 Department of Unusual Certainties (2018). *A Type of Political Map*. Toronto: OCAD, Onsite Gallery. Retrieved March 4, 2019, from <http://diagramsofpower.net/#department-unusual-certainties>

115 Accurat, Google News Initiative (2018). *Building Hopes*. Retrieved March 4, 2019, from <https://www.accurat.it/works/buildinghopes>

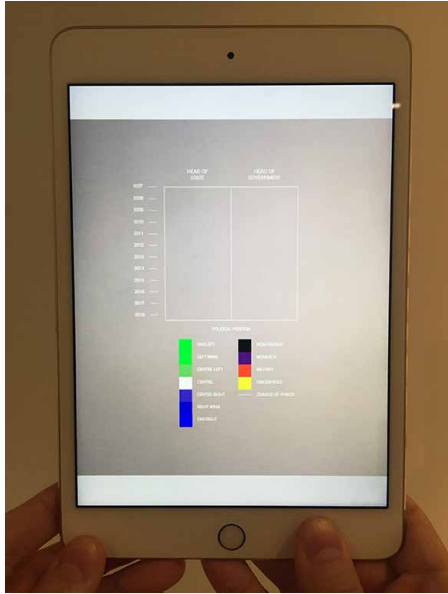


FIG.26 - A Type of Political Map.

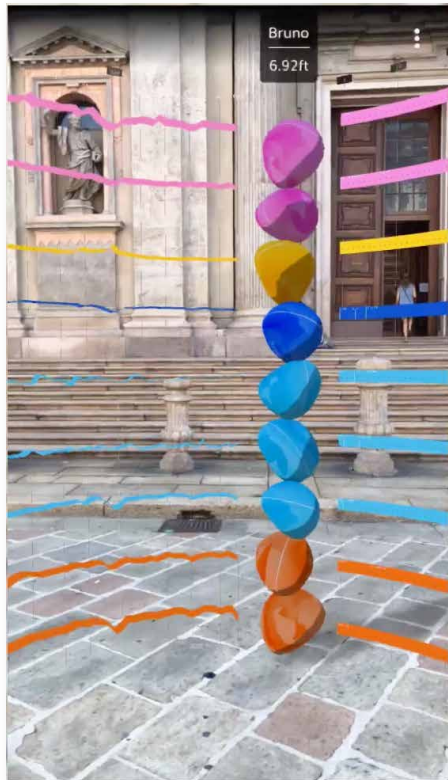
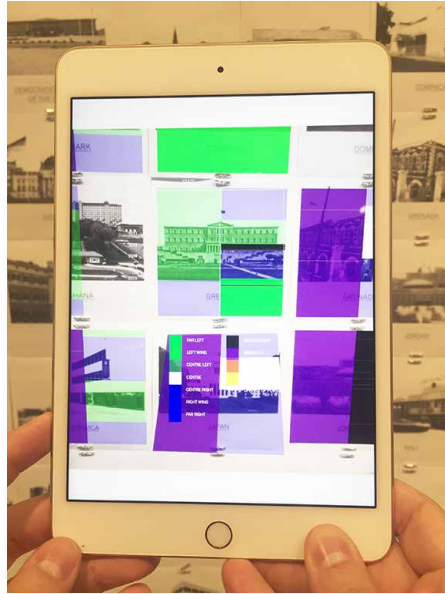


FIG.27 - Building Hopes



News Initiative and the design firm Accurat—for whom I had the pleasure to work for as an intern in the summer of 2018. Through the application users can create virtual sculptures representing their personal ‘hopes’ for the future, and they can place them at a chosen position in space (indoors or outdoors), where sculptures will remain permanently visible to the other users of the app. Through very simple on-screen interactions, each sculpture reveals data visualizations of the subject at the core of the project: the *Google Trends* data related to the topics—*hopes*—picked by their author. Besides its strong participatory component of this project, in which data represents the starting point that allows users to generate and share content reflecting their personal views on the world, this project crucially introduces the idea of location-based visualizations. These can only be observed at the location chosen by their authors, who can thus use space as an important component of their project: location becomes an element that can enhance the meaning of the artifacts created by users, while the artifacts can at the same time activate the spaces they are located in—with extremely interesting results happening in public urban spaces. Digital technologies can be used very effectively to allow people access to visualized urban data at specific locations within the urban space—as demonstrated by a project such as *Helsinki Urbanflow*<sup>116</sup>, with its highly interactive digital street maps, providing a variety of services and information for both tourists and residents. In this scenario, augmented reality still holds a minor role; yet the projects previously presented demonstrate how communicating through this technology can provide an engaging, immersive and spatialized experience of information. This is what led me to propose AR-based, site-specific visualizations as the final step in the Learning From Toronto mobile app user-flow. The more detailed visualizations described in the previous section of this chapter would therefore be primarily accessible as augmented reality installations, allowing urban data visualizations to interact with the space and architecture of the city: they could be virtually projected on facades, squares, monuments and be visible through mobile devices. Moreover, they would be site-specific in a broad sense: not just

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116 Nordkapp, Urbanscale (2011). *Helsinki Urbanflow*. Retrieved March 4, 2019, from <http://helsinki.urbanflow.io>

visible only at specific public spaces within the city, but also set in locations that would be chosen as relevant to the topic the artifacts are addressing—thus providing users with the opportunity to access an enhanced experience both of the topic itself, and of the space where the installations are located. Because the restricted size of a mobile phone screen would seriously limit the accessibility and the comprehension of the more detailed visualizations provided after the interactive survey, augmented reality would also prove to be useful in this respect, providing users with a larger—virtual—space to explore details in the data. The location-specific quality of these installations would also be employed as a way to engage citizens in the use of the app: indeed, the access to LFT could also be suggested by the app itself, via a notification on the user’s device, once he or she has entered an urban space where one of the location-specific visualizations is situated. Users would be notified about the presence of the virtual installation, its position in the space and the topic it addresses: this way, if interested, they would be able to access the app, go through a survey session focused on that particular topic, and then experience the installation through augmented reality.

The research that supported this experimental proposal was an important part of the investigations towards a design outcome for this thesis, especially from the theoretical point of view. After an in-depth research on the possibility to address these concepts also from a practical point of view, I realized that developing AR-based visualizations—albeit only in the form of prototypes—would go beyond the initial and main scope of this thesis. I therefore directed my design work to develop the browser-based interactive visualizations that in the LFT project are envisioned to be accessible through the app’s web version. Nevertheless, my investigations on the possibilities offered by augmented reality to create meaningful visual connections between citizens, urban spaces and urban data will certainly represent a valuable reference for my personal future studies in this disciplinary field.

## **The first design proposal**

I started my work to develop a design proposal for the LFT app by considering several urban issues in Toronto as the possible topics that could be addressed through the application. As described in Appendix A, in the early stages of the research I produced design work targeting issues related to public transportation; I then briefly transitioned to look at crime data in the city, before finally settling on the housing topic as the main subject to develop a first prototype for the application. Within this prototype, the main topic was addressed through 5 questions that were specifically chosen to introduce some of the key issues in the complex ecosystem of housing in Toronto; implementing each question implied the need to identify a suitable visual model to illustrate the underlying data, among the ones developed in the previous design phase. These are the questions and the corresponding visual models (FIG.28) that were developed in the first application prototype:

1. Q: How much of your annual income should rent take for you to consider our home affordable?  
Model: bar chart
2. Q: How extreme is the difference in median home prices among different neighbourhoods?  
Model: three bar charts to compare the most expensive, average and cheapest neighbourhood
3. Q: How have prices for residential units changed in Toronto since 2013? Model: line chart
4. Q: In the last six years, 12,671 new homes were completed in the city. How are they distributed [geographically]? Model: donut chart
5. Q: How many homes do you think are not permanently occupied or unoccupied in Toronto?  
Model: unit chart

This first design proposal was an important attempt at embedding the visual and conceptual principles of the interactive survey into a user interface that aimed to be as coherent and functional as possible. During this design phase, I also developed a first interactive visualization targeting housing in Toronto (Appendix A, page 92), which was specifically based on the issue addressed in question 5.

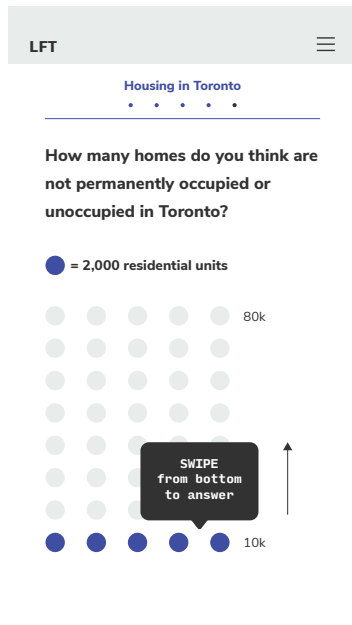
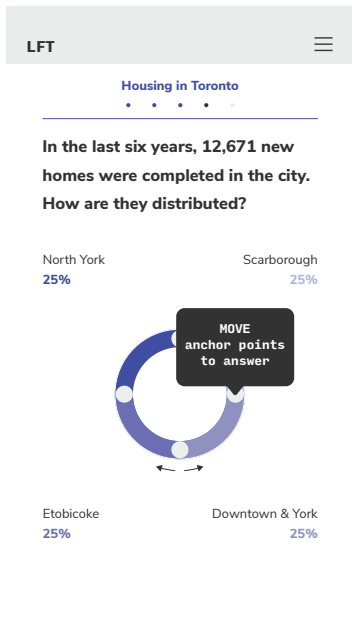
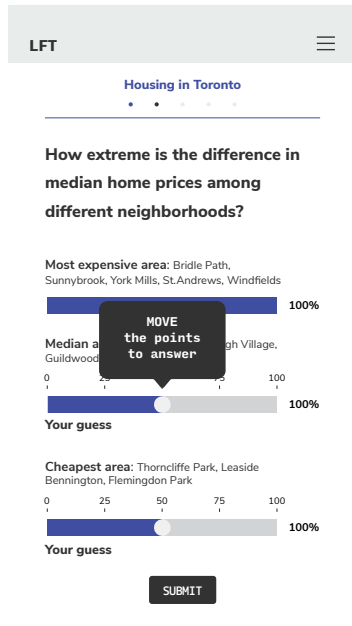
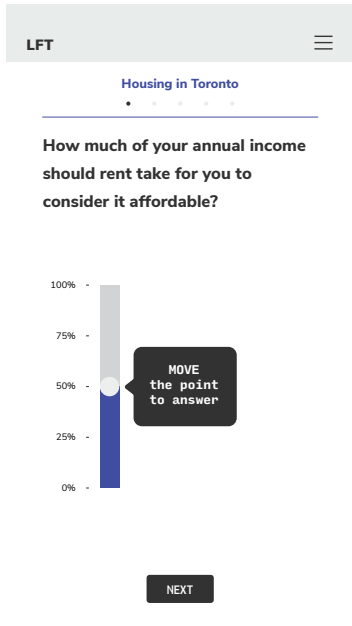


FIG.28 - *Learning from Toronto*. First design proposal—initial interface for each of the five questions in the interactive survey.

This design relies on the information design theory of small multiples<sup>117</sup> to represent the relationship between two important phenomena across the city's 140 neighbourhoods: households classified as in core housing need<sup>118</sup>, and private dwellings that are not permanently occupied by their owners or by tenants. More context on the issues is provided through a visualization of the median prices for residential units in each neighbourhood. Users, by hovering with the cursor on each visual element, can visualize it at a larger scale, together with numeric information on the data that are portrayed, as well as visual references to compare them to urban averages of the same data.

Developing this first design proposal was a fundamental step towards the next phase in the research: building a functioning prototype to test and evaluate the principles behind the Learning from Toronto application, the methodology it is based on, and its design.

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117 Tufte, E. (1997). *Visual Explanations*. Cheshire, CT: Graphics Press. P.105

118 Statistics Canada (2017). *Core housing need, 2016 Census*. Retrieved March 4, 2019, from <https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/chn-biml/index-eng.cfm>

## Chapter 6

### Evaluating And Redirecting

Consistently with the great importance user participation has in the overall strategy for the project, I figured the most valuable and appropriate design research methodologies to evaluate the proposal would be user testing and interviews. The main goal for this phase was to collect feedbacks from potential users on a variety of aspects: the way the application addresses the very complex overarching topic of housing in Toronto; the scope, wording and organization of the questions within the interactive survey; the visual models and languages used in each question; the design of the user interface and of the interactivity; the overall purpose and implications in the LFT application proposal. In order to investigate these topics, I devised the tests as a 45-minute, one-on-one session divided into three sections: a preliminary interview to establish participants' demographics and their level of knowledge about the topics addressed in the test, a user testing session in which they would be asked to interact with a prototype of the application on a mobile phone (FIG.29), and a debrief interview to allow them to express any feedback, doubt, or idea on the project. After having obtained the R.E.B. approval for research involving human participants (presented in Appendix B), I started my recruiting campaign among people either living in Toronto or daily commuting to the city, aiming for a sample as diverse as possible in terms of education, age, ethnicity and professional expertise. In order to allow participants to test the application, I subsequently developed a functioning prototype of the interactive survey. The result was a very simple mobile application in which users could effectively go through the five questions, interact with the visualizations to share their answers, and see them compared with actual data. The development work for this prototype was therefore based on two main activities: I programmed the whole interface using a mobile implementation of the Processing programming language, and I conducted a research among publicly available datasets related to the topic addressed in each question, in order to produce the visualizations of data to be

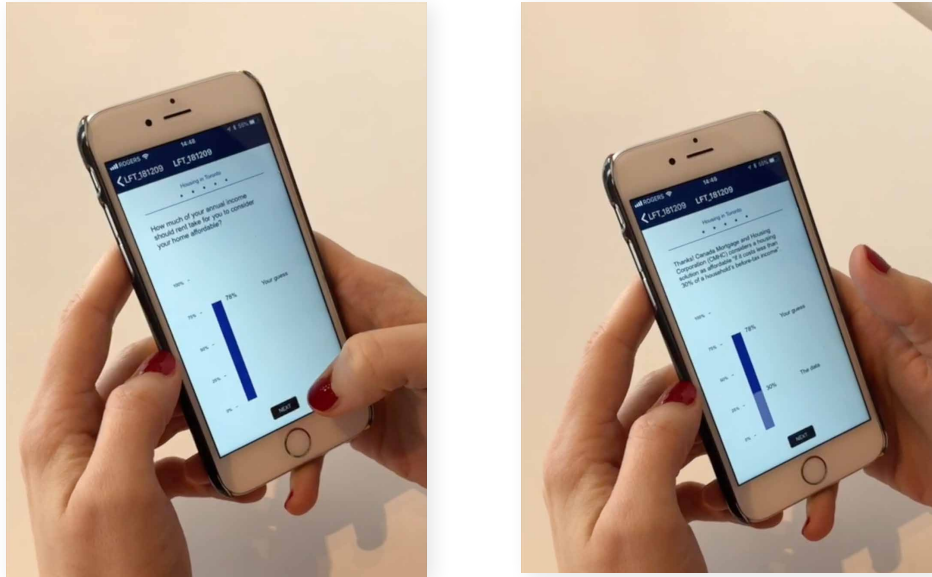


FIG.29 - A participant interacting with the prototype

compared with guesses from users. As in the static prototype described in the previous Chapter, visualizations of multiple answers from other users were simulated, a detail that was clearly stated at the beginning of each test. Between December 2018 and January 2019 I was able to conduct user testing sessions with 7 participants: a small sample for the standards used in similar testing for new digital applications, but one that nevertheless provided key insights to further develop and improve the project. These were identified through an in-depth analysis of each testing session, based on audio recordings of the interviews, as well as on audio-video recordings of each participants actions within the mobile application. The information collected during the tests was also visually analyzed by mapping the user's journey through the different stages of the app, together with the corresponding comments that were made during the interaction with the prototype. A summary of answers from participants is presented in Appendix H.

### **Findings and insights**

The testing sessions, and the design proposal, received an overall positive response from all participants, who also generally claimed to have understood the purpose of the application and

the principles of the interactive survey. The majority of the participants also stated they understood the questions and the visual models, although a few of these were harder to comprehend for some users, who shared their doubts right during the user testing session, or in the debrief interview. All participants were able to complete a full cycle of five questions, although showing very different behaviours in completing the task: for example, some of them frequently asked for clarifications on the questions, while others never interacted with me while testing the application. Besides the testing session, which provided very important clues on how to improve the graphics and the interactivity of the platform, the debrief interviews were also an extremely useful source of feedbacks and ideas—especially with regards to the organization of the survey questions, and to the sub-topics they addressed. This analysis phase allowed me to identify three main insights to further develop the design proposal:

1. The interactive survey might be extended to include more steps, as most users claimed they would have answered more than 5 questions.
2. In some cases the visual comparison between actual data and user's guess might require improvements to avoid perceptual ambiguities between the user's guess and the extent of actual data.
3. The organization of the questions and the sub-topics they address might be improved to provide a more comprehensive overview of the housing situation in Toronto.

These insights were a fundamental resource in developing a revised version of the design proposal, aimed at addressing the limitations that emerged by testing the first one. As to the survey questions, I worked to improve their order and overall organization towards a more comprehensive, high-level presentation of key issues related to housing in Toronto. I therefore continued conducting secondary research on the topic, finally identifying six key points the survey should address—the issues faced by homeowners, those faced by renters, the recent extreme and disproportionate growth in the city's housing stock, its composition among different types of buildings and homes, the subsidized



housing ecosystem and emergency housing situations. Each of these sub-topics was then developed into a new question for the revised version of the application (Appendix A, page 78-80). The topic addressed in this proposal is so complex and nuanced that the above list of key points certainly cannot be exhaustive. Yet, it was developed with the aim to address what appeared to be, both from my research and from interviews with users, the most urgent and important challenges faced by Toronto on the housing front. This high-level overview aims to represent an entry point in the topic for users, who would then be able to conduct further, more detailed explorations of the data in the mobile or browser-based visualizations. From the visual point of view, in this phase I worked to identify a strategy to improve the perceptual distinction between the visualizations of users' guesses and those of actual data overlaid on them. I chose to differentiate the visual element representing data from the geometric point of view, and to modify the color resulting from the overlay towards a darker tone that is more easily recognizable as a mix of the two original hues. Figures 30 and 31 portray an example of this evolution: in the revised bar charts the yellow "data" feature works like a linear element as opposed to the blue, "guess" surface. The revised proposal presented in Appendix A is based on this research; yet it is important to acknowledge that both the new questions and the visual language would require a further iteration of testing to be meaningfully evaluated and considered for implementation in the application.

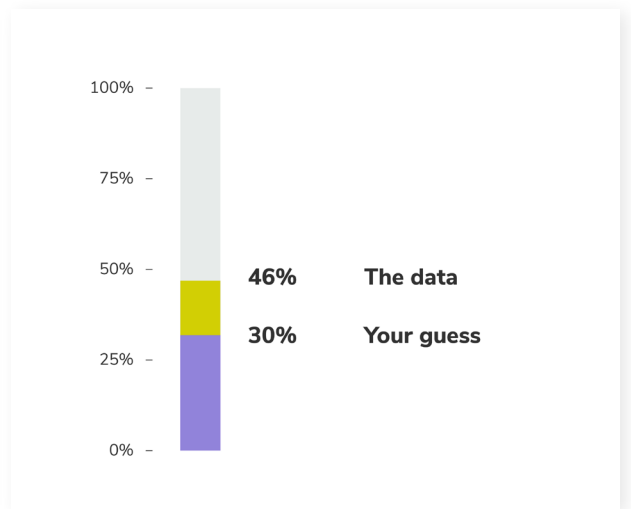
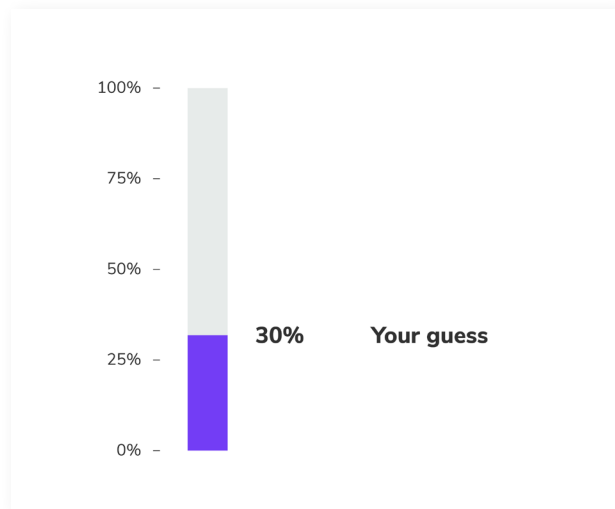


FIG.30 - Original visual strategy (bar chart)

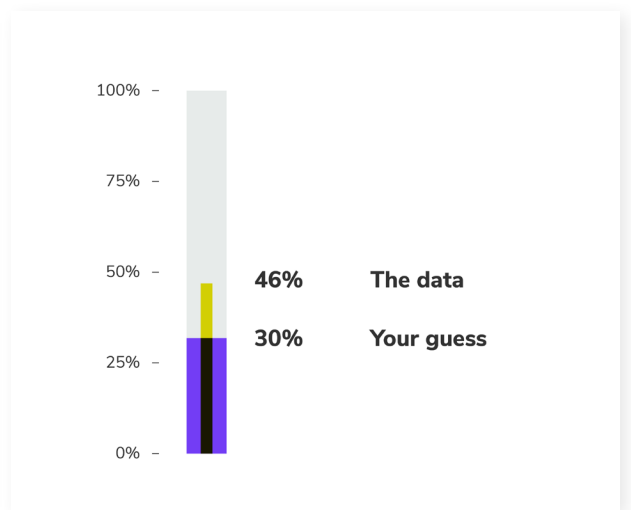
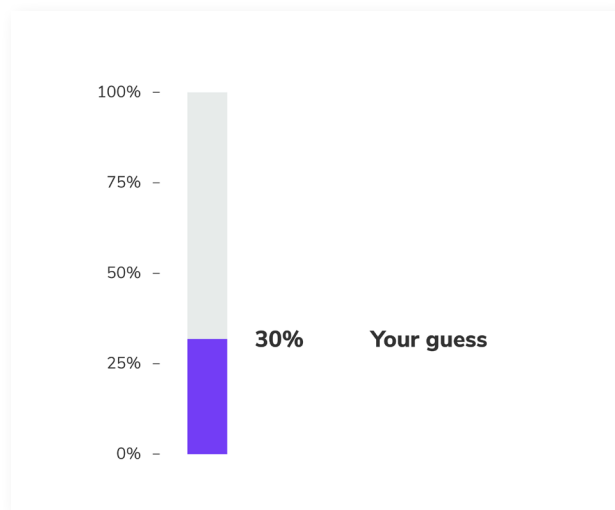


FIG.31 - Example of the revised strategy (bar chart)

## Conclusion

The main goal for this thesis has been investigating design's possible contributions to the current discourse on how information is generated, communicated and assimilated by people through different media. Research on information and perception theories led me to recognize the relationship between people's perception and actual data on the same phenomenon as a problematic one in today's rapidly changing information scenario—and, in turn, to hypothesize how this issue could be addressed through design theory and practice. Focusing on the difference between perceptions and measures of data also represented an opportunity to reflect on the discipline of design as an instrument for social innovation. In fact, I recognized its potential to highlight and question the biases that are inherent both in human perception and in any kind of data. I found a valid paradigm to inform my exploration of those topics in Nathan Shedroff's understanding of interaction as a necessary experiential element to allow a deeper engagement of people with information. Starting from these principles, I proposed a methodology for the communication of information that would not just allow people to interact with a visual interface, but with information itself. To do so, I worked to systematize a strategy originally developed in visual journalism that is based on asking readers to answer questions on a specific topic by interacting with visualizations of data. I therefore focused my research on the discipline of data visualization, which provided me with key support in devising the visual language at the core of the proposed methodology—one that could be as effective, perceptually accurate and semantically meaningful as possible.

In order to test the methodology through a concrete design proposal, I identified urban environments, with their social and spatial complexity, as a suitable subject, specifically focusing on the city of Toronto. A study of best practices in urban data visualization, both from the point of view of design and of the opportunities offered by this discipline to urban communities, was fundamental in developing the design for an application—*Learning from Toronto*—based on the proposed

methodology. Developing the design for this application, which addresses a complex issue like Toronto's problematic housing situation, allowed me to iteratively re-evaluate the methodology itself. It also gave me the opportunity to test it with potential users. This was an invaluable step in the research process: feedback from participants reinforced the hypotheses of interaction design's potential to generate meaningful and deeper connections between people and information, while providing crucial insights on the communication strategy and the application itself, both from the conceptual and the visual point of view. The tests were also helpful in highlighting existing limitations in the design proposal, such as the fact that questions—the key element in the communication strategy—were not developed in the first place as a collaborative effort between designers, citizens and institutions; or the small sample size of the testing campaign itself, which necessarily produced limited—yet helpful—findings.

With this thesis I aimed at investigating the role design can have in facilitating the sharing of information within urban communities, and in exploring and questioning the relationship between people and data. My research proposes a contribution to the ongoing discourse on misperception and cognitive bias from the point of view of information visualization. I drew from research on this subject, to explore it from a more practical perspective, highlighting how design can play a critical role in facilitating a better comprehension of the gap between perception and data, and how a systematic analysis of this issue can contribute to positive innovation for urban communities. In this sense, my proposal introduces novel elements: the concept of a two-way information sharing system, that builds on digital technology to generate a dialogue between citizens and institutions; the possibility to implement a comprehensive platform for urban data visualization, focused on a specific city, suitable to address a variety of relevant issues within a consistent format; the opportunity for such platform to be developed at different scales from smaller areas within cities to the whole urban environment; lastly, the chance for cities other than Toronto to implement a similar system. From a more general design perspective, I proposed a reflection on how visualizations can be

pushed beyond their primary function of communicating information, becoming the actual space for a comparison between the users' perception and data. Thus this work contributes to research in the field on how design can benefit from users' inputs and a participatory approach to provide more inclusive and effective outcomes.

Working to address my research question helped me propose a way to frame these issues, and a methodology to address them, but also generated a whole new series of questions. Therefore, I see the work I produced for this thesis as a starting point for further investigations on the same topics, aimed at answering such new questions. Conducting more extensive studies with potential users is certainly one of the key steps I identify for the future developments of this project. A larger sample of participants would in fact allow a more systematic evaluation of the visual language used in the interactive survey—both in terms of its effectiveness in prompting users to “[...] attend to the gap between their prior knowledge and the observed data [...]”<sup>119</sup>, and of its perceptual accuracy, to identify any potential bias in the visuals or in the questions. A further key development would be to involve citizens, as potential users, in the process of generating and framing the survey questions, so that they could better reflect the variety of perspectives that exist among the population on complex topics of urban relevance. A more direct investigation—or involvement—of possible stakeholders in public institutions and civic organizations would be especially valuable in identifying further urban issues to address, and in devising strategies by which the information gathered from citizens through the survey can be used to foster further research and inform decisions at the institutional level. Investigating more deeply the possibilities offered by emerging mobile technologies towards experiences of urban data within the urban space, which I presented in Chapter 5 but did not directly investigate, would also represent an important continuation of this thesis research.

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119 Kim, Reinecke and Hullman (2017). Explaining the Gap: Visualizing One's Predictions Improves Recall and Comprehension of Data. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 8.

Finally, with regards to the methodology at the core of the Learning from Toronto application, a further crucial test would be to broaden its scope to address different kinds of information rather than just issues related to urban environments. Such an avenue of inquiry would allow to investigate the methodology's general effectiveness in producing an engaging and meaningful communication of information, and in providing a paradigm to reflect on the relationship between human perception and data.

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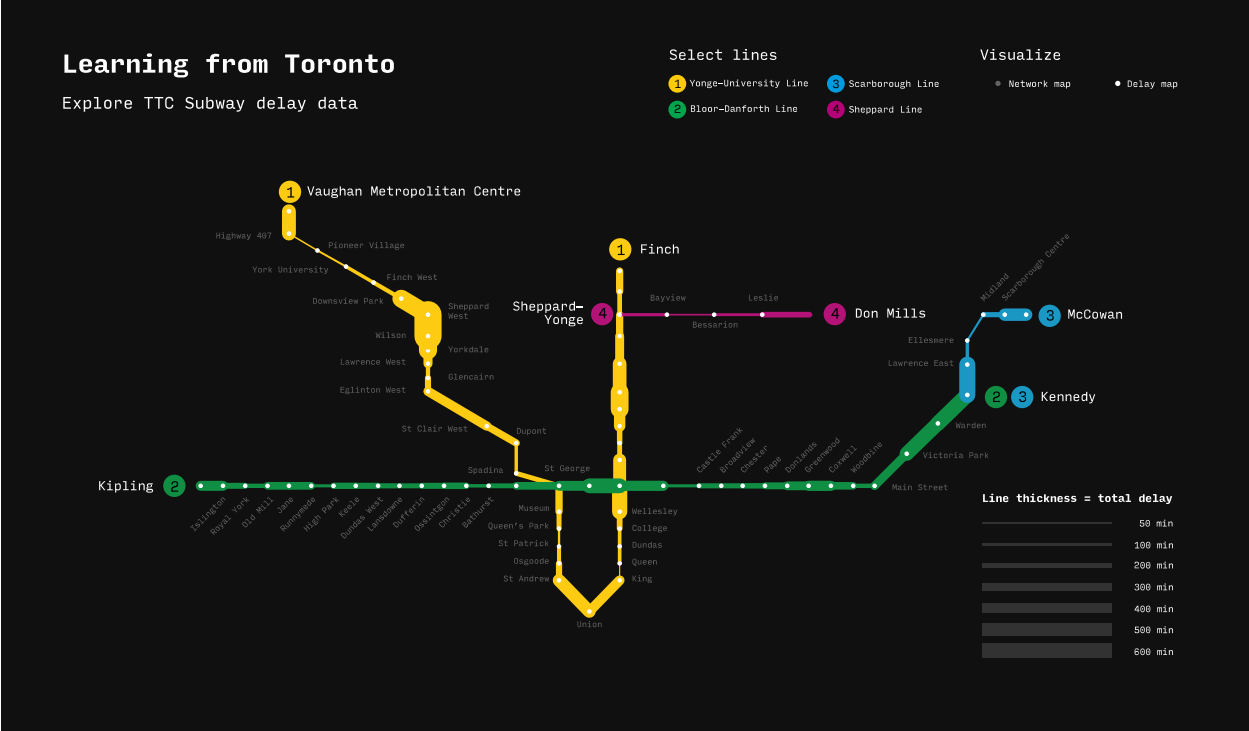
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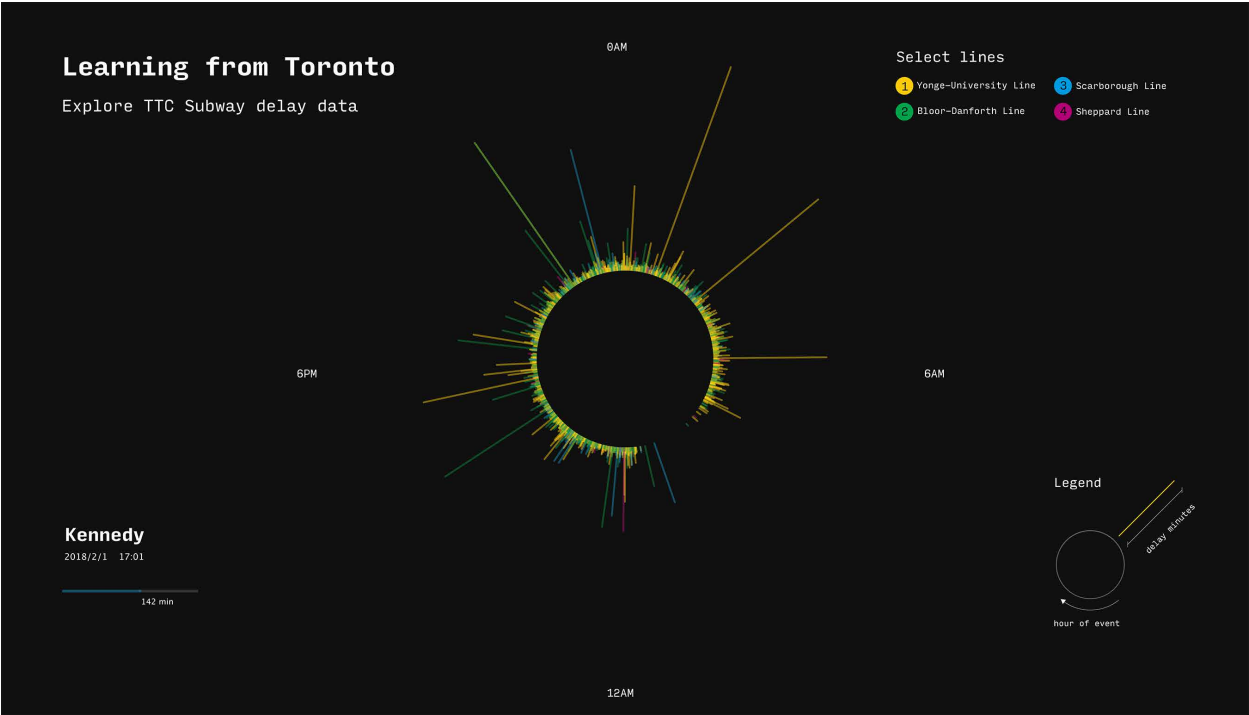
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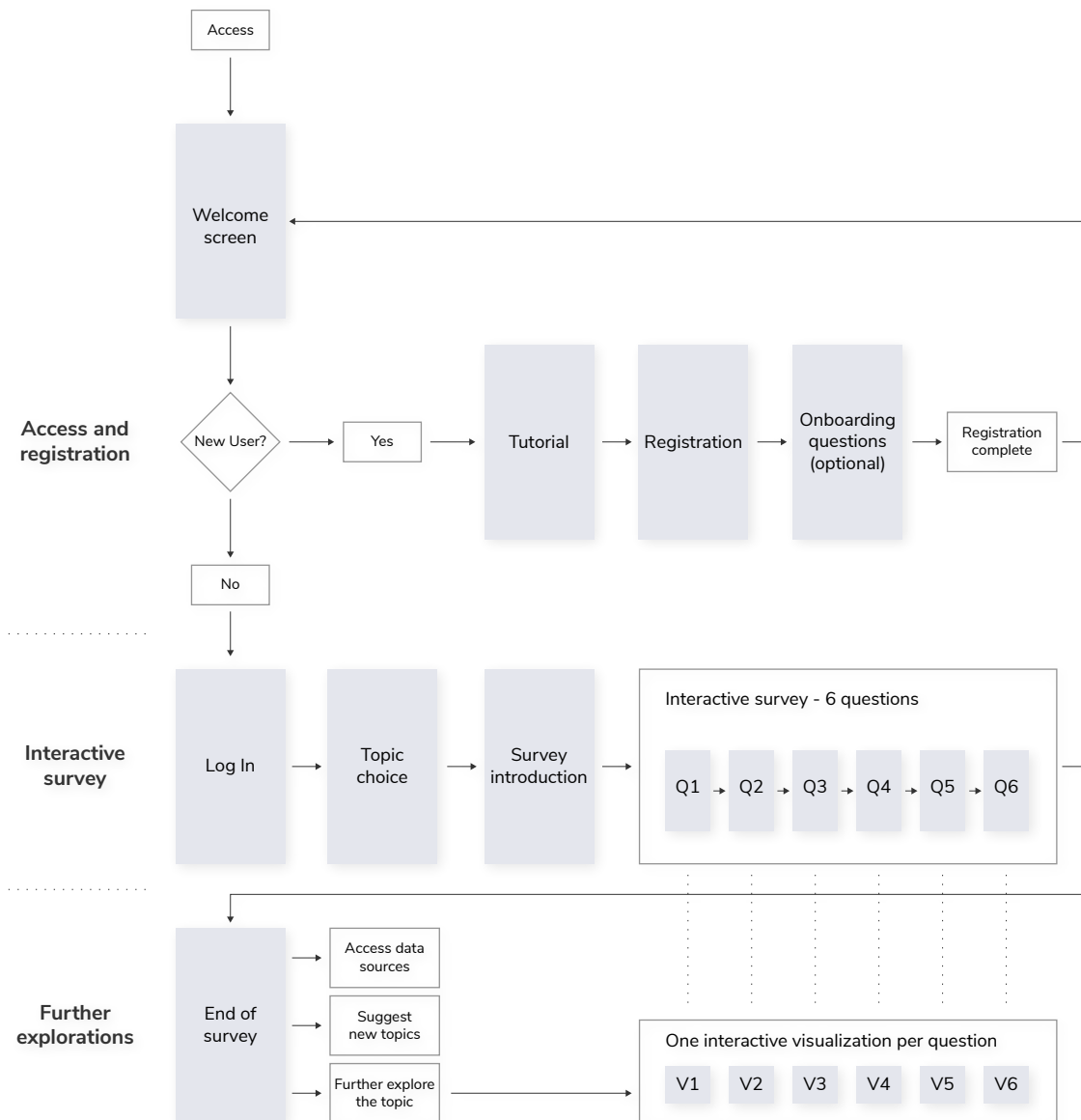
Visualization of the total delay minutes on each subway line through a distortion of the 'classic' Toronto TTC map

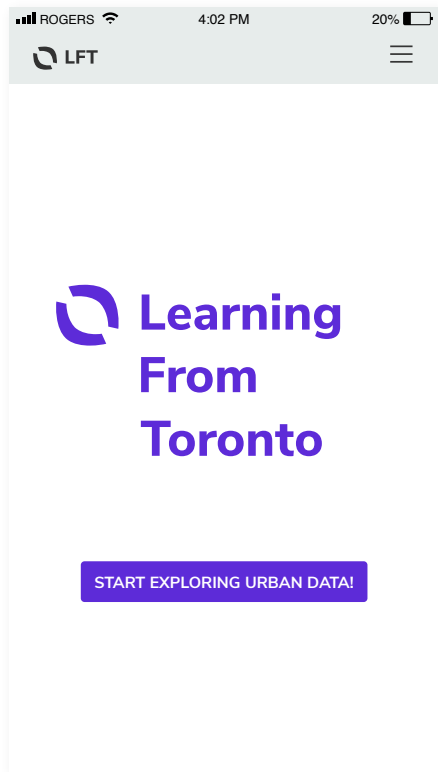


All delay events are arranged in a circle representing a 24-hour clock. Each spike is proportional to the duration of the corresponding delay.

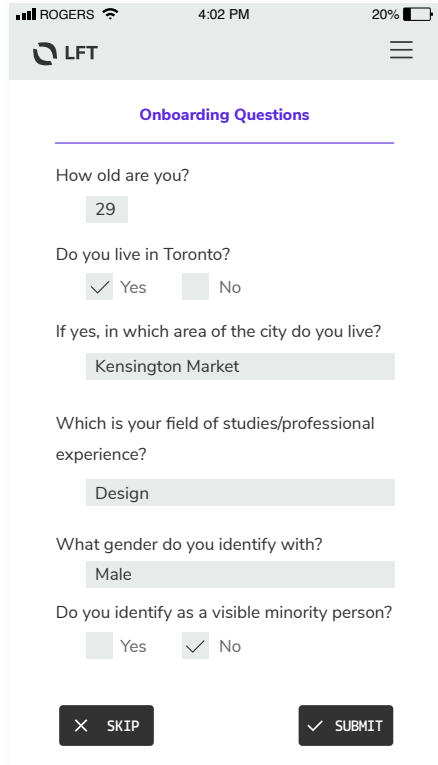
# Learning From Toronto mobile application

## User-flow





Welcome screen



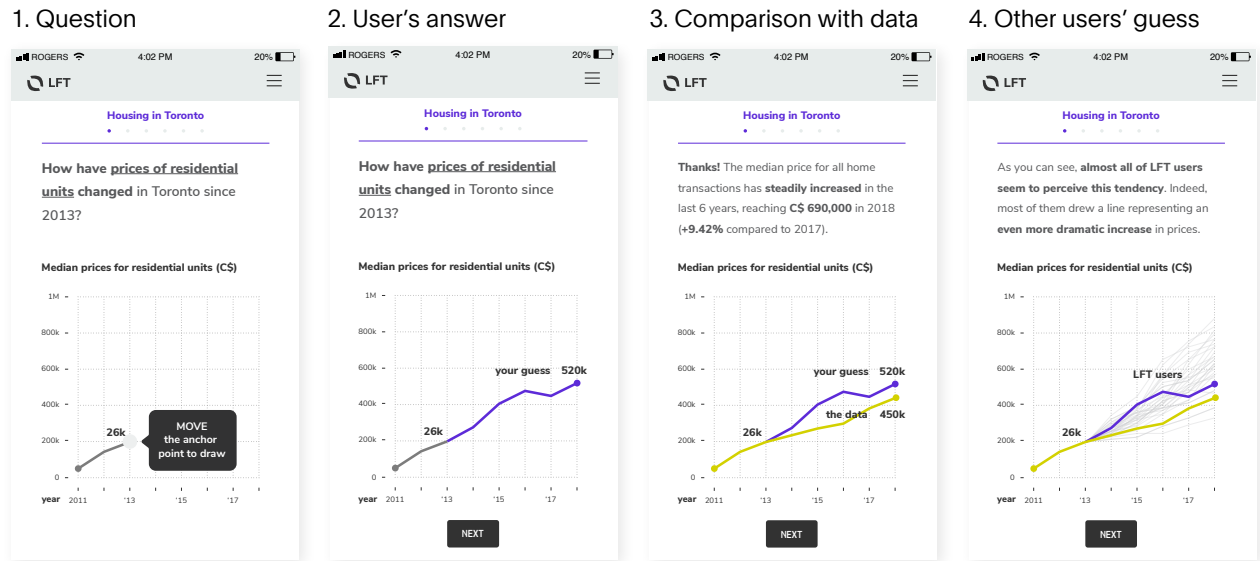
Optional onboarding questions



# Learning From Toronto application

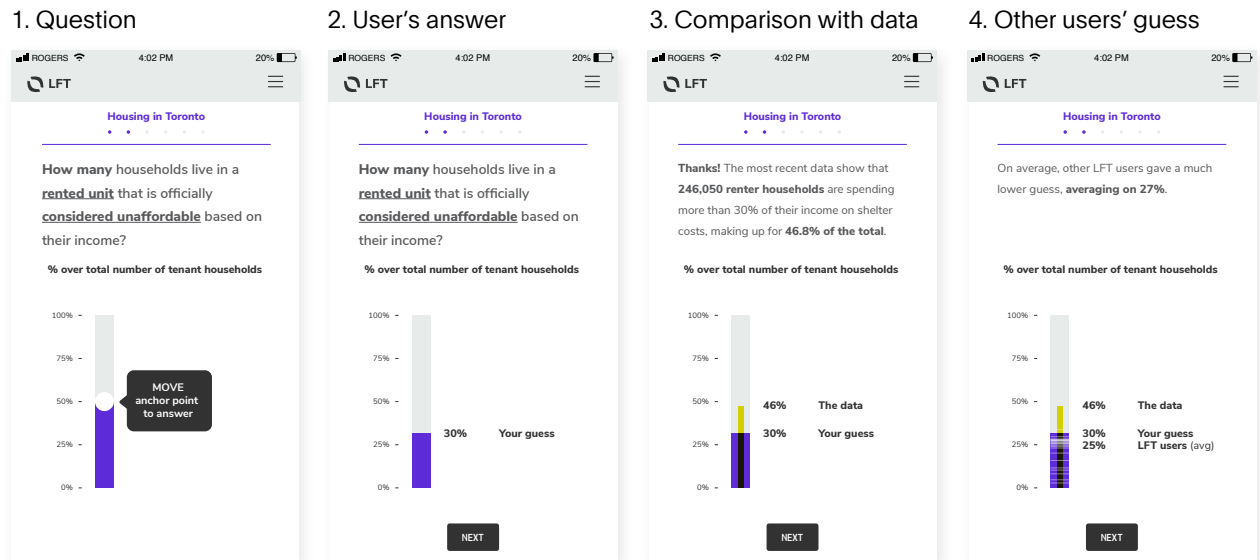
## Revised interactive survey

Answers to each question are submitted through interaction with the visualizations. Users can access a glossary by tapping on underlined terms, and get more information by tapping on the help button.



Question 1: How have prices of residential units changed in Toronto since 2013?

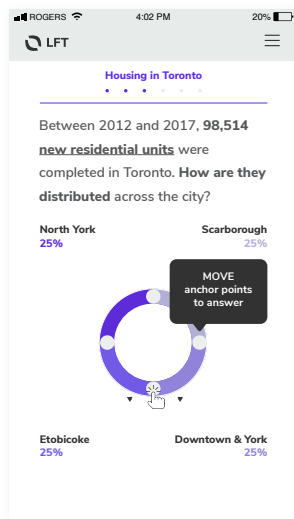
Sources: Toronto Real Estate Board.



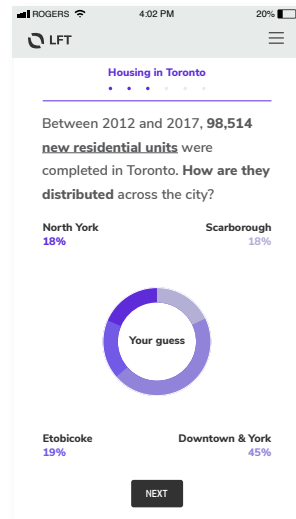
Question 2: How many households live in a rented unit that is officially considered unaffordable based on their income?

Source: Statistics Canada - 2016 Census.

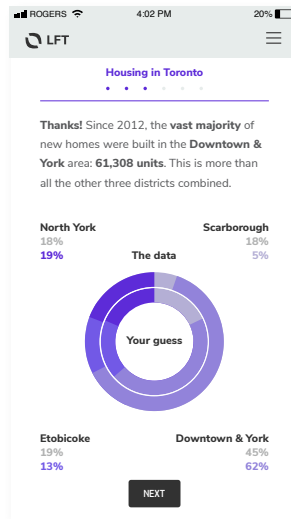
1. Question



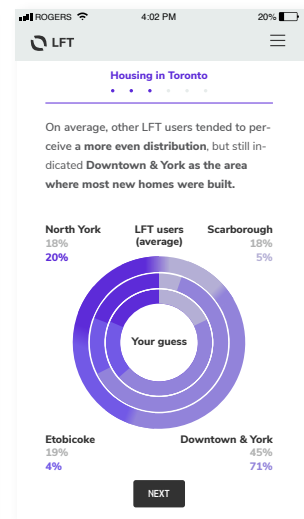
2. User's answer



3. Comparison with data



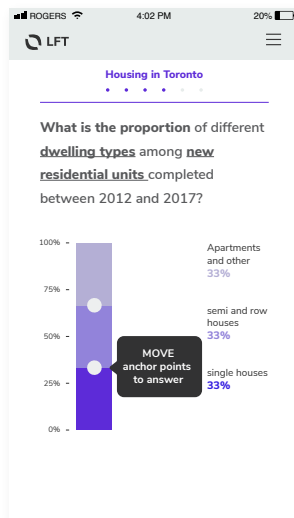
4. Other users' guess



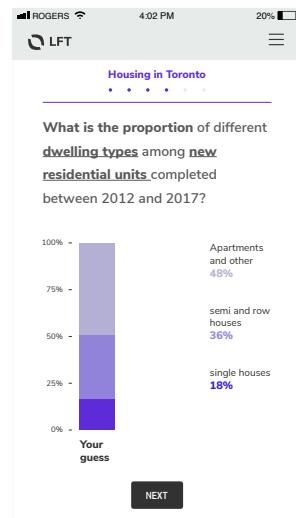
Question 3: Between 2012 and 2017, 98,514 new residential units were completed in Toronto. How are they distributed across the city?

Source: Canadian Mortgage and Housing Corporation.

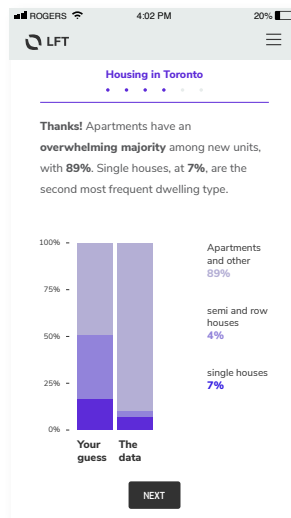
1. Question



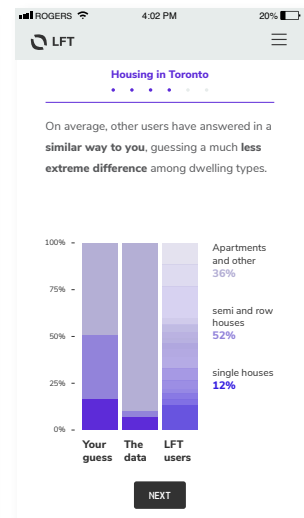
2. User's answer



3. Comparison with data



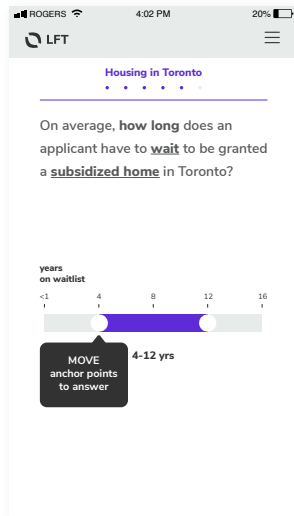
4. Other users' guess



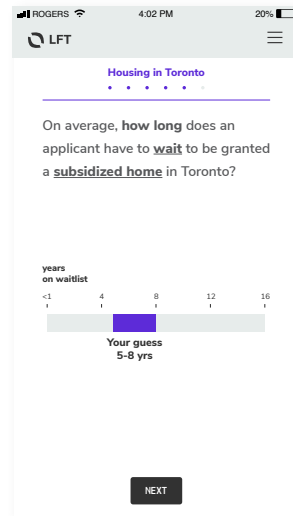
Question 4: What is the proportion of different dwelling types among new residential units completed between 2012 and 2017?

Source: Canadian Mortgage and Housing Corporation.

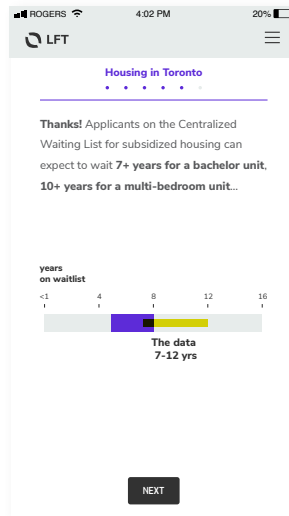
1. Question



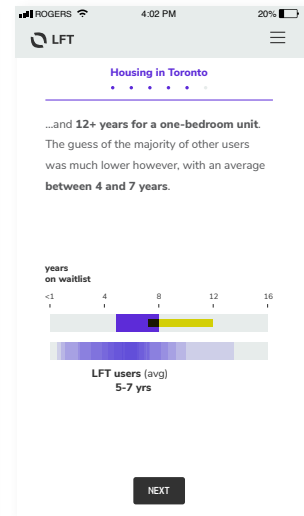
2. User's answer



3. Comparison with data



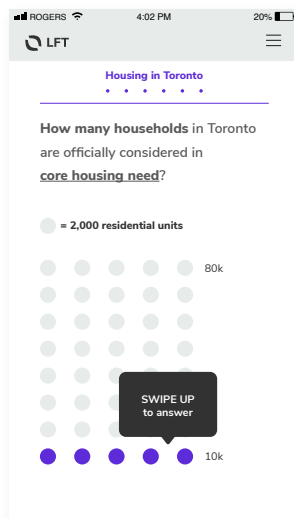
4. Other users' guess



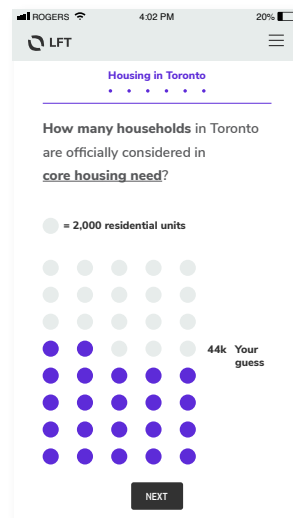
Question 5: On average, how long does an applicant have to wait to be granted a subsidized home in Toronto?

Source: Toronto Community Housing Corporation.

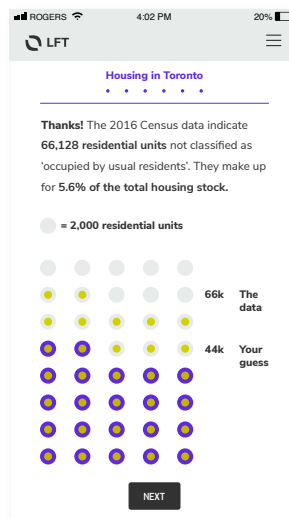
1. Question



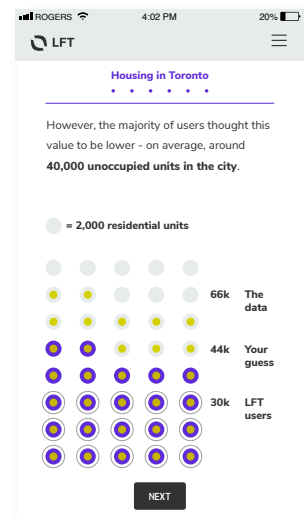
2. User's answer



3. Comparison with data

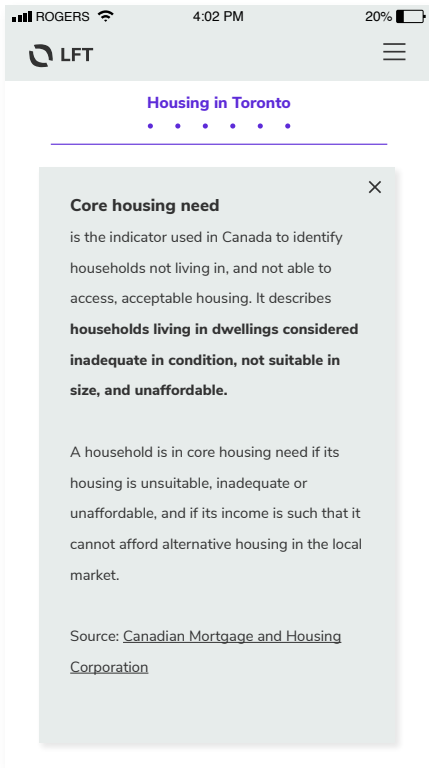


4. Other users' guess

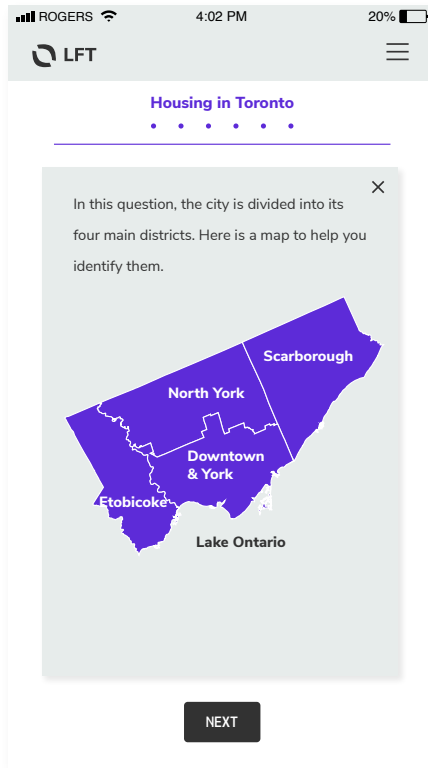


Question 6: How many households in Toronto are officially considered in core housing need?

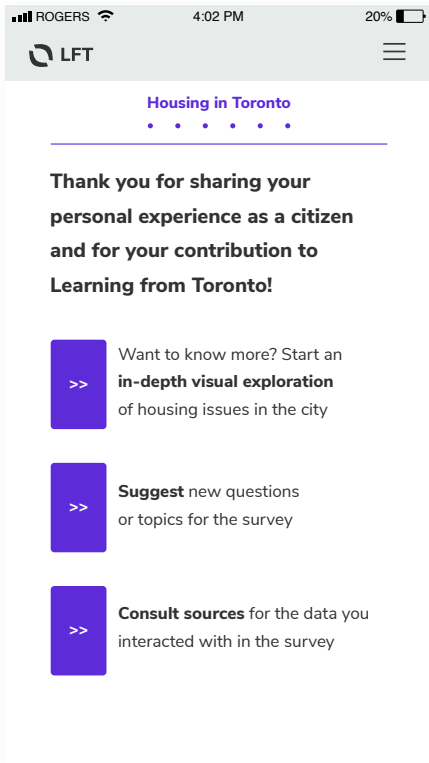
Source: Statistics Canada - 2016 Census.



A



B



C

A: example of glossary page helping readers understand topic-specific terms.

B: example of further help provided to users to understand and answer questions.

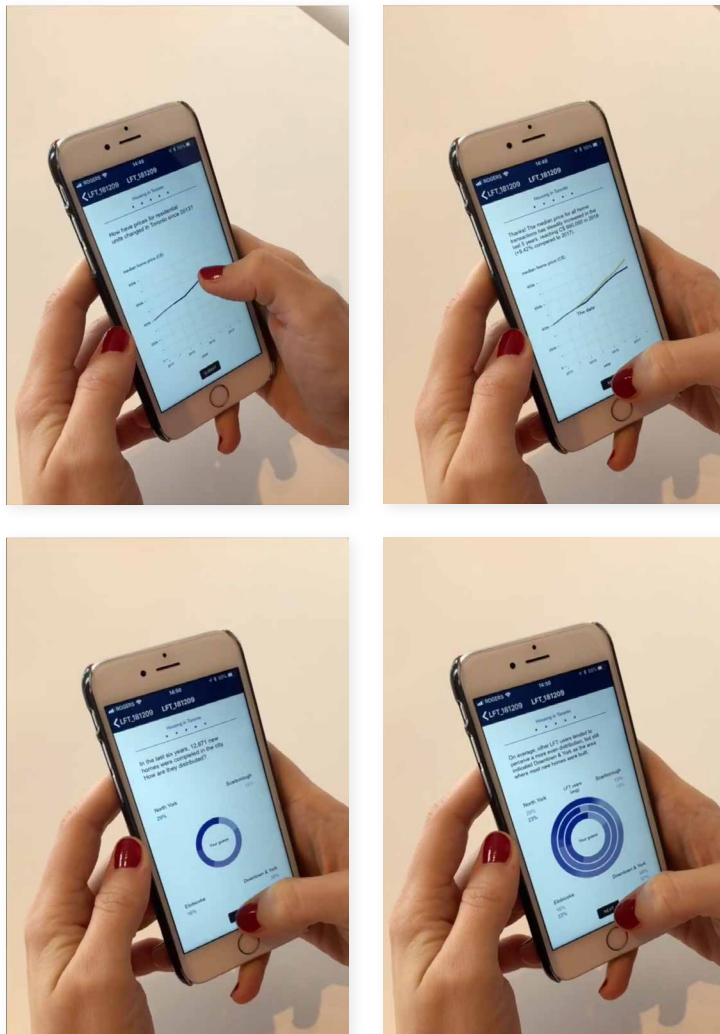
C: Interactive survey—final page. Options to access further visualizations, to suggest new questions or topics to be added in the survey, or to consult data sources.

## Learning From Toronto application prototype

Developed to conduct user testing

This prototype was developed using the mobile version of the Processing language, and is based on the first design proposal for the interactive survey, featuring five questions. Users are able to interact with the visualizations to provide their guess, and to visually compare it with actual data and with a simulation of answers from other users.

**Video of the prototype:** [bit.ly/LFT\\_AppPrototype](https://bit.ly/LFT_AppPrototype)



Still images from a video of the prototype

# Change in Toronto Home Prices, 2011-2018

Interactive, browser-based visualization

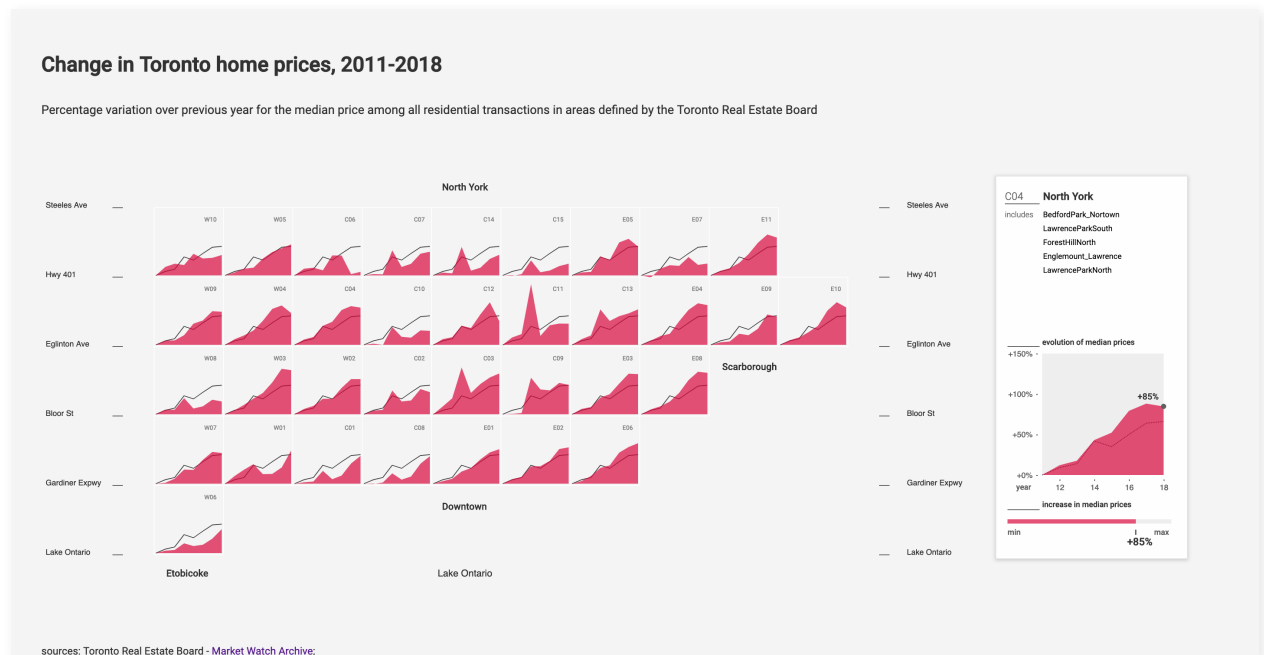
This interactive visualization addresses the topic of the first question in the survey. An area chart depicts the relative change in median home prices for each of the 35 areas used by the Toronto Real Estate Board to subdivide the city. The vertical dimension in the area charts encodes relative change in prices over the previous year. The charts are arranged in a cartogram based on Toronto's topography.

**Corresponding survey question:** #1

**Visual model:** area chart, cartogram

**Sources:** Toronto Real Estate Board—Market Watch Archive. Retrieved March 1, 2019, from <http://www.trebhome.com/index.php/market-news/market-watch/market-watch-archive>

**Video of the interactive application:** [bit.ly/LFTapp\\_prices](http://bit.ly/LFTapp_prices)



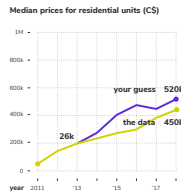
Change in Toronto Home Prices, 2011-2018 - overview.

Remember **question 1?**  
Take a look at more data on the same topic!

**Question 1**

How have prices of residential units changed in Toronto since 2013?

**Your answer**



**Change in Toronto home prices 2011-2018**

Percentage variation over previous year for the median price among all residential transactions in areas defined by the Toronto Real Estate Board

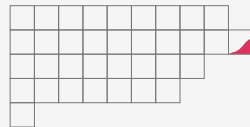
The data

In **Question 1** you shared your guess about the evolution of **median prices for residential units** in Toronto, in terms of absolute value (C\$). Here we drew from the same dataset, published by the Toronto Real Estate Board (TREB), to go a bit deeper in the issue and show you the **rate of change** of this value—its **variation, in percentage, over the previous year**. For statistical purposes, TREB divides the city of Toronto into 35 areas: we developed an area chart, representing the change in prices, for each one of them.

As TREB's areas are not consistent with the city's neighbourhoods as you might know them (they can include more than one, or just portions of them), they are arranged as a map of Toronto—to be precise, a **cartogram**—so that their relative positions mirror as closely as possible the actual territorial divisions. This way, you can look for patterns in the value across the whole city, comparing the data through a consistent visual model. Want to know more? **Hover over an area chart** to see which neighbourhoods it includes and to access more details.

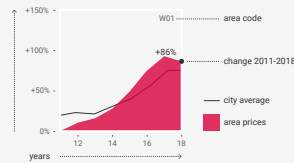
**How to read it**

Toronto cartogram  
35 areas defined by TREB

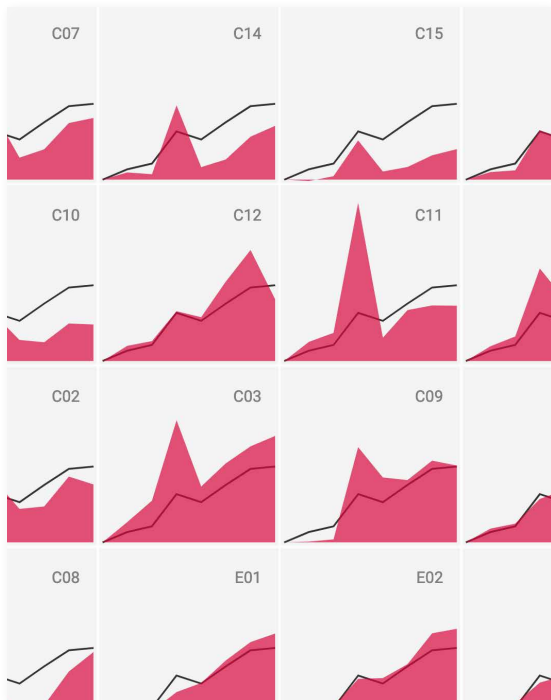


**Area chart**

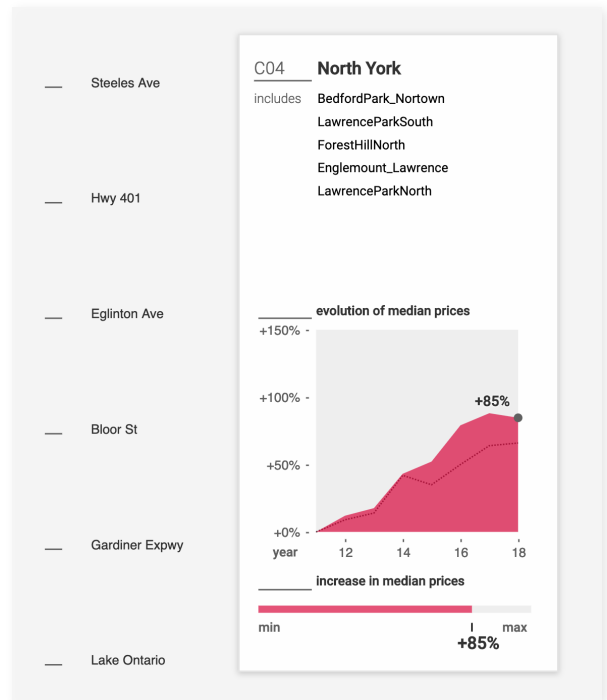
change in price over previous year (%)



Change in Toronto Home Prices, 2011-2018. Introduction page, reminding users of their answer to the corresponding survey question and providing them with contextual information, references and legends before they access the visualization.



Change in Toronto Home Prices, 2011-2018. Close-up.



Change in Toronto Home Prices, 2011-2018. Tooltip accessible by hovering on the graphs.

# Unaffordable Rent in Toronto

Interactive, browser-based visualization

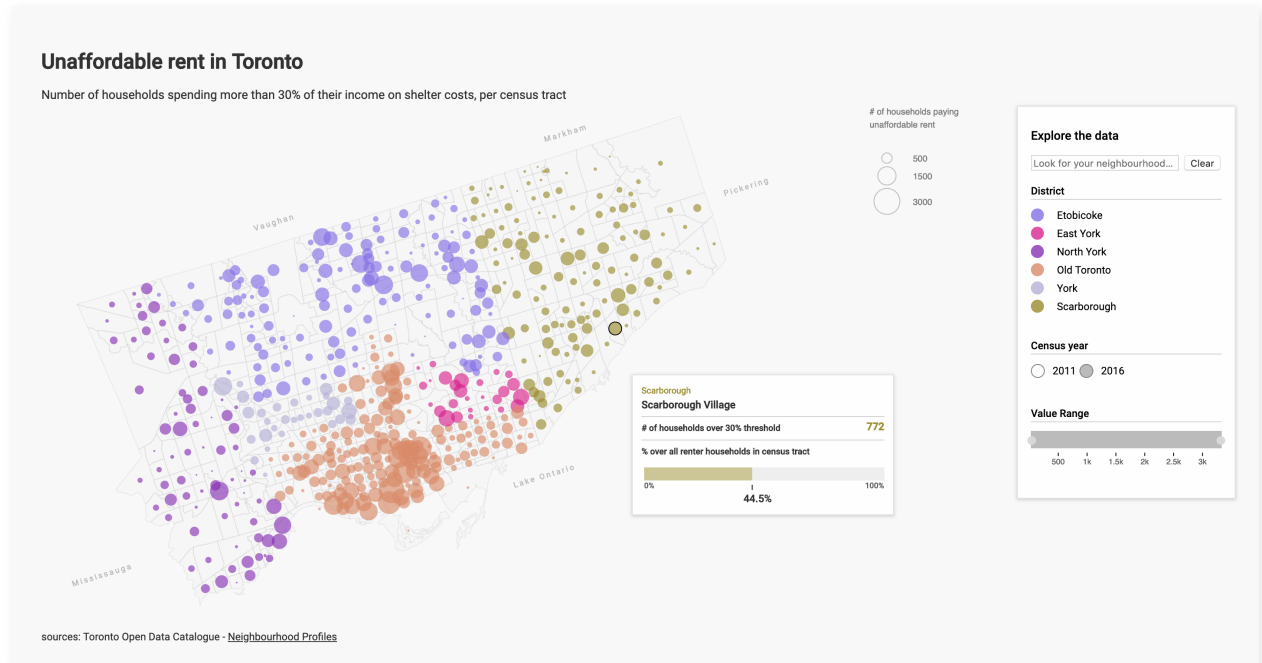
This visualization follows up on Question 2 from the interactive survey, depicting the amount of renter households who are spending more than 30% of their total income on shelter costs (the official threshold by which Statistics Canada defines 'unaffordable housing'). Each census tract is represented through a circle whose area is proportional to the data. Circles are color-coded based on the main districts in the city. Readers can zoom in the map, hover on visual elements to access more information, and use the interactive features in the left panel to filter the data.

**Corresponding survey question:** #2

**Visual model:** map, bubble plot

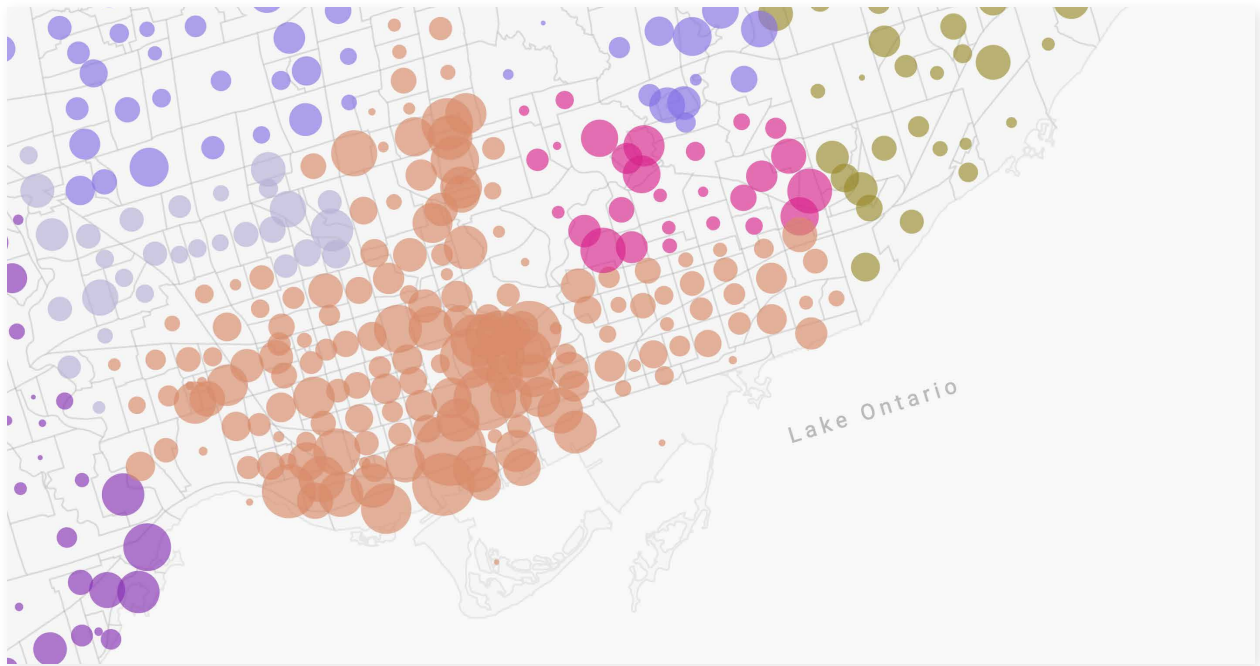
**Sources:** Toronto Open Data Portal—Neighbourhood Profiles. Retrieved from <https://portal0.cf.opendata.inter.sandbox-toronto.ca/dataset/neighbourhood-profiles/>

**Video of the interactive application:** [bit.ly/LFTapp\\_rent](http://bit.ly/LFTapp_rent)

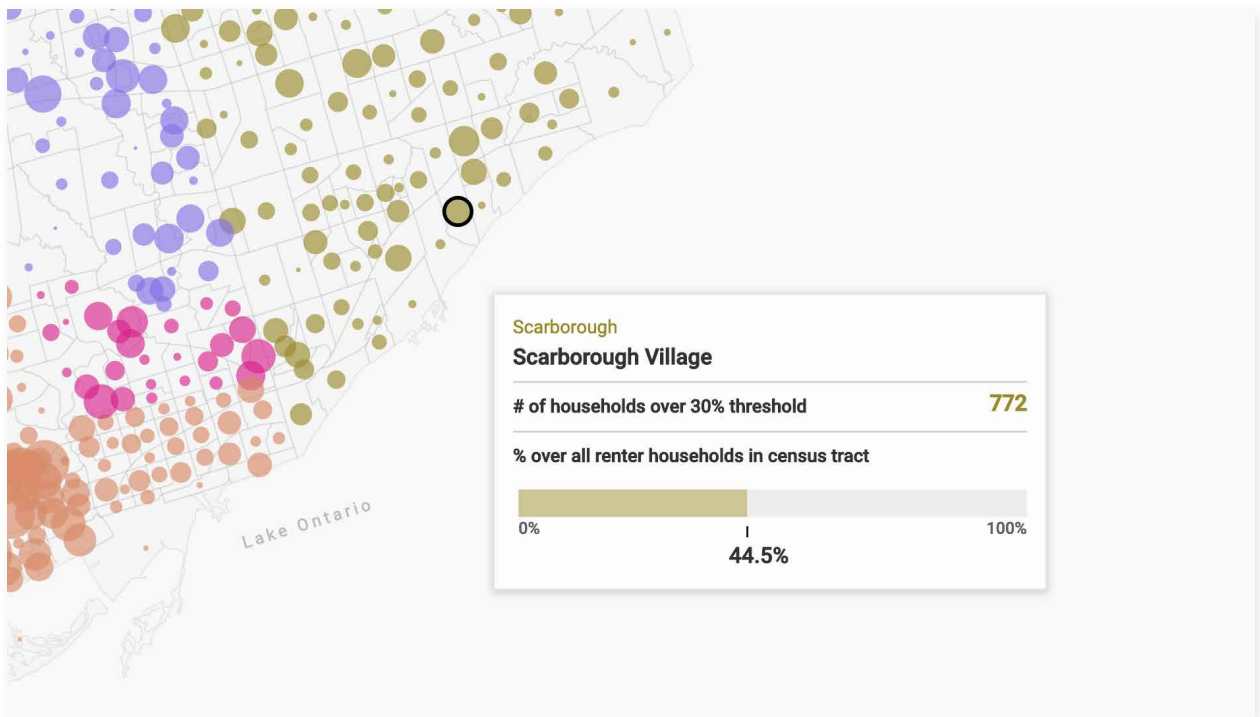


Unaffordable Rent in Toronto - overview.





Unaffordable Rent in Toronto - close up of the downtown area



Unaffordable Rent in Toronto - tooltip

## Distribution of new homes in Toronto

Interactive, browser-based visualization

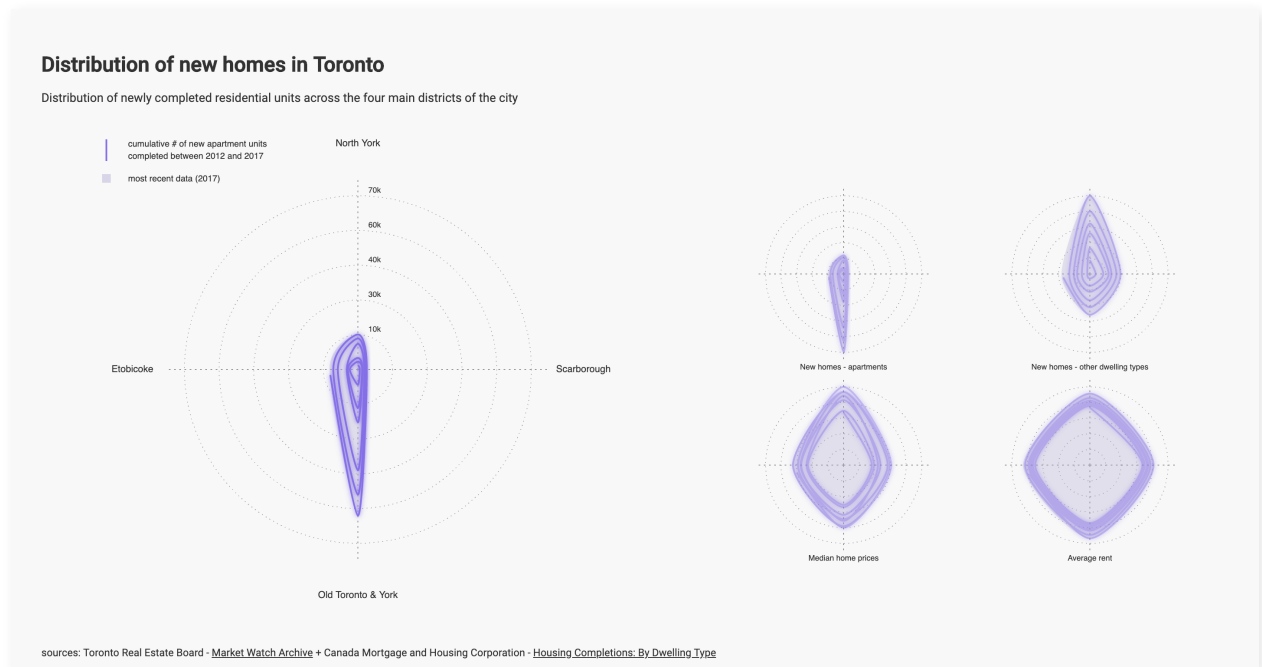
This application builds on the circular layout of the donut chart in Question 3, in which the districts are arranged around the circle according to their true position in the city, to generate a “compass” visualization that allows users to observe recent trends in housing data from a high-level spatial perspective. The charts have two layers: they grey areas follow the principles of radar charts and portray the most recent data; the spirals are animated radial line charts that depict the evolution of each value, from 2012 to the most recent data available. Users can visualize datasets about newly completed homes (apartments or other types of dwelling) but also on home prices and rent, two related topics you already encountered in the first two questions.

**Corresponding survey question:** #3

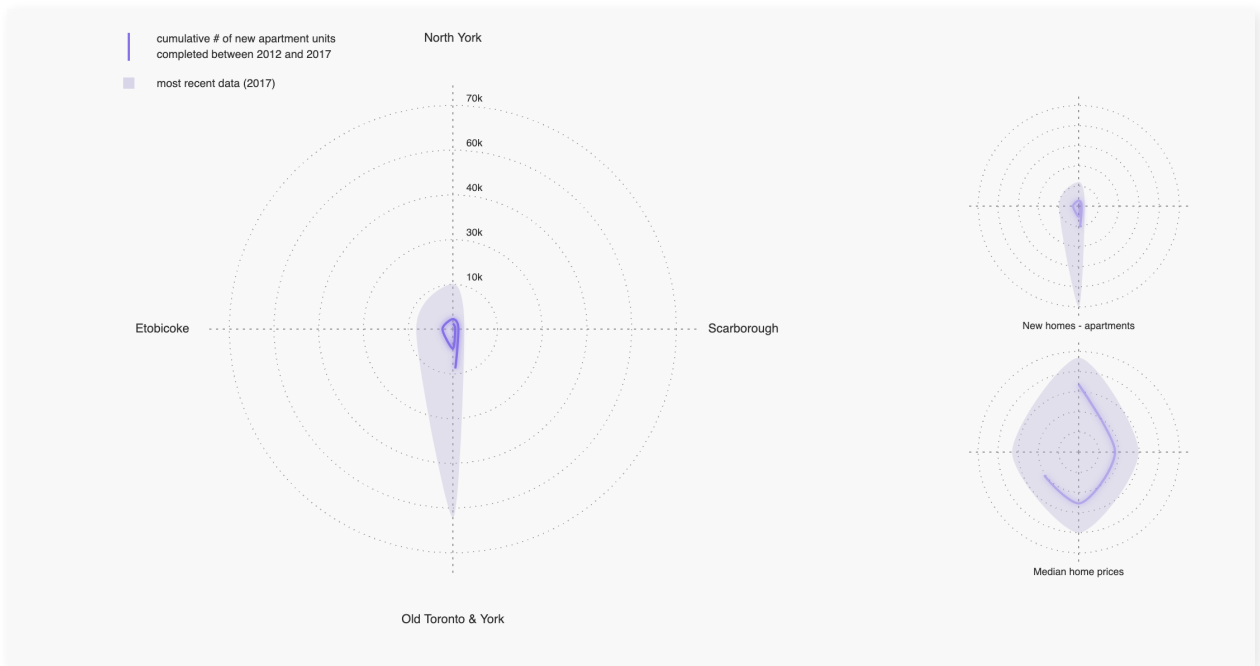
**Visual model:** radar chart, radial line chart (basic structure based on Nadieh Bremer’s d3.js radar chart. Retrieved March 20, 2019, from <https://www.visualcinnamon.com/2015/10/different-look-d3-radar-chart.html>)

**Sources:** Toronto Real Estate Board—Market Watch Archive. Retrieved March 1, 2019 (ibid.); Canada Mortgage and Housing Corporation—Housing Completions: By Dwelling Type. Retrieved March 20, 2019, from <https://www.cmhc-schl.gc.ca/en/data-and-research/data-tables/housing-completions-dwelling-type>

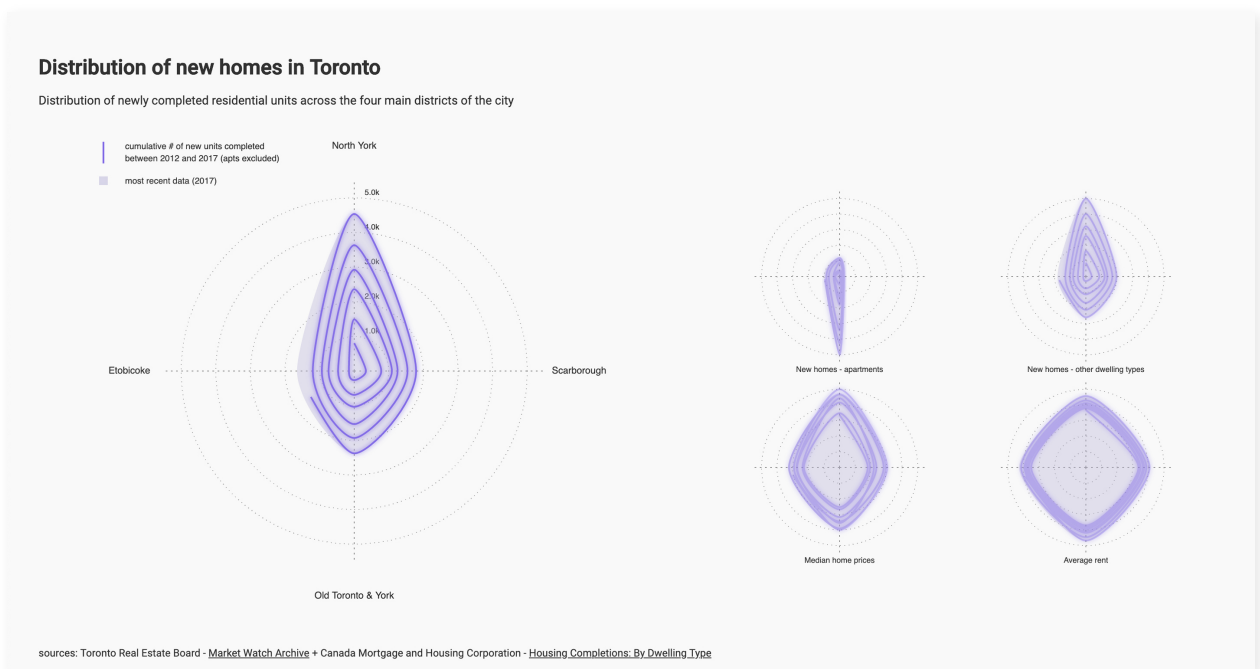
**Video of the interactive application:** [bit.ly/LFTapp\\_newHomes](http://bit.ly/LFTapp_newHomes)



*Distribution of new homes in Toronto - overview.*



*Distribution of new homes in Toronto - close up of the selected graph (cumulative number of residential units completed between 2012 and 2017) during the animation*



*Distribution of new homes in Toronto - cumulative number of new apartment units completed between 2012 and 2017*

## New Homes in Toronto, a Look at Major Urban Streets

Interactive, browser-based visualization

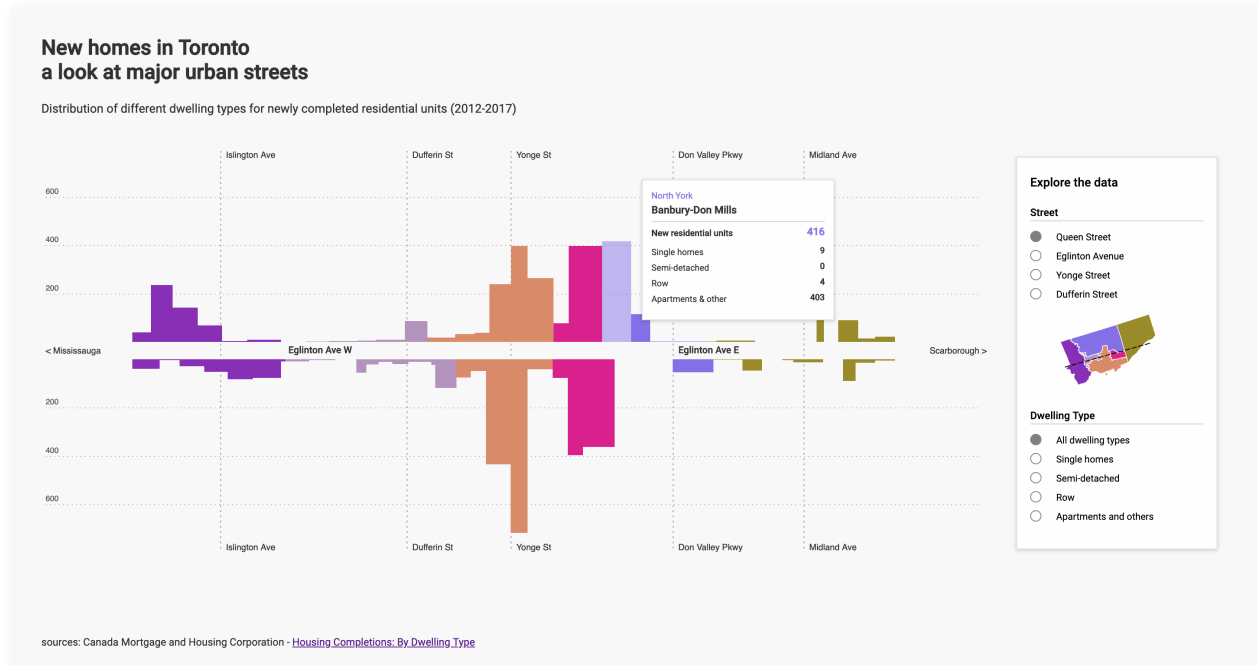
This visualization allows users to explore data about newly completed residential units through “sections” of four major urban streets that cross Toronto’s urban territory: Queen st, Eglinton Ave, Yonge St, Dufferin St. Data for dwelling types, in each census tract on either side of the streets, is visualized as a rectangle: its width is proportional to the extension of the corresponding census tract on the street, while its vertical dimension encodes the number of dwellings. Annotations and a reference map provide contextual information to help readers orient themselves in the visualization. Users can filter the data to focus on a specific dwelling type.

**Corresponding survey question:** #4

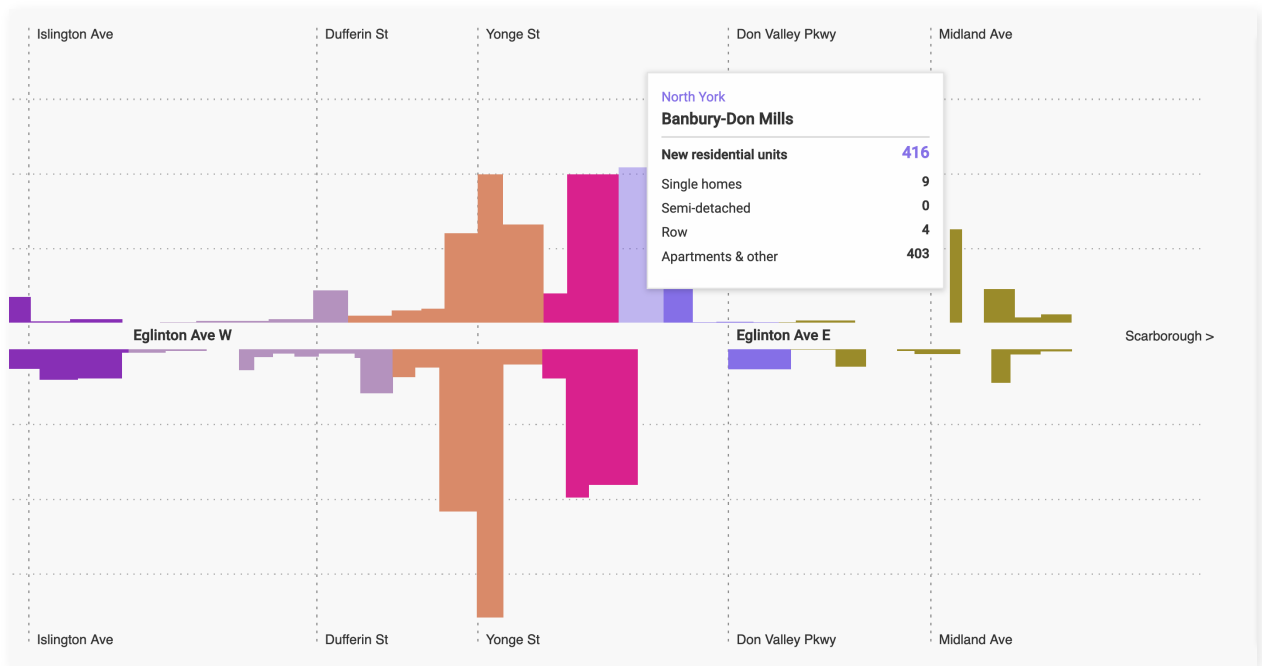
**Visual model:** custom

**Sources:** Canada Mortgage and Housing Corporation—Housing Completions: By Dwelling Type. Retrieved from <https://www.cmhc-schl.gc.ca/en/data-and-research/data-tables/housing-completions-dwelling-type>

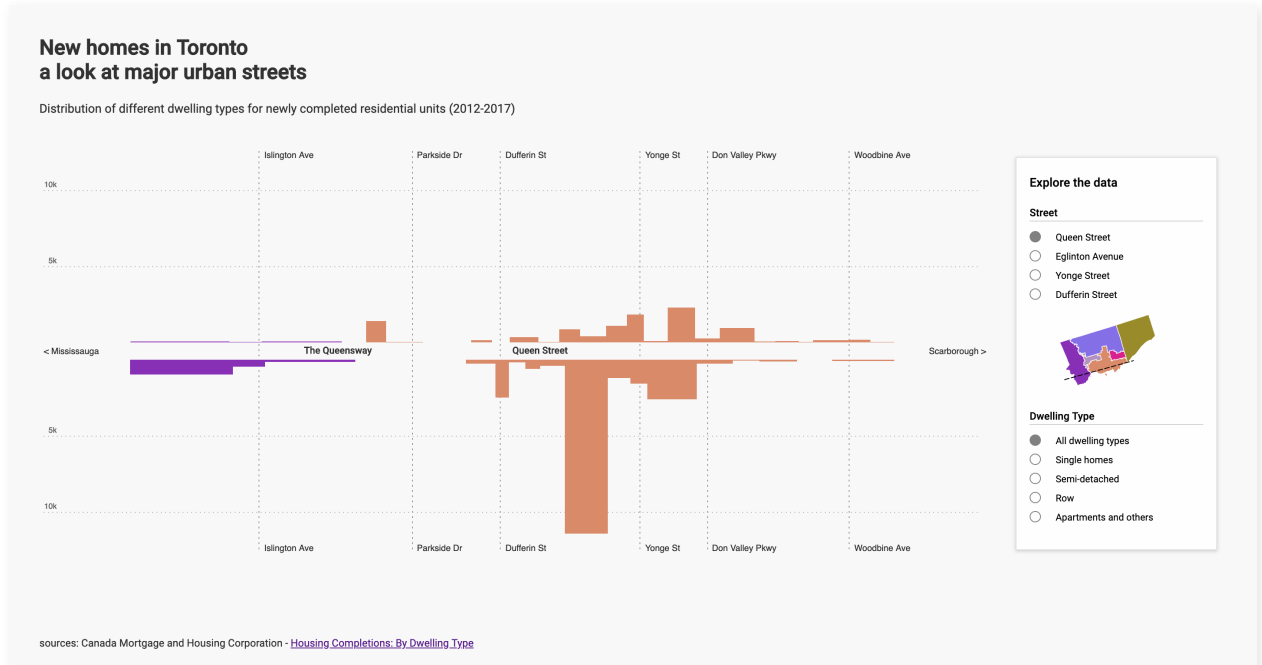
**Video of the interactive application:** [bit.ly/LFTapp\\_streets](http://bit.ly/LFTapp_streets)



*New Homes in Toronto, a Look at Major Urban Streets.*  
Overview of the application portraying data for Eglinton Avenue



New Homes in Toronto, a Look at Major Urban Streets. Close up (Eglinton Avenue)



New Homes in Toronto, a Look at Major Urban Streets. Overview of data for Queen Street

## TCH's housing stock: a timeline

Interactive, browser-based visualization

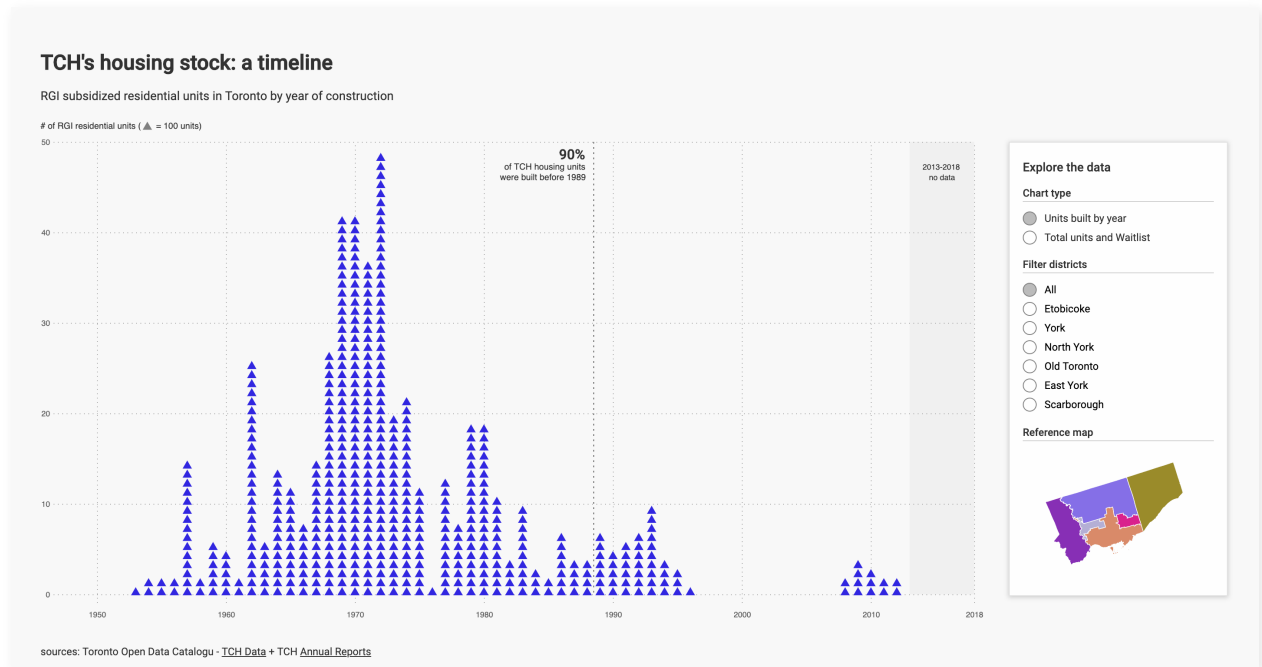
This visualization is connected to Question 5 and takes a closer look at the Toronto Community Housing Corporation through two timelines. In the first one, a unit chart visualizes the Corporation's housing stock. Each symbol represents 100 RGI residential units, arranged on the horizontal axis by year of construction. Users can filter the data to see a breakdown for different districts, and hover on symbols to know which housing developments are represented for each single year. The second visual, which can be accessed by clicking on the Chart Type button, shows the evolution of the total amount of subsidized units in TCHC's stock since 1950 (area chart), while a red line represents the increase in the number of households with an active application on the Centralized Waitlist for subsidized housing.

**Corresponding survey question:** #5

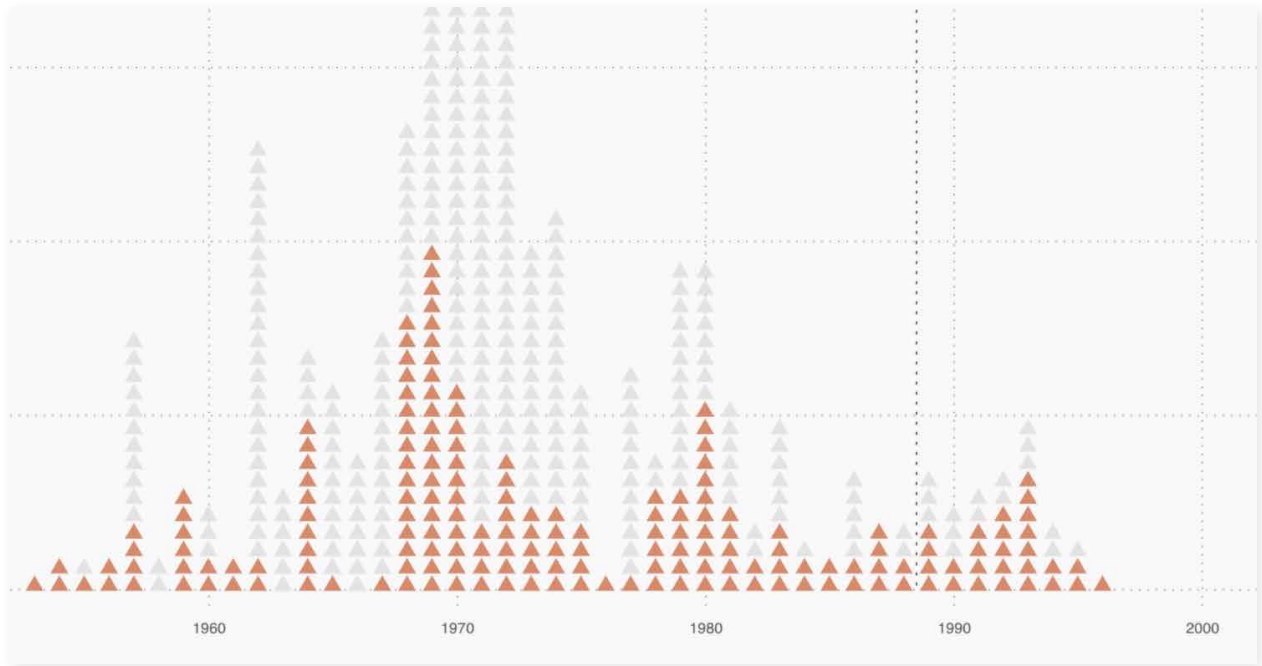
**Visual model:** unit chart, area chart, line chart

**Sources:** Toronto Open Data Portal—Toronto Community Housing Data. Retrieved March 28, 2019, from <https://www.toronto.ca/city-government/data-research-maps/open-data/open-data-catalogue/#3cbd0ba7-4bb2-923d-89d2-aff78797fe55>; Toronto Community Housing Annual Reports. Retrieved March 28, 2019, from <https://www.torontohousing.ca/annual-review>

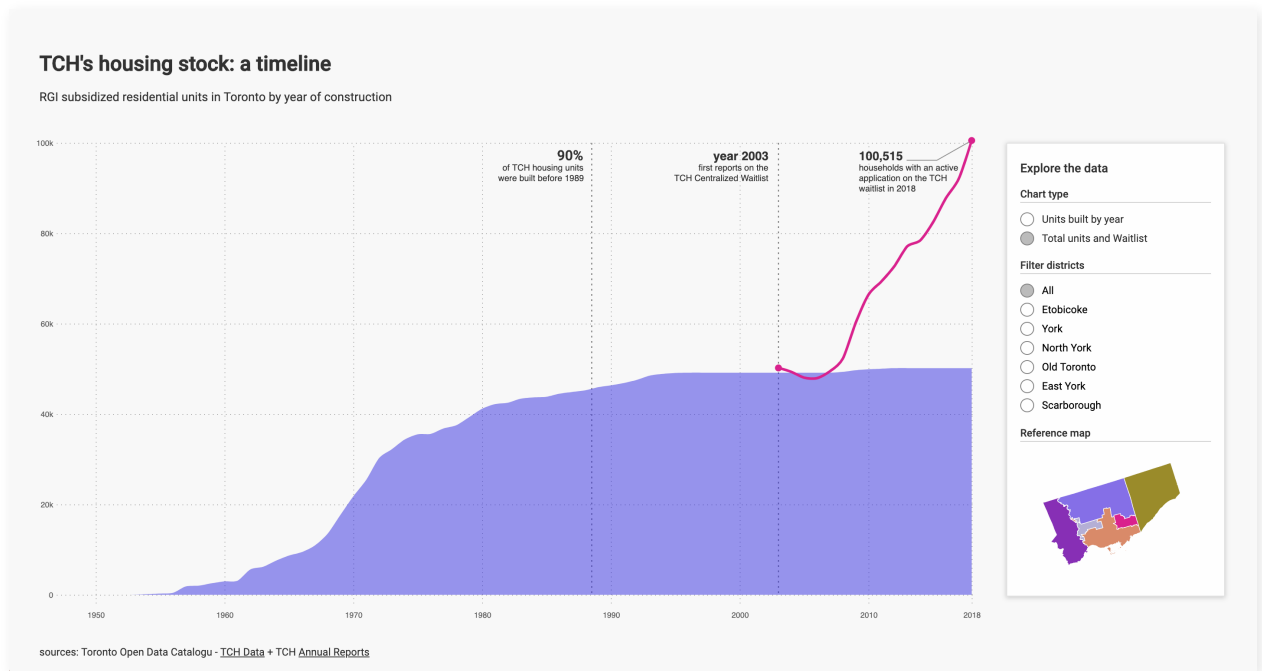
**Video of the interactive application:** [bit.ly/LFTapp\\_tch](http://bit.ly/LFTapp_tch)



*TCH's housing stock: a timeline - overview.*



TCH's housing stock: a timeline - close up with filtered data



TCH's housing stock: a timeline - the cumulative timeline for subsidized residential units (area chart) and the evolution of the number of households on the Centralized Waitlist (line chart)

## Unoccupied Homes, Median Home Prices, Households in Need

Interactive, browser-based visualization

Connected to the topic addressed in Question 6, this visualization uses a grid of small multiples to depict the number of homes classified as not permanently occupied (blue) and the number of households in core housing need (orange) in each of the 140 neighbourhoods in Toronto. The values are encoded by the areas of two semicircles. The length of the black line dividing them represents the median home price for each neighbourhood. Users can filter the data based on district, look for their neighbourhood, and sort the grid based on the three portrayed values, or on location.

**Corresponding survey question:** #6

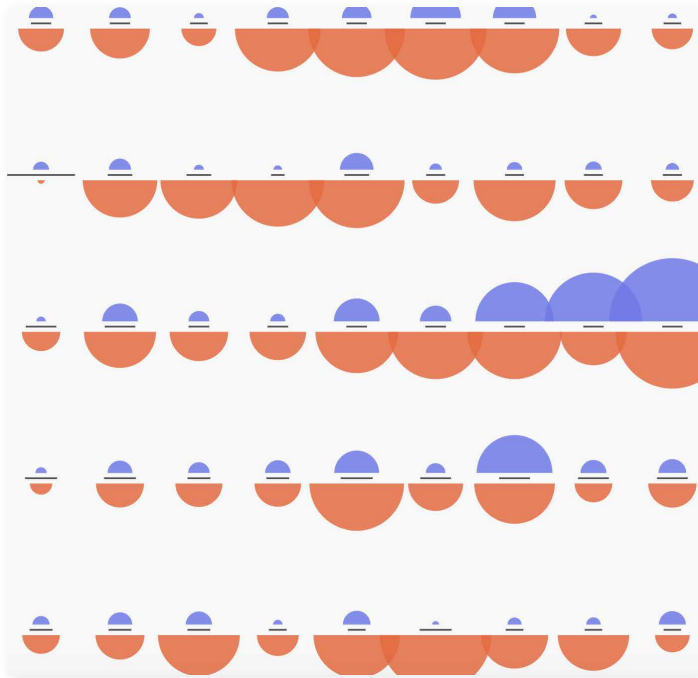
**Visual model:** small multiples, proportional area chart

**Sources:** Toronto Open Data Portal—Neighbourhood Profiles. Retrieved from <https://portal0.cf.opendata.inter>.

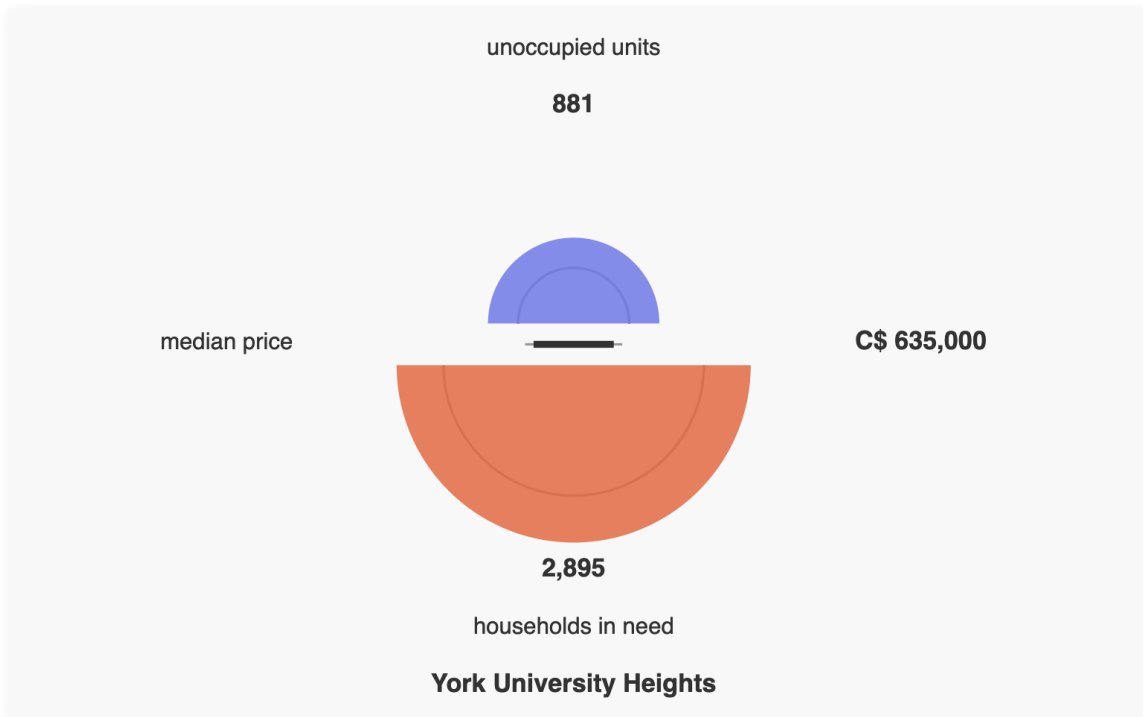


*Unoccupied Homes, Median Home Prices, Households in Need - overview.*





*Unoccupied Homes, Median Home Prices, Households in Need.*  
Close up.



*Unoccupied Homes, Median Home Prices, Households in Need* - this feature, on the left side of the layout, serves as legend and, at the same time, as a tooltip: it provides a magnified version of each small multiple, upon hover.

## Appendix B: Approvals from the York University Research Ethics Board



OFFICE OF  
RESEARCH  
ETHICS (ORE)  
5<sup>th</sup> Floor, Kaneff  
Tower  
  
4700 Keele St.  
Toronto ON  
Canada M3J 1P3  
Tel 416 736 5914  
Fax 416 736-5512  
www.research.yorku.ca

<b>Certificate #:</b>	<b>STU 2018 - 115</b>
<b>Approval Period:</b>	<b>10/25/18-10/25/19</b>

### ETHICS APPROVAL

**To:** **Andrea Giambelli**  
Graduate Student of Design, School of the Arts, Media, Performance and Design

**From:** Alison M. Collins-Mrakas, Sr. Manager and Policy Advisor, Research Ethics  
(on behalf of Veronica Jamnik, Chair, Human Participants Review Committee)

**Date:** Thursday, October 25, 2018

**Title:** **Learning from Toronto: An Experiment in Participatory Urban Data Visualization**

**Risk Level:**  Minimal Risk  More than Minimal Risk

**Level of Review:**  Delegated Review  Full Committee Review

I am writing to inform you that this research project, “**Learning from Toronto: An Experiment in Participatory Urban Data Visualization**” has received ethics review and approval by the Human Participants Review Sub-Committee, York University’s Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines.

Note that approval is granted for one year. Ongoing research – research that extends beyond one year – must be renewed prior to the expiry date.

Any changes to the approved protocol must be reviewed and approved through the amendment process by submission of an amendment application to the HPRC prior to its implementation.

Any adverse or unanticipated events in the research should be reported to the Office of Research ethics ([ore@yorku.ca](mailto:ore@yorku.ca)) as soon as possible.

For further information on researcher responsibilities as it pertains to this approved research ethics protocol, please refer to the attached document, “**RESEARCH ETHICS: PROCEDURES to ENSURE ONGOING COMPLIANCE**”.

Should you have any questions, please feel free to contact me at: [redacted] or via email at: [redacted]

Yours sincerely,

Alison M. Collins-Mrakas M.Sc., LLM  
Sr. Manager and Policy Advisor,  
Office of Research Ethics

## RESEARCH ETHICS: PROCEDURES to ENSURE ONGOING COMPLIANCE

Upon receipt of an ethics approval certificate, researchers are reminded that they are required to ensure that the following measures are undertaken so as to ensure on-going compliance with Senate and TCPS ethics guidelines:

1. **RENEWALS:** Research Ethics Approval certificates are subject to annual renewal. **It is the responsibility of researchers to ensure the timely submission of renewals.**
  - a. As a courtesy, researchers will be reminded by ORE, in advance of certificate expiry, that the certificate must be renewed. Please note, however, it is the expectation that researchers will submit a renewal application prior to the expiration of ethics certificate(s).
  - b. **Failure to renew an ethics approval certificate** (or to notify ORE that no further research involving human participants will be undertaken) **may result in suspension of research cost fund and access to research funds may be suspended/ withheld.**
2. **AMENDMENTS:** Amendments must be reviewed and approved **PRIOR** to undertaking/making the proposed amendments to an approved ethics protocol;
3. **END OF PROJECT:** ORE must be notified when a project is complete;
4. **ADVERSE EVENTS:** Adverse events must be reported to ORE as soon as possible;
5. **POST APPROVAL MONITORING:**
  - a. More than minimal risk research may be subject to post approval monitoring as per TCPS guidelines;
  - b. A spot sample of minimal risk research may similarly be subject to Post Approval Monitoring as per TCPS guidelines.

**FORMS:** As per the above, the following forms relating to on-going research ethics compliance are available on the Research website:

- a. Renewal
- b. Amendment
- c. End of Project
- d. Adverse Event

## Appendix C: Online recruiting form

Learning from Toronto: an experiment in participatory urban data visualization

3/8/19, 2:48 PM

### Learning from Toronto: an experiment in participatory urban data visualization

Hi! my name is Andrea Giambelli,

I'm a 2nd year graduate student in the MDES Master of Design program at York University. I'm currently working on my thesis research, which is focused on investigating the role that a specific design methodology - data visualization - might have in generating meaningful connections between citizens of Toronto and the urban environment they live in. I'm calling for people who live in – or commute to – the city, to participate in a 45 minutes long, one-on-one user testing session to evaluate a mobile application for urban data visualization.

During this event, through a mix of interviews and actual tests of the application prototype, you will have the chance to express your opinions, desires and concerns regarding life in the city of Toronto, and to provide feedback on the effectiveness of the application. In the spirit of user-centered design, the ultimate goal for this test is to encourage participants to generate ideas on how the design and the overall structure of the application might be improved towards a more user-friendly experience.

If you are interested in participating in the study, please fill out the form below to provide your contact information, which will only be used to provide you with more details about the event. The study will take place between January 21st and January 25th at York University (Keele Campus), at Dadaleh Building - 88 The Pond Road, in the Design Graduate Room 4023, 4th floor.

Your input is very important!

I am curious to learn more about your unique, personal perspective as a citizens or city-user of Toronto.

For more information or inquiries, please contact me at:

Thank you, I'm looking forward to hearing from you.

\*Campo obbligatorio

#### 1. What is your first name? \*

All the personal information you share with me at any time during the study will remain confidential and anonymous. Within any material produced during this study, your first name will be substituted with a fictitious one.

---

#### 2. Can you provide your telephone number? \*

If you will make yourself available to participate in the user testing session, you might be selected for a brief follow-up phone call in which you will receive further details on this study. All the personal information you share with us at any time during the study will remain confidential and anonymous.

---

**3. Can you provide your e-mail address? \***

If you will make yourself available to participate in the study, you might be contacted through e-mail to receive further details. All the personal information you share with us at any time during the study will remain confidential and anonymous.

---

**4. Are you a citizen of Toronto, or a person who regularly experiences the spaces and services of the city (commuting to Toronto for work or education, leisure)? \***

*Contrassegna solo un ovale.*

- Yes
- No

**5. Are you available to participate in a 45 minutes, one-on-one user testing session that will take place at York University, Keele Campus? \***

*Contrassegna solo un ovale.*

- Yes
- No

**6. If you are available to participate in the study, please select the date that is most convenient for you**

*Contrassegna solo un ovale.*

- January 21th, 2019
- January 22th, 2019
- January 23th, 2019
- January 25th, 2019
- Altro: \_\_\_\_\_



## Appendix D: Recruiting poster



We are calling for people who live in - or commute to - the city, to participate in a **45 minutes long, one-on-one user testing session** to evaluate a **mobile application for urban data visualization**.

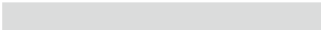
This study is part of a Design Master thesis project developed within the MDES program at York University, Toronto. The research project is focused on investigating the role that a specific design methodology - data visualization - can have in generating meaningful connections between citizens and city-users of Toronto and the urban spaces they live in.

During this event, through a mix of interviews and actual tests of the application prototype, you will have the chance to express your opinions, desires and concerns regarding life in the city of Toronto, and to provide feedback on the effectiveness of the application. In the spirit of user-centered design, the ultimate goal for this test is to encourage participants to generate ideas on how the design and the overall structure of the application might be improved towards a more user-friendly experience.

**We are curious to learn more about your unique, personal perspective as a Torontonians!**

---

**IF YOU ARE INTERESTED, PLEASE VISIT:**



**MORE INFORMATION AT:**



## Appendix E: Recruiting e-mail

York University  
MDES Master of Design Program  
Thesis research  
Study name: Learning from Toronto: an experiment in participated urban data visualization  
Student researcher: Andrea Giambelli  
Supervisor: Professor Angela Norwood

Research project e-mail address: [REDACTED]

### USER TESTING STUDY RECRUITMENT E-MAIL

Dear [name of potential participant],

My name is Andrea Giambelli, I'm a 2nd year graduate student in the MDES Master of Design program at York University. I'm currently working on my thesis research, which is focused on investigating the role that a specific design methodology - data visualization - can have in generating meaningful connections between citizens of Toronto and the urban spaces they live in. In the framework of this research, I'm calling for people who live in the city, or usually experience its spaces and services, to participate in a 2-hour, one-on-one user testing session to evaluate a mobile application for urban data visualization.

This event will be a very hands-on experience in which, through a mix of interviews and actual tests of the application prototype, you will have the chance to express your opinions, desires and concerns regarding life in the city of Toronto, and to provide feedback on the effectiveness of the application. I am specifically interested in the interaction between users, applications and data, and in investigating how such an application might provide new, meaningful connections between citizens and their city. The ultimate goal of the research, following the principles of user-centered design, is to encourage participants to generate ideas on how the design and the overall structure of the application might be improved towards a more user-friendly experience.

If you are interested in participating in the study, please fill out the form below to provide your contact information, which will only be used to provide you with more details about the event. The study will take place on November 26th, November 27th and November 28th at York University (Keele Campus), at Dadaleh Building - 88 The Pond Road, in the Design Graduate Room 4023, 4th floor.

If you want to know more about the project and are interested in participating, please fill out the online form at the following address:

[REDACTED]

Thank you very much, your input is very important!  
I am curious to learn more about your unique, personal perspective as a citizens or city-user of Toronto.

[Signature]

## Appendix F: User Testing—Sample Consent Form for user testing

### Informed Consent Form

**Date:**

December 9th, 2018

**Study Name:**

Learning from Toronto - user testing study

**Researcher name:**

Andrea Giambelli (Principal Investigator)  
MDES Master of Design program, York University

**Contact:**

e-mail: [REDACTED]

mobile: [REDACTED]

**Purpose of the Research:**

This research project is focused on investigating the role that a specific design methodology - data visualization - can have in generating meaningful connections between citizens (or city-users) of Toronto and the urban spaces they live in. Data visualization uses a variety of graphs and principles of visual communication to generate visual artifacts that communicate information effectively, with the goal of helping readers understand, explore and interpret the data. Within this framework, this research investigates the design of a mobile-based, interactive application for urban data visualization, which through the use of computer-mediated technologies would allow potential users to experience a variety of visualized information about Toronto not just in front of their computer, but within the very space of the city. Furthermore, the application will give users the possibility to answer some questions, thus allowing them to share their personal views, opinions, perceptions on each of the addressed topics. I am specifically interested in the interaction between users, applications and data, and in investigating how such an application might provide new, meaningful connections between

1



citizens and their city. The ultimate goal of this study is using your feedback to generate ideas on how the design and the overall structure of the application might be improved. I am curious to learn more about your unique, personal perspective as a citizens or city-user of Toronto.

This study will be conducted using research methods such as observation, survey, user testing and interviews; the resulting data will be used to inform and evaluate visual artifacts and creative works that will be part of the researcher's Master of Design Thesis materials. These will be presented at the final thesis defense, reproduced and/or cited in the thesis support paper, and potentially presented in articles or at conferences.

**What You Will Be Asked to Do in the Research:**

Participants will be asked to join a 45 minutes, one-on-one user testing study conducted by the researcher, featuring a preliminary interview, a user testing session, and a debrief interview. Interviews: preliminary interviews (15 min) will be conducted by asking questions related to the participant's usual experience of Toronto's urban environment, their proficiency with mobile technologies, their interest for urban issues and civic engagement. Debrief interviews (15 min) will be focused on the participant's experience during the user testing session, with the scope of gaining insights to evaluate the design, and to allow participants to share suggestions. Data from the interviews will be collected through audio recordings. User testing (15 min): participants will be asked to interact with the application prototype (using a smartphone or a tablet). Such interactions will include: using the application to answer questions about their personal opinions on topics of urban relevance in the city of Toronto (survey methodology); exploring digital data visualizations of public domain datasets related to the same topics; accessing digital visualizations of their own answers. Besides facilitating this phase by suggesting you how to use the application (only if necessary), the researcher will conduct observations of your interactions with the application: these will be recorded with a software installed on the device, capturing your movements on the app, as well as with audio/video equipment.

**Risks and Discomforts:**

We do not foresee any risks or discomfort from your participation in the research.

2

**Benefits of the Research and Benefits to You:**

Participation in this study does not provide any direct benefits to you. Your contribution will be of crucial value in helping the researcher's investigations on urban data visualization, especially regarding the effectiveness of such a methodology in providing visual information to a wide audience.

**Voluntary Participation and Withdrawal:** Your participation in the study is completely voluntary and you may choose to stop participating at any time. Your decision not to volunteer, to stop participating, or to refuse to answer particular questions will not influence the nature of the ongoing relationship you may have with the researchers or study staff, or the nature of your relationship with York University either now, or in the future.

If you decide to stop participating, you may withdraw without penalty, financial or otherwise.

In the event you withdraw from the study, all associated data collected will be immediately destroyed wherever possible. Should you wish to withdraw after the study, you will have the option to also withdraw your data up until the analysis is complete.

**Confidentiality:**

Unless you choose otherwise, all information you supply during the research will be held in confidence and unless you specifically indicate your consent, your name will not appear in any report or publication of the research. The data collected during the study will remain anonymous: the researcher will assign a fictitious name to each participant, and each file on record will only display the assigned name and a coded number, without containing any personal information.

Data from the study will be collected through handwritten and digital notes, photographic documentation and audio/video recordings. Your data will be safely stored on a password-protected secure server used by the Department of Design, on a password-protected cloud-based secure google drive, and on password-protected computers, and only the researcher will have access to this information. Hard copy data will be securely stored in a locked filing

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cabinet only accessible to the researcher. Hard copy data will be cross-cut shredded; digital stills, audio/video material, notes, questionnaire answers, will be erased from the servers and computer drives by December 31st, 2020.

Confidentiality will be provided to the fullest extent possible by law.

The researcher acknowledges that the host of the online survey (Google Forms) may automatically collect participant data without their knowledge (i.e., IP addresses). Although this information may be provided or made accessible to the researchers, it will not be used or saved without participant's consent on the researchers system. Further, because this project employs e-based collection techniques, data may be subject to access by third parties as a result of various security legislation now in place in many countries and thus the confidentiality and privacy of data cannot be guaranteed during web-based transmission.

**Questions About the Research?** If you have questions about the research in general or about your role in the study, please feel free to contact me at [REDACTED] or my supervisor, Professor Angela Norwood, at [REDACTED] and/or at the phone number [REDACTED]. You may also contact the Graduate Program in Design (MDES) at [mdesyork@yorku.ca](mailto:mdesyork@yorku.ca) and/or at the phone number 416.736.5885.

This research has received ethics review and approval by the Delegated Ethics Review Committee, which is delegated authority to review research ethics protocols by the Human Participants Review Sub-Committee, York University's Ethics Review Board, and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this process, or about your rights as a participant in the study, please contact the Sr. Manager & Policy Advisor for the Office of Research Ethics, 5<sup>th</sup> Floor, Kaneff Tower, York University (telephone [REDACTED] or e-mail [REDACTED]).

**Legal Rights and Signatures:**

I \_\_\_\_\_, consent to participate in Learning from Toronto - user testing study conducted by Andrea Giambelli. I have understood the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

Signature \_\_\_\_\_ Date \_\_\_\_\_  
Participant

Signature \_\_\_\_\_ Date \_\_\_\_\_  
Principal Investigator

**Additional consent (where applicable)**

**1. Audio recording**

I consent to the audio-recording of my interviews.

**2. Video recording or use of photographs**

I \_\_\_\_\_ consent to the use of images of me (including photographs, video and other moving images), my environment and property in the following ways (please check all that apply):

In academic articles	[ ] Yes	[ ] No
In print, digital and slide form	[ ] Yes	[ ] No
In academic presentations	[ ] Yes	[ ] No
In media	[ ] Yes	[ ] No
In thesis materials	[ ] Yes	[ ] No

Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
Participant: (name) \_\_\_\_\_

## Appendix G: Study protocol

York University  
MDES Design Graduate Program  
Thesis research project

Study name: Learning from Toronto: an experiment in participatory urban data visualization  
Student researcher: Andrea Giambelli  
Supervisor: Professor Angela Norwood

Draft user testing study protocol

### Overview

1. Welcome/Warm-up
2. Researcher and study introduction
3. Preliminary interview
4. User testing session
5. Debrief interview
6. Closing

#### 1-WELCOME / WARM-UP

1. Welcome, sit, give consent form
2. Once these are signed, ask if there are any questions before starting.
3. Explain phone app and START RECORDING

#### 2-RESEARCHER AND STUDY INTRODUCTION

1. Brief introduction of the researcher.
2. Research topic introduction: This research project is focused on investigating the role that a specific design methodology - data visualization - can have in generating meaningful connections between citizens and city-users of Toronto and the urban spaces they live in. Data visualization uses a variety of graphs and principles of visual communication to generate visual artifacts that communicate information effectively, with the goal of helping readers understand, explore and interpret the data. Within this framework, this research investigates the design of a mobile-based, interactive application for urban data visualization, which through the use of computer-mediated technologies would allow potential users to experience a variety of visualized information about Toronto not just in front of their computer, but within the very space of the city. Furthermore, the application

will give users the possibility to answer some questions, thus allowing them to share their personal views, opinions, perceptions on each of the addressed topics. I am specifically interested in the interaction between users, applications and data, and in investigating how such an application might provide new, meaningful connections between citizens and their city. The ultimate goal of this study is using your feedback to generate ideas on how the design and the overall structure of the application might be improved. I am curious to learn more about your unique, personal perspective as a citizens or city-user of Toronto.

3. User testing session introduction: today's one-on-one user testing session will last 45 minutes and will be divided into 3 sections: a preliminary interview (15 min), a user testing session in which I will ask you to interact with the application (15 min), and a debrief interview to allow you to express your feedback on the test (15 min). A lot of the questions I will ask to you are quite open ended. This is on purpose because I'd like to hear what comes to mind for you, in your own words. There are no right or wrong answers, and you should feel free to take as much time to think of your answer before responding. Anything you are interested in sharing with me is something that I'm interested in hearing about — there is nothing you could say that might bore me! It's all about understanding what it's like to be in your shoes. If there are ever any questions that you'd rather skip over, that's totally okay too. You will be in charge of this conversation today.

### 3–PRELIMINARY INTERVIEW

I wanted to start off our conversation today with some questions about

- Do you live in Toronto?
- If you are not a resident of Toronto, where do you commute from, how often, and for which purpose?
- How old are you?
- Which is your area of professional/academic expertise?
- How many years have you been living in/commuting to Toronto?
- Is your primary residence owned by you/your family, or rented?
- How do you usually obtain information and news about the city (newspapers, tv, social media, word-of-mouth, etc.)?
- Are you familiar with the terms open data/data visualization?

- If yes, have you ever consulted a data visualization publication/artifact/application specifically related to the city of Toronto?
- Do you have a mobile phone? If yes, what is the main purpose you use your phone for?
- Do you ever look at your phone while walking in the city?
- Are you familiar with the term augmented reality?
- How would you define your level of civic engagement as a citizen/city-user of Toronto?

#### 4–USER TESTING SESSION

The participant will be provided a mobile device (smartphone or tablet) with the application prototype already installed on it. He/She will be asked to interact with the application; such interactions will include: using the application to answer questions about their personal opinions on topics of urban relevance in the city of Toronto; exploring digital data visualizations of public domain datasets related to the same topics; accessing digital visualizations of their own answers; choosing between different design structures, based on their personal criteria of accessibility and effectiveness. Besides facilitating this phase by suggesting participants how to use the application, the researcher will conduct observations of their interactions with the application: these will be recorded with a software installed on the device, capturing the participant's movements on the app, as well as with audio/video equipment. During this session participants will be asked to elaborate on their choices while using the app, and to point out any doubts they might encounter while using it.

We'll now start the user testing session. You will first be presented with a brief tutorial that explains how the application works, before starting to use the prototype. What I'd like to ask you is just to interact with the app and to answer the questions that will appear on the screen. Remember, this is not a test, I am not trying to evaluate your level of knowledge on the topics the app is addressing: there is no right or wrong answer.

#### 5–DEBRIEF INTERVIEW

Debrief interviews will be focused on the participant's experience during the user testing session, with the scope of gaining insights to evaluate the design, and to allow the participant to share suggestions on any aspect of the project by asking questions such as:

- Are you concerned with the topic addressed by the application prototype?
- Did you understand the questions?

- Did you find them relevant to the topic addressed? Were they interesting from your personal point of view?
- Did you find the questions well-suited for your level of knowledge about this topic?
- Was the tutorial helpful to understand the application and the tasks you were asked to complete?
- How would you describe your overall experience interacting with the prototype?
- What was your overall experience with the visualizations in the prototype? Can you rate them in terms of how easy to understand they were? How about how easy it was to interact with them?
- Is there a visualization you found particularly effective/interesting/engaging?
- And one you found hard to read/misleading/not well suited for a particular question?
- Think about the visual comparisons between your answers and the data: was there anything that stood out for you? Something that surprised you? Why?
- Can you recall a question in which your answer and the data were different? How about one in which they were similar?
- How intuitive did you find the visual comparisons between your answers, the data and answers from other users?
- Did you find it easy to visually distinguish between your answers, the data and answers from other users?
- How intuitive did you find the user interface (suggestions, buttons, interactivity)?
- Can you think of one or more questions you think could be added to the interactive survey? Is there any aspect of the topic you wish it was addressed?
- You answered 6 questions in about xx minutes. Did you feel the length of the survey was appropriate/too long/too short, and why?
- Imagine this application was fully implemented and addressed a topic you are really concerned with. Can you picture yourself answering a survey like the one you tested while you are in the city? For example, waiting for the bus, sitting in a square or a park, walking through a mall?



- Is there any functionality you wish it was added to this prototype to make it more useful from your personal perspective?
- Is there any topic regarding urban issues in Toronto you think it would be interesting to address through the application you just tested?
- Would you say the information you accessed during this survey increased your level of knowledge about the topic?
- After this experience, do you feel curious to know more about housing in Toronto?

#### 6-CLOSING

1. Before the end of the event, the researcher will provide the participant with a worksheet and will ask him/her to write on it anything else he/she might want to add on the topics discussed, and any personal feedback on the user testing session they just completed.

Is there anything else you wanted to tell me today? Anything else you thought I would have asked you about?

How did you find today's experience?

Thank you for your time and for your participation in the research project! Is it ok to contact you if we have any additional questions?


# Appendix H: User Testing report

#	QUESTION	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7
1	Do you live in Toronto?	No	Yes	Yes. Yong & Finch - North York	Yes. Busy area in Kensington/Little Italy. Really like urban landscape.	Yes. Borderline of Markham and Scarborough	No. I lived in suburban Toronto growing up but now outside. Bolton, township of Caledon, typically 45 minutes commute	Yes, Yonge & Bloor, it's considered downtown. Border of downtown/midtown
2	If you are not a resident of Toronto, where do you commute from, how often, and for which purpose?	Milton	N/A	N/A	N/A	N/A		
3	How old are you?	33	33	24	19	20	almost 50	43
4	Which is your area of professional/academic expertise?	Law, design	Retail, manager in glass store	Graphic design/printmaking	Interactive design. Editorial design	YSDN graphic designer	Technical support at YorkU	Faculty of interaction design and data visualization at York University
5	How many years have you been living in/commuting to Toronto?	20 years in Toronto, then outside	3 years	22 years	1.5 years	All my life.	25 commuting to Toronto, before on the outskirts depending on what is city limits	15, before commuted a few months from Mississauga
6	How do you usually obtain information and news about the city (newspapers, tv, social media, word-of-mouth, etc.)?	social media	social media, internet. Sometimes word of mouth as a start then research on web	New restaurants w-o-m, social media, internet. Online newspapers sometimes	Facebook, twitter. Maybe friends but mostly online. No newspapers or tv. Social media	Mainly social media. W-o-m, parents watch tv so I get something like that	Online, social media, radio. W-o-m some cases depending on who I'm speaking to.	Websites and sometimes city leaves mail in my mailbox - hydro projects, voting. No tv, no newspapers. W-o-m sometimes casual, unstructured conversations with friends. Hey have you noticed they demolished this and that, they will build another condo...something like that.
7	Are you familiar with the terms open data/data visualization?	Yes	No	Yes	So and so	Heard them before, think I know but not too sure	DV yes, open data no.	Yes
8	If yes, have you ever consulted a data visualization publication/artifact/application specifically related to the city of Toronto?		N/A	When I was at OCAD. Globe and Mail visualized stats on student depression problems in Toronto	Yes, my Info Design class at York. We need to look at urban data. I chose my area	Would it be like the actual To government data website. Looked into it to adopt a pet, they have statistics on that. Not on the news.	Yes, housing and energy usage. Not researched but stumbled upon. Also, events in the city. Typically found online. Elections/politics also.	A while back, article in the local "Now" magazine. I saw the title said: who should own the data for the city of Toronto, store it, maintain it, protect it. Their answer was TPL. Open data website. Not intentionally their visuals
9	Do you ever look at your phone while walking in the city?	Yes, mainly wayfinding	Yes. Internet, social media, messages, podcasts. Not wayfinding. Check if PT arrives	Yeah, everyone does that! If I'm in my area I don't need it. If go to downtown always double check my destination, or restaurant wayfinding	Snapchat, Instagram. Not news. Google maps occasionally, depending on the area	Music, social media, texting, if downtown looking at maps to know where to go.	Directions, locating restaurants since I don't live in the city, or sightseeing	No, just if it rings. Use it at point of sales, check emails waiting in the doctor's office. Sometimes wayfinding walking to a new place. Google Maps or Waze. A little too much on visual design but it works
10	Are you familiar with the term augmented reality?	Yes	No		Heard of it but don't really know	Is it like virtual reality?	Yes	Yes
11	Is your primary residence owned by you/your family, or rented?				I rent + 2 roommates. My rent is more than ideal but is semi-affordable. Still manageable	Live with my family	Own	Own
12	How would you define your level of civic engagement as a citizen/city-user of Toronto?	Very high, volunteering at civic tech, law and design	Pretty high (thinks about civic behavior and ties w/community) rather than engagement. No initiatives.	I volunteer sometimes at smaller galleries close to OCAD and in cultural world. I don't do enough of that.	I'm engaged with the community, but not in a structured way	I was more involved in high school when it was required to do community services. Now no, don't have time. I do go to events like CNE big Toronto events though	I guess very peripheral we don't live in the city but hear about what goes on, but not very engaged.	No [not doing ...]
	Are you concerned with the topic addressed by the application prototype?	Yes, very much	Yes. Prices are scary. Normal for a metropolis but out of control. Cost of life grows, income should follow but it's not the case. [Would you buy house] yes but only with help from others (parents) otherwise not able. And even if I could it would probably be overpriced	I'm interested in this.	Yes. Very good way to understand data. I don't think so much about housing, but I think about how my rent compares to others. Rent.	Not really at my current age but in the future probably yes	Not immediately, but my children maybe will need to move to the city, or also for investment opportunities, I'm looking into it. It might become interesting.	Yes, because I live in the city and I wanna know what's going to happen. Especially now that banks have raised mortgages
14	Did you understand the questions?	Yes, I asked some terminology clarifications but yes	Yes	Yes, understandable. Certain maybe needed more specification if based on rental vs. owning	For the most part, yes. I feel some wording was difficult for me as not an insider specific to the topic.	Terminology was kind of ok but, still because of my age, I might not know some stuff	Most of them, asked some clarifications	Yes, some doubts on Q5

#	QUESTION	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7
15	Did you find them relevant to the topic addressed? Were they interesting from your personal point of view?	Yes, but I'm wondering whether there was a specific point in wanting me to know specific things. Do you want me to go to a certain conclusion.	Yes. Mosto of them were interesting. Q4 is something I thought about, if you need to buy affordable home you need to go out maybe. Thought Etobicoke had more out of all	Yes, really relevant. Personal interest: the one about empty units. My condo some of them. Maybe Air BnB. It's a city-wise problem	Interesting for my personal point of view yes, it would be interesting with more financial data not just housing	Found interesting Q4. I thought more Etobicoke. I work for a real estate agent and most of new listings are there.	Yes, they were relevant. Not all interesting from my personal perspective. You covered a broad range of questions, maybe pricing would be more interesting than occupancy	Yes, but not Q5. [Why?] I cannot find a direct relationship btw those data and how it's gonna change my way of thinking towards the previous four issues. How much downtown new condo is keeping up with services (fire, police stations, hospitals, schools, entertainment, transportation). Tsunami of people coming to the city, high percentage of Asian students. Before Trump they used to go to the states, now Canada. But that flood in my neigh was part of why prices skyrocketed. The boiling frog: we are desensitized.
16	Did you find the questions well-suited for your level of knowledge about this topic?	Yes	Yes	Yes, but need more specification	A little bit too high	I don't have a lot of knowledge on this topic, but I was able to get a grasp	Not being involved in the city market some of the questions maybe I didn't have enough perspective on	Yes, maybe some terminologies.
17	Was the tutorial helpful to understand the application and the tasks you were asked to complete?	Yes	Yes	Yes. But maybe because I use my phone constantly maybe I would have figured it out on my own. But other people might need it	Yes. If I was given the app without the tutorial I wouldn't know what to do.	Yes, it allowed me to understand	Yes	Yes, but the example was based on a single visual model but everytime with a new model I had to re-think about it. Also range, but then no range in questions. Maybe for Q1 and Q5!
18	How would you describe your overall experience interacting with the prototype?	Very good, besides some of the definitions and some axes/labels	Good. Easy straightforward.	Enjoyed it. Interesting to input your guess and then see comparison, and then other users.	Other than the bugs, experience good, app works well	Good experience.	Interaction well. Need to redraw Q3. Size of interactive elements vs finger, or position of suggestions/scales	
19	What was your overall experience with the visualizations in the prototype? Can you rate them in terms of how easy to understand they were? How about how easy it was to interact with them?		Good understanding, good iteration. 9/10	Super simple, legible, choice of colors helps a lot. Good not to feel overwhelmed by data	8/10. Occasionally there were times where wasn't clear what you had to press first but ok.	Simple, very clean, 8/10. Gradient of average people kind of confused me [LFT users guess from Q1/Q2], it fades out a lot. Use of color and contrast very good	Maybe there could have been more information presented? When it overlapped with data it became more obscure	
20	Is there a visualization you found particularly effective/interesting/engaging?	Q4 cool way to present comparative ratios. Why do we do the dots instead of a line? Convey the sense of human. How it's supposed to make me feel? Housing problem. Is there even a problem? Maybe compare to other cities!	Q4 - unexpected data	Line chart, donut chart		Q4, allowed me to see the distribution clearly	Donut - liked interaction and info	Q3, nicely done appropriate easy to compare
21	And one you found hard to read/misleading/not well suited for a particular question?	Q2 harder, also many might not know how high Bridle Path is. Maybe we need distribution.	Q2	Q5 would be better with also horizontal selection			Stacked circles only increment of vertical	Why a dot matrix? Why not a slider? Maybe comparing side by side on bars rather than overlapping? Hard to compare on Q4 donut, so I started looking at the percentage numbers on the corners
22	Think about the visual comparisons between your answers and the data: was there anything that stood out for you? Something that surprised you? Why?	No	Surprised by how right I was many times - I was being more pessimistic than I am but it was right! Shocked by the 66k unoccupied	Not really. This is what's happening so it's not that shocking. I was trying to be optimistic, but maybe more realistic in the end.	Some very close, some very far apart. Anyway, working well. Not really surprised. I ballparked Q2 because I'm not familiar with the areas, so I expected to be very far off. If more questions tailored on specific areas, probably best guesses from people who live there.		In some cases my lack of understanding of the market in a particular area played a part in my surprise. Mentions Q4, I thought there was a little more balance.	
23	Can you recall a question in which your answer and the data were different? How about one in which they were similar?		Different: Q4			Q4 as I said. Not surprised, apart from that, but it's also because I had to guess a lot of data, I didn't really know.	Q4	Q1 I was very close, the other I was VERY off. I was very interesting, mind-opening
24	How intuitive did you find the visual comparisons between your answers, the data and answers from other users?	8 out of 10	9 out of 10	9 out of 10. Not too much info on the page. Even a non-designer can understand DV			Less clarity to where things began and ended?	
25	How intuitive did you find the user interface (suggestions, buttons, interactivity)?	Very good	9 out of 10	It's really simple, so it helps users. More people have the opportunity to understand.	Very good, easy to understand and advance	Very strong, no problems with knowing what to do.	It performed well, besides what I already mentioned.	I understand why on phone, but why not on screen? For digital natives maybe ok, but for digital immigrant I would like a bigger screen, screen real estate. Having help on the side real time on the visual language, rather than having to memorize the tutorial

#	QUESTION	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7
26	Can you think of one or more questions you think could be added to the interactive survey? Is there any aspect of the topic you wish it was addressed?	What is the narrative you are building? Compare to other cities. Is it ok or not ok? Increase people's ability to call bullshit	Differences between older buildings and newer buildings? Very different. New buildings maximize space, smaller houses, maybe it influences that 66k. Differences btw condos/townhouses?	I'm curious to see the empty units and seeing how much further that's gonna go. People buying from overseas, AirBnb, which impact on the market, first-time home owners	Maybe if questions were realted more to an audience (students and finances for example?)	I know that in real estate they often compare different types of housing	Depending on who the audience is. Ownership vs. rental. What is becoming more customary? Is it only a trend because of the high cost? Is it an issue for young people entering the market? Also, condo markets has added costs other than the price, like maintenance and condo fees.	Maybe different versions adapted to people who rent vs. own? Q1 goes with Q3, Q2 + Q4. Did my salary go up???
27	You answered 5 questions in about xx minutes. Did you feel the length of the survey was appropriate/too long/too short, and why?	Yes	I expected longer. I would say it's ok. Afraid it might be too long but ok!	I was getting really into it, so maybe a couple more questions would be great. But these are 5 solid questions.	Good length of time, appropriate	Appropriate time.	2 or more questions further I wouldn't mind	It could have been longer. That was short and sweet!
28	Imagine this application was fully implemented and addressed a topic you are really concerned with. Can you picture yourself answering a survey like the one you tested while you are in the city? For example, waiting for the bus, sitting in a square or a park, walking through a mall?	Yes	Yes	Yes, kind of like a game. Next week, a different set of topics	Sure, if it's 5 minutes long yes	If wouldn't do it on my spare time. Someone would have to ask me to do it. In those situations I would want to play more games, and also there is no reward. Something that would make me want to do it.	It depends, typically before venturing in the city I generally do my research at home. If something like that would have come up as part of a research I was doing or of my navigating in th city then yes.	If I'm in the doctor's office yes, but otherwise not. Unless I have some kind of incentive, rewarding system
29	Is there any functionality you wish it was added to this prototype to make it more useful from your personal perspective?	No	N/A	N/A	No need for further functions	Q5 suggestions [was missing]	More visual engagement of information (?)	
30	Is there any topic regarding urban issues in Toronto you think it would be interesting to address through the application you just tested?		Publ Transit. It's growing not as fast as the population. Most of TP is on the ground not appropriate for climate. City grew lot in the past years but not TP. Even bigger issue than "rent control"	Art & culture. People don't know how to put on shows, or get info, or even just see what's happening. Provide proper data on it. [is it under representer now?] Yes. It's there but virutally non-existing.	Tourist attractions and cultural activities in Toronto. I'm a little biased.	Toronto very multicultural, restarurant scene very dynamic but not lots of data	I'm familiar with Waze, crowdsourcing information is useful. Transportation or even seeking out venues, restaurants, entertainment	Cites a lot, but very generally
31	Would you say the information you accessed during this survey increased your level of knowledge about the topic?	No, but I knew these facts before	Definitely	Some questions, but the majority I kind of new how they would be - living here for so long	A little bit yes. Gave me confirmation that rent is expensive, and just a little bit of extension on other areas	Yes, definitely		Yes
32	After this experience, do you feel curious to know more about housing in Toronto?	No, didn't leave with so many questions. Maybe that could be a goal, leaving questions to users for more curiosity.	I was curious already so it's increased a little bit	I'm always curious to know what's gonna happen next. Market growing and growing and how do I buy a piece of property?	Yes.	Not really, again probably because of my age		Yes

## Appendix I: TCPS Ethics Tutorial Certificate

<b>PANEL ON RESEARCH ETHICS</b>	<b>TCPS 2: CORE</b>	
<i>Navigating the ethics of human research</i>		
<h1><i>Certificate of Completion</i></h1>		
<p><i>This document certifies that</i></p>		
<p><b>Andrea Giambelli</b></p>		
<p><i>has completed the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Course on Research Ethics (TCPS 2: CORE)</i></p>		
Date of Issue:	<b>6 January, 2018</b>	