Getting Smarter About Data and Access in Smart Cities

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Abstract. The purpose of this paper is to explore access in relation to new forms of urban data enabled by more aware people and aware technologies in smart cities. Focusing on the constructs of awareness, learning, openness, and engagement, a review of the research literature for data access and universal access in relation to smart cities is provided. As such, a theoretical space for data access is developed as a dimension of the construct of universal access. The research design for this work employs an exploratory case study approach, using multiple methods of data collection including interviews and survey in small to medium to large sized cities, mostly in Canada and extending to cities in other countries. Content analysis is used as an analytic technique for qualitative data to identify insights while descriptive statistics are used in the analysis of quantitative data. This work makes a contribution to: (a) the research literature for smart cities; (b) urban theory by advancing a conceptual framework for ambient access in learning, smart, and future cities; and (c) spaces for debate, inquiry, theorizing, and everyday interactions pertaining to urban data in smart cities, regions, and communities.

Keywords: Ambient access · Ambient data · Awareness · Data accessibility · Data rights · Future cities · Learning cities · Smart cities · Universal access

1 Introduction

At the intersection of rapid urban growth, aware technologies, and more aware people [1] is the emergence of new forms of data in smart cities. Schmitt [2] describes the flow of data "as the new building material of the future dynamic city" while others [3] describe data as a new type of resource requiring access and rights considerations as in, the need for a 31st human right. According to Stephanidis [4], universal access "is intended to inform the evolution of the information society as a human, social, and technological construct," pointing to the "new challenges posed by pursuing proactive accessibility and usability in the context of ambient interaction" [5]. This is important because according to Konomi and Roussos [6], "we are now going beyond the last decade's conception of smart cities" and moving "towards a deeper level of symbiosis among smart citizens, Internet of Things and ambient spaces." As if in anticipation, Stephanidis [4] called for "methods and techniques to be appropriately expanded and enhanced, as well as validated in practice" for "new technological environments and contexts of use." In response, the aim of this work is to explore access in relation to

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new forms of urban data, as a dimension of the universal access construct. Through a review of the research literature for data access and universal access in relation to smart cities, this work formulates a conceptual framework for ambient access in learning, smart, and future cities. This framework is then operationalized using the constructs of awareness, learning, openness, and engagement to explore the potential for getting smarter about data and access in relation to urban life in smart cities. The research design for this work employs an exploratory case study approach, using multiple methods of data collection including interviews and survey, involving a cross-section of people in multiple small to medium to large sized cities in Canada and beyond. Content analysis is used as an analytic technique for qualitative data to identify insights and descriptive statistics are used in the analysis of quantitative data.

Intended to open spaces for emergent thinking about data access in relation to urban life, the key research question posed in this work is – *How and why is there a potential for access to data to form part of smarter human and urban infrastructures?*

2 Theoretical Perspective

A review of the research literature for data access is provided from multiple perspectives in relation to smart cities including associated frameworks. Perspectives from the research literature are then provided on universal access focusing on data for smart cities. With this background, a conceptual framework for ambient data access in learning, smart, and future cities is formulated in Sect. 2.3.

2.1 Data Access and Smart Cities

The rapid growth of cities and urban regions has given rise to the need for smarter, more responsive cities enabled through the increasing development and use of information and communication technologies (ICTs) [7, 8] and other aware technologies [9]. Townsend [10] describes smart cities as "places where information technology is combined with infrastructure, architecture, everyday objects and even our bodies, to address social, economic, and environmental problems." Evolving understandings of the smart city phenomena reveal new opportunities and potentials for people to interact with technologies and with each other in addressing ever more complex urban issues [11]. Gil-Garcia, Nam, and Pardo [12] advance smarter as a new urban agenda while Gil-Garcia, Zhang, and Puron-Cid [13] provide a conceptualization of smartness in government consisting of 14 dimensions, including – creativity, equality, integration, and openness.

Data Access and Value. Gurevich, Hudis, and Wing [14] note that, "due to progress in technology, institutions have become much better than you in recording data" claiming that such "shared data decays into inversely private" and that "more inversely private information is produced when institutions analyze your private data" that "allows institutions to serve you better." However, Gurevich et al. [14] point to the value of access to this information and refer to "the inaccessibility of your inversely private information" as "the inverse privacy problem" whereby "a good solution should not only provide you accessibility but should also make that access convenient."

Data Access and Control. From a law and policy perspective, Scassa [15] focuses on data ownership and control in the context of open government in smart cities, highlighting "rights to re-use the data whether it is for innovation, civic engagement or transparency purposes." From an economics and innovation perspective, Mazzucato [16] argues for the "making of private data into a public good." And the notion of access to "inherent human data" as a fundamental right is being advanced as a 31st human right, "to assure that our data is our property" [3].

Frameworks for Data Access in Intelligent Environments. Frameworks for data in intelligent environments include those identified by Lea [17] in relation to standards while McKenna [18] articulates an ambient data framework for learning cities and smart cities. Liu, Heller, and Nielsen [19] provide a classification of data in smart cities as "sensitive, quasi-sensitive, and open/public" with a flowchart for accessing published data. Liu, Heller, and Nielsen [19] advance a framework for smart city data management encompassing "data collection, cleansing, anonymization and publishing" as a "generic solution." It is worth noting that Lim, Kim, and Maglio [20] provide a word cloud of the "top 100 words representing the smart city literature" based on "a topic modeling method" and the word smart appears in large print with the word data and the word city in slightly smaller print beneath and the word access embedded within a letter of the word smart at a much smaller scale, suggestive perhaps of the notion of smart access to data in cities, with very little literature, as yet, focusing on access. Osman [21] advances a big data analytics framework for smart cities with model management and aggregation functionality and a comparison of "traditional knowledge discovery approaches" is provided. In recognition of "people's concerns about their privacy" van Zoonen [26] advances a privacy framework for smart city technologies and urban big data privacy, attentive to the notion of "legitimate access." Two data dimensions are featured in the framework by van Zoonen [26], the personal and sensitive in relation to the purpose for data collection as service or surveillance related. A framework for adaptive differential privacy is advanced by Winograd-Cort, Haeberlen, Roth, and Pierce [28] where the use of *privacy filters* along with an *adaptive layer* is highlighted, addressing some of the challenges [29].

Data Access and the Toronto Experience with Sidewalk Labs. It is worth noting that Sidewalk Labs, under the parent company of Alphabet, proposed a draft plan for data privacy for the downtown Toronto initiative through articulation of the notion of a *Civic Data Trust* [22] in response to seemingly intractable issues associated with urban data [23, 24]. As an independent organization, the Civic Data Trust "will control the data" for the smart city project and "set the rules around its use" and also "make it open and accessible to people while offering privacy protection." Two types of data collection are identified for the trust as: "that collected without consent" and that "collected with consent" where the former would include "pedestrian counters and streetfacing cameras, though it would be wiped of personal information" and the latter would include data collected "through websites and mobile apps" and "wouldn't be subject to control of the trust." In the interests of "transparency and safety", recommendations from "a panel of millennials" include the need for organizers of the Toronto project to "address meaningful consent" of "data collection in public spaces" and to "maintain an open data portal to encourage innovation for the public good" as well

as the creation of "an independent data trust to manage all data collected" [25]. McDonald [27] describes Sidewalk Labs' proposal for the Quayside Project in Toronto as "the world's largest Civic Data Trust proposal."

Data Access Alternatives. Lea [30] introduces a framework for people to "begin to share and control access to their personal data" by advancing the case for the smart city data brokerage idea as a solution to the limitations of open data that is said to be "infrastructure centric"; "anonymized" with the intent "to ensure privacy" and this may in turn "reduce usefulness"; while being described as "often 'low value' data, that is easy for "cities and others to 'give away'." By contrast, the data brokerage notion "focuses on making data available" in a way described as "a controlled manner" enabling "organizations to manage who uses this data and what they do" with the data and in some instances even "monetize their data" where "control is managed through specific licensing" providing "an ability to control how data is being used." As such, Lea describes a "spectrum from a freely available open source data set" to one afforded by the data brokerage model that "could be licensed, for a fee, with a specific license that allows a single use." Pointing to examples such as Google or Facebook where "data is gathered in exchange for free services" where "citizens have no control over the data, its usage" as well as often "not even aware that their personal data is being used by third parties," Lea seeks to reverse this situation, advancing the data brokerage for "empowering citizens" as "a powerful tool to unlock valuable data" while enabling people to have "more control over personal data" [30].

Data Access and Literacies. Edelenbos et al. [31] explore a research agenda for "data sensitive governance" noting that the "accessibility" of big data "is in fact limited and selective" giving rise to the need for a focus on policy; analytics and data literacy; legal and social aspects and associated inequalities; and "the reworking of spatial boundaries" in addressing what is referred to as a paradox of increasing livability on the one hand and the "risk of creating very complex urban governance dynamics" on the other hand. Moore, in an interview with Rocker [32] about the Virtual Singapore Project, focused on digitizing the city, points to a shift in access, highlighting the "benefit" for cities of being able to rethink "the possible business models" and "reassess the value of data" while receiving assistance with how "to integrate the data in a smarter way." In the context of data and information architectures in smart cities, McKenna [33] argues for "smarter access" along with "meaningful access" to "inform evolving urban understandings" focusing on smartness and architectures, governance, and data in smart cities, featuring ambient data for smart delivery; potential to build capacity through infrastructures; data access for constructive uses; and mobile apps for real-time collaboration and decision-making.

2.2 Universal Access and Smart Cities

Smith [34] emphasizes the importance of human infrastructures in smart cities, involving cross-sector dialogue, as does Lea [35] in relation to the sharing, exposing, and using of data. Regarding data infrastructures, Gray, Gerlitz, and Bournegru [36] argue for data infrastructure literacy as a way to "cultivate sensibilities" going beyond data science, and extending to "data sociology, data politics" and even to "wider public

engagement with digital data infrastructures" in support of "collective inquiry, experimentation, imagination and intervention around data in educational programmes and beyond." According to Gray et al. [36] such spaces would enable explorations into "how data infrastructures can be challenged, contested, reshaped and repurposed to align with interests and publics other than those originally intended." Pérez-delHoyo, Garcia-Mayor, Mora-Mora, Gilart-Iglesias, and Andújar-Montoya [37] advance "an urban model for improving accessibility" where "the design of intelligent environments, with the automation of processes and functions in urban spaces" is "a safe and effective way to promote inclusion and participation of all citizens." Mollá-Sirvent et al. [38] developed an accessibility index for smart cities involving people in the collection of data in contributing to the visualization of "how accessible a city is" over a period of time. The World Urban Forum (WUF9) advances the importance of accessibility and inclusion in support of "cities for all" [39]. Ang, Seng, Ijemaru, and Zungeru [40] describe applications, architectures, and challenges for the Internet of Vehicles (IoV) articulated as "a convergence of the mobile Internet and the Internet of Things (IoV) while advancing the "novel paradigm" of a "universal Internet of vehicles (UIoV) for smart cities" attentive to various types of access issues. Streitz [41] argues that "a transparent urban ambient intelligence environment" supports "city authorities as well as citizens" in being able to "access and exploit the wealth of all the data collected" in urban spaces.

2.3 Conceptualizing Ambient Data Access in Smart Cities

The theoretical perspective developed in this paper, from a review of the research and practice literature, enables formulation of an ambient data access conceptual framework for learning cities, smart cities, and future cities, as depicted in Fig. 1. The emergence of new forms of data made possible through more aware people and their multisensory capabilities, interacting with more aware technologies enables evolving perspectives on human infrastructures and urban infrastructures. Characteristics of these data infrastructures include adaptive, contextual, connective, interactive, and sensing in support of ambient data and privacy innovations (e.g., ambient, adaptive differential, inverse, etc.) highlighting the potential for accommodating smarter possibilities related to control, creativity, literacies, purpose, rights, and value. As such, this work proposes and develops the construct of ambient data access in support of more dynamic, in-the-moment, and adaptive understandings of accessibility in accommodating the creative, serendipitous, and unpredictable nature of people [42], in keeping with the notion of humans in the loop [41]. This framework builds on work by McKenna [33] where access figured strongly in relation to information infrastructures, governance, and data in smart cities and where creativity and serendipity are highlighted [42].

The framework is operationalized for use in this paper in responding to the research question, reformulated as a proposition under exploration in this study, as follows: in contemporary urban environments:

P: Access to data forms part of smarter infrastructures through *awareness, learning, openness, and engagement* contributing to and influencing urban life for learning, smart, and future cities.

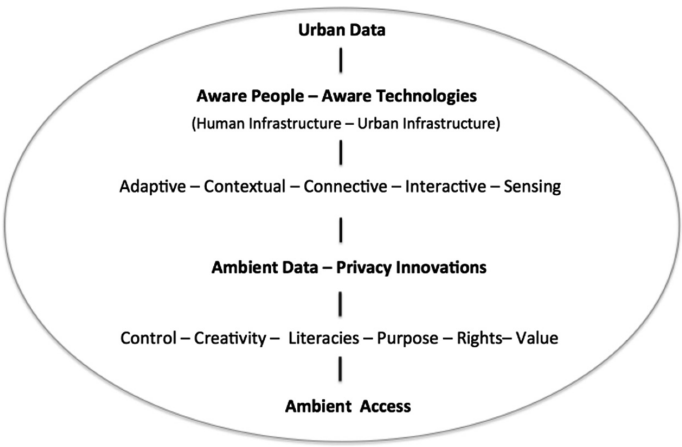

Fig. 1. Ambient data access conceptual framework for learning, smart, and future cities.

3 Methodology

This work employs an exploratory case study approach because it is said to be particularly appropriate for the investigation of contemporary phenomena [43], in this instance, the emergent dimensions of access associated with urban data.

3.1 Process

A website was used to describe the study, enable sign up, and participation in the online survey. During sign up for the urban study, people could self-identify in one or more categories (e.g., student, educator, business, community member, etc.) and demographic data were also collected at this time for age, gender, and geographic location. Interviews were conducted, mostly online, to enable more in-depth discussion of smart city issues and experiences. Notice of the research study was made to online spaces attracting researchers, practitioners, and anyone interested in smart cities and regions. As such, sampling procedures used involved heterogeneity sampling, a form of purposive sampling enabling a broad range of perspectives to emerge [44].

3.2 Data Collection

This study employs multiple methods of qualitative data collection including interviews and survey, involving a cross-section of people in the city. A survey instrument was developed and pre-tested prior to use in the study as well as an interview protocol to guide discussions. As such, quantitative data were gathered through surveys and qualitative data were gathered through interviews and open-ended survey questions in various sized cities in Canada and other areas including northern and southern Europe and beyond.

In parallel with this study, data were also systematically gathered from a wide range of people through group and individual discussions across multiple sectors (e.g., higher education, information technology, business, community members, city councilors, urban educators and innovators, to name a few) in multiple Canadian cities (e.g., Greater Victoria, Vancouver, and Toronto).

3.3 Data Analysis

Content analysis was used as an analytic technique for qualitative data involving pattern matching and explanation building enabling the identification of insights. Descriptive statistics were used in the analysis of quantitative survey data. An iterative approach to all three data sources enabled simultaneous analysis, comparison, and triangulation of data for n = 73 with 41% females and 59% males for people ranging in age from their 20s to their 70s.

4 Results

Findings from this work are presented in relation to the four constructs – awareness, learning, openness, and engagement – used to explore the proposition in this research study.

Awareness. The desire to know more about what is going on in the city on the part of citizens was expressed, as in, "it is hard for the locals to find out what's going on around the city" and by visitors to the city, as in, "what do the locals do", said to be "the most commonly asked question." An individual in St. John's identified the need for information that is "not too dense" enabling people to know "what's happening at a particular point" so that "you can access this type of information and know what's going on in real time almost." When urban interventions are conducted to introduce art in public spaces for example, interest was expressed in the type of data that would assist in understanding how the intervention changed the space in terms of increased usage, quality of use, transformation of urban spaces, and the like. However, in the case of such interventions, it was indicated that funding for identifying, gathering, and making available the data was not yet available. A city councilor pointed to the value of receiving data from people who are interacting with the city through the infrastructures of a bike path on the one hand and a mobile app on the other hand whereby urban users report conditions requiring attention that the city can then act upon in the moment, as in, "through your phone you are able to track accidents" and "create a map with that information" for the city to "create engineering fixes for those intersections."

Learning. A community engagement specialist pointed to the importance and value of pedestrian counts in public spaces to learn more about the vibrancy of the city, referred to by an educator as "human activity in every corner." The importance of the digital and data dimension of information in public spaces was readily acknowledged at the urban level through an expression of interest in learning more about the potential for undertaking small-scale urban data interventions involving the notion possibly of a "smart bench." Similar to urban interventions by Placemaking networks such as a

temporary street closure on a Sunday to provide the experience of more pedestrian friendly urban spaces, urban data interventions place an emphasis on learning more about the value, nature, and complexities of data. In such spaces, pedestrian counts would be of value as an indicator of interest and engagement while data interventions more generally provide an opportunity for "rethinking the traditional norms that we have around data." For example, the notion of a smart bench infused with technology elements that provide information related to use on the one hand with the potential for safety on the other hand, depending on the location, give rise to potential implications if people are aware that the bench contains 'smart elements'. Explorations for learning were also articulated by a student for "geofenced location-based content" in relation to "community interactions" with the juxtaposition of "social media" and "closed communities as well as open" enabling "access" for "citizen inquiry" and "educational institutions" featuring informal and "formalized education." City information technology (IT) staff pointed to the need for data literacies along with the need for funding to support such initiatives indicating that "we're very immature in that overall data sense" in that "we're starting to look at tools to help us mine the data that we already have an interest in" while referring to "that hurdle" of "starting to educate" with respect to "what could be done" along with "educating ourselves." When asked what cities need to do to become smarter, 67% of survey respondents selected the option to "Support learning cities by enabling new forms and configurations for education in the city (e.g., school-university-city collaboration, etc.)."

Openness. Speaking of urban data, City IT staff indicated that, "fundamentally there is a desire to be very, very open with the data" and because "it is public data, we manage on behalf of the citizenry" access is important "where there is a purpose to utilize that data" and "maybe it helps improve something." Potential emerges for the expanding of open data beyond "low value" [30] to richer, more valuable data for more meaningful openness. A student pointed to the wicked challenges associated with the "ownership and privacy" of urban data in relation to "how it is housed" and the "infrastructure by which it is shared" suggestive of the range of complexities associated with data access from control to purpose, to rights, to value along with the opportunity potential for creativity and new literacies. When asked whether they associated openness with smart cities, on a 7 point likert scale (e.g., 1 = not at all, 2 = not sure, 3 = maybe, 4 = neutral, 5 = sort of, 6 = sure, and 7 = absolutely), 33% of survey respondents selected 7 at the upper end of the scale, 33% selected 6 near the upper end of the scale, and 33% selected the neutral position of 4 on the scale. City IT indicated that there is "interest in putting physical infrastructure in place" adding that, "how we interpret using it is still open" suggestive possibly of creative and collaborative opportunities influencing data access elements pertaining to control, purpose, rights, and value.

Engagement. An educator and community member observed that, "we're not smart about how we use the technology", suggestive of implications for all aspects of the data and digital dimension. From the perspective of a student, "we will know more what to do with" the data "that is constantly being made, built" in social media and other spaces "as we work out how to sort" what is being generated, giving rise to "notions of smart delivery." City IT described the notion of "documented engagement" giving rise to new types of datasets for sharing and decision-making. Using the example of an eTownHall

meeting, City IT indicated that "we furnish some of the elements of engagement" using various technologies to create a meeting space for "questions and sharing answers through Twitter" and other platforms. IT staff in the higher education sector emphasized the critical element of access in terms of "getting at that data and using it in constructive ways" in order to enable "benefit to the society and the citizens." In the words of one individual, "you can have all the connectivity you like but if there is no access to data in a meaningful manner" as well as "no interpretation of that data leading to good public policy decisions then" smart cities are "all for nothing." When asked what cities need to do to become smarter, survey respondents, without exception, selected the option to "make engagement smarter" as in, "break down the silos and collaborate more." Given a variety of options to choose from, when asked "How does technology help you in the city?" 67% of survey respondents selected "To access city resources."

5 Discussion

Through a review of the research and practice literature for data access and universal access in smart cities followed by an exploration of the experience of smart cities in relation to the constructs of awareness, learning, openness, and engagement in this study, insights emerge about data control, literacies, purposes, and value, aided by the understanding of more adaptive and dynamic forms of access, as in, ambient access, as depicted in Fig. 2.

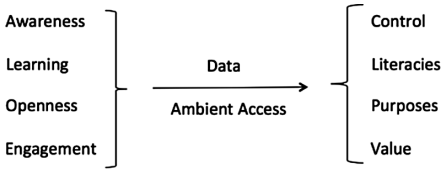

Fig. 2. Ambient access lens for data control, literacies, purposes, and value.

For example, people in this study spoke in terms of the need to be "smart about how we use the technology" while smarter approaches to information delivery were suggested in the form of 'smart delivery'. In discussing the potential for an urban intervention to learn more about data in relation to urban elements such as a bench, a community leader suggested the term 'smart bench' involving data sharing, animating public spaces, and the like. These examples point to a recognition of the potential for ambient access as a more dynamic, adaptive mechanism for rethinking and reconfiguring current understandings of data control, involving new data literacies, new purposes for data, and emerging forms of value for data.

Two dependent variables are identified in this work, as follows: that of *ambient data access and value* and that of *ambient data access and literacies* along with independent variables for each. In the case of *ambient data access and value* the

independent variables include: use of mobile apps and urban infrastructures for sharing data in the moment; the generation and sharing of exploratory urban intervention data; and tools and mechanisms for the interpretation of data. In the case of *ambient data access and literacies* the independent variables include: learning about the importance of the digital and data dimension of information in public spaces; learning about the value, nature, and complexities of data; and new forms and configurations of education in support of learning cities.

6 Future Directions

In advancing the construct of ambient access in relation to urban data, to complement and extend evolving understandings of universal access, this work creates openings for future directions for both practice and research.

6.1 Research

Future research opportunities and challenges enabled by this paper relate to the potential for further validation and exploration of the ambient data access conceptual framework advanced and operationalized in this work as well as the variables identified.

Ambient Data Access Conceptual Framework. This work navigates a pathway toward ambient data access as a possibly smarter approach to the seemingly intractable issues, challenges, and opportunities for urban data in smart, learning, and future cities.

Ambient Data Access Variables. Dependent variables (DV) emerge for *ambient data access and value* and *ambient data access and literacies* along with associated independent variables (IV) for each providing opportunities for exploration and validation.

6.2 Practice

This work highlights some of the needs and interests of practitioners at the urban level in that it explores the *ambient data access* construct in the context of involving people more directly with aware technologies in relation to awareness, learning, openness, and engagement. More specifically, areas for practical involvement include:

Exploratory Urban Interventions. Urban interventions of an exploratory nature provide a practical way for involving people more directly with data in relation to awareness, learning, openness, and engagement.

Data-focused Urban Initiatives. Initiatives with a data focus are encouraged that may be city wide or project-based in support of enhancing some aspect of city life while providing opportunities for involving people more directly with data in relation to awareness, learning, openness, and engagement.

Such interventions and initiatives support the potential to provide insight into the concept of *meaningful openness* while raising the value of urban open data beyond that of what is said to be “low value” [30].

Dependent and Independent Variables. Dependent variables (DV) emerge for *ambient data access and value* and *ambient data access and value.* Associated independent variables (IV) for *ambient data access and value* pertain to: mobile data sharing; urban intervention data sharing; and data interpretation tools. Associated independent variables for *ambient data access and literacies* pertain to: digital data in public spaces; the value, nature, and complexities of data; and new forms of education for learning cities.

7 Conclusion

This paper develops the ambient access construct in relation to urban data through a review of the research literature and an exploratory case study conducted in relation to awareness, learning, openness, and engagement at the urban level. As such, this work creates a space for debate, theorizing, and exploration around the construct of ambient access for data in smart cities, learning cities, and future cities. In addition to the contributions this work makes to urban theory, the data dimension of universal access, and the smart cities literature, the dependent variables of *ambient data access and literacies* and *ambient data access and value* are identified, along with several associated independent variables for each.

A key take away from this paper is the importance of urban data literacies with implications for access and in turn, realization of the emerging value potential of urban data along with the complex issues associated with access. This work will be of interest to students, educators, researchers, data managers and analysts, city managers, policymakers, urban planners and designers, and anyone concerned with smarter approaches to urban data and access in contemporary and future cities.

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