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Implications of smartphone usage on privacy and spatial cognition: academic literature and public perceptions

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Abstract The exponential adoption of smartphones affords the general public access to tools (sensors) that were once only available to highly trained scientists and geospatial technicians. This provides more people with opportunities to contribute and consume information relevant to their current location. Geographers have been applying critical theory to examine privacy implications associated with constant locational aware smartphone usage while applied researchers are measuring spatial cognitive abilities using empirically bound approaches. What remains unknown is how smartphone users perceive implications associated with privacy and spatial cognitive abilities as a result of smartphone use for location based queries. An online survey was administered to collect perceptions related to these issues from the general smartphone-using public. It was found that while participants were mindful of privacy concerns associated with smartphone use, they reported that perceived benefits of smartphone use outweigh associated costs. Additionally, the majority of the participants found that their smartphones provided them with confidence in wayfinding tasks rather than hindering them as some literature suggests. Through this study we aim to describe how a lack of understanding of the general publics' perceptions of smartphone usage may be limiting contemporary theory and practice within volunteered geographic information and location based services related research associated with geography.

Keywords Volunteered geographic information · Location based services · Mobile · Smartphone · Wayfinding

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Introduction

Geographers are particularly interested in the public's use of smartphones for spatial data collection and dissemination. Smartphones are mobile phones that contain additional sensors providing applications, which afford their end user with locational information, Internet access, and other capabilities. Geographers are hopeful that the use of mobile smartphones will be used to reveal and impart knowledge about spatial phenomena through volunteered geographic information (VGI) combined with location based services (LBS) and associated interactive maps

(Goodchild 2007a, b; Sui 2008; Haklay et al. 2008; Elwood 2008). Rapid adoption of technologies associated with smartphone use has had effects, both socially and cognitively, on the users. As we begin to become more dependent on smarthpones for wayfinding and other geographic queries, academic geographers have identified concerns regarding the influence of smartphone use on privacy (Elwood 2008, 2009, 2010; Crampton 2010; Elwood and Leszczynski 2011; Elwood et al. 2012) and spatial cognitive abilities (Maguire et al. 2000, 2006; Ishikawa and Montello 2006; Ishikawa et al. 2008; Willis et al. 2009). What remains unknown is how smartphone users perceive these issues that have been covered in the academic literature. We were particularly interested in privacy concerns and spatial cognitive abilities because they have been covered both in academic literature and the press. Additionally, we aimed to uncover perceptions related to one issue from critical geography (privacy) and one issue from applied geography literature (spatial cognitive abilities), both associated with smartphone use. A lack of understanding of the perceptions of smartphone usage may be limiting contemporary theory and practice within the geography and specifically VGI and LBS related research. Theories about how people *should* use smartphones could be developed lacking insight about how people are *actually* using their smartphones. Therefore it is our aim to identify how perceptions of smartphone use match and diverge from the academic literature.

Here we pose three research questions: (1) Are smartphone users aware of their participation in spatial information contribution associated with VGI and LBS? (2) How concerned are the public with privacy implications associated with smartphone use? (3) How do people perceive their spatial cognitive abilities as a result of smartphone usage for wayfinding? To find answers to these questions, an online survey was administered.

We first present recent academic literature, pertaining to smartphone use, that relate to the research questions. Responses from the survey conducted for this study are shared and then synthesized with relevant literature. We aim to illuminate how smartphone users understand and view VGI and LBS usage, privacy concerns and spatial understandings compared with the perspectives shared in recent academic literature.

Background

Mobile smartphone technology is being rapidly embraced. In 2013, 91 % of American adults had a mobile phone and 55 % of American adults had a smartphone (Pew Internet Project 2014). A growing portion of the population in the United States are using their smartphone to obtain directions, 49 % of those surveyed in 2012 (Duggan 2014) and up to 74 % use smartphones for wayfinding (Pew Internet Project 2014).

VGI + LBS + smartphones

Volunteered geographic information presents an opportunity for individuals to offer spatially relevant data to a wide Internet enabled audience (Goodchild 2007a, b). LBS provide the ability to access locally relevant information to a location aware device user (Gartner et al. 2007; Jiang and Yao 2007). The collection of geographic information from smartphone users may be collected knowingly or unknowingly (Thatcher 2013). Collecting VGI and then distributing it to others via LBS, is an interconnected cyclical process making it difficult to distinguish when and where each act begins and ends (Ricker et al. 2014).

VGI also provides an opportunity to record dispersed and diverse data about physical landscapes through citizen science initiatives on a scale that was previously not possible (Haklay et al. 2008; Goodchild 2007a, b, 2009; Gouveia and Fonseca 2008; Tulloch 2008; Coleman et al. 2009; Wiersma 2010). This has brought about concerns associated with data quality and reliability, and how to organize spatial data infrastructure (SDI) for heterogeneous data (Goodchild and Janelle 2004; Wilmersdorf 2007; Budhathoki et al. 2008; Elwood 2008, 2009), and VGIs role in citizen science (Gouveia and Fonseca 2008; Tulloch 2008; Coleman et al. 2009; Goodchild 2007a, b, 2009; Wiersma 2010;).

Volunteered geographic information scholars have also focused on the contention between what is and is not considered participation (Goodchild 2007a; Seeger 2008; Tulloch 2008; Cinnamon and Schuurman 2013) what is and is not represented on digital maps created by publics (Zook and Graham 2007; Crampton 2009a, 2010; Kelley 2014), as well as a rationale for

their contribution (Goodchild 2007a; Coleman et al. 2009; Wiersma 2010; Walker and Rinner 2013).

From a critical cartography perspective, scholars are questioning resulting power relations from maps generated or modified through bottom up VGI approaches (Zook and Graham 2007; Crampton 2010; Elwood and Leszczynski 2012; Elwood et al. 2012; Brunn and Wilson 2013; Haklay 2013), highlighting that digital divides are reflected in VGI contribution (Cinnamon and Schuurman 2013; Kelley 2014). While these services can be harnessed for the collection and digitization of local knowledge, bringing attention to places and issues that may not receive notice otherwise, other communities may go under represented making digital divides (in)visible digitally (Zook and Graham 2007; Wilson 2011, 2012; Elwood and Leszczynski 2012; Cinnamon and Schuurman 2013; Stephens 2013). Stephens (2013) clearly illuminates how content relevant to woman are glaringly missing from OpenStreetMaps (OSM), one of the most prominent open source VGI projects on the web. Haklay (2013) warns that the likelihood of VGI democratizing geographic information systems (GIS) is severely overestimated.

Other noticeable topics regarding opportunities for VGI covered in academic literature include urban planning and political participation (Johnson and Sieber 2013), education (Goodchild 2007b; Sui 2008; Haklay et al. 2008), epidemiology (Wasserman 2011; Cinnamon and Schuurman 2010, 2013; Goranson et al. 2013), health (WHO 2011; Cromley and McLafferty 2012; Cinnamon and Schuurman 2013; Zargaran et al. 2014) and disaster management (Andrienko and Andrienko 2007; McFerren et al. 2007; Meier 2012; Roche et al. 2013).

With this in mind, 49 % of smartphone users use (what we consider) LBS while only 8 % of Americans claim to share VGI (Duggan 2014), the outspoken few (Zook and Graham 2007). Given these numbers it is surprising how much literature focuses on a phenomenon (VGI) where relatively few presently contribute. Without an inspection of the perceptions held by the public, who are the main drivers of the opportunity associated with VGI, there is a significant possibility that the technology may dictate users' behavior, rather than technology adapting to needs of the users, which may render the technology frivolous (Kessler 2011). While an increasing number of people are embracing mobile technology, their habits (rituals?) are continually evolving. Focusing on location awareness, in the next sections we present current literature pertaining to the use of VGI and LBS and users' perceptions of privacy/surveillance, and spatial cognitive abilities resulting from smartphone use.

It is worth acknowledging that when a volunteer is entering or consuming spatial data, or any kind of data, they are *alone* sitting at their desk or behind their smartphone, not engaging directly with another person or physical place (McConchie 2008).

Privacy

While smartphones and associated LBS can connect some and disconnect others, it is also increasingly possible for unintended viewers to access content being posted. When a volunteer contributes information to one application, this information may be repurposed in often unknown ways when an application makes their application programming interface (API) open and sharable to other applications (Elwood and Leszczynski 2012; Leszczynski 2014). We do not want people who have power over us, to use our online content against us. It is hard to post content for an intended audience, when your audience could be anyone (boyd 2014).

There are a number of ways in which users can share their location knowingly either through check-ins (touch a button to document where they are in that moment) or sharing their location in a post on social media (ex. Geotagged Tweet), yet only 8 % of Americans claim to share locational information in these ways (Duggan 2014). Users are often able to share their location without knowing; sometimes an application may collect their geographic coordinates to then give them recommendations (including advertisements) based on their current position. App developers can use the orientation sensor in the user's device to detect which direction the user is facing, proximity sensor to see how close they are to a point of interest, and even the geomagnetic field sensor to sense the raw field strength for each coordinate axis, then figure out if the user is on a bike, in a car or sitting still (Apple 2014; Android Developer 2014). While these advances are remarkable, we know little about how the public perceives this location aware phenomenon. Understanding risk is difficult because the perception of risk is a subjective experience influenced by various individual factors (Slovic 1987).

Both academics and the general public seem to be well aware of these privacy concerns. LBS literature regarding privacy of location and use for tracking purposes has been covered from multiple perspectives and is a growing literature (Iqbal and Lim 2007; Mascetti et al. 2007; Clarke and Wigan 2011; Thurman 2011). Geosurveillance is defined as "the surveillance of geographical activities" (Crampton 2010: 113) or simply the observation of instances or movements across space. Crampton (2010) uses several examples of how governments and people with great amounts of power can use this information for sinister purposes. Foucoult's (1975) description of a panopticon, a prison where the guard is in the center and may or may not be looking at the prisoners at any time, where the prisoner constantly feels watched, acts as a metaphor for the surveillance society in which now live (Crampton 2010). Now someone always has a camera in his or her back pocket or hand. People have the ability to take a (geotagged) photo of whatever is happening at any given moment that can be contributed to the Internet. We live in a location aware omnopticon where the many survey the many as a result of the ubiquity of mobile smartphones (Rose-Redwood 2006; Elwood and Leszczynski 2011). Users of smartphones are increasingly aware of the omnopticon however likely not in those terms.[1]

In one recent empirical study, participants were asked to observe, reflect and record experiences with LBS to investigate readiness to share locational information (Abbas 2011). Experience and willingness to share information differed dramatically between participants, based on their relationship and concerns of trust between partners, parents, employers and security relating to strangers (Abbas 2011). Kar et al. (2013) found that smartphone users were largely aware of privacy concerns but did not change behaviors based on their concerns, seeing the value of smartphone usage to outweigh the drawbacks. The notion of privacy is being reconfigured and documented (Clarke and Wigan 2011; Elwood and Leszczynski 2011; Turkle 2011; Kar et al. 2013; boyd 2014). Teens have different privacy expectations. They believe that just because they post something online for anyone to read, it does not mean everyone *should* read it (boyd 2014).

It is not just teens that are sensitive about who has access to material they present online, educational background also may influence perceptions and understandings of privacy. Mathews et al. (2013) found that students who have taken a GIS course are more aware and concerned with privacy issues surrounding smartphone use, but are no less likely to contribute VGI or use LBS. Largely, LBS users want to use their smartphones to help them call attention to their whereabouts, and/or their movements, engaging in "conspicuous mobility" (Wilson 2012).

Despite concerns associated with privacy and LBS use, the cost benefits of using these applications often outweigh the risks on varying scales. From a large-scale perspective, society stands to benefit from the use of this data for public health and criminal surveillance purposes. During Vancouver Riots in 2011, law enforcement shared video surveillance footage and invited the public to help identify those who engaged in criminal activity since there were not enough police officers to enforce the law in real time (Michael and Michael 2011). The use of VGI could also be used to identify epidemiologic patterns necessary to link time, place, and people associated with transmission of disease (Goranson et al. 2013) and injury trends (Cinnamon and Schuurman 2010). However, collecting sensitive health data and associated locational information poses serious privacy risks to those who contribute this personal information (Jones et al. 2011; Goranson et al. 2013). What remains unknown is how these evolving digital practices will increasingly influence both in person and online social norms.

Spatial cognitive abilities

Researchers are starting to investigate social and geographic learning implications of smartphone use. Roth (2013) provides an extensive literature review describing what we know and what we still need to learn about interactive cartographic visualizations, rightfully calling for a reevaluation of the literature to accommodate mobile map usage. Initial studies testing spatial understanding, primarily for wayfinding, one of the most common geography related tasks associated with smartphone use, have identified negative implications that result from smartphone use (Ishikawa

[1] A photo of Prince Harry was recently taken in Las Vegas when he was dancing naked with women, photo leaked as a result of the omnopticon not panopticon http://www.bbc.com/news/uk-21119721.

et al. 2008; Willis et al. 2009). These studies are being conducted in fields that traverse geography and psychology.

As humans navigate an environment or interact with a map, they use spatial cognition to construct a cognitive map or mental map of the area traveled (Downs and Stea 1973; Kitchin and Blades 2002; MacEachren 2004; MacEachren et al. 2004; Davies et al. 2010). These cognitive maps are developed procedurally, building configurational understandings of a landscape over time (Kitchin 1996; Kitchin and Dodge 2007). Imparting configurational knowledge while providing adequate navigational visualizations and direction is a well-known challenge filled with tradeoffs in terms of mobile map and user interface design (Kitchin 1996; Kettunen et al. 2012; Münzer et al. 2012; Roth 2013).

Navigational performance is reduced by preoccupation with secondary tasks such as viewing a smartphone, rather than observing the environment in which the user is situated (Lindberg and Gaerling 1983; Willis et al. 2009). To compare the differences and the implications of smartphone use for wayfinding versus traditional paper maps, Willis et al. (2009) organized two groups of participants navigating a real environment: one group learned an environment from a map, the others learned using a mobile map. Willis et al. (2009) found that mobile map users performed worse than map users on route distance estimation, indicating that pedestrian navigational systems have potential to effectively convey local space visible to the user in that moment, but fail to transfer configurational knowledge. Navigational performance is reduced by preoccupation with secondary tasks such as tending to the smartphone user interface (Lindberg and Gaerling 1983; Willis et al. 2009). Ishikawa et al. (2008) also reported negative implications of using mobile devices because GPS users traveled more slowly, made larger directional errors, drew sketch maps with poorer topological accuracy, and rated wayfinding tasks as more difficult than subjects who participated in direct-experience. Willis et al. (2009) identify cognitive problems associated with mobile maps to include attentional fragmentation, lack of reference between interface and environment and passive user interaction. Negative implications associated with the use of GPS for wayfinding tasks may be mitigated with improved and tailored user interface (Davies et al. 2010; Haklay 2010; Haklay and Skarlatidou 2010).

Studies from tourism literature indicate that tourists visiting a new landscape feel more confident when they use smartphones (Wang et al. 2012). They felt encouraged to visit more places and try new things (Wang et al. 2012). From a spatial cognitive perspective, there seems to be a spectrum of benefits and drawbacks associated with smartphone usage where the perceived benefits differ from the cognitive benefits.

Methods

The research questions we are seeking to answer are: (1) Are smartphone users aware of their participation in spatial information contribution associated with VGI and LBS? (2) How concerned are the public with privacy implications associated with smartphone use? (3) How do people perceive their spatial cognitive abilities as a result of smartphone usage for wayfinding?

To find answers to these research questions an online survey was created and implemented. The survey instrument posed a multiple choice, Likert scale and open-ended questions. The questionnaire consisted of ten multiple choice (radio buttons or check boxes), one ranking question, and nine open ended questions.

Three undergraduate geography classes at Simon Fraser University in Burnaby, BC, Canada and three undergraduate geography courses at Frostburg State University in Frostburg, MD, United States were recruited to participate in this survey. Those targeted for this survey were undergraduate students and likely tech savvy digital natives. While these geography students may have had a class where a few of the topics from geography literature pertaining to VGI and LBS were brought up, these were GIS, cartography and remote sensing courses, so the students were not experts or particularly familiar with the literature that was presented in the background section of this manuscript. Responses from the survey were collected from Feb. 29, 2012 to March 14, 2012 and responses to a modified updated version of the questionnaire were collected from March 25, 2013 to May 3, 2013. Those who took the survey in 2012 and 2013 had similar demographic characteristics.

The original survey that was implemented in 2012 posed questions regarding privacy, participation in terms of VGI vs. LBS and spatial cognition. Responses from the open-ended questions revealed increasing concern about how smartphones infringe on social interactions. Therefore a similar survey was implemented in 2013 replacing some of the former questions with new questions relating to topics that emerged from the open-ended questions. These questions related to social interaction and spatial cognitive abilities. See "Appendix" for questions that were included in the online survey opened in 2012 and 2013.

All data collected were tallied using Excel. From the data collected via the open-ended questions, two research assistants (one being the first author) thematically coded the responses. The themes and subthemes that emerged were identified and matched to existing literature and associated research questions.

Table 1 Sample gender makeup from each year we collected responses to an online survey regarding participants' perceptions of Smartphone usage

Sample size	Men	Women	Total
2012	40	46	86
2013	21	35	56
Total	61	81	142

Table 2 Break down of the age ranges of the sample, 91 were under the age of 30 while 50 were over the age of 30

Age	2013	2012	Total
18–25 years old	17	49	66
26–30 years old	10	14	24
31–40 years old	12	19	31
41–50 years old	7	1	8
51–60 years old	4	0	4
>61	4	2	6
Decline	0	1	1

Results

Here we present the responses from 142 participants who responded to the online survey in 2012 and 2013. Eighty-one participants were women and 61 were men. (See Table 1 for gender breakdown of participants).

The majority of the participants in this study were under the age of 30 and therefore considered digital natives (See Table 2 for age demographic).

One hundred thirty-one of the participants said that they used their smartphone several times an hour or several times a day. Only eight participants said they used their smartphone once a day or less, meaning all of the respondents were avid smartphone users. Responses indicated that users feel attached to their smartphones and use them for a wide variety of purposes.

Responses related to VGI and LBS

From those who participated in 2012 and 2013, 50 % (n = 71) said yes they had contributed VGI, 35 % (n = 50) reported, no they have not contributed VGI and 15 % (n = 21) were unsure if they had or did contribute VGI. Very few respondents reported that they share VGI in the form of geotagged photos (n = 15), or track their movements (n = 9). Seventy-nine percent used smartphone for LBS (n = 111 to obtain directions, n = 88 to find transit information). While citizen science participation related questions were not asked explicitly, when asked if participants had contributed any other kind of VGI in the open ended-question; no one reported that they had taken part in citizen science initiatives, political participation, or mobile health related apps. Figure 1 displays the percent of the total sample that answer 'yes' or 'no' to specific questions about participation.

From the open ended question about why you 'do' or 'do not' contribute VGI, fifteen people shared responses related to privacy or safety for reasons 'not to' share VGI, four people said they allow apps to access their locational information to obtain better service from the apps, while only four people said it was fun to share this information with social media. Three said they share this information with specific people, and two people said they see no use for sharing VGI. One person said they didn't contribute VGI because they didn't have the money for a data plan. Examples of direct quotes from open-ended questions related to why they 'do' or 'do not' share VGI are shared below:

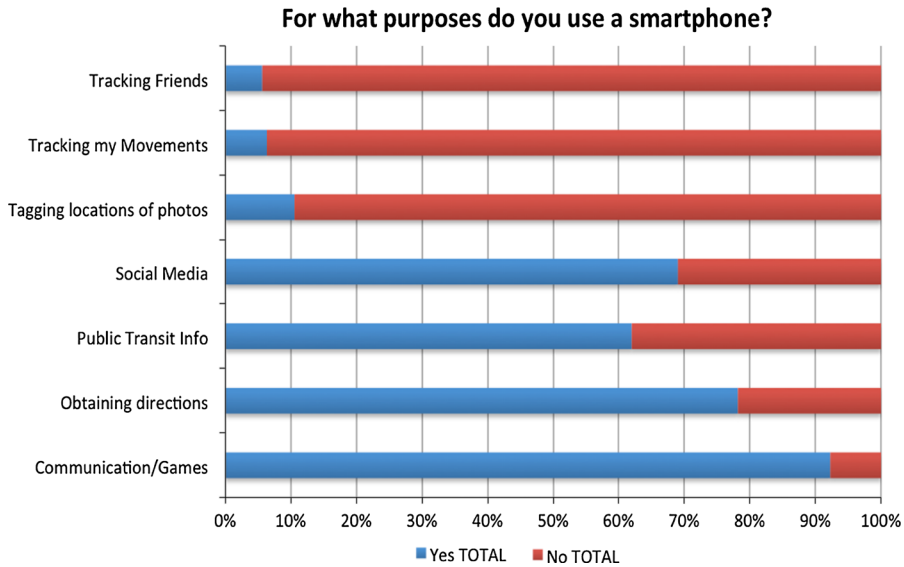

Fig. 1 Percent of total responses from multiple-choice question, "For what purpose do you use a smartphone (Please select all that apply)

> "If I feel an application will work better, I will allow it to track where I am going. Sometimes I accidentally allow it to and don't bother turning it off."
> "I only shared the personal geographic information using a Smartphone in very public or commonly known places such as a mall or busy restaurant."
> "Don't have apps that would ask for it."

Responses related to privacy

The issue of privacy came up frequently in responses to the open-ended questions. Very few of the participants answered that they use geolocational services to track their own (n = 9) or their friends movements (n = 8), or even knowingly geotagging photos (n = 15). While participants indicate that they do consume locationally relevant information (transit information, directions), they do not wish to post information about their movements in cyberspace. In an open-ended question about privacy specifically in 2013, only 36 responses were collected. Each response had to do with a fear of strangers, the government, or cyber criminals and stalkers using this locational information for sinister purposes. Four people brought up data mining and targeted advertising as a specific concern.

The specific term "privacy" was brought up in the open-ended questions 13 times in the 2013 survey and 5 times in 2012. In the 2013 survey there was a question specific to privacy, 9 of the respondents mentioned fear of the government having their information. Below are two direct quotes from the 2013 survey:

> "I am concerned about the potential misuse of said data by telephone companies or government agencies."
> "I'm not generally concerned, although I do realize that there could be risks involved in this surrendering of privacy. I do not like the idea, for instance of the government and law enforcement having unfettered access to the whereabouts of everyone using a smartphone. I probably should be equally uneasy about a private company having such access… but for the time being those companies' use of such info has seemed relatively benign. My views on this may evolve if I see evidence of more nefarious usage."

Responses related to spatial cognitive abilities

Participants used their smartphone frequently in both unfamiliar environment (80 %, n = 115) and in familiar places (84 %, n = 120).[2] Forty-six percent (n = 67) reported that they had tried a new restaurant or found a new business as a result of using their smartphone. Fifteen percent (n = 4) used smartphones to get to a destination

[2] For ranking questions including this one, we counted all responses that were 3, 4, 5 and categorized them as being "most frequently".

more quickly, while 54 % (n = 78) use them to avoid being lost, yet 18 % (n = 26) reported they have gotten lost while using their smartphone for directions. Twenty-six percent (n = 36) reported to have gotten lost when following directions. Seventy-five percent (n = 106) of the respondents said they had NOT gotten lost while using a smartphone, and some even said they felt more confident with their smartphone in tow.

In the 2013 survey when asked specifically if they were concerned with their resulting cognitive abilities, of the 56 people who responded, 43 total reported to be concerned (n = 22) or very concerned (n = 21) about this implication. When asked explicitly if their cognitive abilities had changed of the 56 who responded, 17 reported 'yes', 27 said 'no' and 12 were 'unsure'. While the majority reported to not being aware of changes in their cognitive abilities, they were still concerned there may be changes.

From the qualitative data collected via the open-ended questions, ten people relayed responses that indicated they feel more confident navigating an environment when they have their smartphone for help. Four people shared responses that indicate that they think their sense of direction has improved; three responses indicated they have less awareness of their surroundings. Five respondents had positive responses about smartphone usage.

> "I've gained confidence in navigating without GPS due to exposure of new routes. I've experienced more places and towns because I can rely on GPS. To get me there and back."

This confidence also included convenience of constant access to information relevant to their location. In an open-ended question about how your life would be different without a smartphone, 10 responses used the specific word 'convenience' while 40 of the responses were coded under the idea of convenience, since they used terms like "easily." If they also used words referring to social media or communication then they were counted under the theme of social connection as well.

Discussion

Considerations for VGI and LBS moving forward

From the survey we administered online, the majority use LBS (for transit information) and half reported that they knowingly contributed VGI. This displays higher percentage contributing VGI compared to those surveyed in a Pew recent report (Duggan 2014), but this may be due to the age demographic and the educational background (geographers) of the sample in our survey, as well as possible mismatches between how VGI and LBS are understood and defined.

Table 3 Comparing the percent of the sample from our online survey with results of the entire American population from a resent Pew Report

Report	VGI	LBS
2013 Pew (Duggan 2014)	8 % of Americans	49 % of Americans
Online survey for this study	35 % of our sample	79 % of our sample

Yet, this survey indicated that there is a higher proportion of LBS consumers than VGI contributors, which largely reflects the findings from Pew report (Duggan 2014), supporting the claim that "the outspoken few" largely control the content offered via LBS (Zook and Graham 2007). Table 3 shows a comparison between the findings collected from the sample for this survey compared to a 2013 Pew report collecting information about VGI and LBS (Duggan 2014).

No one who participated in this survey made mention of using VGI or LBS for urban planning and political participation (Johnson and Sieber 2013), education (Goodchild 2007b; Sui 2008; Haklay et al. 2008), epidemiology (Wasserman 2011; Cinnamon and Schuurman 2010, 2013; Goranson et al. 2013), health (WHO 2011; Cromley and McLafferty 2012; Cinnamon and Schuurman 2013; Zargaran et al. 2014) and disaster management (Andrienko and Andrienko 2007; McFerren et al. 2007; Meier 2012; Roche et al. 2013) all of which are areas where VGI and LBS hold great promise.

Smartphone users may or may not be digitizing places they know to benefit themselves or represent their lived experiences for reasons other than personal interest (Zook and Graham 2007; Crampton 2009a, b; Crampton 2010; Coleman et al. 2009; Wiersma 2010; Goodchild 2007a, b; Walker and Rinner 2013), they are likely unaware of the possible resulting power relations that may result from their contribution as suggested by Zook and Graham (2007), Elwood and

Leszczynski (2012), Brunn and Wilson (2013) and Haklay (2013). While those who participated in this survey seemed more worried about their personal privacy; they did not make overt reference to any understanding of the importance or power that may come from contributing VGI than what is discussed in recent Geography literature (Zook and Graham 2007; Crampton 2009a; Crampton 2010; Elwood and Leszczynski 2012; Brunn and Wilson 2013; Haklay 2013; Leszczynski 2012). Goodchild (2007a, b) suggests that the value in VGI is bringing attention to local values and phenomena that may go unnoticed otherwise, people are enjoying the documentation of these local business through the use of LBS.

Contemporary research and resulting literature pertaining to VGI and LBS usage could benefit from insight into perceptions and the rationale held by the general public who are using smartphones. Perhaps more people would be willing to contribute VGI to citizen science, epidemiology and other spatial data collection endeavors that would benefit science and society, if a service of value to the data contributor, or the app user, such as displaying aggregated data, or incentivizing the process in some way. For example an additional service could be unlocked if the user contributes VGI. More research into this realm is needed. As Kessler (2011) warns, if we don't understand this, the technology will dictate what people do, rather than people dictating the technology to meet their needs.

Considerations regarding privacy and surveillance

Literature regarding privacy and VGI seems right on point matching concerns with the public. Many of the debates in geography literature related to VGI and privacy are relevant to the general public. The majority of the respondents indicated that they do not contribute VGI for privacy reasons, which matches ideas illuminated by Crampton (2010) highlighting concerns regarding government surveillance of the general public.

Participants in this study seemed aware that governments, unwanted watchers, and marketers have the ability to infringe on their privacy through the use of other smartphone services, but they are not concerned enough to stop using their smartphone, which matches ideas posed by Elwood and Leszczynski (2011). No one admitted to being one of the watchers. If they are using smartphones for tracking purposes, it is likely they will not admit it since they see this behavior as "creepy". (Abbas 2011; Kar et al. 2013). While the general public may not be using the same jargon as academics to describe concerns, the awareness of the privacy implications associated with the omniopticaon are present. Those who participated in this survey agree with scholars who indicate that notions of privacy are dramatically and rapidly evolving, we are aware of possible privacy infringements associated with smartphone use but not concerned enough to stop using the services at this time, much like what has been suggested by Clarke and Wigan (2011), Elwood and Leszczynski (2011), Turkle (2011), Kar et al. (2013), boyd (2014).

Participants in this study made it clear they want to enjoy the services provided by apps that offer locally relevant information. They admit to knowing there is a threat to their privacy involved in this exchange. For the time being, they are willing to make this tradeoff. This isn't to say but this may change in the future. We are in the "wild west" of app development and repurposing data collected from users, where laws are being written as security breaches are being violated and not before. Increasingly, users are aware of this trend but until some significant privacy breach or drawback occurs, it seems users are willing to continue using LBS and VGI as is.

Contemporary literature pertaining to privacy associated with smartphone use could benefit from investigating public perceptions of privacy and the evolution of privacy concerns. Further attention could be brought to illuminate the benefits of sharing personal information for aggregation, and analysis and social good such as for public health purposes, crime prevention, or environmental modeling.

Spatial cognitive literature versus public perceptions

While it is well known that navigation ability and spatial cognition diminish as a result of using mobile maps (Lindberg and Gaerling 1983; Maguire et al. 2000;

Ishikawa et al. 2008; Willis et al. 2009) it was found that the participants don't seem to notice or care that their spatial cognitive abilities may be shifting. Literature suggests that people get lost longer as a result of being highly distracted during wayfinding (Lindberg and Gaerling 1983; Ishikawa et al. 2008; Willis et al. 2009) only 26 % of those surveyed, reported to have ever gotten lost while using their mobile device for wayfinding.

In fact, participants reported to feel more confident during wayfinding tasks when they had their smartphone in tow. Given reports about the negative implications of using a device for wayfinding reported in the literature (Maguire et al. 2000; Ishikawa et al. 2008; Willis et al. 2009), this was surprising. However, tourist literature has studied public perceptions of smartphone use for tourism related tasks and found that people were more confident and comfortable in a new place with these wayfinding aids and associated LBS (Wang et al. 2012). Those in our study reported that they use their phone in familiar and unfamiliar environments, which indicates that people use their phones everywhere if they need them for wayfinding or finding a new business. The majority of participants in this study reported that they had tried a new restaurant or found a new business as a result of using their smartphone, which also matches Wang et al. (2012) findings from tourism literature. Our relationship with navigating new and old environments with the use of smartphones is changing our expectations of experience in place.

It is possible that more people are reporting that they are getting lost less often because user interfaces have improved tremendously. The Willis et al. (2009) and Ishikawa et al. (2008) studies were conducted over 7 years ago, a lot has changed in terms of data access and availability, user interface design, user comfort level with technology and their expectations. Perhaps mobile map makers have incorporated suggestions made by Willis et al. (2009) and made more references between interface and environment, making user interaction more active and less passive, and created more tailored user interfaces.

Whatever the specific reason, people are becoming increasingly depended on their smartphones for wayfinding. Studies should be continuously conducted to monitor spatial cognitive abilities associated with smartphone usage based on interface evolution and user expectations and experience. Contemporary literature should be mindful of user perceptions and user needs associated with mobile mapping. Geographers are in a strange conundrum in that, as geographers and cartographers our responsibility is to design cartographic products to meet user needs. However, it is worth investigating how to help users meet their needs while imparting as much geographic understanding as possible in the process.

Limitations

Through this online survey we were only able to collect *perceptions* of behaviors rather than actual *behaviors*. It is unknown if the participants have in fact taken part in a citizen science initiative, public participatory or epidemiological study without knowing it. They may report using their smartphones in certain situations or report never getting lost when in fact they have gotten lost or taken longer to get to their destination without knowing it.

Another challenge while building the questionnaire was selecting terms that were semantically relevant to the general public and correctly matching them to terms from academic literature. It is unclear whether the participants fully understood what each question was asking, for example in the open-ended responses with questions regarding spatial cognitive abilities, two respondents answered with comments about their ability to navigate an application user interface rather than navigate, an environment associated with for wayfinding. As with all surveys, another limitation is that certain responses may be prompted inadvertently based on previous questioning in the survey. These are a representative population of smartphone users today.

Conclusions

The aim of this study was to illuminate how a lack of understanding of the perceptions of smartphone usage may be limiting contemporary theory and practice within the geography and specifically VGI and LBS

related research. They are limited in that the priorities of the researchers do not always match the perceptions of the general public in terms of smartphone use and associated with geographic thinking. By investigating recent geographic literature and collecting perceptions of smartphone use through the implementation of an online survey, it was found that the literature largely matches the interests of the public. Similar to a recent Pew study (Duggan 2014), far more people consume LBS than contribute VGI. People are primarily using their smartphones to find locational and temporally relevant information such as transit times. They are less likely to share locational information primarily due to privacy concerns, but also because many do not see the utility. There is a large body of literature that is very excited about VGI for research purposes, even though a very small portion of the population contributes this type of information.

Therefore, we tried to provide insight into how a lack of understanding of the perceptions of smartphone usage may be limiting contemporary theory and practice within the geography and specifically VGI and LBS related research. Without this insight, we risk creating technology that is not useful to the target audiences, and investigating theory and ideas that are not of interest to the general public and who are the main drivers of content collected via VGI.

Through this research it was found that while smartphone users are largely aware of privacy risks associated with smartphone use, they are not willing to change behaviors at this time. They understand that the content the provide on their smartphone maybe reused in unintended ways, most sharing that they were concerned the government would gain access to their private information.

Additionally, smartphone users are not concerned with resulting spatial cognitive abilities associated with smartphone use, they are more concerned with achieving wayfinding goals. They report feeling more confident navigating an environment with the aid of their smartphone device despite that spatial cognitive literature suggests otherwise. Early research regarding smartphone use for wayfinding found that people suffered negative consequences from the use of these mobile devices getting lost longer and making larger directional errors. If this is now the case outside of the confines of research contexts, the general smartphone user does not seem to either notice or mind these seemingly negative consequences. This could be due to the fact that mobile user interfaces have improved greatly since these early studies or that people are more familiar with navigating them.

Social norms and expectations will continue to evolve as mobile technology increasingly permeates our lived experiences and assists us with day-to-day tasks. As researchers, it is important for us to study ways in which we can use this technology for good, but also how the general public is already using the technology, so we can better design LBS and VGI projects that will be successfully embraced in the future. Understanding public perspectives and existing use may help in this endeavor.

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Appendix: Here we present the questionnaire that was provided to the sample population to collect information regarding perceptions of smartphone use. Text in strikeout font represent questions that were present in the 2012 questionnaire but not in 2013. Text in bold was presented in 2013 only and not in 2012 questionnaire

~~1. How long have you been using a computer?(Select one best answer)~~

~~a. 0-1 year~~
~~b. 2-4 years~~
~~c. 5-10 years~~
~~d. 11-15 years~~
~~e. 16-20 years~~
~~f. 20+years~~

2. How often do you use a Smartphone? (Select one best answer)
    a. Never
    b. 1-5 times in my life
    c. Once a week
    d. Once a day
    e. 3-5 times a day
    f. 3-5 time an hour

3. Do you own a Smartphone? (Smartphone is a mobile phone or a mobile computer with Internet capabilities) Select Yes or No.
    a. Yes
    b. No- skip to Question 15

4. What do you use a Smartphone for? (Select all that apply)
    a. Texting
    b. Email
    c. Surfing the Internet
    d. Games
    e. Finding new places
    f. Finding my friends
    g. Facebook

5. Where do you use a Smartphone? (Select all that apply)
    a. Places I am familiar with
    b. Places I am not familiar with
    c. Urban environments
    d. Non-urban environments
    e. All of the above

6. How does your Smartphone use facilitate interaction in an environment? (Select all that apply)

    a. I have tried a new restaurant
    b. I have found a new business

7. Have you ever been bothered by Smartphone use?
    a. No
    b. Yes
    c. If Yes –Textbox

8. How would your life be different without a Smartphone?
    a. Textbox

~~9. What apps do you use regularly?~~
~~a. Textbox~~

10. Have you ever shared geographic information using a Smartphone?
    a. Yes
    b. No
    c. Not sure

11. Please indicate why you have or have not shared geographic information using a Smartphone.
    a. Textbox

12. On a scale of 1-5 how concerned are you with privacy and contributing geotagged /locational information? (1 not very concerned 5 highly concerned)

13. Who do you perceive as being a threat in viewing your geographic information?
    a. Textbox

14. Have you noticed a change in your perception of a neighborhood you have visited or you live in since you have started using a Smartphone?
    a. Yes
    b. No
    c. Unsure/neutral

15. Have you observed any changes in your navigation abilities since you have started using a Smartphone?
    a. YES
    b. NO
    c. If Yes- textbox

16. Do you view these changes in your navigation abilities as positive or negative?
    a. Positive
    b. Negative
    c. Neutral

17. If you responded that you see these changes in your navigational abilities as positive or negative, please explain.
    a. Textbox

18. On a scale of 1 to 5 how concerned are you with implications of Smartphone use influence on social skills (1 not very concerned to 5 highly concerned)?

19. What appeals to you about Smartphone use?
    a. Textbox

20. Did you take a similar questionnaire last year?
    a. Yes
    b. No
    c. Unsure

21. What is your age range?(Select one best answer)
    a. 18-25 years old
    b. 26-30 years old
    c. 31-40 years old
    d. 41-50 years old
    e. 51-60 years old
    f. 61+

22. What is your gender?(Select one best answer)
    a. Female
    b. Male

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