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Invisibility through the interface: the social consequences of spatial search

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Abstract
Location-based services are mobile applications that use a device's location to provide relevant results. Spatial search applications are a popular subset of location-based services that enable people to search through their surrounding space to find nearby locations. This article examines spatial search applications through a framework that combines critical geography research with research on the power search engines exert over information visibility. The main argument of the article is that popular spatial search applications, such as Yelp, may subtly reproduce existing forms of spatial segregation by rendering certain location invisible through the mobile mapping interface.

Keywords
foursquare, hybrid space, inequality, locative media, mobile media, smartphones, spatial search, yelp

The city of Denton, Texas, is one of the 10 fastest growing cities in the United States (Census.gov, 2012). Like many cities and towns in Texas, Denton features a sizable Hispanic population and, unfortunately, the same types of segregation that are part of the American urban landscape. That segregation shapes the demographic makeup of Denton's various neighborhoods, and it also plays out in the spatial distribution of its restaurants, particularly on one of the main streets leading to the city's town square. The street is the epicenter of Denton's Mexican food culture and is known locally as the 'East McKinney taco corridor'. The street got that nickname because it features five small,

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authentic taquerias on a 1-mile stretch of road. The restaurants' clientele are mostly Hispanic, and many customers speak only rudimentary English.

One of the five restaurants is called Veronica's Café, a tiny taqueria near the end of the East McKinney taco corridor. Veronica's Café is often packed for breakfast and lunch, and yet for someone relying on the popular mobile application Yelp or similar applications like Google Places and Foursquare to map nearby locations, the restaurant barely exists. As of July 2015, the restaurant had 11 reviews on Yelp (one of them by me) and two reviews on Foursquare (one of them by me). Many of the more Americanized restaurants a quarter mile away have over 200 Yelp reviews and more than 50 Foursquare tips. That same lack of representation on Yelp and similar mobile applications is present on almost all of East McKinney street, in effect filtering out the more Mexican part of the city through the lack of representation in the spatial search results. To the mobile applications' algorithms and for some people relying on these applications to search through and filter their surrounding space, the East McKinney taco corridor barely exists.

This article uses the Veronica's Café example as a jumping off point to examine the social consequences of spatial search applications. Spatial search applications such as Yelp, Zomato, Foursquare, and Google Places are examples of location-based services that use people's physical location to provide spatially relevant results. Like with other location-based services, spatial search applications have become an increasingly important lens through which people view and experience their surrounding space, and companies such as Yelp have been valued at billions of dollars. While restaurant reviews may seem like a mundane example of the social impacts of digital media, I argue that these reviews play an important role in shaping how people understand and interact with representations of their surrounding space. They also show the importance of the 'spatial turn' (Wiley and Packer, 2010) in communication and media studies because of the ways these applications mediate how people interact with space and place. Consequently, this article extends work on the increasingly interdisciplinary relationship between place and media (Adams and Jansson, 2012; Jansson and Falkheimer, 2006) to examine how spatial search applications as a media form are contributing to new formations of contemporary spatiality.

Spatial search applications are a specific form of locative media. Locative media refer to technologies that are able to be located in physical space and provide information about the device's surrounding space. In effect, locative media are technologies of mapping (Farman, 2015). Whether through an in-car global positioning system (GPS) display or the interface of a smartphone, these media technologies are able to situate the device in relation to its distance from various types of digital information. Consequently, drawing from critical geography research on the power of maps and media studies research on the power of search engines, I argue that representations of spaces (and therefore spaces themselves (Pickles, 2004)) are increasingly produced through commercial spatial search algorithms that fail to equitably represent certain, often poorer, parts of contemporary cities. To support my analysis of spatial search, I begin by discussing research on technologies of spatial representation by focusing on the power of maps. I then move on to research on the social impacts of search engines, specifically focusing on how the algorithmic filtering of results can influence how people see the world. The final section brings these two bodies of research together in a discussion of Yelp within

the context of Denton, Texas. While my analysis focuses mostly on Yelp and Denton, I intend for the argument to also apply to other places and other spatial search applications such as Google Places, Foursquare, and Zomato. As I argue, these applications are useful, but many voices – particularly those from certain communities – are left out of the dense layers of user-generated location-based information being produced about our spaces.

Locative media, maps, and the power of representation

Locative media refer to technologies of positioning. A few examples of these technologies include in-car GPS displays, tablet computers, and, most importantly for this article, contemporary smartphones. Smartphones are able to be located in physical space and run third-party software applications that provide digital information about that surrounding space. These mobile applications are called location-based services, and they are a type of software meant to influence how people experience the physical world through access to location-based digital information (Frith, 2015). Consequently, location-based services are important from a media-geography perspective that has been developed around the intertwined relationship between software and the production of contemporary spatiality (Crang and Graham, 2007; Frith, 2012; De Souza e Silva, 2006; Frith, 2015; Kitchin and Dodge, 2011; Thrift, 2007).

Scholars have introduced multiple concepts for understanding the social impacts of the merging of physical space and digital information through software. A few examples include code/space (Kitchin and Dodge, 2011), augmented reality (Graham et al., 2013; Graham and Zook, 2013; Liao and Humphreys, 2014), augmented space (Manovich, 2006), and hybrid space (De Souza e Silva, 2006). These concepts each have intricacies, but they all build on the same observation: location-based digital information accessed through locative media (and various other forms of software as well) become a *part* of physical space, not a separate informational layer existing separate from the physical. As Paul Dourish and Genevieve Bell (2011) argue, 'Information technologies, particularly those of mobile networking and positioning, become a new lens through which the spatialities of urban space can be viewed' (p. 120).

These technologies of positioning often rely on a much earlier technology: the map. As Jason Farman (2015) points out, the default interface for many locative media projects involves mapping, and while maps are not the default on spatial search applications like Yelp, people can display nearby locations on maps. I argue, however, that even when people are presented with location information in textual form, we still must think of these displays as an alternative form of mapping. After all, location-based information is spatial because it is embedded with locational metadata (longitude and latitude coordinates) that allow it to then be displayed in relation to the location of the smartphone. So even on a spatial search application like Yelp in which people can access location information in list form (e.g. Zara's Coffee is 1.1 km from your location), that list then becomes an alternative form of mapping, one built around a different type of representation of physical space and distance. Consequently, to analyze how certain places can be left out of the development of hybrid spaces, it is necessary to first reflect upon the power of maps.

The map is one of the more important technologies of human history. Maps have been a necessary element of global trade, countries have nearly fought wars over the placement of national boundaries on maps (Jacobs, 2012), Google Maps provides different maps in different countries to address critical political issues (Ribeiro, 2009), and mapmakers wield significant influence over how people represent and understand the world (Farman, 2010). For example, the world map most people are familiar with is the Mercator Projection. Our world maps, however, are far from an objective representation of space. Instead, in order to preserve the relative shape of land masses, enable safe nautical exploration (Dourish, 2006), and overemphasize the size of Europe for political purposes (Harpold, 1999), the Mercator Projection radically shifts the relative size of land masses. The Southern Hemisphere, most notably Africa and South America, are rendered much smaller than they actually are in relation to Europe, Greenland, and North America. For most anyone familiar with the world map we are taught in schools or access through Google Maps, Greenland is roughly the size of Africa. In reality, Africa is more than 13 times larger than Greenland.[1]

The case of the Mercator Projection is a reminder that maps are never an objective representation of reality (Wood, 1992). They can never represent a space in its entirety. In actuality, the representation of the space often does more to shape how people experience and understand the world than the actual physical space. As Jean Baudrillard (1994) famously argued, 'The territory no longer precedes the map, nor does it survive it' (p. 1), or as geographers Rob Kitchin et al. (2011) put it, 'space is constituted through mapping practices, amongst many others, so that maps are not a reflection of the world, but a re-creation of it; mapping activates territory' (p. 6). Consequently, maps are always technologies of power. Mapmakers must make choices, and the choices made when creating maps 'inscribe boundaries and construct objects that in turn become our realities' (Pickles, 2004: 145). For that reason, a movement of critical geographers arose who pushed back against the supposed objectivity of maps to reveal how mapping is a techne that always involves biases and politics hidden behind the seemingly innocuous lines used to represent the world (Pickles, 2004).

And of course, it would be impossible to create a map without biases, a map that represents everything it could about a physical space. To do so, as Jorge Luis Borges (1998) points out, would involve creating a map that is literally as large as the territory it represents, a map that would be unusable. So instead, 'A good map tells a multitude of little white lies; it suppresses truth to help the user see what needs to be seen' (Monmonier, 1996: 25). The issue of power arises because it is the mapmaker who decides what needs to be seen, and lurking behind the supposed objectivity of any mapping interface are the political, commercial, and cultural choices of the entity that creates the map. Building on that point, Farman (2015) points out that 'maps tend to obscure their own authorship to deliver their content, thus seeming to erase the interface (and its politics) entirely. As a result, the networks of circulation that allow maps to arrive are often obscured' (p. 89).

The spatial search applications examined in this article are ultimately technologies of mapping, and they consequently hide their politics behind their interfaces. Even if someone accesses the list form on Yelp or Google Places rather than the map form, the results are still displayed and organized based on physical distance, showing why, building on Foucault (2008), Carlos Barreneche (2012) labels spatial search applications 'environmental technologies'. Barreneche also points out that because the results returned through

the smartphone become more than a simple representation of the locations present in a territory, academic research must examine the algorithms that produce the results returned by these spatial search mapping technologies. I return to this discussion of the power of maps later in this article, but first, I transition to another technology that has significant influence over representation and visibility: the search engine.

Search algorithms and visibility

Marketing has built an entire sub-industry on Search Engine Optimization, the practice of designing content to appear higher in search results. For many businesses, failure to rank highly on a Google search means a significant decrease in revenue and visibility. This argument was set forth in Alexander Halavais' (2009) book *Search Engine Society*, which details how various iterations of Google's search algorithm can in large part determine what will thrive online and what will be rendered invisible. What people see is determined by search rankings, and experimental research has shown that people place great trust in search engines' ability to provide relevant information, even trusting top results when later results are more relevant to the search term (Pan et al., 2007).

The fact that Google's search algorithm emphasizes some content over other content is obvious. That is what search engines are designed to do. But that emphasis does give search algorithms outsize power in determining what succeeds and fails online. As Sivaid Vaidhyanathan points out, 'we are folding the interface and structures of Google into our very perceptions. Does anything (or anyone) matter if it (or she) does not show up on the first page of a Google search?' (p. 7). The empirical research on search results suggests most things do not matter if they do not show up on the first page of search (Machill et al., 2008), which is why people fear search engines' (particularly Google's) power to emphasize their own content over other sources returned in search results (Halavais, 2009; Pariser, 2011; Vaidhyanathan, 2011). What, in effect, occurs is that many people do not reflect upon *why* they are seeing the results they see (Machill et al., 2008); they tend to accept the results as the best results for their search term without questioning the objectivity and the biases of the search algorithm (Rieder and Sire, 2013).

In effect, search engines, though obviously a significantly different technology, share some similarity with the mapping discussed earlier. They are a partial (the first few pages of search results) representation of a territory (all possible results). Just as the mapmaker wields significant influence on how people view a physical space, the search engine exerts power over informational visibility on the Internet (Mansourian et al., 2008). Consequently, it is important to recognize how search engines influence how people view the world and analyze the consequences of the necessarily partial representation of available information. The rest of this article builds on this discussion of both mapping and search engines to show how spatial search applications combine the concerns of both areas. The main argument set forth in the next section is that media scholars must remain cognizant of the hidden biases present in the spatial representations rendered through the smartphone.

The consequences of spatial search applications

Spatial search applications are a popular subset of location-based services. People can use applications like Yelp to search for nearby restaurants or other categories of locations, and

the application returns results in list and map forms. The results are filtered based on the distance from the smartphone, the positivity of the reviews, the number of reviews, and other factors Yelp has chosen not to make public (Mott, 2014). This focus on the local and the social is why the tech press has identified applications like Yelp as part of the 'SoLoMo (Social-Local-Mobile) revolution', which is a tech buzzword dreamed up by three venture capitalists in mid-2010 to describe the increasing importance of local search applications (Fiegerman, 2013). The buzzword describes three converging trends that have shaped the mobile application ecosystem in various ways.

While other forms of supposed SoLoMo applications have been widely studied in media studies literature – particularly location-based social networks and location-based gaming (Bertel, 2013; de Souza e Silva and Frith, 2012; Frith, 2013, 2014; Hjorth and Richardson, 2014; Humphreys, 2010, 2012; Liao and Humphreys, 2014; Licoppe and Inada, 2006; Ozkul and Gauntlett, 2013; Richardson, 2010; Wilken, 2014) – spatial search applications have not received nearly as much attention,[2] despite a larger user base. The most popular spatial search application, at least in the United States, is Yelp, which has over 150 million unique users with more than half accessing the site through mobile devices (either through the application or through the mobile website), and Yelp has been valued at over US$3b (Taylor, 2012; Yelp Overview, 2015). Yelp enables people to filter through their surrounding space by highlighting certain locations over others, and it relies on its user base to provide ratings and review information that can influence how people view a location. While ratings and reviews may seem like a mundane practice, they do have real effects on the decisions people make. A study from the Harvard Business School found that an increase in positive Yelp reviews can increase an establishment's revenue by 5%–9% (Luca, 2011) and can improve a restaurant's chances of being full by 19% (Anderson and Magruder, 2012). A 5%–9% increase in revenue can often be the kind of margin that determines whether small businesses succeed or fail.

As Yelp has become more popular, its ability to represent people's surroundings and drive foot traffic has increased. The application developers also created an opaque algorithm that removes up to 20% of all reviews to make sure the system is not being scammed. Importantly, many small businesses have accused Yelp of manipulating its spatial search algorithm to emphasize negative reviews for locations that choose not to form advertising partnerships with Yelp (Mott, 2014). Yelp has denied the practice but also argued in response to a class action lawsuit filed by multiple businesses that Yelp has the right to manipulate its search algorithm in any way the company sees fit. The charges of extortion filed against Yelp are a reminder that, even when maps and location lists seem to be produced through user-generated content, all maps hide politics and biases behind the interface (Farman, 2015).

Yelp is far from alone in the spatial search market. As Wilken (2014) showed in his analysis of trade press publications, Facebook has focused on building its location layer and 'might be, and I argue ought to be, understood as a location platform' (p. 2). One of the areas Facebook has begun to focus on is its 'Nearby' feature, which has begun to 'refocus the company as a local recommendation service (taking on the likes of Foursquare, Yelp, and Groupon)' (p. 2). While Facebook is still in the early stages of entering the spatial search and recommendation market, Wilken persuasively makes the case that many of the company's acquisitions have pointed in that direction, and the fact

that tech giants like Facebook (and also Google through the growing Google Places database) have begun to focus on social, mobile, and local content shows the significant growth potential in this area. Other mobile applications, such as Foursquare, have also built spatial search capabilities, with Foursquare going so far as to develop a passive recommendation system that points people to locations without direct requests for information.

The growing popularity of spatial search applications raises important questions about the cultural impacts of locative media. As discussed above, maps have always been a technology of power; they shape how people see the world and selectively represent space. Search engines also raise questions of power by exerting an important technological agency over information visibility in online spaces. The final section of this article – through a more detailed discussion of research on inequality in hybrid space and the physical space of Denton, Texas – argues that spatial search applications combine these concerns. They, like many forms of locative media (Farman, 2015), are essentially mapping applications that display and highlight locations within a physical space; they are also search engines that use algorithms to determine information visibility and shape how people access information about their surroundings. Consequently, the argument below is that spatial search applications can contribute to new forms of invisibility in hybrid spaces by rendering certain types of locations invisible through the interface of the smartphone. As people increasingly rely on various forms of locative media to map and interact with their surrounding space, it will become crucially important to analyze the potentially pernicious effects of the algorithmic production of space.

Invisibility through the algorithm

One of the main goals of the critical geography movement is to push back against the supposed objectivity of maps. As discussed earlier, maps are the result of choices. Maps can never objectively represent space, and the choice of what to represent and what to leave out shows the power of the mapmaker (Pickles, 2004; Wood, 1992). Leaving a road off a map renders it invisible for many people using that map to navigate a place; choosing not to label a town or placing a region inside one national border rather than another is a choice fraught with political consequences (Farman, 2010). As hundreds of years of geography show, those who create maps wield influence over how spaces are perceived and understood.

Like many other areas of cultural production, the Internet has opened up opportunities for more people to create and contribute to maps than ever before. Haklay et al. (2006) call the social mapping movement ‘neogeography’, and they examine myriad ways users can create social maps using digital tools. In addition, much of the information shared on social media that includes locational metadata, including geotagged Instagram photos and Facebook check-ins, enable people to create maps of their digital content that can influence how other people experience a place (Frith, 2015). And the spatial search applications discussed above are yet another form of social mapping (Barreneche, 2014). Restaurants can be mapped on Yelp or displayed in lists that rely on the spatial distribution of content; these results are produced, in part, by the users who choose to review the locations and boost them in the algorithmic search display. While social mapping has its

limits and still typically (though not in the case of some services such as OpenStreetMap) relies on large corporations that control the data, it is clear that more people are mapping information than ever before.

Social production, however, does not mean everyone gets to produce. As Haklay (2010) warns in his analysis of OpenStreetMap, some groups are left out of the 'open data' revolution because they do not have access to the right technologies or the inclination or digital literacies necessary to contribute to community mapping projects. Research has also shown that only a small minority of users actually create spatial content for location-based services, and as Graham et al. (2013) point out, 'This results in a relatively small group of people authoring representations in augmented reality and a correspondingly high power to influence representations of places' (p. 469).

Issues of language, access, and digital literacy should be a major focus in discussions of who gets to contribute to the mapping of information through location-based services, especially in the case of spatial search results that represent space in new ways and influence where people decide to go. As Frith (2012) argued in his discussion of the concept of 'splintered space', locative media 'raises the specter of a two-tiered system of city travel: one group will move through malleable, personalised, digitally infused streets, and the other group will move through streets that remain as impersonal as ever' (p. 146). Supporting that argument, Graham and Zook (2013) found that the density of spatial content uploaded to Google maps was widely variant, with some areas featuring dense layers of spatial information and some none at all. In addition, their analysis of the 'geolinguistic contours of the Web demonstrates that some languages enjoy far greater visibility than others' (p. 96). Unsurprisingly, they found that English is the dominant language for geotagged media.

The research cited above points to an important issue concerning spatial search and recommendation applications: spaces are not evenly represented in the results returned through the applications. The anecdote that began this article is illustrative of this phenomenon. In Denton, Texas – like in much of the United States – businesses are often segregated in much the same way as neighborhoods. The majority of their clientele tends to fall along demographic lines, so it matters if certain demographics of people are less likely to contribute to spatial search applications. That means those establishments then do not show up as highly when people search, and as Graham and Zook (2011) argued in an earlier work, 'Visibility and invisibility in material space are increasingly being defined by prominence, ranking, and presence on the Internet' (p. 115). If certain locations are rendered partially invisible through spatial search algorithms because of lack of representation from people of certain races or social classes, then these spatial search applications subtly reproduce existing forms of spatial segregation, a topic I examine in more detail in the next section.

Denton, Texas, and the invisibility of spatial representation

Here, I want to return to the physical space of Denton, Texas, as a pseudo case study into the theory explored in this article. As the previous section discussed, research has shown how certain groups are underrepresented in geocoded data. A brief discussion of the history

of Denton's segregation can show how older forms of segregation and underrepresentation are reproduced through tools of locative media. Denton is a college city on the northern edge of the seven million person Dallas-Fort Worth metro area. It is home to two major universities and has a population of 130,000 people. The city also, not uniquely, has a history of racial segregation. In the early 20th century, for example, the city's primary African American neighborhoods – known colloquially as 'The Quaker' – were razed to build Quakertown Park, and the residents were moved into areas southeast of downtown (Treat, 2013). Almost 100 years later, those areas are still overwhelmingly African American. The history of Hispanic segregation in Denton does not feature as clear a turning point as the razing of 'The Quaker'; however, Denton's Hispanic population has historically been segregated from the Caucasian population, which can be seen in Image 1. The image is a subset of the national map created by University of Virginia's Dustin Cable (2013) and published through the Weldon Cooper Center for Public Service. Cable's work color codes the entire map of the United States along racial and ethnic lines, placing a single dot for every person in the U.S. census and coding the dots by color based on self-identified race and ethnicity (for a color version of this subset of the larger map, go to http://imgur.com/JmnDQ2Y). The image also includes a few road names, including the East McKinney St. discussed in this article.

The racial dot map of Denton clearly shows segregation at the neighborhood level, with the overwhelmingly Hispanic part of the map located on and to the north of the part of East McKinney St that makes up the taco corridor.[3] The 'taco corridor' is the Hispanic

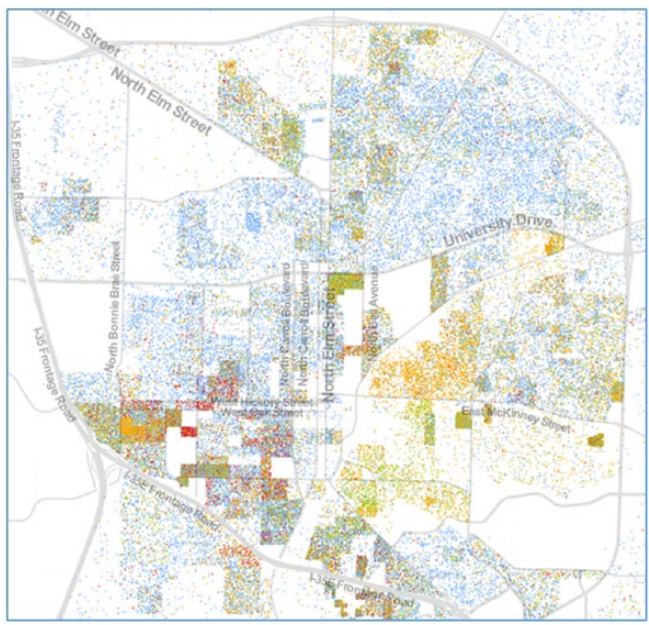

Image 1. A subset of the Weldon Cooper Center's Racial Dot Map showing Denton, Texas. Green: African American, Blue: White, Red: Asian, and Yellow: Hispanic.

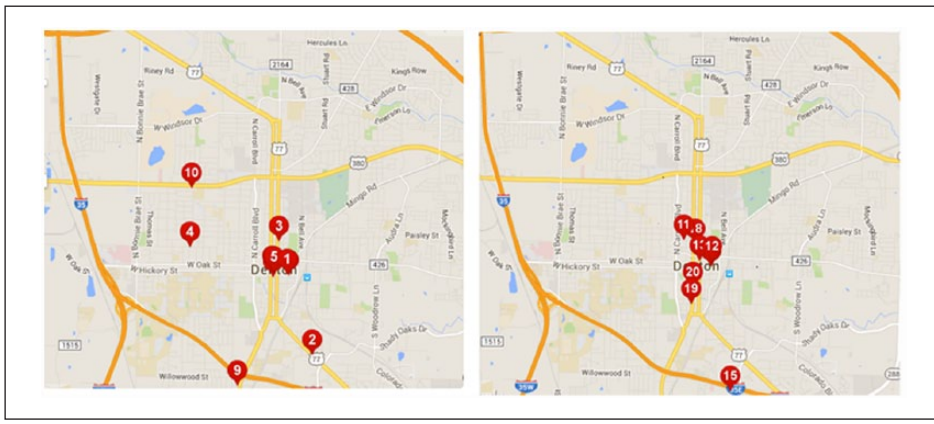

Image 2. The Yelp map of numbers 1–10 (on the left) and 11–20 of the most reviewed Denton restaurants.

part of town, featuring dominantly Hispanic residential areas and many of the Mexican taquerias that are underrepresented through spatial search. In effect, the history of segregation and urban politics that marked downtown, north, and far south as 'white' and east as 'Hispanic' then become reified once again in the visual representations of geocoded data. As an example of this phenomenon, one can go to the Yelp search results for Denton and choose the 'Most Reviewed' filter. Most of the top 10 is centered around downtown, with a few exceptions being long-standing restaurants that are Denton staples. Not a single of the often packed taco corridor taquerias appears in the top 40 (the filter only returns the top 40 search results) of Denton restaurants, with the highest (Taqueria Guanaujuato) featuring 40 reviews, whereas number 40 on the list contains 61 reviews. For a visual representation, compare Image 2, which includes maps of the top 10 and 11–20 most reviewed Yelp locations, to the racial dot map to see how Yelp's data emphasizes the 'white' parts of Denton.

The images show how the Hispanic population of Denton is underrepresented in Yelp's dataset. For someone using the application as a gauge of what is popular in the city, they would only be shown what is popular with a certain segment of the population. The same issue of underrepresentation can be found in the case of the *Livehoods* project that displayed Foursquare check-in data for the city of Pittsburgh. The map of Pittsburgh was filled with check-ins to all types of places, but one area of the map was noticeably devoid of data. That area – known colloquially as The Hill – is predominantly African American, and according to the creators of the project, the area lacked 'any representation in our mapping thus implying a low rate of smartphone usage, and providing a possible depiction of the digital divide' (Cranshaw et al., 2012: n.p.). For someone relying on *Livehoods* as a map of what was going on in the city, it would seem as if The Hill was an area devoid of activity. That, of course, was not the case. The residents of the neighborhood just did not use Foursquare as frequently as users in the richer parts of the city. They were consequently rendered invisible through the big data mapping display of

Livehoods, just as the activity of certain segments of Denton's population is rendered invisible through the unequal distribution of Yelp reviews.

And these questions of spatial representation will only become more important as the technical capabilities of these applications improve. For example, while applications like Yelp focus on direct user search, other applications, such as Foursquare and Google Now, have developed algorithms to predict what users want before they know they want it. Foursquare, using its Pilgrim location tracking system, now suggests nearby places to people based on their physical location and social graph algorithms (for a discussion of geodemographic spatial matching, see Barreneche, 2014). These suggestions then map one's surroundings in a very specific way, giving visibility to one location above all others through the push notification. This type of predictive spatial search is referred to in Computer Science literature as 'semantic spatial search', and in the following paragraph, Kelsey (2014) discusses how future spatial recommendation engines will differ from applications like Yelp that require specific queries from users:

> For instance, instead of reacting to an explicit query for the locations of nearby coffee houses, a device might act in anticipation of the desires and interests of a user by exploring connections between semantically organized information on the Internet and all available sensory and background information from the user (such as GPS location, time of day, current weather, personal profile, personal calendar, web search history, Facebook status, Twitter feed, or friends). So, rather than produce a list of coffee houses on request from the user, the device implicitly anticipates when to prompt the user to redirect her or his movement through space in order to maximize exposure to districts in the city which have both high concentrations of coffee houses and a range of other social or cultural activities that best fit the user's interests. (p. 842)

So how should we theorize the possible consequences of existing and future models of spatial search? The first point to keep in mind is that technology early adopters tend to be younger, whiter, and more educated than the average population (Jackson, 2012). There is no reason to think the same does not apply to spatial search applications. Consequently, these early adopters review and rate certain locations which can then cause those locations to appear more favorably in 'places nearby' search results or get pushed to phones more frequently as recommendations. After all, as Barreneche (2014) points out in his discussion of Google's spatial search services, 'A given place is ranked considering not only the 'distance from the geographic identifier in the search term' but mainly through the calculation of its non-cartographic attributes, namely, its online presence' (p. 335). In other words, the information displayed on these applications is not just determined by physical location; it is also determined by number of positive reviews. Later adopters may then be influenced by those reviews and choose those places over other places that either do not appear or do not appear as favorably.

In this way, these early users have significant influence over the 'presentation of location' (de Souza e Silva and Frith, 2012), and the types of places they frequent as often whiter, more middle or upper middle class users receive a more prominent placement that influences the behaviors of the wider population as they begin to adopt the same applications (Graham et al., 2013). So, for example, a new Denton resident who relies on Yelp may be more likely to end up in the 'whiter' part of town because of the underrepresentation of

other areas in Yelp's database. Another way of thinking through this issue is what network analysts call the 'Matthew effect' (Merton, 1968), which describes the phenomenon of 'the rich get richer while the poor get poorer'. As certain locations receive more positive reviews on Yelp or similar applications, the places are elevated as recommendations and people are more likely to go to them. Those locations then receive more foot traffic and more reviews that can cement their high placement in search results, imposing what Barreneche (2014) calls a '"PageRank epistemology" onto the world' (p. 337).

The other side of the increased visibility for certain locations frequented by certain types of people is that other categories of location are pushed further and further down the spatial search results. In some cases, these locations may not appear on the mapped or textual representation of someone's surroundings, in effect being rendered invisible through the algorithm. After all, Internet access necessary to contribute spatial information is lower within minority communities (Mossberger et al., 2012), spatial information tends to be dominated by English language posts (Graham and Zook, 2013), and early adopters can often wield outsize influence over later adopters' behavior (Graham et al., 2013). Internet research is filled with claims that digital media are allowing more people to create content and speak than ever before, and locative media scholars have argued that places are becoming more polyvocal as more people are able to use locative mobile technologies to create location-based texts (Frith, 2012; Farman, 2013); these claims are true, but we must remain cognizant of the voices left out of the production of location-based texts. In the case of spatial search applications, the lack of those voices can render locations partially invisible to the increasing number of people who rely on mobile applications to discover their surroundings.

Returning to the title of this piece, I want to conclude by noting the polysemic way in which I am deploying the concept of 'invisibility'. This article began by discussing a specific street in Denton, Texas, a street filled with locations that do not have high levels of information visibility on spatial search applications like Yelp. Combining literature on the biases of maps with the power of search engines, I have argued that spatial search applications can render underrepresented parts of the city invisible through the mobile interface. The bulk of this section has been devoted to explaining how that occurs in practice by examining both Denton in more detail as well as research on underrepresentation in hybrid spaces. However, the concept of invisibility can be applied to another part of this analysis as well: the algorithms that power these spatial search applications. All maps lie (Monmonier, 1996); they all choose to represent one aspect of a space over something else. With spatial search, those choices of representation are powered by algorithms that remain invisible to the end users who often – as search engine research suggests (Machill et al., 2008) – do not critically reflect on why they receive certain results. Consequently, an important area for future media studies research will come in examining both types of invisibility. We must remain cognizant of the people and places that are left behind with the increasing adoption of locative media, and as David Beer (2009) has argued, we must also provide analyses of the different ways seemingly unseen algorithms are enacting new cultural formations. The issue of algorithmic invisibility is especially important because spatial search applications derive their power through private data ownership and the ways in which they filter and display their data. I used a single street in Denton, Texas, as illustrative of this type of invisibility, but I likely could have chosen from various streets in many cities in the world to look at how the algorithms of spatial search applications work through practices of invisibility.

Conclusion and future research

This article examined the social impacts of spatial search applications. These applications enable people to filter information in their surrounding space to find specific locations. Much like online search engines, however, spatial search applications rely on algorithms that determine which nearby locations are presented to users. In effect, these applications do not fully represent the fullness of people's surrounding space, and as this article argued, they may result in certain parts of the city being underrepresented through the mobile mapping interface.

My main goal was to begin theorizing the social impacts of the uneven distribution of spatial search data through applications like Yelp. I also hope this article has pointed toward important areas of future research. As others have argued, media theorists must pay closer attention to how biases are built into and hidden behind the supposed objectivity of algorithms (Beer, 2009). In the case of spatial search, which results are presented highly and which are not? What are the differences when participatory geocoded data are owned by private companies as compared to the more open data explored in research on OpenStreetmap (Haklay, 2010)? And along those lines, what can research into applications like Yelp or Google Places tell us about the impacts of participatory culture? Research has repeatedly shown that only a small percentage of people contribute content on sites like Wikipedia and various user forums (Van Dijck, 2013). This small percentage of the population drives conversations. Spatial search applications likely reflect a similar phenomenon, but as I argued throughout this article, they also raise new issues about the limits of participatory culture because the user-generated content has the potential to produce experiences of space in new ways. Future research should more closely link the impacts of participatory culture in general to how the limits of social participation will impact how people map and come to know their surrounding space.

The article began by discussing the city of Denton, and I want to conclude by returning to that here. As critical geographers have argued (Pickles, 2004; Wood, 1992), people tend to view maps as 'true' representations of space, as direct representations of their surroundings, just as people often uncritically view highly ranked search engine results as the best match for their search terms (Pan et al., 2007). Spatial search applications combine the supposed objectivity of maps with the power of search results, supposedly displaying nearby locations in as straightforward a way as possible. However, 'While the duplicity of code lies (in part) in its appearance of neutrality and its complex and technically impenetrable nature, code never simply "is" as it appears to be' (Graham et al., 2013: 467). The mobile applications people use to navigate their surroundings and discover locations have hidden biases. They emphasize certain locations over others and recommend locations frequented by certain types of users. As spatial discovery increasingly becomes reliant on user-generated data and algorithmically filtered results, the Veronica's Cafes of the world may fade into the background of our contemporary spatial representations. As the research examining how Yelp reviews drive foot traffic suggests (Anderson and Magruder, 2012; Luca, 2011), that invisibility can have very real effects on where people go and which locations thrive in our contemporary informational environment.

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Notes

1. The Gall-Peters Projection is likely the most famous alternative world map. The Gall-Peters Projection maintains the relative size of the world's land masses, but consequently, distorts their shapes (Wood, 1992).
2. One notable exception was a December 2014 conference titled 'Spatial Search' held at the University of Santa Barbara. A link to the conference program is here: http://spatial.ucsb.edu/wp-content/uploads/smss2014-agenda.pdf
3. The Hispanic area on the map can be most accurately described as bound by E. McKinney to the south, Mingo Road to the North, Audra Lane to the west, and the train tracks to the east.

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