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Authors: Ian Babelon, Alexander Ståhle, Berit Balfors

Title

Toward Cyborg PPGIS: exploring socio-technical requirements for the use of web-based PPGIS in two municipal planning cases, Stockholm region, Sweden.

Abstract

Web-based Public Participation Geographic Information Systems (PPGIS) are increasingly used for surveying place values and informing municipal planning in contexts of urban densification. However, research is lagging behind the rapid deployment of PPGIS applications. Some of the main opportunities and challenges for the uptake and implementation of web-based PPGIS are derived from a literature review and two case-studies dealing with municipal planning for urban densification in the Stockholm region, Sweden. A simple clustering analysis identified three interconnected themes that together determine the performance of PPGIS: i) tool design & affordances; ii) organisational capacity; and iii) governance. The results of the case studies augment existing literature regarding the connections between the different socio-technical dimensions for the design, implementation and evaluation of PPGIS applications in municipal planning. A cyborg approach to PPGIS is then proposed to improve the theoretical basis for addressing these dimensions together.

Keywords: PPGIS; cyborg; socio-technical; urban densification: softGIS.

1. Introduction

Web-based Public Participation Geographic Information Systems (PPGIS) are increasingly used to engage the public in urban planning (Jankowski, Czepkiewicz, Młodkowski, & Zwoliński, 2015; Kahila-Tani, Broberg, Kyttä, & Tyger, 2016). Public Participation GIS can

be described as a participatory form of interactive mapping that engages the public to inform environmental and urban planning in local councils and public agencies (Brown & Kyttä, 2014). Given the motley of PPGIS conceptualisations in the scientific literature, PPGIS concepts can overlap with Participatory GIS (PGIS), and even with Voluntary Geographic Information (VGI)[1]. In contrast to protype-based experiments (e.g. Bugs, Granell, Fonts, Huerta, & Painho, 2010; Butt & Li, 2015; Hall, Chipeniuk, Feick, Leahy, & Deparday, 2010; Narooie, 2014), a smaller number of PPGIS applications have been used in real-life situations, often in formal spatial planning (Al-Kodmany, 2001; Broberg, Kyttä, & Fagerholm, 2013; Carver, Evans, Kingston, & Turton, 2001; Kyttä, Broberg, Tzoulas, & Snabb, 2013; Poplin, 2014). Web-based PPGIS have the potential to engage larger numbers of urban residents as well as more diverse publics than legalistic public consultation meetings, especially when delivered at city-scale, because they can be accessed at any time and location (Kahila-Tani et al., 2016). Urban residents can also participate with more flexibility in online surveys than by means of physical, face-to-face modes of participation (Kahila & Kyttä, 2009). Additionally, Internet-based PPGIS surveys can be designed to engage random population samples and ensure greater representativeness than voluntary, small-group PPGIS workshops (Brown, Donovan, et al., 2014).

Web-based PPGIS are sometimes called "SoftGIS". SoftGIS is both a method (i.e. a way of collecting and processing local knowledge) and a type of tool (i.e. a range of bespoke web-based PPGIS) which aims to collect residents' knowledge about their local environment (Jankowski et al., 2015; Rantanen & Kahila, 2009). The online mapping applications are often Open-Source (e.g. Google Maps API-based) and feature text questionnaires, to which participants respond by tagging places on the map and providing comments. Applications are

[1] For a brief overview of differences between PPGIS, PGIS and VGI, see Brown & Kyttä (2014).

designed with easy-to-use interfaces so as to facilitate the collection of residents' local knowledge, with a view to mediate a sharing of expertise between planning experts and lay citizens (Kahila & Kyttä, 2009; Rantanen & Kahila, 2009). The collected data is termed "soft" as it concerns attitudinal values about existing places or development preferences. This "soft" data is meant to complement expert GIS data to inform more effective and accountable planning decisions. The survey results can be aggregated for complex spatial analyses and quantification, for example analysing the spatial distribution of comments, querying the content of comments, and analysing potential conflicts between different place values (Brown & Raymond, 2014; Jankowski et al., 2015). SoftGIS surveys enable multiple purposes simultaneously: "In the SoftGIS approach, Internet-based methods are developed to support the use of local knowledge in research, communicative planning practices and long-span development processes" (Rantanen & Kahila, 2009, p. 1981). At least in theory, SoftGIS surveys can support the full life cycle of project proposals and plans, although they have been mostly used in early planning stages (Brown & Kyttä, 2014). SoftGIS applications contrast with expert-led PGIS, which may be more cumbersome to use and less adequate for mapping qualitative data (Elwood, 2010; McCall, 2003), and are perhaps less used in formal spatial planning processes (cf. Brown & Kyttä, 2014; McCall, 2003). SoftGIS also contrast with PPGIS that function as geocollaboration tools that may be less suitable for large respondent samples (e.g. Hall et al., 2010; Sidlar & Rinner, 2009). The web-based PPGIS reviewed here are SoftGIS applications.

The use of PPGIS in municipal planning arises from the convergence of Web 2.0 technologies and the digitisation of government services (i.e."e-Government") (Choudrie, Ghinea, & Songonuga, 2013; UN-DESA, 2014). This has led to emerging practices in online public engagement, including social media, gamification and mapping surveys, to inform more accountable urban planning (Anttiroiko, 2012a). Together, these innovative trends in

participatory planning have been alternatively coined “crowdsourced urban governance”, “e-Governance” and “Planning 2.0” (Anttiroiko, 2012b; Brabham, 2013; Silva, 2013).

The claim was still made recently that there is a lack of real world PPGIS applications (see Bamberg, 2013; Rinner & Bird, 2009). It now seems instead that research is lagging behind the increased deployment of web-based PPGIS in urban planning, and fails to take stock of a flurry of commercially and open-source developped web-based PPGIS applications (to name but a few: *CommonPlace, Mapping For Change, Carticipe, coUrbanize*). The latter applications constitute fertile research material that could help fill important research gaps in the literature and better address the different socio-technical dimensions of PPGIS (see Brown & Kyttä, 2014; Sieber, 2006). Many hurdles remain for the uptake of PPGIS in municipal planning which go beyond the technology itself, and which seem under-addressed by the bulk of the literature, which tends to be concerned with the evaluation of PPGIS prototypes (e.g. Bugs et al., 2010; Nuojua, 2010; Sidlar & Rinner, 2009). PPGIS research would therefore benefit from an augmented theoretical basis that addresses the challenges and opportunities facing the uptake and implementation of web-based PPGIS in municipal planning, particularly the different socio-technical requirements affecting their performance.

The aim of this paper is to explore different socio-technical requirements for the uptake and implementation of web-based PPGIS in municipal planning, in contexts of urban densification. Three research questions were formulated: i) Which are some of the main socio-technical requirements for the uptake and implementation of web-based PPGIS surveys in municipal planning in contexts of urban densification?; ii) How are these requirements interrelated?, and iii) How could theory be augmented to better conceptualise the interrelations between these different requirements? This study provides a preliminary outline on the basis of a literature review and the analysis of two case-studies in the Stockholm region, each featuring the use of a different web-based PPGIS application.

After introducing the method and case-study results, the case-studies are then discussed in light of the literature on PPGIS. In the last part, suggestions are made to strengthen the theoretical basis for considering the multiple, interlinked dimensions which determine the performance of PPGIS applications in municipal planning, where the "cyborg" is proposed as a means of better conceptualising the interrelated socio-technical dimensions of web-based PPGIS.

2. Method

A case study approach is used to explore the use of two different PPGIS in municipal planning[2]. The data for the two case studies consisted of: i) the results of one semi-structured interview and two questionnaires with a total of three experts, conducted in October-November 2014; and ii) a review of relevant urban policy documents. The experts consulted were: two urban planners responsible for implementing or commissioning the online mapping surveys in the local councils of Tyresö municipality and Solna City, located in the Stockholm region; and one expert working at the Swedish Association of Local Authorities and Regions (Sveriges Kommuner och Landsting – SKL) who provides support for the PPGIS *Geopanelen* among Swedish local authorities. The interviewed senior expert had a good understanding of the perspectives of planners across Sweden, and was therefore considered a key informant. One of the authors of this paper is a planning consultant who was responsible for the implementation of one of the tools (*Bästa Platsen* in Bergshamra district).

To obtain complementary information for the discussion of the case-study results, two experts at the consultancy firm Mapita that provides the tool *Maptionnaire*, were interviewed informally regarding the use of PPGIS linked to urban densification policies in municipal

[2] "Municipal planning" is used here as synonymous to town/urban planning carried out by local councils.

planning in Finland[3]. An additional planner at Sollentuna municipality was also interviewed regarding the use of a bespoke *Bästa Platsen* for mapping place values in green areas.

The two planners kindly answered a paper questionnaire as they were unavailable for interview. The semi-structured interview with the expert at SKL lasted for an hour and was not recorded. The interviews/questionnaires were conducted and translated from Swedish by the main author. The interviews/questionnaires were tailored to the case-study and respondent at hand. Three main themes were addressed in the interviews/questionnaires: i) public participation and its perceived value for informing planning practice;; ii) the perceived relationship between the outputs of public participation and actual decision-making within local authorities, and iii) the role of PPGIS as a tool and method in the three above themes. The case-studies both featured explicit urban densification policies. This enabled to explore how different PPGIS applications could inform municipal planning for urban densification, which few publications have been found to do, with notable exceptions (Brown & Kyttä, 2014).

The results from the interviews/questionnaires were complemented with an overview of policy recommendations and local government documents relevant to the case studies. The literature review focused primarily on PPGIS. The combined results from the review of the academic literature, policy documents and interviews/questionnaires were analysed using a simplified inductive content analysis of the qualitative data (see Mayring 2000). The main identified themes and parameters for the uptake of PPGIS in municipal planning were then clustered manually according to theme and organised into "Table 1", which constitutes the main research output for this paper. On the basis of "Table 1", it is suggested that the

[3] The use of *Maptionnaire* has already been well covered in the academic literature (e.g. Brown & Kyttä, 2014; Kahila-Tani et al., 2016).

theoretical basis for addressing the three main identified themes simultaneously can be augmented by treating PPGIS systems as "cyborgs".

The scope of the research did not allow for a longitudinal analysis of the case studies, or a systematic analysis of the content of the survey responses. The aim was rather to explore some of the main substantive issues for the uptake and implementation of web-based PPGIS in municipal planning.

3. Case Studies

The two case-studies are located in the Stockholm region, Sweden, and were reviewed to exemplify different PPGIS applications in a variety of municipal planning contexts related to urban densification.

The case-studies concern two tools: *Bästa Platsen* and *Geopanelen*. The PPGIS tools consist of web-based interactive maps (featuring Bing or Google base-maps) combined with text questionnaires. Although they differ somewhat in functionality and appearance, the PPGIS applications share basic features including: the ability to mark and comment locations; ease of use; compatibility of output data with professional mapping software; cloud-based storage of the survey data; and relative affordability. Both tools are designed to support professional planning practice and accountability in similar ways, with the aim to deliver quality consultation that would extend beyond legally-required consultation procedures. Both tools have also undergone iterative development in real-life planning situations. The PPGIS were not found to have been covered in the scientific literature.

Concerning the planning context in Sweden, it is important to note that local differences in planning practice arise, notably in terms of public engagement. This is due to the fact that municipalities (i.e. local councils) are solely responsible for spatial planning. National agencies (e.g. Boverket, the National Board of Housing, Building and Planning)

provide general guidelines which planners should refer to in their plans, leaving some discretion and flexibility to planners as regards their implementation. This flexibility is commonly referred to as the planning "monopoly" (Böhme 2012; Lundström, Fredriksson, and Witzell 2013; Larsson 2006).

3.1. Bästa Platsen

Bästa Platsen is provided by the Swedish planning consultancy Spacescape. The *Bästa Platsen* application considered here was carried out in Bergshamra district in Solna City, a municipality located just north of Stockholm City. Besides Bergshamra, the tool has also been applied in: Hagalund, Sollentuna and Lidingö in the Stockholm metropolitan region, the city of Göteborg (Gothenburg) in Sweden, and the city of Bergen in Norway[4]. The results of the online survey results can easily be queried by categories such as age group, gender, stated place of residence etc, so as to derive simple statistical distributions. *Bästa Platsen* generally features a concise georeferenced questionnaire tagged to each location marked by the user. Respondents also usually have the opportunity to submit additional comments at the end of the questionnaire.

The online mapping tool is typically part of a wider consultancy service for mapping "sociotopes". Sociotopes are the sum of use values and qualities which different people derive from particular places. They can be understood as the social counterparts of biotopes. The sociotope mapping approach combines online mapping surveys that are accessible to the public with in-depth interviews of local residents groups. In addition, expert observations of particular places are made to corroborate or confront the results from the online mapping survey and interviews. The end result is a sociotope map of the area that integrates both

[4] Appendix 1 features links to completed surveys in those cities

citizen and expert knowledge with a view to inform land use management and planning decisions[5] (SBK, 2003; Ståhle, 2006).

Bästa Platsen applications are always bespoke. In Bergshamra, the application simultaneously enabled a baseline survey of place values and an evaluation of a preliminary urban infill and redevelopment strategy proposal, displayed in the mapping interface as two different layers[6]. The tool allowed respondents to switch freely between the two layers. The online mapping survey application was conducted between April and May 2014. Different marker colours denoted different kinds of location-based comments, displaying either "positive" (green) or "to-be-improved" (red) place tags. A total of 376 location-based comments were submitted, of which 194 "positive" ("*Bästa Platsen*") and 182 "to-be-improved". The vast majority of participants were residents in Bergshamra district, a small proportion resided outside Bergshamra district in Solna City municipality, and a small minority were residents from outside Solna City altogether. Specific resident groups were interviewed to attempt to fill gaps in the age groups of the online survey respondents, focusing primarily on school pupils. The combined online survey and individual interviews aimed to establish a respondent sample that was as representative as possible. One of the main outputs of the multi-method baseline survey of place values was a sociotope map of the area depicting the variety of cultural ecosystem services or "place values" ("naturvärden") across the district (see Spacescape, Nerlund Arkitekter, & Media A. B., 2014, p. 50).

3.2. Geopanelen

Geopanelen, was elaborated at the Swedish Association of Local Authorities and Regions (SKL in Swedish). *Geopanelen* is based on Open Source coding and adapted to fit different

[5] For a detailed description and history of sociotope mapping see (Ståhle, 2006).

[6] The final survey map is available permanently at: http://dialog.spacescape.se/bergshamra/

planning needs. In its initial forms, the tool was not envisioned to be used in formal urban planning processes. Over time, the tool has been tested and used in a diverse range of local planning contexts, such as improving safety in public space, mapping children's walking itineraries to school, and participatory budgeting of municipal investment (e.g. for refurbishing public parks).

In 2013, *Geopanelen* was used in the municipality of Tyresö, located in the south of the Stockholm metropolitan region, to inform early comprehensive planning, including to provide orientations for infill development in and about the town centre. The *Geopanelen* application was tailored to provide thematic location-based comments visualised as coloured dots on the map, with each colour denoting a different land use. The aim was to frame the online mapping process so as to enable an immediate, synthetic and thematic overview of location-based comments. The application interface functioned as a simplified online GIS software, featuring several layers that could be ticked on and off. Respondents could visualise various municipal services (e.g. locations of schools, health services, public transport routes) on top of the base map. Three layers allowed users to provide location-based comments and answer related land uses. One layer allowed respondents to comment what they liked or disliked about existing environment. Another layer allowed users to locate areas which they deemed acceptable for housing (labelled "new neighbours") and choose from four coloured tags to specify the kind of housing (yellow: houses; orange: multi-storeyed apartment buildings; red: residential block; light green: keep undeveloped for recreation). A third layer allowed users to locate potential areas for new land uses (e.g. green: green areas; dark green: sports and recreation facilities; bright blue: shops; purple: culture and entertainment; dark grey: enterprise and industry; brown: a different land use to be specified by the respondent). The online mapping survey produced 120 location-based comments. Response rates were

probably hindered by technical failures which made the online mapping survey periodically inaccessible.

The online mapping survey was part of a wider public engagement strategy to inform the early stages of comprehensive planning. The results of the survey, along with the output of other measures for public participation, have informed the initial Comprehensive Plan proposal released for public review in 2015, with a final Comprehensive Plan proposal expected for the summer of 2016 that is also to undergo public review. Amongst other techniques, a drop-in exhibition space was located next to the main shopping and public services area in the city centre to encourage visitors of all ages to pin location-based comments on a large map of the municipality. Social media were also used, such as an Instagram photo-competition and discussions on Facebook, and residents were invited to send comments by email or post. Additionally, community and resident groups were encouraged to book meetings with the comprehensive planner at Tyresö municipality.

4. Results

The main results of the literature review and the case-studies are summarised in "Table 1". It is the result of a thematic clustering of the main issues concerning the uptake of PPGIS in municipal planning, which were identified through a review of the academic literature, policy documents, and the interviews/questionnaires. The inductive content analysis yielded three main analytical themes: i) tool design and affordances; ii) organisational capacity; and iii) governance. The statements followed by question marks indicate uncertainties or research areas beyond the scope of the paper that could require further exploration. Because the parameters listed under each theme have important implications for every other theme, the thematic clustering of the parameters is exploratory rather than definitive.

"Table 1" Exploring the main parameters for the uptake and implementation of PPGIS in municipal planning.

4.1. Tool design & affordances

"Tool design" refers to the technical considerations for the design of PPGIS applications. The term "affordances" is used here to denote the functionalities and use values which online mapping survey tools provide to users. This notion of affordances is derived from the Human Computer Interaction (HCI) literature, particularly the mediated action perspective proposed by Kaptelinin and Nardi (2012), which departs from its original use in Gibson's theory of ecological perception (see Gibson, 1979). In effect, affordances are largely determined by a tool's functionalities, and differ for different users depending on such factors as ability, age, gender, spatial cognition, digital skills and access to digital technologies.

The PPGIS in the case studies displayed differences in their affordances. The use of *Bästa Platsen* in Bergshamra district was unique in that it facilitated both a baseline survey of place values *and* the commenting of a preliminary development strategy proposal for the area, accessible as two separate layers in the Google Map application. A unique feature of *Geopanelen* in Tyresö municipality was the ability for both survey respondents and planners to have an immediate thematic overview of the survey inputs as well as view GIS layers of public services (e.g. public transportation routes, school locations etc.). The use of different coloured icons to denote different land uses was also unique to *Geopanelen* and enables a quick synthesis of the respondents' views accessible to both online survey respondents and professional planners.

The two online mapping applications also shared basic features, such as the ability to mark and comment locations, the opportunity to view all other respondents' survey responses, and accessibility to the general public.

Ease-of-use, a well-defined use, simple data management, accessibility, and the ability to view other survey responses were design and affordance considerations that were highlighted by the three experts. For instance, the expert at the Swedish Association of Local Authorities and Regions (SKL) indicated that survey design should be kept simple. Few, well-formulated questions are preferable, as there is a risk of long questionnaires creating confusion among respondents, either introducing too much complexity or requiring too much time to complete the survey. Ease-of-use was perceived to be a key design feature by the expert at SKL and the planner at Tyresö municipality, as it allows ordinary people to map their local knowledge and views without any GIS expertise. The planner at Tyresö municipality also expressed that ease-of-use concerns the visualisation of survey responses for both respondents and planners alike, which can also facilitate the processing of comments.

The expert at SKL considered that because PPGIS may not reach all segments of a population, online mapping surveys should be conducted as part of a "tool box", rather than as a single tool. While online mapping surveys can be convenient for many, it is important to combine digital modes of engagement with offline/physical tools and methods. Open accessibility, while enabling wider participation, was perceived to be a double-edged sword. The planner at Solna City was concerned that widely accessible web-based mapping surveys could potentially be misused by particular users wishing to divert or block the initial intent of the mapping survey.

4.2. Organisational capacity

"Organisational capacity" mainly concerns the institutional and organisational parameters guiding the uptake and performance of PPGIS. To a lesser extent, organisational capacity can also concern urban residents' own capacity to respond to surveys, as due to lifestyle for

example.

The interviewed expert at SKL, who has regular contact with planners across the whole country, indicated that not all municipalities have the financial resources or staff to undertake online mapping surveys, or even to engage the public actively beyond legalistic consultation. The expert further expressed that not many planners use use active public participation ("dialog") as a way of working, adopting participatory tools and methods on a per-project basis instead.

The planner at Tyresö expressed that online map surveys, alongside social media, enable to reach many residents with few resources, and provide valuable local insight. A simplified visualisation of output data is necessary time-constrained planners. The planner emphasised the importance of guided questions, where coloured tags can provide an advantageous substitute to numerous written comments:

"There can be so many views that it can be difficult to get an overview. It is important that the place tags should stand out on the map and speak for themselves, allowing an overview… That is, the place tags should not all have the same colour which would then require to read every single comment. It can be difficult to get an overview of what citizens actually express, which makes the usefulness of the method dubious".

This makes for an interesting contrast with the use of *Bästa Platsen* in Bergshamra, where the range of colours was more limited. Nonetheless, the planner at Solna City also viewed that the online mapping survey facilitated the processing of residents' viewpoints:

"It is an easy way to gather viewpoints about what is considered important in a specific area... it is easy to locate where "most voices" end up. The end result can serve as a confirmation (or not) of the hypotheses one already has".

4.3. Governance

"Governance" denotes the wider planning and urban governance context in which public consultation/participation is carried out, and the manner in which the inputs of online collaborative mapping surveys may be used in decision-making.

The interview and questionnaire results showed that the use of PPGIS in municipal planning is inseparable from urban governance, particularly in terms of the contributions of public participation to decision-making.

The questionnaires sought to clarify the informants' understanding of public participation. There are many different understandings of "public participation" in the literature on governance and public engagement (see Rowe & Frewer, 2005; Schlossberg & Shuford, 2005), which also affect the Swedish context. There are nuances for example between "medborgardialog" and "medborgarsamverkan", which can be literally translated as "citizen dialogue" and "public collaboration" respectively. The National Board of Housing, Construction and Planning (Boverket) associates "medborgardialog" with public participation, or the exercise of engaging citizens in the early stages of comprehensive planning. Public participation extends beyond legally-required consultation (samråd), which is the exercise of consulting the public on comprehensive and local plans which have already been determined to a large extent (Boverket, 2016).

The expert at SKL expressed that public participation can improve the accountability of planning decisions, in a country where the majority of politicians tend to be white middle-class men. Efforts to engage the public may suffer from experts and politicians who are afraid of giving up their expertise and power. At the same time, the expert at SKL viewed that the interests and expertise of planning experts, politicians, and lay urban residents should be balanced. Interest groups may express views that run against the "common interest". Particularly in the Stockholm metropolitan region where housing shortage is acute, there is a

need for fast construction that can come at odds with the narrower interests of individual community groups.

The planner at Solna City expressed preference for public participation (medborgardialog), viewed as open participation, in contrast to public collaboration (medborgarsamverkan), which was understood as a representative form of participation. The planner viewed that public participation can mediate greater groundedness of planning work, and generate valuable insight about how local residents perceive their neighbourhood. The planner at Tyresö municipality understood "medborgarsamverkan" as citizen control[7], expressing preference for public participation as a form of dialogue and mutual recognition of expertise between planners, politicians and residents. The planner emphasised important factors such as politicians' willingness to actively consider the views of urban residents and the fact that public participation can improve citizens' understanding of local planning issues, particularly the constraints and opportunities which influence what the planning system can achieve.

The planners also viewed that public participation can support compact city policies. The planner at Solna City expressed that public participation can improve the acceptability of urban densification measures. In particular, PPGIS can help set aside important natural areas in a context of sustained urban development. The planner at Tyresö municipality considered that building a green, compact city requires clear communication on the part of municipalities, securing trust and convincing stakeholders about the possibility to combine urban densification and green areas in a way that benefits the majority of urban residents.

The expert at SKL indicated that PPGIS design and implementation have implications for urban governance. First, the design of the online survey should consider precisely the

[7] Citizen control is the top rung of Arnstein's (1969) ladder of participation, which may be interpreted as as a normative goal of collaborative planning (cf. IAP2, 2014; Innes & Booher, 2004)

level of participation desired. The purpose of the survey should be communicated clearly to the public, indicating whether the planning process can be influenced by public input. In terms of representativeness, a clear strategy should be formulated by the organisation to consider groups usually absent from public consultation, such as ethnic, religious, or recreation/leisure groups, which may not be adequately engaged through online mapping surveys or public meetings.

The long-term challenges facing the use of PPGIS in municipal planning are also linked to governance practices in terms of process and outcome. As the planner at Solna City indicated:

"The challenge lies in meeting the expectations which citizens' expectations get when they share their desires and suggestions for change. If nothing "comes out" of their viewpoints, it is also likely that the end result will not be good".

5. Discussion

The main results from the case-studies are discussed in light of the literature review about PPGIS, with a special focus on the interrelations between the three main identified themes, namely: i) tool design and affordances; ii) organisational capacity, and iii) governance. The core aim of the section is to explore the thematic hybridity of the different parameters of web-based PPGIS used in municipal planning in contexts of urban densification.

5.1. Tool design & affordances

Tool design and affordance parameters have important implications for both organisational capacity and governance.

The design and implementation of web-based PPGIS often follows an iterative cycle that involves different end-user groups and enables product refinement and customisation over time and across projects (Kahila & Kyttä, 2009; Nuojua, 2010). *Geopanelen* especially

was a case in point. Such iterative development can particularly improve the usability of applications (Haklay & Tobón, 2003; Nuojua, 2010).

PPGIS applications are often bespoke and can serve multiple purposes simultaneously. For example, *Bästa Platsen* in Bergshamra enabled to collect baseline place values as well as attitudinal views to a preliminary development proposal. The functionalities of *Geopanelen* in Tyresö framed participation for providing place values as well as explicit suggestions for the location of new housing and alternative land uses. Other researchers showed that the use PPGIS in the context of the Helsinki Master Plan Process likewise enabled respondents to express development preferences as well as other attitudinal views (Kahila-Tani et al., 2016). Mapping place values and development preferences simultaneously also enables to identify potential land-use conflicts (Brown & Raymond, 2014; Kyttä et al., 2013). This contrasts with other researchers who recommend conducting collaborative mapping in a two-step process: i) beginning with problem-exploration and establishing a relative consensus among participants; and ii) problem-solving (e.g. Ramsey, 2009). The differences seem largely attributable to the mode and context (online survey vs. community workshop) of the PPGIS project. Interestingly, the use of a PPGIS in an architectural competition process in the city of Vaasa, Finland, did follow a two-step process of problem-exploration, followed by problem-solving, which served to inform the redevelopment of a central urban area (Eräranta, Kahila-Tani, & Nummi-Sund, 2015).

The questionnaire results show that providing an immediate overview of survey inputs can both augment dialogue between participants and planners and improve organisational capacity. While an immediate thematic overview can facilitate planners' work, this affordance can potentially affect the quality of responses. There is a risk that allowing respondents to see other respondents' comments may influence participants' own views and skew the results of public participation. At the same time, participants may learn from others'

inputs and respond accordingly, submitting comments and land use orientations which they may not have thought to provide otherwise. The ability to view others' responses is an important component of other web-based PPGIS, such as the application *Carticipe* used in several French cities, which allows respondents to display support for other respondents' development ideas (i.e. by voting or "liking" an idea) (Douay & Prévot, 2015). Making responses visible to all participants thus affects the dialogic nature of web-based PPGIS. Making online platforms openly accessible can also bias representativeness by inviting non-residents and technologically-savvy web users to respond, as warned by Graham and Aurigi (1997) in their analysis of early European virtual city portals. Despite the risk of significant bias in participation, municipalities may still deliberately choose to keep PPGIS surveys as open and transparent as possible (Kahila-Tani et al., 2016).

5.2 Organisational capacity

The overall cost of a PPGIS is an important consideration for organisational capacity, especially for resource poor municipalities, as indicated by the planner at SKL. Low expertise in GIS and the Geoweb, and limited capacity to invest in software or staff training can affect municipalities in other contexts, such as rural Québec (e.g. Johnson & Sieber, 2012). The cost of software developed from Open Source code is low to non-existent (e.g. Bugs et al., 2010; Nuojua, 2010). However, in all case-studies the PPGIS applications were procured at a cost by the municipalities, especially for Solna City which procured a sociotope mapping service from a planning consultancy. PPGIS projects also require resource allocation, such as staff hours for managing or following-up on surveys.

A national support network such as the Swedish Association of Local Authorities and Regions (SKL) can help disseminate best practice about public participation, including web-based PPGIS. At the same time, a PPGIS expert at the Finnish consultancy Mapita expressed

that despite receiving extensive information about a wide array of public engagement tools, some planners may not perceive the immediate value of online mapping surveys, or may be too busy to experiment with them. This echoes with observations that factors such as personal, professional and organisational culture and habits may limit the adoption of innovative technologies for public engagement among planners (Brown & Kyttä, 2014; Slotterback, 2011).

While the technology can be applied to virtually any stage of the planning process, web-based PPGIS is mostly used in early planning stages, which leaves greater room for influencing development strategies and proposals (e.g. Jankowski et al., 2015; Kahila-Tani et al., 2016). Tensions in land use preferences can emerge in the mapping process (Brown & Raymond, 2014), which can arguably be better managed in earlier than in later stages (Eräranta et al., 2015; Kahila-Tani et al., 2016). Follow-up and feedback should be continuous to make the planning process accountable, which has implications for governance.

Organisational capacity may be real or perceived. Tracing evolutions in spatial governance in the UK from 1998-2010, Grange (2013) points to declining political awareness among local authority planners, and their perceived inability or limited agency to contribute to sustainable development projects and proposals. Local councils and public agencies may be relunctant to adopt interactive modes of public engagement, including PPGIS, as due to red tape, limited budgets, socio-cultural resistance, or unfamiliarity with collaborative planning practices (cf. Brown, 2012; Slotterback, 2011).

Another important feature of the two PPGIS applications is that the output data is compatible with professional GIS software, which can greatly facilitate its integration in urban planners' workflow. Nonetheless, survey results may not be used directly by planners in their work. As planners at Helsinki City confided to PPGIS researchers, hardly any of them

had opened the files on their desktop, although they admitted having benefitted from the survey results (Kahila-Tani et al., 2016).

Organisational capacity also concerns urban residents' propensity to participate in web-based PPGIS, particularly as related to lifestyle. PPGIS researchers have indicated that despite enabling flexible participation, modern lifestyles, among other reasons, can contribute to low response rates for online mapping surveys (Brown & Kyttä, 2014; Pocewicz, Nielsen-Pincus, Brown, & Schnitzer, 2012). Regarding the use of *Bästa Platsen* in Sollentuna municipality (Stockholm region, Sweden), a planner expressed that online mapping surveys should not coincide with surveys so as to avoid solliciting urban residents excessively, which could result in low response rates(personal communication). Surveys should therefore be planned adequately local council departments.

5.2. Governance

The governance of knowledge-production processes and participatory spatial planning are core aspects of participatory forms of GIS (McCall & Dunn, 2012; Schlossberg & Shuford, 2005; Sieber, 2006). Urban governance settings are both beyond and central to the design and implementation of PPGIS applications. The case-studies indicated that PPGIS systems are dependent on the local governance context, as well as the organisational capacity of the local councils. The PPGIS in the two case studies were valued as mediating dialogue, learning and problem-solving between urban residents and planners. Both process (the participatory mapping survey) and outcome (the final map of georeferenced comments) were seen to add value to the planning process and extend public participation beyond ordinary consultation (samråd). The interviewed planners valued PPGIS because it provides insight about local socio-cultural contexts and gives direct expression to residents' expertise, as opposed to more representative forms of consultation. This view echoes with a SoftGIS approach to local knowledge, and its value for bridging planners' and residents' expertise (Kahila & Kyttä,

2009; Rantanen & Kahila, 2009). At the same time, the deployment of PPGIS software can generate expectations from residents about empowerment and decision-making (Sieber, 2006), as highlighted by the planner from Solna City. Anticipating and knowing how to manage these expectations seems to be a core consideration for the design and implementation of web-based PPGIS, which touches on the three main themes discussed here (i.e. design and affordances, organisational capacity as well as governance).

Frameworks exist for evaluating the governance of PPGIS. Most importantly, specifying both *who* and *how* to engage are fundamental considerations for the design, implementation and evaluation of PPGIS projects, for which Schlossberg and Shufford (2005) propose a preliminary assessment grid that can adapted per context. To better evaluate the governance of participatory mapping through the Geoweb, Walker and Rinner (2013) suggest a qualitative framework that assesses: i) the chosen medium of engagement (*engagement*); ii) participants' needs, skills, knowledge, and stakeholder status (*empowerment*), and iii) the manner in which engagement affects decision-making (*enactment*).

Despite the present of these frameworks which can support transparent governance, the use of PPGIS in urban planning continues to face multiple governance-related hurdles. First, the representativeness of PPGIS responses is an issue of concern. Response rates in online mapping surveys may be significantly lower than for other modes of public participation, such as mail-based mapping surveys (Pocewicz et al., 2012). The digital divide[8] in society limits the adoption of PPGIS by individuals and community organisations, which has important implications in terms of social and environmental justice (Crutcher & Zook, 2009; Elwood, 2010). Related to respondents' digital skills, there seems to be a trade-off

[8] The digital divide refers to poor access to or lack of skills in using digital technologies. It runs along multiple socio-economic determinants of exclusion (e.g Helsper & Reisdorf, 2016).

between the extent of participation and the technical and cognitive intensity of mapping tasks in web-based PPGIS, which can limit the scope of public participation to more basic forms of spatial knowledge (Jankowski et al., 2015). Respondent samples can also affect the quality and representativeness of survey responses. Both case-studies featured openly accessible online mapping surveys. With a view to broaden participation and improve the transparency of planning, local councils may wish to commission widely-accessible online mapping surveys (Kahila-Tani et al., 2016). While open accesssibility enables to reach as many participants as possible, voluntary participation can negatively influence the statistical representativeness of the survey results by encouraging participation only from interested residents (Kahila-Tani et al., 2016). However, open and random samples can lead to very different PPGIS survey outputs and policy recommendations (Brown, Kelly, & Whitall, 2014). Instead of choosing between open and random sampling, a middle-way is to to run both simultaneously so as to enable comparison of survey results. This enables a more rigourous assessment of the value of participation in municipal planning for urban densification, and provide a more robust evidence base for urban policies (Brown, Kelly, et al., 2014; Kahila-Tani et al., 2016).

Second, PPGIS applications remain map-based. The map as a communicative medium and artefact necessarily constrains the scope of representation, making it impossible to map outside the map (Harley, 1989). PPGIS maps frame dialogue and knowledge construction as do other types of maps used in public consultation (see Van Herzele & van Woerkum, 2011). PPGIS affordances specifically determine what can be mapped and the types of knowledge that can be produced (Douay & Prévot, 2015; McCall & Dunn, 2012), and *de facto* undermine alternative spatial explorations and problem formulations. For example, the *Geopanelen* application used in Tyresö municipality framed participation by encouraging the

use of coloured, thematic dots and limiting text-based responses, with a view to optimise the processing of responses.

Third, the wider context for public participation may undermine opportunities for engagement technologies to influence public policies. The outputs of participatory mapping are meant to inform better decision-making (Aggett & McColl, 2006). However, despite considerable experimentation with both methods and technologies for public participation, participation outcomes are often weak, which pre-empts opportunities for truly innovative participation (Fung, 2015). Innovations in participation often reinforce the status-quo instead of enabling the formulation of policy alternatives, through careful steering of technologies and the underlying rationalities for engaging the public (Rosol, 2015; Swyngedouw, 2005). Besides a recurrent lack of political will to support tangible participation outcomes, related hurdles include lack of leadership for championing best practice, and the lack of benchmarking and common agreements as regards the role and value of public engagement (Fung, 2015). The outcomes, costs and benefits of public participation are seldom formally assessed (Lukensmeyer, Goldman, & Stern, 2011; Wang & Bryer, 2012), which does not help to benchmark performance. The relative novelty of web-based PPGIS technology and its recent uptake in municipal planning, especially, can make it difficult to assess its outcomes on urban planning (Kahila-Tani et al., 2016). More systematic, longitudinal comparative studies are therefore required to evaluate the effectiveness of PPGIS, which could perhaps further motivate the uptake of the technology in local councils and public agencies (Brown & Kyttä, 2014).

The value of web-based PPGIS lies not in replacing existing technologies for public participation, but in complementing them. As highlighted by the expert at SKL, PPGIS seems to perform best when combined with other methods, as part of a wider "toolbox", as was the case most explicitly in the Tyresö case-study. Likewise, researchers recommend conducting

PPGIS alongside paper-based map surveys, community workshops and other methods to optimise participation from different sociodemographic groups of residents (e.g. Brown, 2012; Meng & Malczewski, 2010), and conduct online and offline public engagement technologies together (Slotterback, 2011; Stern, Gudes, & Svoray, 2009). PPGIS is no universal panacea for public engagement, as it suffers from inherent limitations related to the GIS technology which cannot be overcome with improved functionality or digital access (Sieber, 2006).

Toward Cyborg PPGIS

This section proposes a cyborg approach to PPGIS to better consider the hybridity of the themes discussed above. After referring to existing socio-technical frameworks for researching and implementing PPGIS projects, the value of a cyborg approach to PPGIS is discussed in terms of ontology and epistemology.

PPGIS experts have already emphasised that the performance of PPGIS surveys relies on technical as well as governance and organisational capacity factors, though not necessarily in those exact terms (Brown & Kyttä, 2014; Carver et al., 2001; Narooie, 2014; Sieber, 2006). Sieber (2006) proposes an analytical framework that considers: i) *Place and People*; ii) *Technology and Data*; iii) *Process*; and iv) *Outcomes and Evaluation*. The framework emphasises the complex interconnections between the socio-cultural, institutional and technological dimensions of PPGIS, and the importance of context. A socio-technical approach to PPGIS echoes with Harvey and Chrisman's (1998) discussion of GIS as boundary objects. Boundary objects can be loosely defined as "a sort of arrangement that allow different groups to work together without consensus" (Star, 2010, p. 602), an object whose periphery attracts interested stakeholders as much as they can exclude them. Applying a notion of boundary objects to GIS as socio-technical systems, the implementation of a GIS

appears as the product of locally contingent social forces, which mediates collaboration and negotiation across diverse groups of stakeholders with different aspirations, but can also exclude important stakeholders. Certainly for web-based PPGIS, the digital divide acts an exclusionary factor for an otherwise promising technology that can engage very diverse individuals in urban planning. Roth (2013) also applies a socio-technical approach to interactive mapping, which centres on six fundamental questions that can guide the design, implementation and evaluation of cartographic interaction: "What? Why? When? Who? Where? How?". Likewise, Brown and Kyttä (2014) consider the multiple technical and governance aspects affecting the uptake PPGIS in a systems perspective rather than in isolation, and point to related research gaps.

Both the above frameworks and the case studies indicate the need to better acknowledge the hybridity of the themes that determine the performance of web-based PPGIS in municipal planning. Toward this end, a "cyborg" analogy allows to merge these themes and support a more fluid appraisal of PPGIS systems. A cyborg is part-human, part-machine[9]; it is a complex organism that seamlessly combines disparate elements. It is this particular ontological quality of cyborgs which is of main interest for PPGIS, as well as the complementary ways of knowing which cyborgs' human and machinistic sensory abilities mediate.

Appropriations of the cyborg in geography and urban studies originate from the work of Donna Haraway (Gandy, 2005; Wilson, 2009). Among other themes, these have focused on the interplay between technology and the modern human body, gender, urban metabolisms, urban infrastructures, urban space, and cyberspace (e.g. Gandy, 2005; Haraway,

[9] The cyborg can be defined as "a bionic human; a person whose body contains mechanical or electrical devices and whose abilities are greater than the abilities of normal humans" (Merriam-Webster dictionary, 2016, http://www.merriam-webster.com/dictionary/cyborg).

1990; Mitchell, 2003; Swyngedouw, 2006). The cyborg analogy has enabled to better represent ontological complexity, particularly to transgress dualisms between nature and technology (Haraway, 1990), and between natural and human-made urban environments (Swyngedouw, 1996). A fundamental characteristic of the cyborg is its hybridity, and the looseness with which it can be applied to diverse objects of critical enquiry. Particularly, it allows to map "the co-evolution of social and technological systems" in complex urban contexts (Gandy, 2005, p. 41).

Theorising PPGIS applications as cyborg or hybrid systems enables to connect their different socio-technical parts. A cyborg approach to PPGIS can foster a synergetic performance of their technical, organisational, and governance components. As a corollary, inadequate tool design or poor consideration of PPGIS survey results in decision-making affects their performance. An example is the first trial of an online mapping survey launched in the city of Vaasa, Finland. An interview with PPGIS experts at the Finnish company Mapita revealed that the initial use of the PPGIS application *Maptionnaire* in Vaasa was stalled due to a lack of interest or support on the part of citizens and planners. Later applications in the city were however based on stronger collaboration with planners and more adequate planning of the project, which led to a more successful performance, contributing to a socially-acceptable urban development proposal in a city formerly characterised by resistance to new construction projects (see also Eräranta et al., 2015).

Beyond its ability to portray ontological complexity, the cyborg also enables epistemological hybridity (Wilson, 2009). Critical geographers have adopted hybrid forms of knowledge to bridge the divide between quantitative and qualitative uses of GIS, and address gender and socio-economic marginalisation within GIS practices and society (Elwood, 2006, 2010; Kwan, 2004; Schuurman, 2002). Appropriating Haraway's phrase, Schuurman (2002) has called for a "cyborg manifesto for GIS", largely to encourage feminist appropriations of

GIS technology which makes full use of the different forms of knowedge production which the technology can mediate.

The cyborg has yet to be applied to PPGIS research, however. For instance, a bridge can be made between epistemological hybridity and SoftGIS approaches to knowledge. Web-based PPGIS can conveniently mediate a SoftGIs approach to local knowledge (Jankowski et al., 2015; Rantanen & Kahila, 2009), and bridge "soft" GIS data emerging from residents' views about their living environment with expert data and knowledge to inform more transparent and effective urban planning and decision-making (Kahila & Kyttä, 2009). A cyborg-inspired epistemology, on the other hand encompasses reflexive, situated, and embodied forms of knowledge (Gandy, 2005), or "views from somewhere" (Haraway, 1988, p. 590), which contrast with positivism and empiricism, and seek greater objectivity through acknowledgment of the inherent subjectivity of the researcher (Haraway, 1988; Wilson, 2009). In urban theory and practice, reflexive, embodied knowledge can also take the form of dialogue and knowledge-sharing between residents, planning professionals and decision-makers (Innes & Booher, 2004; Kahila & Kyttä, 2009). The planner at Tyresö municipality indicated support for such epistemological hybridity, translated as mutual recognition of expertise between residents, planners and politicians, and perceived to be a key to more informed urban planning decisions in a context of urban densification.

An ontology and epistemology of web-based PPGIS as cyborgs requires further development. The cyborg can become a useful heuristic analogy for conceptualising ontological and epistemological complexity and hybridity in research and practice. However, practitioners (especially planners) may perhaps find it outlandish or abstract. Notwithstanding, the cyborg can function as a mnemonic device for conceiving Public Participation Geographic Information System applications as *systems* rather than simple tools. Operationalising a cyborg approach to PPGIS in municipal planning would require

weighing out the different socio-technical parameters and themes in relation to each other, and determining their relevance per project or planning context. A cyborg-inspired ontology and epistemology could inform case-surveys of web-based PPGIS, taking stock of the flurry of recent web-based PPGIS deployed in municipal planning that are largely missing from the international academic literature (e.g. the UK-based *Commonplace* and *Mapping for Change*, and the French *Carticipe*). Web-based PPGIS are now integral parts of online public participation platforms which combine diverse functionalities, such as: project descriptions, discussion threads, social media, budget allocation, and polling (e.g. Neighborland, coUrbanize, EngagementHQ, MetroQuest). These platforms deserve greater attention (see Seltzer & Mahmoudi, 2013). Likewise, the increased interoperability of geospatial data, and the gradual georeferencing of architectural design and construction management processes have the potential to enable a seamless integration of the output data of web-based PPGIS with all levels of design, planning, and construction. This trend termed Planning 2.0 by Anttiroiko (Anttiroiko, 2012b) constitutes a promising new field of enquiry. Together, these emerging, interlinked digital technologies would benefit from, as well as expand, cyborg theorisation, both ontologically and epistemologically.

Conclusion

Web-based PPGIS are increasingly being used to inform municipal planning in contexts of urban densification. The rapid deployment of such PPGIS applications is outpacing research on the topic. Particularly, there is a dearth of studies that consider the full socio-technical context of PPGIS applications. Despite unprecended levels of technological innovation in public participation, which include web-based PPGIS, the actual outcomes of such participation innovations remain weak or indeterminate. Based on the analysis of two PPGIS applications used in municipal planning in the Stockholm region (*Bästa Platsen* in Bergshamra district and *Geopanelen* in Tyresö muncipality), some of the main opportunities

and challenges for the uptake of PPGIS in urban planning were explored. The results complement existing research by focusing explicitly on the use of web-based PPGIS in municipal planning in contexts of urban densification. In particular, the results confirm existing literature that web-based PPGIS should complement existing public engagement technologies, as part of a wider "toolbox" for public participation. Three broad analytical themes emerged from a simple clustering analysis of the case studies and the literature: tool design and affordances; organisational capacity; and governance. Together, these themes provide an alternative lens to the appraisal of PPGIS.

Beyond revealing overlaps with existing analytical frameworks, the research results address the thematic hybridity between the different parameters that influence the uptake and implementation of web-based PPGIS in municipal planning. With a view to better address such thematic hybridity, a cyborg approach to the ontology and epistemology of PPGIS is proposed that builds on the work of Donna Haraway and critical geographers. It is argued that a cyborg theorisation of PPGIS enables a more adequate conceptualisation of the complex hybridity of PPGIS as objects of enquiry, as well as of the hybrid qualitative and quantitative forms of knowledge which the technology mediates, particularly its capacity to bridge different forms of expertise in urban planning. Furthermore, it is expected that the interoperability of geospatial data and software used in architecture, construction and urban planning, coined Planning 2.0 by researchers, will further facilitate the technological integration of multiple forms of expertise at all planning stages. Despite these technological advances, it is also expected that unsupportive governance and organisational contexts, as well as the digital divide, will remain the most significant hurdles to the uptake of web-based PPGIS in urban planning. The technology itself suffers from inherent limitations which necessarily constrain the dialogic nature of online mapping surveys. For these reasons, future research should continue to explore and assess how different technologies can complement

each other to support accountable decision-making in urban planning, and the value of web-based PPGIS in relation to these. As online mapping surveys continue to be rapidly deployed in multiple forms, even now in 3D and 4D , systematic, longitudinal case surveys would significantly expand knowledge about what works, how, and in which contexts.

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