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Article

Urban Narrative: Computational Linguistic Interpretation of Large Format Public Participation for Urban Infrastructure

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Abstract
Urban Narrative works at the interface between public participation and participatory design to support collaboration processes for urban planning and design. It applies computational linguistics to interpret large format public consultation by identifying shared interests and desired qualities for urban infrastructure services and utilities. As a proof of concept, data was used from the Christchurch public engagement initiative called 'Share an Idea,' where public thoughts, ideas, and opinions were expressed about the future redevelopment of Christchurch after the 2011 earthquakes. The data set was analysed to identify shared interests and desired connections between institutional, communal, or personal infrastructures with the physical urban infrastructures in terms of buildings, public places, and utilities. The data has been visualised using chord charts from the D3 JavaScript open source library to illustrate the existence of connections between soft and hard urban infrastructures along with individual contributions or stories. Lastly, the analysis was used to create an infographic design brief that compares and contrasts qualitative information from public consultation with quantitative municipal statistical data on well-being.

Keywords
city; computational linguistics; infrastructure; narratives; public participation; urban narrative

Issue
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1. Introduction

As recognised by the UN SDG 11, cities are more than hard infrastructures of utilities, buildings and public spaces (United Nations, 2018a). Cities are communities of individuals and families with different backgrounds, needs and aspirations (United Nations, 2018a, 2018b). For cities to work well, they need to reflect the underlying value system(s) of these communities together with more formal institutions and the corresponding qualities required of soft and hard infrastructures as described by Dyer, Gleeson, and Grey (2017). This requires urban practitioners to listen to both *what* people need and critically understand *why* based on underlying value systems. In the past, it has been difficult to capture this information at a large scale simply due to the practicality of liaising with large groups without losing contextual information about people's needs and aspirations (Certomà, Dyer, Pocatilu, & Rizzi, 2017; Dyer, Corsini, & Certomà, 2017).

With this in mind, Urban Narrative was funded by the New Zealand National Science Challenge for Better Built Homes Towns and Cities to adapt and develop digital tools to process large text-based data sets from public engagement exercises. Working in partnership with the Christchurch City Council, this article outlines the development of such tools to facilitate evidence-

based decision-making at multiple scales by processing data from the post-earthquake 'Share an Idea' public consultation. Using syntactic text analysis software, text data from 300 stories taken from the Christchurch City Council's *Common Themes from Public Ideas* report (Christchurch City Council, 2011) were processed in relation to soft and hard infrastructures to reveal citizen interests and expectations for urban infrastructure. In this instances, the term 'soft' refers to public administrative, organizational, and social structures present in a city, whereas the term 'hard' describes the physical components of a city that enable the soft infrastructure to function (Campbell, 2011; Casey, 2005; Landry, 2012; Newman & Jennings, 2012; Tonkiss, 2014). The result is a visual data story of citizen contributions based on 'lived experience' of a place and expectations from urban infrastructure. The digital tools have been shown to have the capacity to share knowledge about urban systems at multiple spatial scales and enable a more collaborative approach to urban planning and design by bridging the gap between top-down and bottom-up planning process as illustrated in Figure 1.

2. Theoretical Foundations

2.1. Public Participation vis-a-vis Participatory Design

Urban Narrative works at the interface between public participation and participatory design. The former is concerned with enhancing public democracy processes by providing direct participation in government, whereas the latter occurs more in the private sector as a means of improving design processes for specific products, places, or services. At first sight, the processes might appear distinctly different; yet, in practice, there is a lot of common ground between these processes where each is concerned with who and how people participate along with their ability to influence decision-making. In that regard, the seminal works by Fung (2003, 2006) characterised public participation as having three distinct elements (or dimensions), namely: who are the participants, how the participants communicate, and what is the impact of the participation exercise. The approach is developed further as a three dimensional 'Democracy Cube.' In a similar manner, the later work by Nabatchi (2012) advocated a framework for designing public participation comprising eight elements (or propositions). The main characteristics of both frameworks for public participation can be summarised as follows:

- Deliberative modes of communication to identify and understand public values
- Collaborative process focussed on common interests (values) instead of fixed positions
- Shared decision-making to resolve values-based policy conflict
- Provision of information to better inform participants and aid good quality decision-making
- Recruitment strategies that are representative of diverse stakeholders and avoid bias

In comparison to public participation processes for public policy, participatory design is an overarching term for one of several different people centred design processes (Sanders & Stappers, 2008). A key feature of participatory design is the involvement of the 'user' as a design partner in the design process rather than being a subject to be observed or observer. As such, it places people at centre-stage within the design process and differs from user-centred design which focuses on use and usability (Ehn, 2008). Hence, participatory design is fashioned from two complementary values, the first being the right to participate in design activities and the second a means of bringing tacit or non-discursive knowledge of users into design thinking. In practice, it generates design activities and prototypes as part of the design process. The designer becomes a facilitator or what Ehn (2008) describes as a responsive designer, one who alternates the leadership roles in a project depending on whose skills are most relevant, including her own, while at the same time keeping

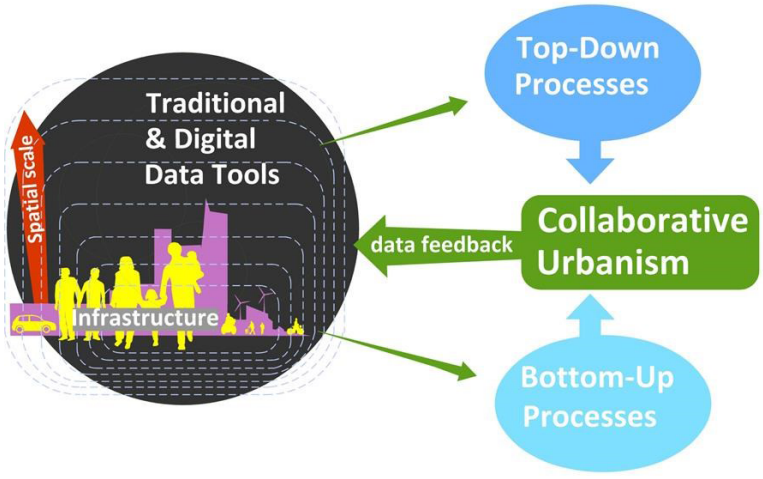

Figure 1. Big and small data informing top-down and bottom up processes. Source: Grey, Dyer, and Gleeson (2017).

all participants involved. Intriguingly, Dewey (1984), as one of the thought leaders for public participation in the early twentieth century, implicitly recognised the overlap between public participation mechanisms and participatory design by once remarking that "the man who wears the shoe, not the shoemaker, knows best where it pinches.''

As recognised by Fung (2003, 2006), Nabatchi (2012), and later Dyer, Gleeson, Ögmundadottir, Ballantyne, & Bolving (2017) plus Gleeson and Dyer (2017), one of the major challenges with participatory mechanisms is the creation of a deliberative process for a representative group of participants to critically define and solve a problem whether it be in the public policy arena or in the design of a new product. Traditionally, the scale of the deliberative process is a controlling factor. As observed by Nabatchi, a large format process typically takes place in townhall style meetings that tended to foster one-way communication, whereas a small table format process of 8–12 individuals fosters two-way communication but needs integration and up-scaling to be representative of a wider audience.

One relatively recent approach towards democratizing decision-making for public policy has been the emergence of participatory mapping using online Geographic Information Systems (GIS). Termed Public Participation Geographic Information System (PPGIS) from a meeting of the National Center for Geographic Information and Analysis in the US in 1996, the novel participatory mechanism was viewed as an opportunity to bridge the gap between the expert-driven technical world of land use planning and bottom-up lay knowledge from lived experiences. As critiqued by Brown and Kytta (2014), there are numerous case studies worldwide where PPGIS has been implemented to improve data collection by individuals or groups to inform and influence land planning and management decisions. Case studies typically involve recording positive or negative subjective spatial attributes connected to physical locations, such as fishing activity linked to a body of water. However, has noted by Brown and Kytta (2014, 2018), the idealised version of PPGIS has not substantially materialised. Instead numerous barriers have emerged to negate collaborative processes in the public administration. These barriers are attributed to a risk adverse culture, lack of incentives, short term budgets, planning horizons, etc.

Some of these barriers was observed by Dyer, Corsini, and Certomà (2017), where an extensive bibliometric analysis of 14,883 articles from ISI Web of Knowledge found a noticeable divide between published research into urban governance, urban planning, and urban design. The results were plotted using terms extracted from articles sourced using key phrases 'urban planning,' 'urban development,' 'urban design,' or 'urban governance,' where each publication had at least one key phrase in both the title and abstract of the manuscript. The term map indicated a significant divide between the traditional fields of social sciences, built environment disciplines, and information technologies. Typically, the reviewed published articles recorded research into urban governance that did not translate into design decision-making for land use or alternatively focused exclusively on urban planning and design with little attention to urban governance. There seemed to be negligible common understanding or framework to translate aspirations for greater citizen participation into improved planning, design, and construction of city infrastructures.

Exemplars do exist of public participation influencing public policy at the city scale. For example, the ethnographic study reported by Dyer and Ögmundardóttir (2018) documents the successful transition of two Scandinavian cities towards becoming fossil-fuel free conurbations. The success depended on each city populace identifying common but distinctly different narratives that resulted in significant new investment in renewable energy infrastructure, refurbishment of homes together with establishment of new education facilities for reskilling workers. In the case of Växjö the common narrative was one of protecting and valuing the environment through making good use of local resources in particular from forestry. Whereas the theme for Sønderborg was one of job creation and business opportunities brought about by the creation of Project Zero as a formal partnership between private and public sector organisations. In both cases, the transition teams benefited from the involvement of enthusiastic champions from either grassroots activists (Växjö) or business leaders (Sønderborg) who facilitated dynamic two-way communication and networking that was backed by political consensus. The outstanding success led the researchers to speculate if computational linguistics could be used to support similar large-format public participation mechanisms by identifying common narratives centred around share interests.

2.2. Computational Linguistics

As a first step towards analysing meta data sets from public consultation, Urban Narrative employed syntactic analysis and in particular collocation of key words to identify references to key features or attributes of urban infrastructure (e.g., green space, safe streets, affordable public transport) of importance to individuals or groups.

Syntactic analysis is a component of computational linguistics that employs computer science techniques to analysis and synthesis language and speech that includes the syntax and semantics of a sentence. Syntax itself is concerned with the structure of sentences in a language (e.g., nouns, verbs, adjectives, etc.), whereas semantics is the study of meaning in language.

As noted by Wu (2010), the term 'collocation' has many definitions in the literature. Nattinger and DeCarrico (1992) define collocation as "a string of specific lexical items that co-occur with a mutual expectancy greater than chance." Nation (2001) identifies collocations as "items which frequently occur together and

have some degree of semantic unpredictability." Benson, Benson, and Ilson (1986) call them "fixed, identifiable, non-idiomatic phrases and constructions." In the view of Lewis (1997), "collocations are those combinations of words which occur naturally with greater than random frequency." Sinclair (2004) describes the phenomenon of collocation as "the choice of one word conditions the choice of the next, and of the next again." In statistical terms, a collocation is two or more consecutive words with a special behavior (Manning & Schütze, 1999). In practice, extracting collocations from a corpus of text generally involves five steps:

- extract a set of candidate collocations from the corpus,
- calculate a statistical score for each one,
- rank candidates according to the scores,
- select a predetermined number of the top candidates for manual inspection, and
- confirm the true collocations manually.

Candidate collocations are often word *n*-grams as a contiguous sequence of words usually as bigrams. In the simplest case, the first step involves considering all pairs of consecutive words in the corpus as candidate collocations. In this case, linguistic analysis was applied to identify candidates that follow particular syntactic patterns, e.g., adjective + noun, or verb + noun. Next, there were several possibilities for the statistical score such as ranking by frequency to syntactically filtered data. However, high frequency can be accidental, in which case hypothesis testing was employed as a statistical technique to assess whether or not an occurrence was a chance event. More information about the methodology is given in later sections.

2.3. Soft and Hard Urban Infrastructures

When applying computational linguistic analysis to public participation meta data, a framework is needed to interpret the interests and attributes identified by individuals and groups. Based on previous case studies (Dyer et al., 2019), a framework comprising soft and hard urban infrastructures was adopted. As defined earlier, the term 'soft' referred to public administrative, organizational, and social structures present in a city, whereas the term 'hard' described the physical components of a city that enable the soft infrastructure to function (Dyer et al., 2019). This categorisation of urban infrastructure has been developed further in Table 1 by describing in more

Table 1. Soft and hard urban infrastructures.

Hard Infrastructure	
Utilities	Utilities are considered to be physical services such as transportation, water and waste systems, ICT, etc. These utilities connect and operate equally across all urban scales, including national and international interconnectivity.
Urban Space	Urban spaces are considered to be largely as bounded space, in the form of streets, urban plazas or local squares, playgrounds, parks, etc. Urban space is typically identifiable at the neighbourhood or district scale, depending on the nature of the open space and pattern of land ownership.
Buildings	Buildings are considered to be architectural space defined as single or grouped buildings forming part of an urban block. This will include dwellings, educational buildings, healthcare buildings, etc.
Soft Infrastructure	
Institutional	Institutional infrastructure refers to public and private systems which provide certain services within the city such as local government, legal frameworks including land ownership, healthcare services, or educational services. It may also include sporting, art and culture, or official community support organizations. These institutions are typically top-down and more formal in nature.
Community	Community infrastructure refers to formal and informal networks, community or local business groups that occur within neighbourhoods or districts. These infrastructures rely on bridging and linking social capital. While 'Communities of Interest' or online communities may not be location specific, many community organizations will relate to a specific physical community delineated by political, parish or physical boundaries (a river, large street, etc.). In this regard community infrastructures will often operate within the district scale and arguably at a more identifiable level at the neighbourhood scale.
Personal	Personal infrastructure refers to the support systems a person will have at an individual, family, or friendship level. This will often involve bonding social capital where membership of a family or social group is critical to a sense of belonging. It will also include educational attainment and other support systems that occur at an individual level.

Sources: Grey et al. (2017) and Dyer et al. (2019).

detail types of utilities, urban space, and buildings, and of institutional, community, and personal infrastructures.

At the same time, it is important to recognize that these infrastructures potentially overlap and intertwine at different scales across the city. An appreciation of the relationship between soft and hard urban infrastructures and spatial scale contributes to an understanding of the perspective of different individuals and groups across the city (Dyer et al., 2019). It can help explain the varying interests and positions adopted by different stakeholders. For example, when collecting data from stakeholders, Moughtin and Shirley (2006) contended that public engagement is most effective at the city quarter, or neighbourhood level, as these represent a scale where residents can contribute their local knowledge and expertise. This is because neighbourhoods, quarters, or districts of the city have a somewhat identifiable boundary, recognisable to both residents and outsiders alike. As recognised by Lynch's (1960) seminal work, neighbourhoods are structural elements common to most cities that influence people's perception of the city, thus making the urban environment more intelligible and legible. In addition, most people interact with the urban environment on a daily basis at the neighbourhood scale, and therefore this scale has a significant impact on their quality of life.

3. Methodology

3.1. Software Systems Architecture

As explained earlier, the study adapted the linguistic software tool FLAX (Flexible Language Acquisition) developed by Wu and Witten (2015). This software is capable of analysing large text data sets from public engagement exercises to identify common themes and reoccurring topics of conversation that reflect community interests and desired qualities of soft and hard infrastructures. The software employs syntactic analysis to identify collocations of two or more consecutive words that appear more frequently than random. For instance, the phrase 'shuttle bus' could be identified in a sentence, rather than 'bus shuttle,' as an example of high-frequent word combinations that indicate high-trending topics of interest to people.

The FLAX software overcame the inherent problem of languages having large numbers of collocated words by automatically employing sets of syntactic patterns to retrieve a list of collocation words specific for individual data bases. The collocation extraction heuristic procedure firstly assigns part-of-speech (POS) tags to all the words using the Apache Open Natural Language Processing Library (Apache Software Foundation, n.d.). Secondly, it matches these tagged words with a set of predefined patterns and identifies the collocation words. Lastly, it collects all the collocations, groups them by matched patterns, and sorts them by the frequency usage.

The POS tagging technique identified the collocation word as 'noun,' 'verb,' 'adjective,' 'adverbs,' etc., and labeled it with the corresponding word type. FLAX POS tagging adopted the PennTreebank POS tagset at word level and assigned one POS tag to each word. For example, the collocation 'green spaces' is tagged as 'green/JJ spaces/NNs.' The symbol 'JJ' represents the word 'green' as adjective, and 'NNs' indicates the word 'spaces' as a plural common noun. Later on, tagging information helped with recognition of keywords in contributions from participants.

Taking all these features into account, the Urban Narrative Data Analytics and Visualisation software architecture for analysis of large format data from the Christchurch's *Common Themes* public consultation exercise is illustrated in Figure 2. Using the 300 stories as a sub-set from the Christchurch's *Common Themes* report, FLAX collocation analysis identified sub-categories of soft and hard infrastructures using the 'noun + noun' pattern and the desired attributes from those city infrastructures using 'adjective + noun' pattern.

Starting with the 'noun + noun' patterns, each infrastructure sub-category was encoded as a structured XML to show the text ('text' element), type ('noun + noun' elements [NN]) and POS tag ('tagged_text' element) as illustrated in Figure 3 (left). For instance, the term 'car parks' appears eight times in all story contexts, and the word 'car' is tagged as a singular noun and 'parks' as a plural noun. Each infrastructure sub-category is mapped as either soft or hard infrastructures. Hard infrastructure categories include 'utilities,' 'public space' and 'building,' and soft infrastructures comprise 'institutional,' 'community' and 'personal.' In this case, 'bus exchange' and 'car parks' are associated with 'public space' infrastructure.

Likewise, collocations of 'adjective + noun' patterns were used to retrieve terms describing desired attributes or qualities of soft and hard infrastructures by identifying connections between infrastructure categories. These terms derive from the Flax collocations 'adjective + noun,' 'adjective + to + verb,' and 'adjective + preposition + noun.' Similar to infrastructure categories, terms describing the desired qualities of urban infrastructures are encoded as an XML document where the adjective is denoted as 'JJ.' For example, in the phrase 'green spaces' in Figure 3 (right), the term 'space' belongs to the 'public space' sub-category of hard infrastructure category, and the adjective 'green' describes the desired quality for that infrastructure sub-category.

3.2. Pairing Soft and Hard Urban Infrastructures

Once the respective sub-categories and qualities of infrastructure were identified, individual contributions or stories from public consultation were grouped by pairing soft and hard urban infrastructures. The pairing exercise had three stages, namely (1) building a glossary of terms, (2) identifying pairs of stories with the same sub-categories of soft and hard infrastructures, and sub-

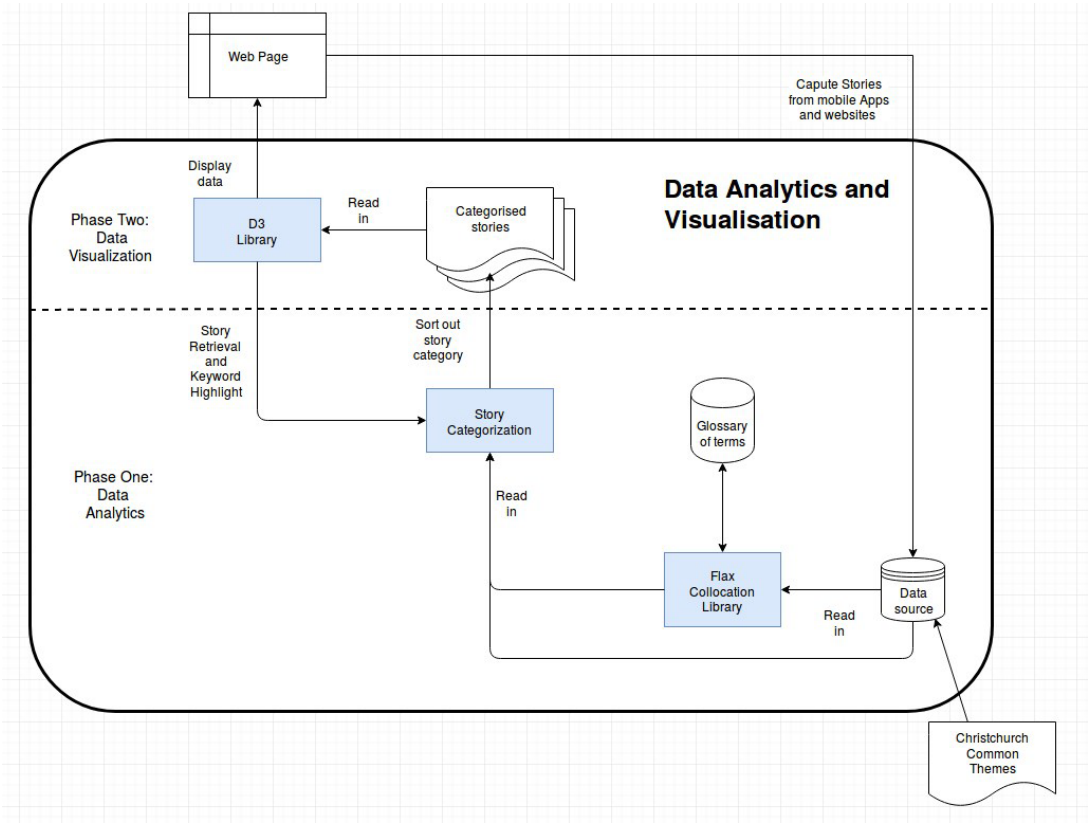

Figure 2. Urban Narrative data analytics and visualisation architecture. Source: Authors.

Figure 3. Sub-categories of urban infrastructures (left); qualities of urban infrastructure (right). Source: Authors.

sequently (3) undertaking statistical analysis, such as counting how many stories are connected with two subcategories. The terms used to establish a glossary for soft and hard urban infrastructures required domain knowledge and expertise in urban design. However, once the FLAX library extracted all the collocated words for the 'noun + noun' and 'adjective + noun' patterns, the terms were listed and examined by experienced urban designers to understand the relative importance attached to different combinations of soft and hard urban infrastructures by the public consultation exercise and expected qualities for those infrastructures to promote greater liveability and livelihood.

Having focussed on the term 'city centre,' the phrase 'bus exchange' was found to be the next most frequently occurring FLAX collocation (noun + noun), as shown in Figure 4, along with other collocations that related to transport (i.e., 'bus exchange,' 'car parks,' 'transport options,' 'shuttle buses,' and 'car parking') that made up a substantial number of stories, 36 in total. Interestingly, the collocations about transport related primarily to two topics, cars (16 stories) and buses (15 stories). In both instances it was the destination/arrival points which were the main topic of discussion, i.e., the exchange and parking areas. While the collocation 'transport options' requires further contextualisation, this supported the finding that 'transport' was the top trending topic amongst citizens of Christchurch in relation to the city centre.

Notwithstanding the top three most frequent collocations, the frequency of the remaining collocations was noticeably less, each attracting between five to four comments. These included references to 'buildings' which relates to five commentaries about building heights, both high- and low-rise. Buildings use was also a topic of discussion, in terms of appropriateness ('sex shops') and physical location ('ground floor') within the city centre. Furthermore, the collocation of the term 'city living' primarily related to discussions around increasing activity within the city centre at different times of day and night through the re-introduction of residential uses.

In comparison, when FLAX investigated the desired qualities or attributes of urban infrastructures by using the collocation pattern for 'adjective + preposition + noun' it revealed 'safety' as being the main topic of interest, as shown in Figure 5. In particular, citizens commented about safety in the city centre ('safety around the central city' and 'safe at all times') and how soft and hard infrastructures could create a safe urban environment, such as the presence of security wardens in the city centre as part of a soft infrastructure. Commenting further on expected attributes of an urban environment, citizens placed a lot of importance on visitors' experience in the city centre ('great for tourists' and 'attractive for visitors'). For example, the collocation of words for one commentary referred to 'to its enhanced function' which related to the retention of tourism through quality public realm. Likewise, connectivity between the city centre and suburbs was considered an important theme in terms of 'interconnecting with the suburbs,' as did the topic of inclusivity in regard of the collocation 'accessible to everybody.'

3.3. Data Visualisation from Public Consultation

Although 300 stories is a relatively small sample size compared to the total number of stories received from the public consultation exercise, analysis of collocations demonstrated the potential for natural language processing and expert knowledge to quickly identify top trending topics, or priorities among citizens in relation to the city centre of Christchurch. The next step was to use data visualisation techniques to explore connections between soft and hard infrastructures. From a review of three well-known tools (D3.js, Google Chart, and vis.js) the open source library D3 (Bostock, n.d.) was chosen for developing data visualisation tools. In particular, chord

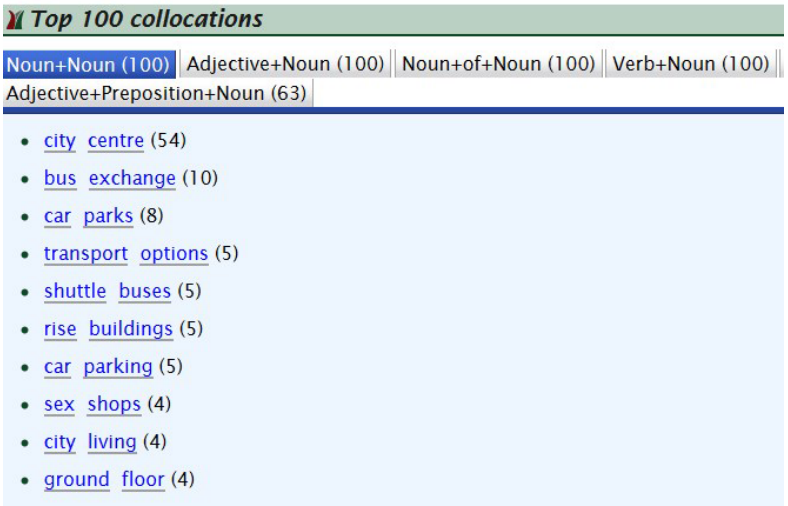

Figure 4. FLAX collocations (noun + noun) for 'city centre.' Source: Authors.

Figure 5. FLAX collocations ('adjective + preposition + noun') for 'city centre.' Source: Authors.

diagrams were used to illustrate inter-relationships between sub-categories of soft and hard infrastructures (Holten, 2006). This was undertaken in conjunction with MarkJS (JavaScript keyword highlight; mark.js, n.d.) to highlight key words in the text of different categories and qualities of hard/soft infrastructure being referred to in the Christchurch public consultation exercise.

Based on this approach, an initial chord chart was produced which illustrated connections between nine different combinations of soft and hard infrastructures. In practice, this was achieved by using multiple single-label classification questions as follows to categorize individual contributions:

1. Does this story use any glossary of term from 'utilities' infrastructure?
2. Does this story use any glossary of term from 'public space' infrastructure?
3. Does this story use any glossary of term from 'building' infrastructure?
4. Does this story use any glossary of term from 'institutional' infrastructure?
5. Does this story use any glossary of term from 'community' infrastructure?
6. Does this story use any glossary of term from 'personal' infrastructure?

The approach produced a list of categorized stories, as shown in Figure 6, where each row referred to one story or contribution along with its associated infrastructure sub-categories ('Category' column) and keywords identification ('Keywords' column). This approach transformed the multi-label to single-label classification which greatly reduced the complexity for the prototype.

Using the output from the CSV file, this led to production of a relationship matrix of an array of six items, where each $mat[i]$ has an additional array of 6 items, and $matrix[i][j]$ represents the number of stories from i-th category to j-th category. Hence the matrix row and column represent 'Utilities,' 'Public Spaces,' 'Building,' 'Institutional,' 'Community' and 'Personal' accordingly. So the 1st row $mat[0]$ represents all the links identified between 'Utilities' with the other five infrastructure categories. $mat[0][1]$ denotes the link from 'Utilities' to 'Public Spaces,' and $matrix[0][5]$ represents the link from 'Utilities' to 'Personal.' However, $mat[0][0]$ is zero as no link from/to 'Utilities' itself. The matrix is bi-directional, so $mat[i][j] = matrix[j][i]$.

4. Findings and Discussion

Based on this methodology, primary chord charts were created from the FLAX analysis of ten stories from the Christchurch's *Common Themes* as shown in Figure 7. A preliminary review of the primary chord chart shows contributions from residents of Christchurch focussed more on hard infrastructures than soft infrastructures, where the sub-set for hard infrastructure attracted 20 in-

Category	Story	Keywords
|Public Space|Institutional	Mix of views on university – some say bring it back into the city centre others say leave it at Ilam.	|Public Space:-city centre-city centre||Institutional:-university|
|Public Space|Building|Institutional|Community	"Some suggest bringing components back into city centre (e.g. Music school, artistic displays, law school, study space, accommodation) ""We really have to be positive about bringing the whole university back into town."	|Public Space:-city centre-city centre||Building:-study space||Institutional:-university-music school-artistic displays-law school||Community:-town|

Figure 6. Snippet of categorized stories CSV file. Source: Authors.

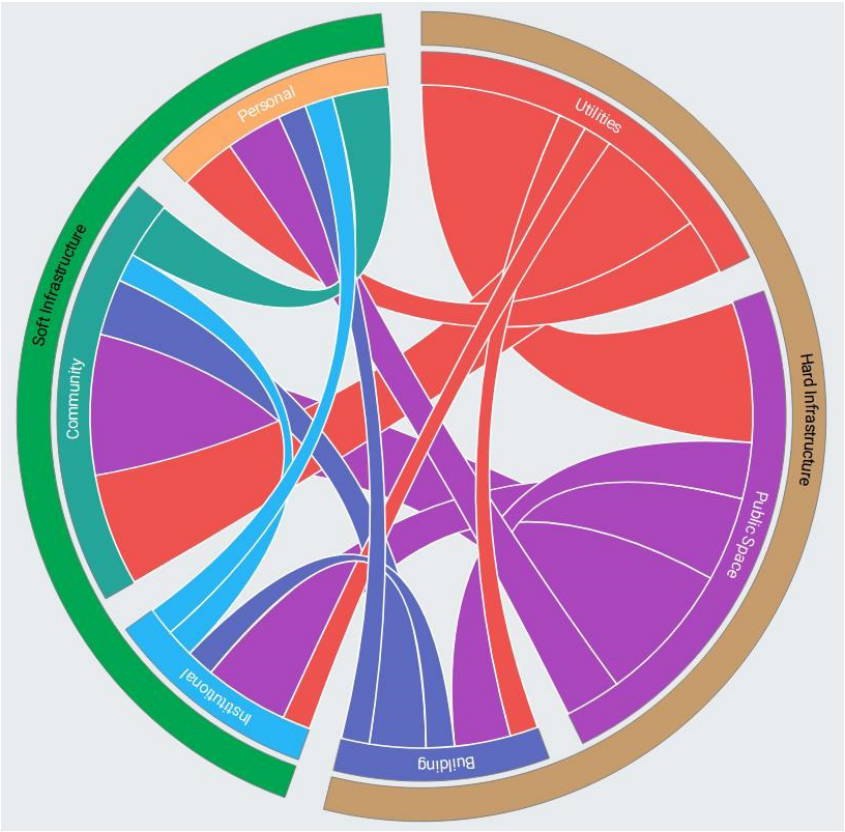

Figure 7. Primary chord chart illustrating connections between soft and hard infrastructures from the FLAX syntactic analysis of ten stories from the Christchurch's *Common Themes*. Source: Authors.

dividual contributions and soft infrastructures 12 individual contributions. In particular, the hard infrastructure category of 'Public Space' attracted the greatest number of contributions as well as the highest number of connections with other infrastructure types. This preliminary result showed that participants in the public consultation exercise placed a great deal of emphasis on the physical infrastructure following the destruction caused by the major earthquake of 2011. The preliminary result also indicated that public space was a top trending topic for the residents of Christchurch and should be a priority for the future development of the city centre of Christchurch.

When exploring the findings in further detail, a secondary chord chart was generated to highlight residents' contributions that referred specifically to one or more glossary terms for the 'Public Space' category. This secondary chord chart is shown in Figure 8. Apart from identifying relationship chords between 'Public Space' and other soft and hard infrastructures, it was possible to retrieve individual stories using the D3.js JavaScript library. Extracts of these individual stories are also reproduced in Figure 9 for the relationship chord connecting 'Public Space' with 'Institutional' infrastructures. The extracts of text show terms referring to 'Public Space' and 'Institutional' infrastructures boxed with adjectives describing desired qualities of infrastructure in green-coloured font. For example, one story refers to police in terms of soft 'Institutional' infrastructure and, in particular, the desire for greater visibility and presence of policing within the city centre. Although these cases referred to hard infrastructure in terms of 'dark,' 'seedy,' 'late,' 'low,' etc., the collocated adjectives indicated a desire for increased personal safety. Hence, an important narrative that emerged from the analysis was 'policing of secure and safe public spaces in city centre.'

Finally, further insights from the text analysis of public consultation were obtained by comparing qualitative syntactic text data from Christchurch's *Common Themes* with quantitative municipal statistical data. Figure 9 illustrates the comparison of the qualitative and quantitative data sets using an infographic display. The smaller font in quotation marks represents core messaging from citizens compared with municipal statistical data shown in larger font size (Christchurch City Council, 2019). The example illustrates one approach for bridging the gap between bottom-up and top-down processes by comparing qualitative public opinion in relation to quantitative statistical data. In this case, the topics ranged from public transport usage to provision of street lighting. Even though the infographic draws upon a relatively small data source, it demonstrated the capacity of infographics to integrate bottom-up and top-down perspectives to create a more holistic Urban Narrative. As such, it is a potentially powerful tool to facilitate a deliberative discussion and collaborative approach towards decision-making that is evidence-based.

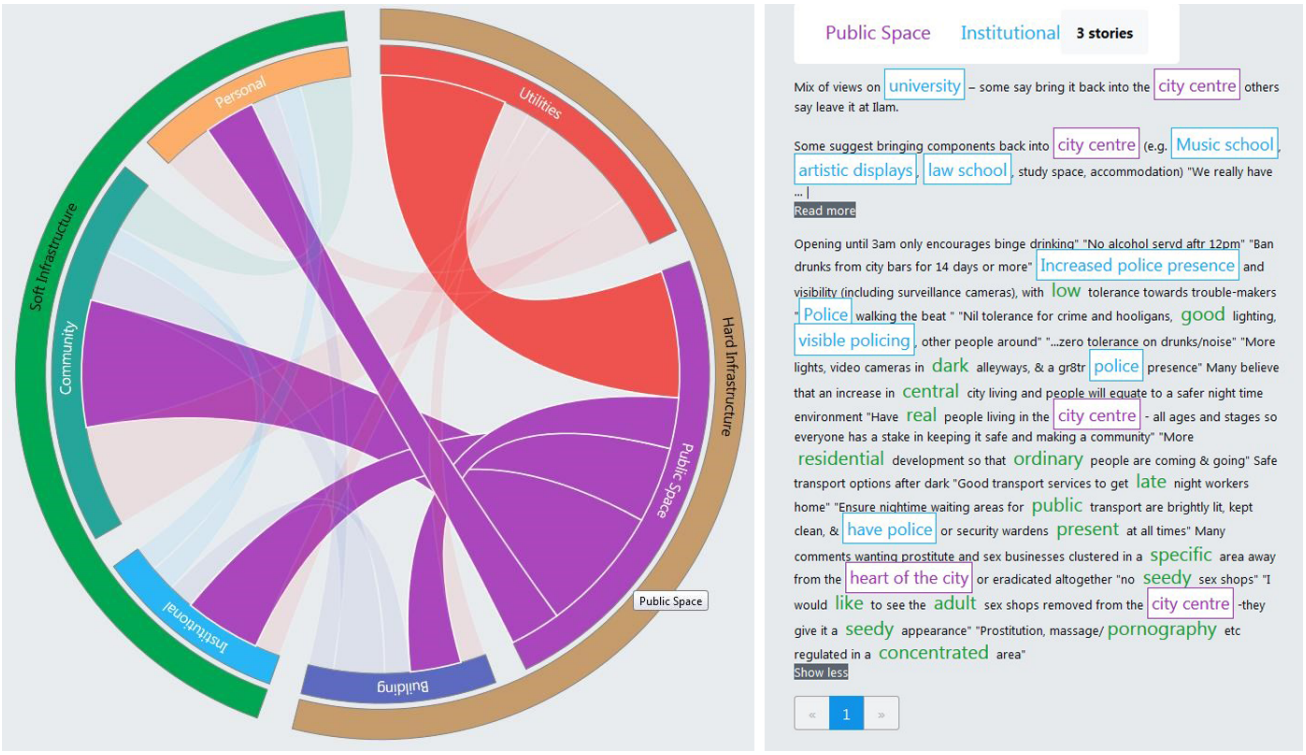

Figure 8. Secondary chord chart illustrating connections between soft and hard infrastructures under the category of 'Public Space' with associated stories shown alongside from the Christchurch's *Common Themes*. Source: Authors.

Figure 9. Infographic comparing qualitative syntactic information from Christchurch's *Common Themes* with quantitative statistical municipal data. Source: Authors.

5. Conclusion

The United Nations estimates that 68% of the world's population will be living in urban areas by 2050 (United Nations, 2018b). To facilitate greater social inclusivity as well as creating built environments that promote improved liveability, there is a need to transfer the digital skills and technology from social media and e-economy to create a step change in collaborative processes for urban planning and design that captures the underlying interests of individuals and communities. There is still a place for traditional consultation processes using 'town hall'-style meetings and charrettes but digital tools offer an opportunity to upscale participatory design methods in response to an increasingly complex urban system to ensure future inhabitants have access to "safe and adequate housing, clean air and basic services and live in resilient and sustainable communities." (United Nations, 2018a)

In response, Urban Narrative has been designed to develop shared narratives about individual interests and desired attributes for urban infrastructure. The inspiration arose from the successful use of common narratives at the Scandinavian cities Växjö and Sønderborg to motivate transition towards becoming fossil-free conurbations beyond land use planning horizons and political cycles. As such, it differs from the participatory mapping of PPGIS by aiming to integrate contributions from individuals into data storytelling.

With those aims in mind, the linguistic software FLAX has been shown to be a powerful digital tool for identifying issues of importance for residents and how those issues could translate into improved services by better connecting the soft communal and institutional infrastructures of a city with the physical fabric of the city in terms of utilities, buildings, and public spaces. The approach supports the old paradigm that the physical infrastructures are a "means to an end and not the end in themselves." Yet there is often too little research and knowledge about the social benefits of infrastructure, or post-occupancy evaluation of built infrastructure to understand the mutual benefits for improved livelihood and liveability. For example, the case study showed that improved safety and security was deemed highly important by individuals, and hence required a coordinated response that connects soft infrastructures (policing) with hard infrastructures (late night public transport, better lit and monitored alleyways and public spaces).

In conclusion, Urban Narrative as a concept functions at the interface between public participation for democratic processes and participatory design for products, place-making and services. It has demonstrated the potential benefits of using computational linguistics to identify individual interests in relation to desired attributes of soft and hard urban infrastructures. Hence, it has the ability to harness the collective knowledge of individuals to understand not just *what* people want, but also *why* they want it, and has the potential to shift design thinking by enabling higher quality design that effectively meets the needs of citizens.

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Conflict of Interests

The authors declare no conflict of interests.

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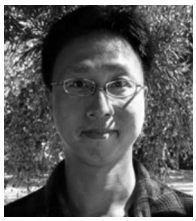

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