

Space vs. Place: Comparing Space-based Movements and Place-based Experiences at the Roskilde Festival 2015

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ABSTRACT

This paper applies urban informatics methods and techniques on big data generated from the concentrated environment of the second largest music festival in the world, Roskilde Festival. First, we explain how to utilize relevant dimensions from human geography theories towards mapping a ‘Geography of Importance’. Second, we elaborate on methods deployed for collecting both mobile GPS and social media traces that the smart phone generates in physical spaces. Third, we compare and contrast the automatically geocoded presence in space and at events with the intentionally socially tagged consumption of these spaces and events as place-based experiences. In doing so, these two layers of space-based movements and place-based experiences reveal the appropriation of affordances and choices of aesthetic appreciation by the crowd at large of what is subjectively and relatively meaningful, actionable, and valuable.

CCS Concepts

Information systems~Data analytics • Applied computing~Sociology

Keywords

Social Media, Urban Informatics, Mobility, Geospatial, Geofenced

1. INTRODUCTION

For one week every summer an event of city-wide proportions is held on the outskirts of Roskilde, Denmark. The Roskilde Music festival¹ has been held annually since 1971 and is currently the second largest music festival in the world. Its attraction is often propelled by legendary musicians who play alongside free-spirited campground communities. The event is of such great magnitude that the quiet farmland on the outskirts of the Roskilde town temporarily becomes the fourth largest city in the country of Denmark (population-wise) for one week each year. Besides the festivities, this world-famous cultural event also has a long tradition among researchers and urban planners who make use of temporary ‘city’ spaces (such as campgrounds, art installations, restaurants, bars and stages) that collectively serve as an area to deploy experiments in urban informatics².

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There is an estimated population of about 110,000 individuals on the ground each day at Roskilde Festival (RF) - be they full-week campers, single-day concertgoers, staff, or some of the 31,000 volunteers – who share one thing in common, the mobile phone. The mobile phone in their pocket is almost always a smart device, a beacon for precise location tracking of each person who explicitly volunteers to share via the opt-in feature of the RF mobile app. Like the mobile phone hardware itself, social media is embedded in many of these people’s lifestyles [1, 2]. As in everyday life, the smartphone affords a means of production and consumption of the spaces they occupy and places they experience [3, 4]. Photos and status updates are produced to friends near and far with elevated importance [5], while local information about festival activities and places to eat or drink are consumed with heightened relevance [6].

Our big data analytics study of urban informatics has been made possible with over 39,000 participants voluntarily providing Global Positioning System (GPS) tracking of their movement within the 2015 Roskilde Festival grounds. Almost 20,000 photograph postings (geo-tagged to Instagram) were collected, adding to 35,000 Twitter mentions (later filtered for geo-tagged posts), and over 33,000 public posts on all other online channels (Blogs, Forums, Facebook³, mainstream news and Video/Photo sharing sites). The temporary duration of the festival thus offered a unique opportunity to track large numbers of people and their corresponding interactions at volumes that would take much longer to solicit in traditional urban spaces.

This paper applies urban informatics methods and techniques [7] on big data generated by the concentrated environment of RF15. First, we will explain how to utilize relevant dimensions from human geography theories towards mapping a ‘Geography of Importance’. Second, we will elaborate on methods deployed for collecting both social and mobile traces that the smartphone generates in physical spaces. Third, we compare and contrast the automatically geocoded presence at events with the intentionally socially-tagged consumption of these spaces. In doing so, these aspects act as complimentary layers to reveal the appropriation of affordances [8] and choices of aesthetic appreciation [9] by the crowd at large of what is personally and socially meaningful, actionable, and valuable.

THEORETICAL FRAMEWORK

2.1 Mobility & Social Relevance

The online social spheres we are investigating are made possible by the “concomitant convergence” [10] of Social, Local and Mobile

³ Only publicly-shared content; Posts where users do not have their privacy setting set to ‘public’ were not accessed.

¹ www.roskilde-festival.dk/

² www.scenariomagazine.com/roskilde-festival-a-laboratory-of-cities/

(SoLoMo) technologies that the smartphone affords, representing a convergence of social computing, mobile technology, and information retrieval whenever and wherever we go. The three combined lenses of SoLoMo allow us to analyze how humans move through and interact with the physical landscape and appreciate specific aspects of it. A resulting ‘mobilization of social media’ can be better understood by looking at the interplay of elements that motivate people to engage in a lifestyle that is intertwined with the smartphone and social media [4]. This SoLoMo theoretical framework (Figure 1) divides the elements of our digital social transformation into two contrasting dimensions: the physical and online worlds, a distinction that will be contrasted in the use of physical space vs. social place within the analysis of this paper.

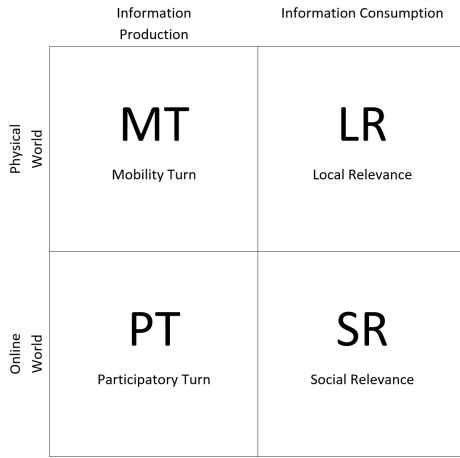


Figure 1: SoLoMo Theoretical Framework, taken from [4].

The framework begins with a Mobility Turn (MT) that has enabled people to navigate the world with increasingly powerful and affordable computers in their pockets and purses, while allowing online access to transcend time and space in an intertwined interface, as the phone becomes an extension of the self for a majority of us [11, 12]. Meanwhile, a Participatory Turn (PT) in online social spheres has shown that people find it increasingly meaningful to share their daily activities with friends, family and the general public [10, 13-15]. Taken together, these yield both a local relevance for consuming information by social others at the same exact place, as well as a social relevance to perceive and share what social others we know are doing. The relationships between these four elements (mobility turn, participatory turn, local relevance and social relevance) work together to facilitate a collective creation of a digital reflection of the consumption of physical space and social place [4].

2.2 Four Conceptual Distinctions

Place-centric information is when place is the center of relevance for information, such as a business, intersection, landscape feature or any position that has been formally or informally named. *Location-centric information* has specific geographical X,Y coordinates of latitude and longitude. *People-centric information* is when a person is the center of relevance for information, arising from their individual movements and physical behavior within the environment. *Network-centric information* is when the network is the center of relevance, amassing information from multiple users’ actions along interactive, social and online channels.

2. Methodology

The Roskilde Festival consists of many concerts over four headline festival days. These windows in time provide a unique opportunity

to compare and contrast the consumption of physical space with social place along the real-world and online-world dimensions. At the convergence of these entangled worlds, we seek to build on the SoLoMo theoretical framework and the four conceptual dimensions discussed earlier to analyze physical movement paths and show how social media is now “walking around” with us. In doing so, we can pinpoint patterns in usage during events that reflect whether people are collectively ‘in-the-moment’, or dividing their attention between personally experiencing the concert and socially sharing content online.

3.1 GPS Data (Mobile GPS Tracking)

Of the 60 thousand people who installed the festival application, 44 thousand opted-in to allowing anonymous tracking; yielding 38,678 unique users who were present inside the festival area that provided mobility data to our study. With this GPS data we have a measure for how many people are at a given place and time. The app provided up-to-the minute location coordinates for all users who voluntarily agreed to share data. This allows a count of both unique persons at each concert event, as well the amount of collective minutes spent watching each artist.

3.2 Social Data (Geofenced, Geotagged and Mentions)

The general population of smartphone owners (with or without the festival app) also had the opportunity and desire to volunteer content on social channels. Unlike GPS data that is location-centric (lat, long), geotagged posts are place-centric posts that are attached to a nearby place of relevance to the user. The public portion of these streams were collected on a large scale on all channels using [GeoFeedia](#) (geofenced posts), [FollowTheHashtag](#) (Twitter mentions, including geocoding) and [Radian6](#) (all other online mentions except Instagram). Other additional tools were deployed but used for reference purposes only, including [Talkwalker](#) (offering real-time statistics), and a custom tool built to fetch from posts from the Instagram API). Figure 2 presents the overview of the data collection.

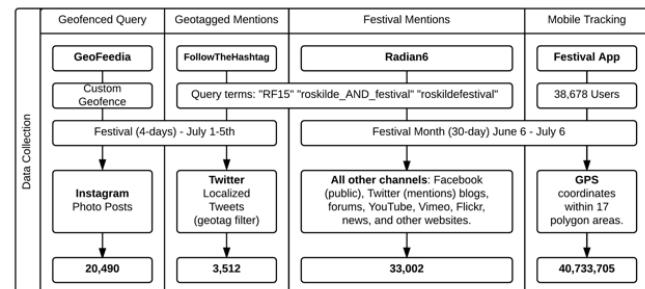
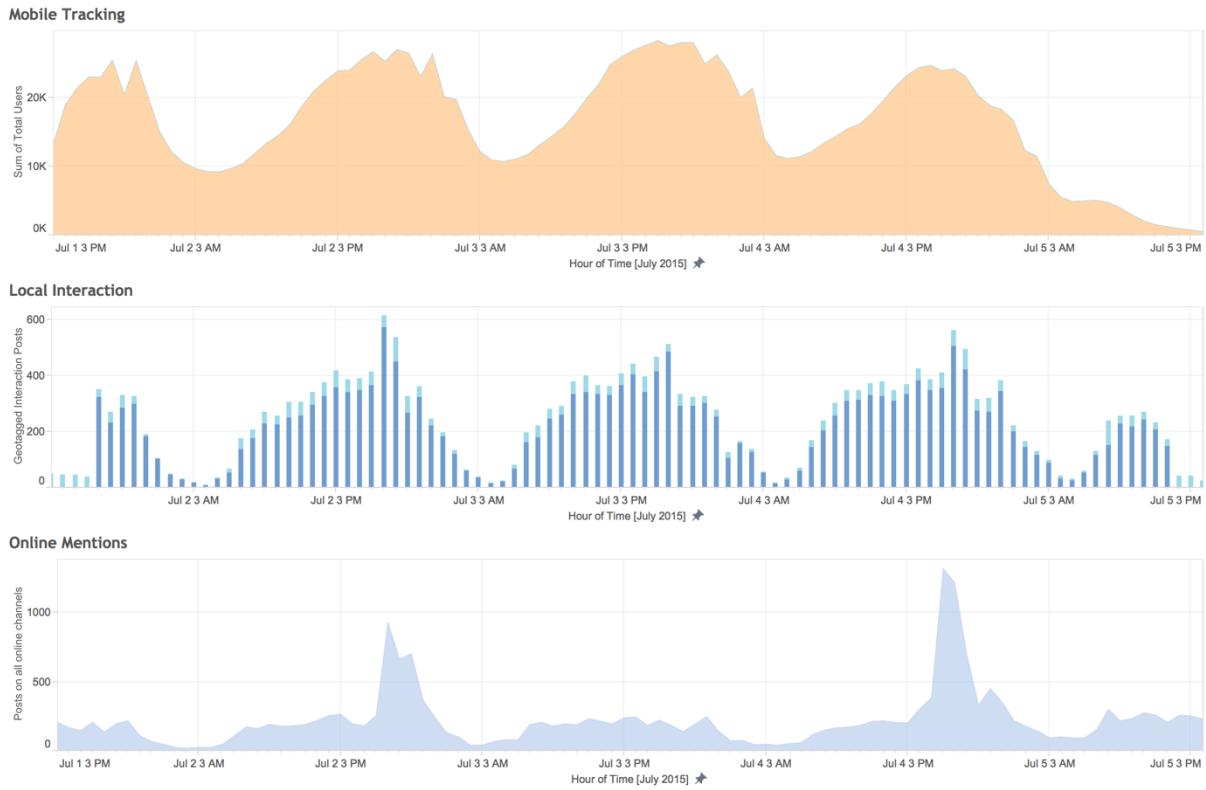


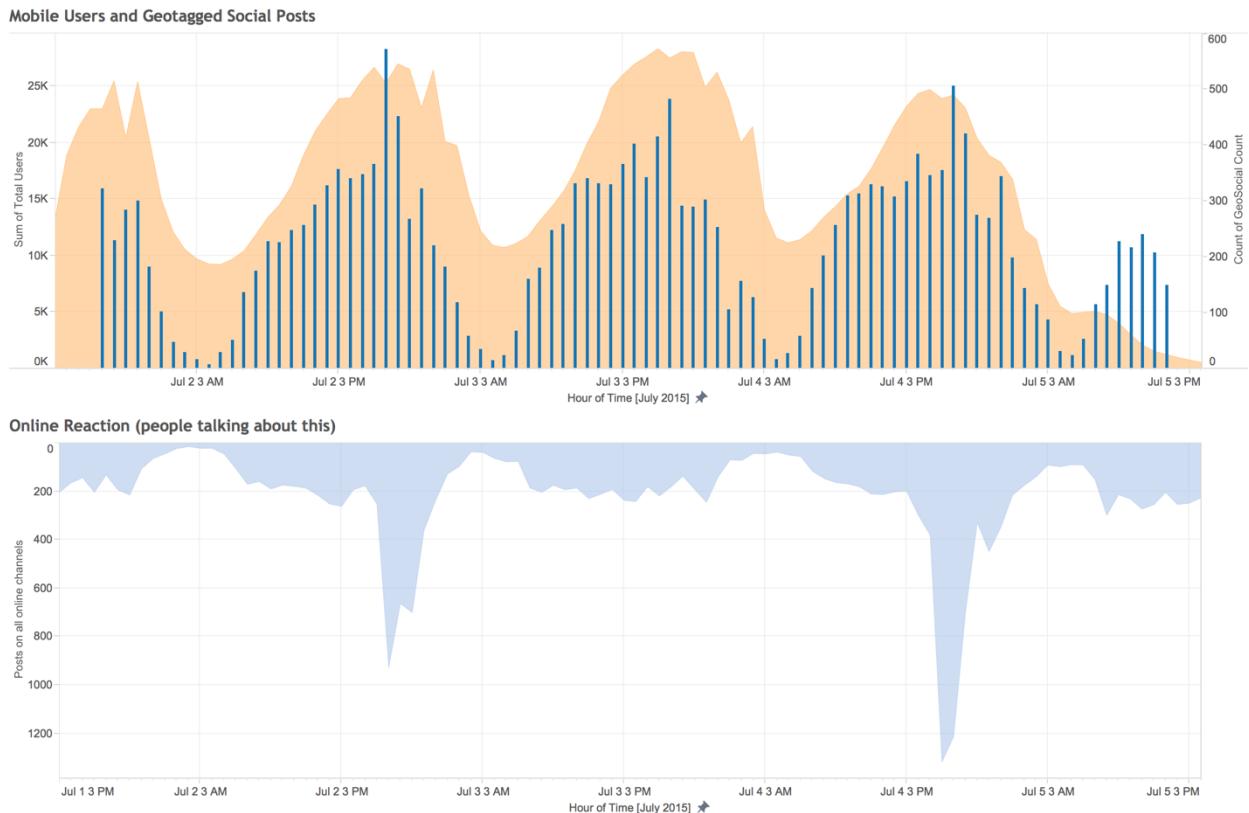
Figure 2: Data Collection Overview.

3.3 Data Attributes

We follow past distinctions of affiliation in counting different interactions on social channels. Social channels offer different audiences to the producer of content with varying combinations between family-friend, public-private, personal-professional, mutual connections, text length and media richness. When content is shared on LinkedIn the perceived audience is often a professional network. Twitter, for many users, is a public forum where anyone who wants to can participate, thus, mixing private and professional connections. Because Facebook requires mutual connections of a personal nature, this audience is mostly people we know and care about (friends and family) except for interactions on public Facebook walls.



Figures 3a and 3b: DATA DIMENSIONS – Distribution of three dimensions over the full festival. The alternate format below (b) combines these measures in the real world (attached geospatially) along a dual axis at the top, with the online pulse of general discussion as a reflection in the bottom half. This configuration is later used as a fingerprint to compare multiple events.



The understanding of mobile and social data signals on the physical, cultural and social landscape of the festival lies in the intentions of the user who is sharing information, and more specifically the community who is intended to interpret the tweet, Instagram, blog, etc. [4]. Given the interpretation of data signals as they are applied to public spaces, two signals were of particular interest to collect. The **photo** can be considered a direct measure of *appreciation*, requiring physical presence and costing little time to compose. Instagram users (often with public profiles) who take photo of the space around them are sending a signal to followers of appreciation for what they see. What people say in **textual posts** was also analyzed specifically. While text content can be contributed from outside the physical proximity of the spaces, the mention (or buzz) level online offers a general signal level that events are generating. People often (but not always) talk more about things that they like or are interested in. Buzz levels of people talking about the festival therefore serve as an indirect measure of *interest*. Sentiment analysis could tighten the accuracy of positive interest/appreciation, however past studies have found that the pulse of conversation offered a stronger proxy of interest than sentiment polarity⁴ [16]. The Twitter channel in particular has a large percentage of public accounts and contributed to significant proportion (80.7%) of the total mention volume, in addition to abilities for geocoding. The act of '**liking**' on Facebook was collected from Facebook walls but intentionally not used in this study. The 'like' is considered a signal of direct *affinity* towards a band or the festival itself. However, this action of strong affinity can be performed from anywhere in the world, since Facebook Graph API doesn't expose the timestamp for 'likes', it is difficult to determine if and when the like action was performed. That is, if the 'like' action was performed on-location during the minutes of the event studies we examine here.

With the collection of geofenced social media posts, we can then measure interaction, appreciation, interest and sentiments as added layers on the map of the public sphere [17], as people's "opinions, behavior, and notions of relevance shift over time and space in an ever-changing fashion" [4]. These signals are sent in the form of Facebook posts, tweets, photos, Flickr images, YouTube videos, blogs, forums, to name the more popular outlets people share publicly. They are examples of network-centric information and thus differ in relevance to people-centric information from mobile tracking. Such broadcasts help us construct a digital reflection of the physical space that can be contrasted to the places people, as traced by the GPS tracking in mobile phones.

3.4 Public Places

Having elaborated on the differences between social media data types and signals, one can look at the public domain and ask what are the most frequent types of public spaces that receive social media endorsements? Restaurants, airports, street landmarks, and green spaces all regularly receive high levels of endorsements. Yet concerts, conventions and sporting events are also highly represented in cities [4]. This can be explained in the fact that attending a sports match is a memorable event, and thousands of people affiliate themselves with the stadium or arena, in order to help broadcast a heightened moment in their lives. This is the "look at me, look where I am" behavior for posts that is often accompanied by a picture and tagging others in the photo. However, it is important to note that venues whose business it is to shift different acts across their stage benefit from a wide variety of

⁴ Additionally, a significant portion of posts were contributed in Danish, a language not supported by the sentiment classifiers we use and would require dedicated training – an opportunity for further work using the Danish portion of the corpus.

affinity circles. For example, a stadium may be the location for photos and check-ins from teenagers watching a pop concert on a Friday night, a more middle-aged female demographic of Madonna fans on a Saturday night, and a male demographic on a Sunday for a football match. Event venues have accounted for as much as 7% of city check-ins by holding memorable events, while the facility itself receives less than 2% of likes of their Facebook page⁵. This is because fans are more likely to project their direct online endorsement to the fan page of an artist than the facility who is housing them for only one day or night.

3.5 Mobile Data

Figure 4 shows an overview of the GPS data analytics process. All GPS data analyses has been done in MS SQL server 2014 using the geospatial database functions on tracker data imported from IBM's dashDB and 75 area of interest polygons digitized from technical and areal maps of the festival (see Polygons, Appendix 3).

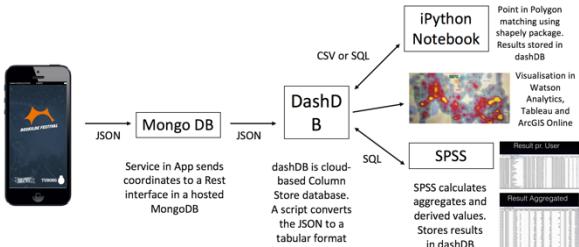


Figure 4: Mobile Data Pre-Processing.

3.6 Social Data

Physical spaces become digital places when humans attach themselves to a given location that gives them meaning [18]. For the most part, people at the Roskilde festival attached their photos to a pre-registered place in the Instagram, Twitter or Facebook app such as the 'Orange Scene' main stage in particular, or Roskilde Festival at large. We used Geofeedia's geofencing tool to outline the perimeter of the festival polygons. This allowed us to collect any and all public social media data that was generated within the physical confines of the festival, accurate to the meter, and outlining the entire perimeter of campgrounds and parking lots around the more central village areas. Unlike mention queries typically used for collecting social data, this allowed the collection of posts where keywords may not even be present and yielded posts that were truly from on-location, rather than chatter from fans about the festival the world over. These layers of mobility, local interaction and online chatter are then combined (Figure 3). Volumes of participants who come to the festival are visible for each four days at the top, swelling daily to show a doubling of the population of people who remain overnight at the camp. Peaks in interaction (bar chart) correlates as these contributions were made in the same physical space. Online chatter (bottom) acts somewhat as a reflection and is characterized by two dramatic volume spikes in conversation which pinpoint some of the headlining music shows.

3. Findings and Discussion

Total participants included 39,738 unique mobile phones, of which 38,678 were inside the 'Orange Scene' main stage at some point. This main stage venue provides an area of focus to contrast the highest volumes of people during eight of the headlining music acts; time windows with the largest volume.

⁵ According to statistics collected from the social bakers website (www.socialbakers.com).

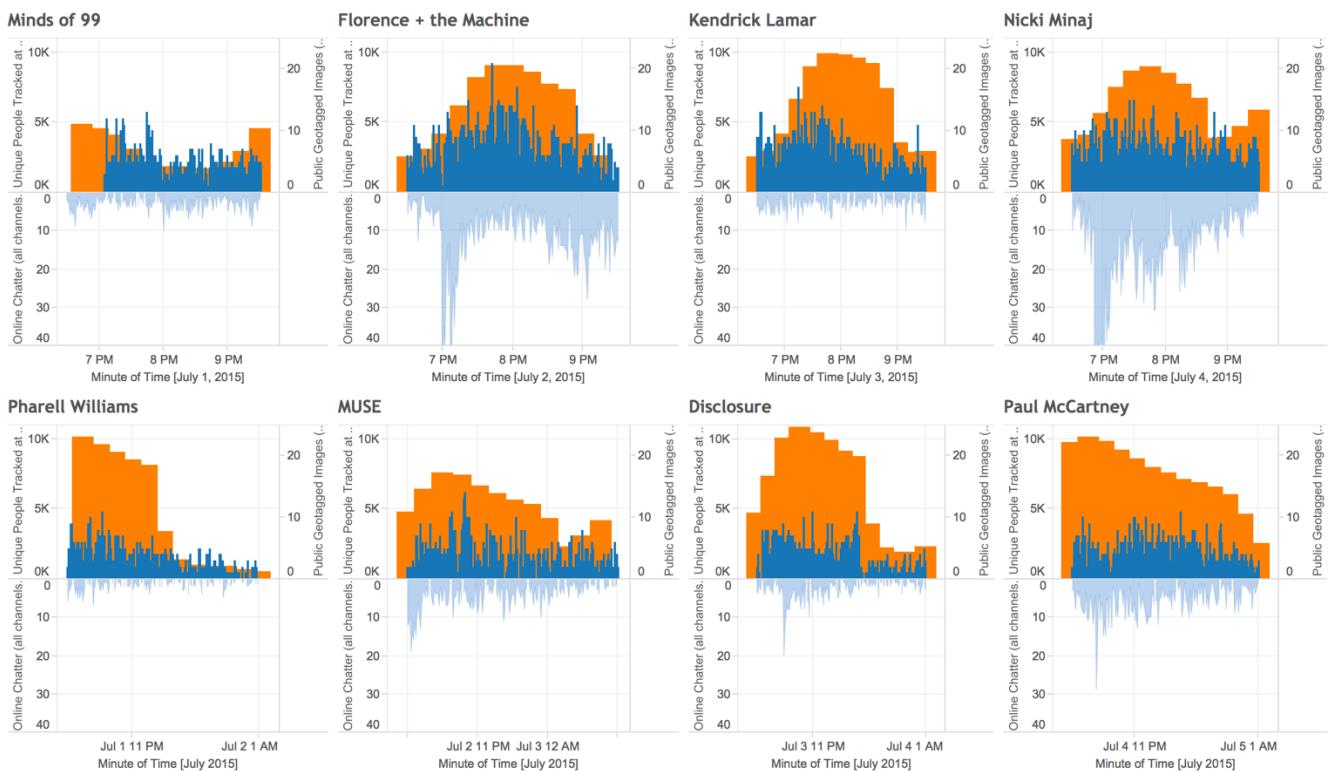


Figure 5: TIME DISTRIBUTION (per event) – Each concert event consist of 3 hour windows of data in order to show pre-event and post-event levels. Daily 7pm shows are displayed in the first row followed by 10pm shows in the second row.

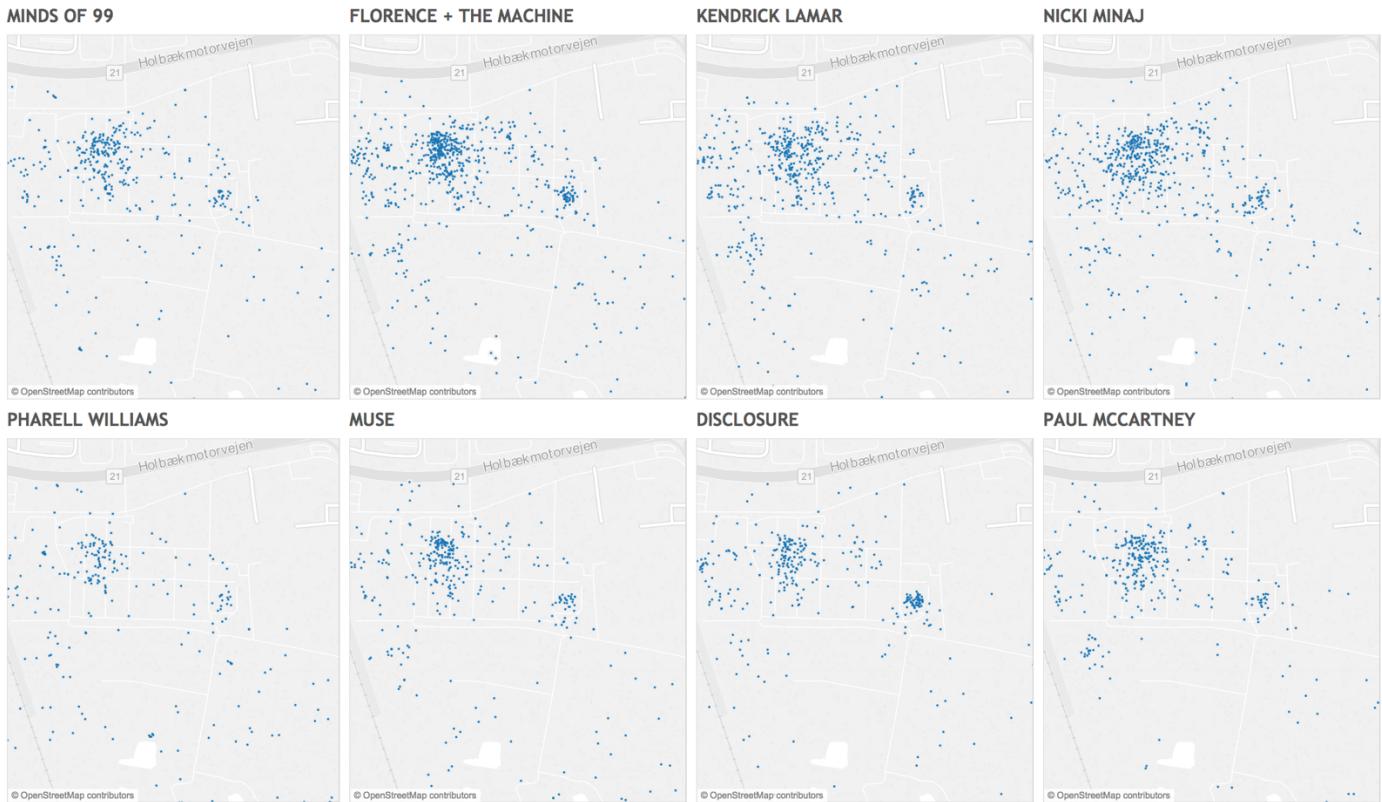


Figure 6: SPACE DISTRIBUTION The geo-social data layer showing eight headlining acts photographed in the same timeframe.

Based on the overall measure of physical presence from mobile data, rapper Kendrick Lamar was the most popular artist, generating 328,258 tracking points (observations), or GPS coordinates transmitted. At the concert's peak, he was watched by 9,994 participants and the collective audience were watching for a combined 1.37 million minutes (note this level does not account for people who did not download the app, disallowed its tracking, running Android or Windows phones, without an internet-enabled smartphone, or without a working or charged phone). This example of peak activity can both be contrasted to other headline events across the four days, and more importantly compared to several other measures of presence and interactivity.

4.1 Appreciation Affordance

Counting unique participants present provides a proxy for the number of people who had the opportunity to post online with their smartphone. To define these places geospatially, the audience areas for each stage are outlined in a polygon drawn around its perimeter. The GPS tracking data from the Roskilde app provides a proxy for the number of people at a given time and space. Looking only at the top half of each event in Figure 5, one can contrast people who had their smartphone versus those who chose to use it to interact and share moments they found meaningful. The 'Minds of 99' and 'Florence + the Machine' concerts appear to have relatively high levels of such appreciation signals consistently over time. When one looks at other such 'fingerprints' of events, some examples have high levels of people and relatively low levels of photo appreciations and geolocated posts of interest, such as the 'Disclosure' concert.

4.2 Attention-Interest Salience

Comparing real-world activity in the physical space with the online level of chatter resulted in the bottom half of each graph in Figure 5. The most dramatic spikes pinpoint the beginning of two of the concerts ('Nicki Minaj' and 'Florence + the Machine'). Social data reveals a fluctuating level of people talking about the concert as an interest proxy [19, 20], and measure the number of photos taken, considered as a signal of appreciation [4]. People typically, but not always, talk about and take pictures of things of interest or appreciation [16]. However, a paradox exists within this measure since posting during a concert reduces actual attention, while buzz levels before and after a concert an increased level of anticipation and interest. By comparing temporally (horizontally in Figure 5) when people choose to publish their content, differences in attention-interest salience can reveal behavior choices from one concert to the next.

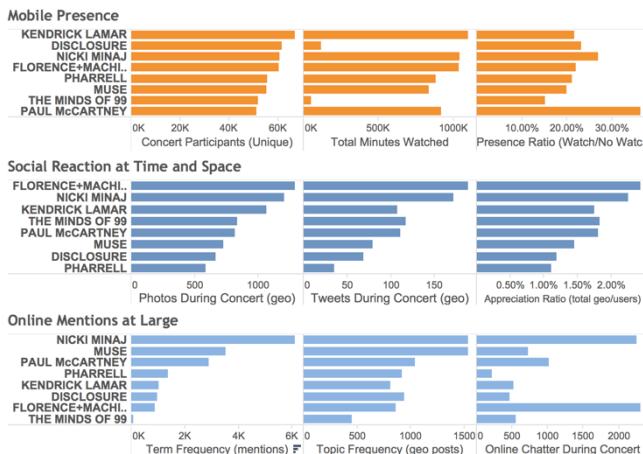


Figure 7: Ranking of total measures for all headline concerts.

4.3 Opportunity Cost

It is important to note that concerts at Roskilde Festival often happen simultaneously. Another measure worth investigating is the opportunity cost impacts of concertgoers on the ground. Like the enormous offerings of things to do in cities, Roskilde festival has many simultaneous concerts and events on its schedule, except here people are in a semi-private domain where they have paid additional money to be here. Choices between two artists therefore carry a heightened trade-off for the cost of people's time at the festival. It is thus worth measuring not only the attendance within a particular stage event, but also the number of people who deliberately chose to see other shows and do other things. For example, Figure 6 shows a geospatial distribution of appreciation signals (photos and geotagged posts) with the main stage showing the greatest magnetism in the upper left area. However, some events had smaller, concentrated clusters at the Apollo stage at center right, especially detracting from the 'Disclosure' concert.

4.4 Mobile Presence

As mentioned earlier, the overall greatest presence was detected at the Kendrick Lamar concert, both in terms of total unique people and total minutes spent at the main stage. However, when one compares the ratio of people who chose to be at a given concert compared to opportunity costs (competing concerts, food, and walking around) the Paul McCartney event had by far the greatest proportion of all people who had the opportunity to see it (Figure 7).

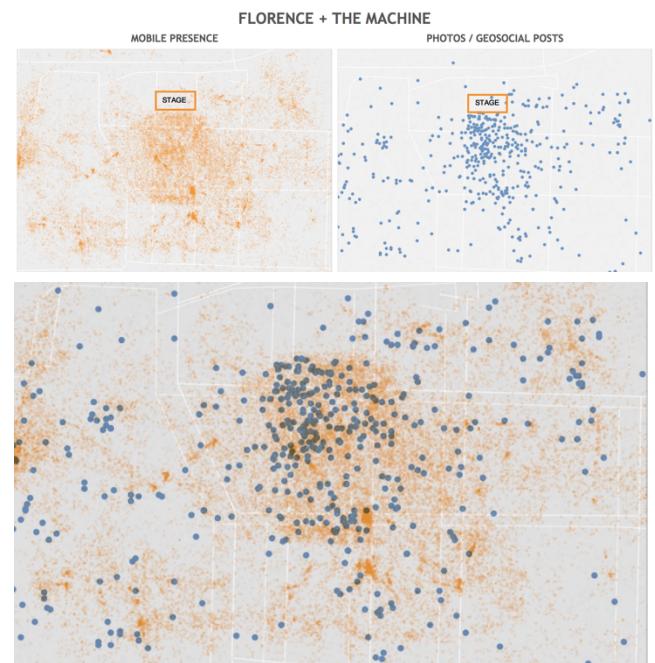


Figure 8: Comparison and combination of data layers.

4.5 Social Reaction

Volumes of geospatial social data were far greater at certain events such as the Florence + the Machine concert. However, when one looks at the highly-populated Kendrick Lamar event, it receives low relative appreciation signals in proportion to the amount of participants tracked (when compared to several events with lower raw volumes of geosocial data such as Paul McCartney and Minds of 99). Figure 7 presents each of the total results for Mobile Presence, Social Reaction and Online Mentions as well as appreciation ratios (see table in Appendix 4 for full results). We

further examine reaction spatially, by focusing on the Florence + the Machine concert that received the highest proportionate appreciation. If we examine where people gathered (orange nodes) we see a fairly even distribution in front of the main stage, except for some dense clusters at the back right. By overlaying a layer of photos from Instagram we see increasing appreciation density closer to the main stage (Figure 8).

4.6 Online Mentions: Flows in Conversation

Ebbs and flows of activity have thus far been shown in online and offline volumes, revealing a contrast between action and interaction across time and space. However, the conversation text itself can be mined to show flows across topics rather than shifting volumes of people across spaces. Text mining was used to investigate trends using the MineMyText (minemytext.com) research prototype. Term frequency reveals a lot of chatter around Muse, who are famous for live performances, as well as Nicki Minaj whose performance involved risqué language and costumes that may have been discussed by the public or whose mere presence may have been noted by a larger Twitter fan following.



Figure 9: Conversation Flows (Topic Modeling) - Artists detected by topic modelling, displayed in order of appearance.

Topic modelling [21] was then used to generate 20 topics, 12 of which corresponded to specific concert/bands while the rest were about facilities, bars and the summer weather, to take just a few examples. Some of the topic model themes included two acts that were discussed together to such a degree that they were identified by as thematically being within the same topic. When the flow of topics is then examined over time one can see escalations in specific chatter during performances (Figure 9). The duration immediately after a performance is not the same for each artist and differences also exist in how much people continued talking about a specific band over the remaining festival days.

4. Place-making and Measuring Stickiness

As a study founded in urban informatics, the festival venue admittedly differs from city and streetscapes. People use the city differently than an event-packed festival where a considerable amount of money was spent to witness specific events and partake in various goods and services. Like a festival, a city is filled with agendas and places to be, necessary appointments and bus waiting times. Yet spur of the moment decisions is often made to stay longer in leafy squares, markets, riverbanks, for example. Placemaking in particular involves the choice to stop moving through the environment, combined with a desire to pause and

enjoy one's surroundings. As the venerable urbanist Jan Gehl has pointed out: "People stay in a place if it is a beautiful, meaningful, pleasant place to be. The good city has many similarities to a *good* party: the guests stay on because they are enjoying themselves." Opportunities to stay and invitations to linger are considered key to a lively city, and the length of stays are essential to the creation of "socially viable" city life in public places [22]. As these decisions are made by people over and over again, we seek to capture a cumulative view of the 'stickiness' of public spaces [23]. Up until this point we have concentrated on contrasting the largest venues and their corresponding gatherings. While physical presence can be measured in absolute terms (counting the number of unique people), places can also be measured in terms of duration and how much people chose to remain serendipitously around the concert schedule. For this we exclude the main stage concert venues (which have inherent consumption) and focused on areas that constitute city-like spaces within the event such as areas for eating, drinking, shopping, recreation, art installations, parking, toilet facilities and the main throughways that all constitute part of the festival 'village'. We then aggregated our data to measure two new metrics that align with urban informatics: instances of 'lingering' and 'stays'. A 'linger' event (greater than 5 minutes) is measured when a unique user has five observations within a space-time box aggregated to 5 minute intervals. A 'stay' event (greater than 15 minutes) is counted when a unique user has 15 observations within a space-time box, aggregated to 15 minute intervals and only if they are present within the same space-box for all 15 minutes. Unfortunately location data transmitted by mobile phones is irregular in terms of GPS accuracy and inconsistent in terms of time frequency, requiring statistical interpolation⁶.

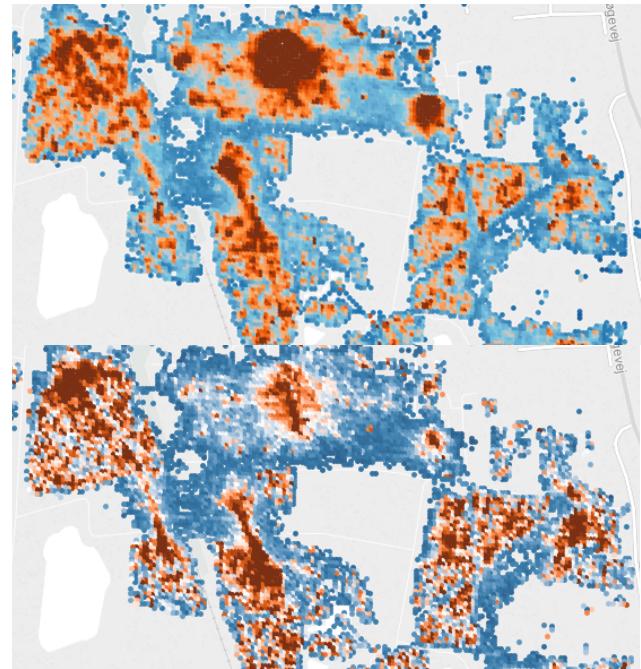


Figure 10: Measuring short 'lingers' greater than 5 minutes (top) and longer 'stays' greater than 15 minutes (bottom).

The space-time box is a way of capturing presence by means of an area of 10m x 10m x 1 minute in order to capture presence despite irregular transmissions of location data⁷. Such measurements allow

⁶ A histogram of the distribution of TrackPoint distance between user points (in time and space) revealed the majority of data (75%) is within 25 meters and 150 seconds.

us calculate and illustrate the ‘stickiness’ of spaces on a granular level, offering questions to ask of the data such as: why does one dining area have people staying for longer periods of time? Where does one linger (by the toilets) and where do people convene unexpectedly? Where are new spaces for social interaction created?

5. Discussion

Understanding the nuances of what makes a space enticing does of course require local, cultural, social and on-the-ground and in-the-moment knowledge. However, the traditional architectural methods of manual counting human activity on a large scale can be complemented with mobile and social media tracking [4]. Assuming people typically keep their phone on them, digital tracking has enormous advantages over analogue surveys with an ability to transcend time and time and space. The mobile phone serves as an extension of the human body and can be used for accurate tracking of people and their consumption in and between places. Mobile tracking of people on a large scale provides a direct reflection of presence at a given space and time. However, the collection of social data - with limited context and respecting privacy – can only offer an *indirect reflection* of the real world. Photos and online chatter are thus indirectly traced as interest and appreciation. Yet simply tracing where people go and stay via mobile sensors, cannot glean the same insights on what they more specifically *do*, or pay attention to (the photo) at a tracked location, what they *say* (the post) about it, and even what they *think* (the ‘like’). While social data collected is publically accessible, connecting posts to the mobile-tracked participants was not attempted, for obvious privacy concerns. Yet by contrasting these layers of data, proxies of interest, as well as measures for stickiness, there is an enormous potential towards understanding the cumulative usages of space in cities and major events.

6. Conclusion

We offer theoretical distinctions between location and place, networks and people, as well as build on a framework that explains the interplay between the creation and consumption of space in both online and offline spheres of existence. Our methodology interprets social media signals that mark-up our physical landscapes based on the intended audience and a resulting affordance the user capitalizes on to show either interest, affinity or appreciation. We have examined how meaningful spaces become digital places and vice versa when they attach themselves via posts, as well as place-making in the physical sense as participants stick to certain areas for longer durations. Ultimately we utilize these signals as proxies for relevance that can be combined with mobile tracking data as a representation of physical presence and attention (to a certain degree). We have shown that where people go and post/talk about is not the same on the ground as it is globally online, and just because people are present at a concert, their ways of consuming the space offers different footprints of interaction across time and space.

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References

- [1] Karanasios, S. and Allen, D. Mobile technology in mobile work: contradictions and congruencies in activity systems. *European Journal of Information Systems*, 23, 5 (2014), 529-542.
- [2] Satyanarayanan, M. Mobile computing: the next decade. *ACM SIGMOBILE Mobile Computing and Communications Review*, 15, 2 (2011), 2-10.
- [3] Humphreys, L. and Liao, T. Mobile Geotagging: Reexamining Our Interactions with Urban Space. *Journal of Computer-Mediated Communication*, 16, 3 (Apr 2011).
- [4] Zimmerman, C., Hansen, K. and Vatrapu, R. A Theoretical Model for Digital Reverberations of City Spaces and Public Places. *Int. J. Electron. Gov. Res.*, 10, 1 (2014), 46-62.
- [5] Rabbath, M., Sandhaus, P. and Boll, S. Automatic Creation of Photo Books from Stories in Social Media. *AcM Transactions on Multimedia Computing Communications and Applications*, 7, 1 (Oct 2011).
- [6] Lockstone, M. R., Olga Junek, Leonie, Hudson, S. and Hudson, R. Engaging with consumers using social media: a case study of music festivals. *International Journal of Event and Festival Management*, 4, 3 (2013), 206-223.
- [7] Foth, M. *Handbook of Research on Urban Informatics: The Practice and Promise of the Real-Time City: The Practice and Promise of the Real-Time City*. IGI Global, 2008.
- [8] Vatrapu, R. Explaining culture: an outline of a theory of socio-technical interactions. *Proceedings of the 3rd ACM International Conference on Intercultural Collaboration (ICIC 2010)* (2010), 111-120.
- [9] Born, G. The Social and the Aesthetic: For a Post-Bourdieuian Theory of Cultural Production. *Cultural Sociology*, 4, 2 (Jul 2010), 171-208.
- [10] Vatrapu, R. *Understanding Social Business*. Springer, City, 2013.
- [11] e Silva, A. d. S. and Frith, J. *Mobile interfaces in public spaces: Locational privacy, control, and urban sociability*. Routledge, 2012.
- [12] Ling, R. *The mobile connection: The cell phone's impact on society*. Morgan Kaufmann, 2004.
- [13] Okunna, C. S. Small Participatory Media Technology as an Agent of Social-Change in Nigeria - a Nonexistent Option. *Media Culture & Society*, 17, 4 (Oct 1995), 615-627.
- [14] Williams, C. and Gulati, G. Social Networks in Political Campaigns: Facebook and the 2006 Midterm Elections. In *Proceedings of the Annual Meeting of the American Political Science Association* (Chicago, Illinois,, 2007), [insert City of Publication],[insert 2007 of Publication].
- [15] de Zuniga, H. G. Social Media Use for News and Individuals' Social Capital, Civic Engagement and Political Participation. *Journal of Computer-Mediated Communication*, 17, 3 (Apr 2012), 319-336.
- [16] Asur, S. and Huberman, B. A. *Predicting the future with social media*. IEEE, City, 2010.
- [17] Robertson, S. and Vatrapu, R. *Digital Government*. City, 2010.
- [18] Lefebvre, H. *The production of space*. Oxford Blackwell, 1991.
- [19] Asur, S., Huberman, B., Szabo, G. and Wang, C. *Trends in social media: Persistence and decay*. City, 2011.
- [20] Romero, D., Galuba, W., Asur, S. and Huberman, B. Influence and passivity in social media. *Machine Learning and Knowledge Discovery in Databases* (2011), 18-33.
- [21] Aggarwal, C. C. and Zhai, C. *Mining text data*. Springer Science & Business Media, 2012.
- [22] Gehl, J. *Cities for people*. Island press, 2013.
- [23] Gehl, J. and Svarre, B. *How to study public life*. Island Press, 2013.

⁷ Most geospatial temporal methods require observations to be equidistant in time. The raw tracker points lack this property since the data for individual users are sampled in irregular intervals, ranging from a series of tracker points 1 second to several minutes apart. From the original dataset, a new normalized dataset is constructed using SAS EXPAND to interpolate missing observations at minute intervals and

aggregated with the original data to yield one observation per user per space-time box.

Appendices

Appendix 1: Roskilde Festival Program for each of the four days. The ‘Orange’ main stage was used to analyze the largest events.



WEDNESDAY
1 JULY

TIME	APOLLO	PAVILION	AVALON	ORANGE	GLORIA	ARENA	TIME
17	+15 FUTURE BROWN		+30 OFF!		+45 SANTIAGO		17
18		+00 COMMUNION		+30 THE MINDS OF '99		+00 TIMBUKTU & DAMNI	18
19	+15 BATKING			+00 ANTEMASQUE			19
20	+45 YOUNG FATHERS	+00 MINI GIZZARD & THE LIZARD WIZARD			+00 NOURA MINT SEYMAJI	+30 NOEL GALLAGHER'S HIGH FLYING BIRDS	20
21			+30 BARETO				21
22	+30 RUSTIE	+00 HONNINGSBARNA		+00 PHARRELL WILLIAMS	+00 ELECTRIC EYE		22
23						+00 THE WAR ON DRUGS	23
00		+00 BARGOU DB					

Resident DJ (from 18:00)

DJ Mam

NON-PROFIT
SINCE 1972

FRIDAY
3 JULY

TIME	APOLLO	PAVILION	AVALON	ORANGE	GLORIA	ARENA	TIME
12				+00 KRONOS QUARTET		+30 HUDNA	12
13			+00 BROKEN TWIN				13
14	+00 RANGLEKLØDS			+30 SUSANNE SUNDFØR		+30 CABO SAN ROQUE	+00 PEDA B & DJNOIZE
15		+00 METÀ META					15
16	+00 SPECKTORS + NONSENSES					+30 KIPPI KANNIUS	+00 THE TALLEST MAN ON EARTH
17		+00 KWABS	+00 THE GASLAMP KILLER EXPERIENCE	+00 MARIE KEY			17
18	+00 KATE TEMPEST	+30 DOLOMITE MINOR				+30 LYDIA AINSWORTH	+30 LARS H.U.G.— SPECIAL SHOW
19				+30 KENDRICK LAMAR			19
20	+00 LEIF	+30 GRETCHEN PETERS	+00 EINSTÜRDEN NEUBAUTEN			+30 LINDIGO	20
21						+00 RUN THE JEWELS	21
22	+00 DJ MUSTARD	+00 M.A.X.U. SOUNDSYSTEM	+00 ENSLAVED	+30 DISCLOSURE	+30 ALICE BOMAN		22
23						+30 LAMB OF GOD	23
00	+00 EGYPTRIXX	+30 DECAPITATED	+00 GOAT				00
01				+00 MEW	+00 FOSSILS		01
02	+00 POWELL	+30 TWIN PEAKS	+00 OQUADRO			+00 KYGO	02

Resident DJ (from 18:00)

THURSDAY
2 JULY

TIME	APOLLO	PAVILION	AVALON	ORANGE	GLORIA	ARENA	TIME
12		+00 SARABI		+30 FOSHORN STRINGBAND			12
13	+00 DJ MAM		+00 EVERY TIME I DIE				13
14		+00 STEVE GUNN		+30 EZRA FURMAN	+00 VERONICA MAGGIO	14	
15	+00 DALHOUS		+00 C-EAZY				15
16		+00 KHARA ARBY		+30 DREAMERS CIRCUS	+00 JUPITER & OKWESS INTERNATIONAL	16	
17	+00 CHANCHIA VIA CIRCUITO		+00 FATHER JOHN MISTY	+00 RYAN ADAMS			17
18		+00 FERRO GAITA		+30 SOAK	+00 ST VINCENT	18	
19	+00 BATIDA		+00 FOXYGEN	+30 FLORENCE + THE MACHINE			19
20		+00 PERFUME GENIUS		+30 LUST FOR YOUTH	+30 MASTODON	20	
21	+00 ILOVEMAKONNEN		+00 JUNGLE				21
22		+00 PALLBEARER		+30 MUSE			22
23	+00 KAYTRANADA		+00 KASAI ALLSTARS	+00 PHARMAKON	+00 BIKSTOK	23	
00		+00 DOUGHT					00
01		+45 DOOMTREE	+00 DIE ANTWOORD	+00 CHOUK BWA LIBÉTÉ			01
02	+30 TROPILLAZ	+00 FAT WHITE FAMILY			+00 HOT CHIP		02

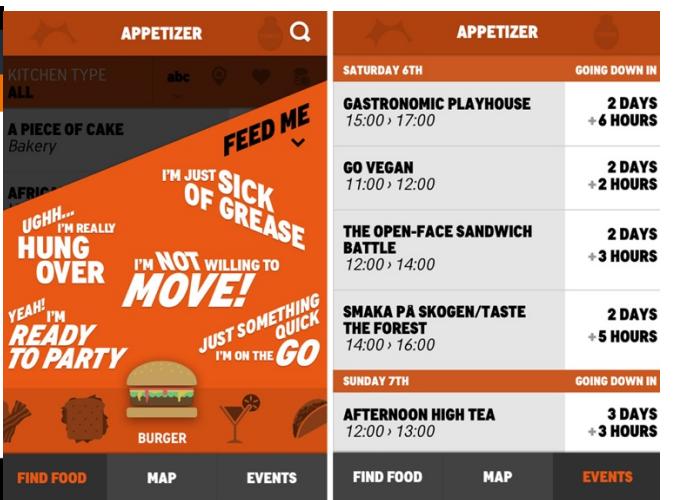
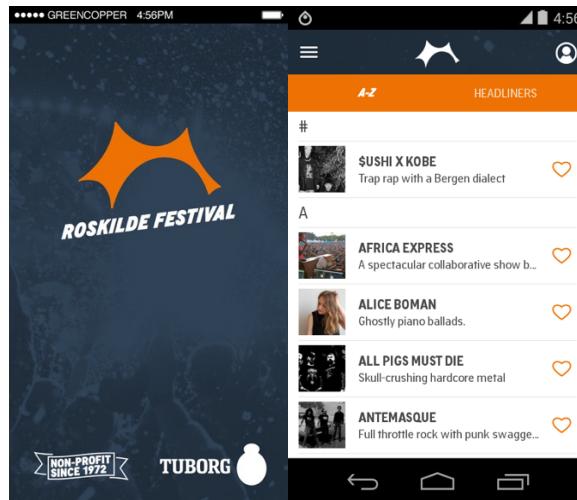
Resident DJ (from 18:00)

DJ Mam

SATURDAY
4 JULY

TIME	APOLLO	PAVILION	AVALON	ORANGE	GLORIA	ARENA	TIME
12				+00 SPIDERGAWD		+30 SABIR KHAN	12
13	+00 KANE WEST		+00 WARM GRAVES				13
14			+00 ALL PIGS MUST DIE		+30 WE LIKE WE	+00 THE MOUNTAINS	14
15	+00 SEINABO SEY		+00 PERFECT PUSSY				15
16			+00 THE POLYVERSAL SOULS		+30 TBA	+00 WHOMADEWHO	16
17	+00 UKENDT KUNSTNER	+00 JOANNA GRUESOME			+00 BARRINGTON LEVY		17
18			+00 CORROSION OF CONFORMITY			+30 SONGHØY BLUES	+00 THÅSTRÖM
19	+30 KEVIN GATES	+00 BENJAMIN BOOKER			+30 NICKI MINAJ		19
20			+00 NILS FRAHM		+30 CHELSEA WOLFE	+30 FIRST AID KIT	20
21	+30 CLARK	+00 TOMBS					21
22		+30 DEAFHEAVEN	+00 TBA	+00 PAUL McCARTNEY	+30 SELVENTHER		22
23	+00 DIXON					+00 AFRICA EXPRESS	23
00		+00 MYRKUR	+00 DRENGE				00
01		+30 YOUNG AND IN THE WAY			+30 SUSPEKT	+00 TBA	01
02	+00 JAMIE XX				+00 KODALINE		02

Resident DJ (from 18:00)



Appendix 2: Official App - Example screenshots from the official festival app. After installation, a popup asks users if they will allow the app to transmit geolocation details on a regular basis.

Appendix 3: Festival Grounds - This google earth image was taken during the festival week, illustrating the infrastructure of the temporary city such as camping and tent installations. The polygons used by the festival are overlayed to delineate sub-areas such as parking (pink), eating and drinking (blue), camping (green) and music stages (orange).



Appendix 4: Total Measurements per headlining concert - Table of measures used in the analysis, sorted by participation.

Artist/Event Results (Totals)

Artist	Participants at Concert (Unique)	Total Minutes Watched	Presence Ratio (Watching / Not Watching)	Photos During Concert (geo posts)	Tweets During Concert (geo posts)	Appreciation Ratio (total geo posts / participants)	People Talking During Concert (online global posts)	Term Frequency During Festival (artist mentions)	Topic Frequency During Festival (geo posts)
KENDRICK LAMAR	67,180	1,101,197	21.57%	1,067	107	1.75%	519	1,038	813
DISCLOSURE	61,807	120,174	23.23%	665	69	1.19%	463	969	942
NICKI MINAJ	60,914	1,041,774	26.88%	1,204	172	2.26%	2,251	6,114	1,537
FLORENCE + THE MACHINE	60,549	1,035,642	21.94%	1,292	188	2.44%	2,311	898	862
PHARRELL WILLIAMS	55,803	885,158	21.13%	585	35	1.11%	222	1,381	920
MUSE	55,346	838,443	19.93%	728	79	1.46%	731	3,515	1,537
THE MINDS OF 99	51,992	49,518	15.22%	838	117	1.84%	553	92	455
PAUL McCARTNEY	51,302	918,431	36.31%	816	111	1.81%	1,021	2,898	1,041